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CENTRAL PLANT IMPROVEMENT
CHAPARRAL BUILDING 2023
223 N. CHAPARRAL
TEXAS A&M UNIVERSITY CORPUS CHRISTI
CORPUS CHRISTI, TEXAS

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SECTION 22 05 00 BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.
- B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings are deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect for approval as soon as practicable. No such departures shall be made without the prior written approval of the Architect.
- C. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, such reference shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect, expressed in writing, is equal to that specified.

1.02 SCOPE OF WORK

- A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form the complete and functioning systems in all of its various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The contractor shall review all pertinent drawings, including those of other contracts prior to commencement of Work.
- B. This Division requires the furnishing and installing of all items Specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.
- C. The approximate locations of Mechanical (HVAC) and Plumbing items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the Review of the Owner or

Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.

- D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.
- E. All discrepancies between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to the bidding, where this cannot be done at least 7 working days prior to bid; the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.
- F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.
- G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".
- H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.

1.03 SCHEMATIC NATURE OF CONTRACT DOCUMENTS

- A. The contract documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the approved shop drawings.
- B. All duct or pipe or equipment locations as indicated on the documents do not indicate every transition, offset, or exact location. All transitions, offsets clearances and exact locations shall be established by actual field measurements, coordination with the structural, architectural and reflected ceiling plans, and other trades. Submit shop drawings for approval.
- C. All transitions, offsets and relocations as required by actual field conditions shall be performed by the contractor at no additional cost to the owner.
- D. Additional coordination with electrical contractor may be required to allow adequate

clearances of electrical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

1.04 SITE VISIT AND FAMILIARIZATION

- A. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.
- B. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.
- C. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.05 WORK SPECIFIED IN OTHER SECTIONS

- A. Finish painting is specified. Prime and protective painting are included in the work of this Division.
- B. Owner and General Contractor furnished equipment shall be properly connected to Mechanical (HVAC) and Plumbing systems.
- C. Furnishing and installing all required Mechanical (HVAC) and Plumbing equipment control relays and electrical interlock devices, conduit, wire and J-boxes are included in the Work of this Division.

1.06 PERMITS, TESTS, INSPECTIONS

- A. Arrange and pay for all permits, fees, tests, and all inspections as required by governmental authorities.

1.07 DATE OF FINAL ACCEPTANCE

- A. The date of final acceptance shall be the date of owner occupancy, or the date all punch list items have been completed or final payment has been received. Refer to Division 1 for additional requirements.
- B. The date of final acceptance shall be documented in writing and signed by the architect, owner and contractor.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct properly protected from incidental damage and weather damage.
- C. Damaged equipment, duct or pipe shall be promptly removed from the site and new, undamaged equipment, pipe and duct shall be installed in its place promptly with no additional charge to the Owner.

1.09 NOISE AND VIBRATION

- A. The heating, ventilating and air conditioning systems, and the component parts thereof, shall be guaranteed to operate without objectionable noise and vibration.
- B. Provide foundations, supports and isolators as specified or indicated, properly adjusted to prevent transmission of vibration to the Building structure, piping and other items.
- C. Carefully fabricate ductwork and fittings with smooth interior finish to prevent turbulence and generation or regeneration of noise.
- D. All equipment shall be selected to operate with minimum of noise and vibration. If, in the opinion of the Architect, objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of the Work, the Contractor shall rectify such conditions without extra cost to the Owner.

1.10 APPLICABLE CODES

- A. Obtain all required permits and inspections for all work required by the Contract Documents and pay all required fees in connection thereof.
- B. Arrange with the serving utility companies for the connection of all required utilities and pay all charges, meter charges, connection fees and inspection fees, if required.
- C. Comply with all applicable codes, specifications, local ordinances, industry standards, utility company regulations and the applicable requirements of the following nationally accepted codes and standards:
 - 1. Air Moving & Conditioning Association, AMCA.
 - 2. American Standards Association, ASA.
 - 3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., ASHRAE.

4. American Society of Mechanical Engineers, ASME.
 5. American Society of Plumbing Engineers, ASPE.
 6. American Society of Testing Materials, ASTM.
 7. American Water Works Association, AWWA.
 8. National Bureau of Standards, NBS.
 9. National Fire Protection Association, NFPA.
 10. Sheet Metal & Air Conditioning Contractors' National Association, SMACNA.
 11. Underwriters' Laboratories, Inc., UL.
 12. International Energy Conservation Code, IECC.
- D. Where differences existing between the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, the more stringent or costly application shall govern. Promptly notify the Engineer in writing of all differences.
- E. When directed in writing by the Engineer, remove all work installed that does not comply with the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, correct the deficiencies, and complete the work at no additional cost to the Owner.

1.11 DEFINITIONS AND SYMBOLS

- A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 1.
- B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.
- C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.
- D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied

meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.

- E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.
- F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.
- G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.
- H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.
- I. Installer: Entity (person or firm) engaged by the Contractor or its subcontractor or Sub-contractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.
- J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor, or when so noted by other identified installers or entities.
- K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.

- L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by 2004 ASHRAE Fundamentals Handbook, chapter 37 "Abbreviations and Symbols", ASME and ASPE published standards.

1.12 DRAWINGS AND SPECIFICATIONS

- A. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.
- B. Should items be required by these Specifications and not indicated on the Drawings, they are to be supplied even if of such nature that they could have been indicated thereon. In case of disagreement between Drawings and Specifications, or within either Drawings or Specifications, the better quality or greater quantity of work shall be estimated and the matter referred to the Architect or Engineer for review with a request for information and clarification at least 7 working days prior to bid opening date for issuance of an addendum.
- C. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is equal to the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturers' standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.
- D. The Architect or Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.
- E. Products by other reliable manufacturers, other materials, and other methods, will be accepted as outlined, provided they have equal capacity, construction, and performance.

However, under no circumstances shall any substitution be made without the written permission of the Architect or Engineer and Owner. Request for prior approval must be made in writing 10 days prior to the bid date without fail.

- F. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.
- G. Wherever a definite material or manufacturer's product is specified and the Specification states that products of similar design and equal construction from the specified list of manufacturers may be substituted, it is the intention of the Owner or Engineer that products of manufacturers that are specified are the only products that will be acceptable and that products of other manufacturers will not be considered for substitution without approval.
- H. Wherever a definite product, material or method is specified and there is a statement that "OR EQUAL" product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method or an "OR EQUAL" product, material or method may be used if it complies with the specifications and is submitted for review to the Engineer as outline herein.
- I. Where permission to use substituted or alternative equipment on the project is granted by the Owner or Engineer in writing, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available which includes allowances for all required Code and maintenance clearances, and to coordinate all equipment structural support, plumbing and electrical requirements and provisions with the Mechanical (HVAC) and Plumbing Design Documents and all other trades, including Division 26.
- J. Changes in architectural, structural, electrical, mechanical, and plumbing requirements for the substitution shall be the responsibility of the bidder wishing to make the substitution. This shall include the cost of redesign by the affected designer(s). Any additional cost incurred by affected subcontractors shall be the responsibility of this bidder and not the owner.
- K. If any request for a substitution of product, material or method is rejected, the Contractor will automatically be required to furnish the product, material or method named in the Specifications. Repetitive requests for substitutions will not be considered.
- L. The Owner or Engineer will investigate all requests for substitutions when submitted in accordance with above and if accepted, will issue a letter allowing the substitutions.

- M. Where equipment other than that used in the design as specified or shown on the Drawings is substituted (either from an approved manufacturers list or by submittal review), it shall be the responsibility of the substituting Contractor to coordinate space requirements, building provisions and connection requirements with his trades and all other trades and pay all additional costs to other trades, the Owner, the Architect or Engineer, if any, due to the substitutions.
- N. The electrical design and electrical drawings are based on the equipment and/or electric motors of the type, size and electrical characteristics shown and specified on the mechanical drawings. Any change in equipment and/or motor size or type brought on directly or indirectly by a substitution or mechanical equipment having characteristics requiring a change, shall be the responsibility of the Mechanical Contractor and the entire cost of such change, including conduit, wiring, motor starting equipment, etc., shall be paid for by the Mechanical Contractor at no additional charge, unless the substitution was initiated by the Owner. Submittals must clearly show and deviations. Mechanical Contractor is responsible for coordinating any required changes with the Electrical Contractor, prior to Electrical Contractors ordering of panels and associated equipment.

1.13 SUBMITTALS

- A. Coordinate with Division 1 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded the Contractor shall submit a minimum of eight (8) complete bound sets of shop drawings and complete data covering each item of equipment or material. The first submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain one (1) copy each of all shop drawings for their files. Where full size drawings are involved, submit one (1) print and one (1) reproducible sepia or mylar in lieu of eight (8) sets. All literature pertaining to an item subject to Shop Drawing submittal shall be submitted at one time. A submittal shall not contain information from more than one Specification section, but may have a section subdivided into items or equipment as listed in each section. The Contractor may elect to submit each item or type of equipment separately. Each submittal shall include the following items enclosed in a suitable binder:
1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
 2. An index page with a listing of all data included in the Submittal.
 3. A list of variations page with a listing all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page

shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.

4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of $1/4" = 1'-0"$, as required to demonstrate that the alternate or substituted product will fit in the space available.
6. Identification of each item of material or equipment matching that indicated on the Drawings.
7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.
8. Additional information as required in other Sections of this Division.
9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".

- B. Refer to Division 1 for additional information on shop drawings and submittals.
- C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.
- D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.
- E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:
 1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.

2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.
 3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.
 4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.
 5. CONTRACTOR'S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required stating the submittal meets all conditions of the contract documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.
 6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified, the Contractor will automatically be required to furnish the product, material or method named in the specifications. Contractor shall not order equipment where submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.
- F. Materials and equipment which are purchased or installed without shop drawing review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.
- G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.
- H. Submittals are required for, but not limited to, the following items:
1. Pipe Material and Specialties.

2. Pipe Fabrication Drawings.
3. Basic Materials.
4. Variable Air Volume Boxes.
5. Air Handling Units.
6. Cooling Towers.
7. Chillers.
8. Air Cooled Condensing Units.
9. Water Treatment.
10. Expansion Compensation.
11. Variable Frequency Drives.
12. Noise and Vibration Controls.
13. Plumbing Fixtures and Specialties.
14. Plumbing Equipment.
15. Sanitary DWV Fittings, Pipe and Accessories.
16. Domestic Hot and Cold Water Pipe, Fittings and Accessories.
17. HVAC Pipe and Duct Insulation.
18. Hydronic and Plumbing Valves.
19. Hydronic Piping and Accessories.
20. Hydronic Pumps.
21. Roof-Top A/C Units.
22. Heating Water Boiler.
23. Portable Pipe Hanger and Equipment Supports.
24. Duct Specialties.
25. Duct Fabrication Drawings.
26. Air Distribution Devices.
27. Fan Coil Units.
28. Filters.
29. Fans.
30. Fire Dampers and Fire Smoke Dampers.
31. Temperature Controls and Control Sequences.
32. Test, Adjust and Balance Reports.
33. Testing, Adjusting and Balancing Contractor Qualifications.
34. Coordination Drawings.

- I. Refer to other Division 22 sections for additional shop drawing requirements. Provide samples of actual materials and/or equipment to be used on the Project upon request of the Owner or Engineer.
- J. Contractor to submit Mechanical/Electrical equipment coordination sheet with equipment submittal for all AHU's, ACCU's, and Fans. Reference chart at end of section. Provide copy to electrical subcontractor.

1.14 COORDINATION DRAWINGS

- A. Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
 - a. Wall and type locations.
 - b. Clearances for installing and maintaining insulation.
 - c. Locations of light fixtures and sprinkler heads.
 - d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - e. Equipment connections and support details.
 - f. Exterior wall and foundation penetrations.
 - g. Routing of storm and sanitary sewer piping.
 - h. Fire-rated wall and floor penetrations.
 - i. Sizes and location of required concrete pads and bases.
 - j. Valve stem movement.
 - k. Structural floor, wall and roof opening sizes and details.
 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.
- B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
- C. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

1.15 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Special Project Requirements, in addition to the requirements specified in Division 22, indicate the following installed conditions:
1. Duct mains and branches, size and location, for both exterior and interior; locations of dampers, fire dampers, duct access panels, and other control devices; filters, fuel fired heaters, fan coils, condensing units, and roof-top A/C units requiring periodic maintenance or repair.
 2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
 3. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 4. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 5. Contract Modifications, actual equipment and materials installed.
- B. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.
- C. The Contractor shall maintain a set of clearly marked black line record "AS-BUILT" prints on the job site on which he shall mark all work details, alterations to meet site conditions and changes made by "Change Order" notices. These shall be kept available for inspection by the Owner, Architect or Engineer at all times.
- D. Refer to Division 1 for additional requirements concerning record drawings. If the Contractor does not keep an accurate set of as-built drawings, the pay request may be altered or delayed at the request of the Architect. Mark the drawings with a colored pencil. Delivery of as-built prints and reproducible is a condition of final acceptance.
- E. The record prints shall be updated on a daily basis and shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents which are required for coordination. All dimensions shall include at least two dimensions to permanent structure points.
- F. Submit three prints of the tracings for approval. Make corrections to tracings as directed and delivered "Auto Positive Tracings" to the architect. "As-Built" drawings shall be furnished in addition to shop drawings.

- G. When the option described in paragraph F., above is not exercised then upon completion of the work, the Contractor shall transfer all marks from the submit a set of clear concise set of reproducible record "AS-BUILT" drawings and shall submit the reproducible drawings with corrections made by a competent draftsman and three (3) sets of black line prints to the Architect or Engineer for review prior to scheduling the final inspection at the completion of the work. The reproducible record "AS-BUILT" drawings shall have the Engineers Name and Seal removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

DATE:

(NAME OF GENERAL CONTRACTOR)

BY: _____
(SIGNATURE)

(NAME OF SUBCONTRACTOR)

BY: _____
(SIGNATURE)

1.16 OPERATING MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 and in addition to the requirements specified in Division 1, include the following information for equipment items:
1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 4. Servicing instructions and lubrication charts and schedules.

1.17 CERTIFICATIONS AND TEST REPORTS

- A. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and schedule date for each test. This detailed completion and test schedule shall be submittal at least 90 days before the projected Project completion date.
- B. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule submitted.
- C. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.
- D. Certifications and test reports to be submitted shall include, but not be limited to those items outlined in Section of Division 22.

1.18 MAINTENANCE MANUALS

- A. Coordinate with Division 1 for maintenance manual requirements, unless noted otherwise bind together in "D ring type" binders by National model no. 79-883 or equal, binders shall be large enough to allow ¼" of spare capacity. Three (3) sets of all approved shop drawing submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections and labeled for easy reference and shall utilize the individual specification section numbers shown in the Mechanical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 22 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins.
- B. Prepare maintenance manuals in accordance with Special Project Conditions, in addition to the requirements specified in Division 22, include the following information for equipment items:
 - 1. Identifying names, name tags designations and locations for all equipment.
 - 2. Valve tag lists with valve number, type, color coding, location and function.
 - 3. Reviewed shop drawing submittals with exceptions noted compliance letter.
 - 4. Fabrication drawings.
 - 5. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable, i.e., description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts.

6. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 7. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions, servicing instructions and lubrication charts and schedules.
 8. Equipment and motor name plate data.
 9. Wiring diagrams.
 10. Exploded parts views and parts lists for all equipment and devices.
 11. Color coding charts for all painted equipment and conduit.
 12. Location and listing of all spare parts and special keys and tools furnished to the Owner.
 13. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.
- C. Refer to Division 1 for additional information on Operating and Maintenance Manuals.
- D. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer a minimum of 14 working days prior to the beginning of the operator training period.

1.19 OPERATOR TRAINING

- A. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include 12 hours of on site training in three 4 hour shifts.
- B. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
- C. Refer to other Division 22 Sections for additional Operator Training requirements.

1.20 FINAL COMPLETION

- A. At the completion of the work, all equipment and systems shall be tested and faulty equipment and material shall be repaired or replaced. Refer to Sections of Division 22 for additional requirements.
- B. Clean and adjust all air distribution devices and replace all air filters immediately prior to final acceptance.

- C. Touch up and/or refinish all scratched equipment and devices immediately prior to final acceptance.

1.21 CONTRACTOR'S GUARANTEE

- A. Use of the HVAC and Plumbing systems to provide temporary service during construction period will not be allowed without permission from the Owner in writing and if granted shall not be cause warranty period to start, except as defined below.
- B. Contractor shall guarantee to keep the entire installation in repair and perfect working order for a period of one year after its completion and final acceptance, and shall furnish free of additional cost to the Owner all materials and labor necessary to comply with the above guarantee throughout the year beginning from the date of issue of Substantial Completion, Beneficial Occupancy by the Owner or the Certificate of Final Payment as agreed upon by all parties.
- C. This guarantee shall not include cleaning or changing filters except as required by testing, adjusting and balancing.
- D. All air conditioning compressors shall have parts and labor guarantees for a period of not less than 5 years beyond the date of final acceptance.
- E. Refer to Sections in Division 22 for additional guarantee or warranty requirements.

1.22 TRANSFER OF ELECTRONIC FILES

- A. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner's risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney's fees arising out of or resulting thereof.
- B. Because data stored in electric media format can deteriorate or be modified inadvertently, or otherwise without authorization of the data's creator, the party receiving the electronic files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.
- C. When transferring documents in electronic media format, Engineer makes no representations as to the long term compatibility, usability or readability of documents

resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.

- D. Any reuse or modifications will be Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.
- E. The Texas Board of Architectural Examiners (TBAE) has stated that it is in violation of Texas law for persons other than the Architect of record to revise the Architectural drawings without the Architect's written consent.

It is agreed that "MEP" hard copy or computer-generated documents will not be issued to any other party except directly to the Architect/Owner. The contract documents are contractually copyrighted and cannot be used for any other project or purpose except as specifically indicated in AIA B-141 Standard Form of Agreement between Architect and Owner.

If the client, Architect/Owner, or developer of the project requires electronic media for "record purposes", then an AutoCAD based compact disc ("CD") will be prepared. The "CD" will be submitted with all title block references intact and will be formatted in a "plot" format to permit the end user to only view and plot the drawings. Revisions will not be permitted in this configuration.

- F. At the Architect/Owner's request, Engineer will prepare one "CD" of electronic media to assist the contractor in the preparation of submittals. The Engineer will prepare and submit the "CD" to the Architect/Owner for distribution to the contractor. All copies of the "CD" will be reproduced for a cost of reproduction fee of Five Hundred Dollars (\$500.00) per "CD".

The "CD" will be prepared and all title blocks, names and dates will be removed. The "CD" will be prepared in a ".dwg" format to permit the end user to revise the drawings.

- G. This Five Hundred Dollars (\$500.00) per "CD" cost of reproduction will be paid directly from the Contractor to the Engineer. The "CD" will be prepared only after receipt of the Five Hundred Dollars (\$500.00). The Five Hundred Dollars (\$500.00) per "CD" cost of reproduction is to only recover the cost of the manhours necessary to reproduce the documents. It is not a contractual agreement between the Contractor and Engineer to provide any engineering services, nor any other service.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Provide materials and equipment manufactured by a domestic United States manufacturer.

- B. Access Doors: Provide access doors as required for access to equipment, valves, controls, cleanouts and other apparatus where concealed. Access doors shall have concealed hinges and screw driver cam locks.
- C. All access panels located in wet areas such as restrooms, locker rooms, shower rooms, kitchen and any other wet areas shall be constructed of stainless steel.
- D. Access Doors: shall be as follows:
 - 1. Plastic Surfaces: Milcor Style K.
 - 2. Ceramic Tile Surface: Milcor Style M.
 - 3. Drywall Surfaces: Milcor Style DW.
 - 4. Install panels only in locations approved by the Architect.

PART 3 - EXECUTION

3.01 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected via reviewed submittals.
- B. Refer to equipment specifications in Divisions 2 through 28 for additional rough-in requirements.

3.02 MECHANICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate mechanical systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 - 7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing

- regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with architectural action markings on submittal, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, resolve conflicts and route proposed solution to the Architect for review.
 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
 10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location and label.
 11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified.
 12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
 13. Provide roof curbs for all roof mounted equipment. Coordinate with roof construction for pitched roof. Provide roof curb to match roof slope. Refer to architectural drawings and details.
 14. The equipment to be furnished under this Specification shall be essentially the standard product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the product of the same manufacturer.
 15. The architectural and structural features of the building and the space limitations shall be considered in selection of all equipment. No equipment shall be furnished which will not suit the arrangement and space limitations indicated.
 16. Lubrication: Prior to start-up, check and properly lubricate all bearings as recommended by the manufacturer.
 17. Where the word "Concealed" is used in these Specifications in connection with insulating, painting, piping, ducts, etc., it shall be understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. "Exposed" shall be understood to mean the opposite of concealed.
 18. Identification of Mechanical Equipment:
 - a. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Shop drawings shall include dimensions and lettering format for approval. Attachments shall be with escutcheon pins, self-tapping screws, or machine screws.
 - b. Tags shall be attached to all valves, including control valves, with nonferrous chain. Tags shall be brass and at least 1-1/2 inches in diameter.

Nameplate and tag symbols shall correspond to the identification symbols on the temperature control submittal and the "as-built" drawings.

3.03 CUTTING AND PATCHING

- A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
- B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
 - 1. Uncover Work to provide for installation of ill-timed Work.
 - 2. Remove and replace defective Work.
 - 3. Remove and replace Work not conforming to requirements of the Contract Documents.
 - 4. Remove samples of installed Work as specified for testing.
 - 5. Install equipment and materials in existing structures.
 - 6. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer/Owner's observation of concealed Work, without additional cost to the Owner.
 - 7. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers; refer to the materials and methods required for the surface and building components being patched; Refer to Section "DEFINITIONS" for definition of "Installer."
- C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, mechanical ducts and HVAC units, plumbing fixtures and trim, and other mechanical items made obsolete by the new Work.
- D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

3.04 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER

- A. The Owner will cooperate with the Contractor, however, the following provisions must be observed:
 - 1. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Sub-Contractors and the

SECTION 22 14 00 SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Pipe, and equipment hangers, supports, and associated anchors.
- B. Sleeves and seals.
- C. Flashing and sealing equipment and pipe stacks.

1.02 RELATED WORK

- A. Section 232400 - Vibration Isolation.
- B. Section 222600 - Piping Insulation.
- C. Section 232800 - Equipment Insulation.
- D. Section 211300 - Fire Protection System.
- E. Section 224100 - Plumbing System.
- F. Section 235100 - Hydronic Piping.
- G. Section 235300 – Refrigerant Piping

1.03 REFERENCES

- A. ANSI/ASME B31.1 - Power Piping.
- B. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- C. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.

1.04 QUALITY ASSURANCE

- A. Supports for Sprinkler Piping: In conformance with NFPA 13.
- B. Supports for Standpipes: In conformance with NFPA 14.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division 1.
- B. Indicate hanger and support framing and attachment methods.

PART 2 - PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipe Sizes 2 to 4 Inches Carbon steel, adjustable, clevis.
- C. Hangers for Pipe Sizes 6 Inches and over: Adjustable steel yoke, cast iron roll, double hanger.
- D. All hangers, supports and rods in areas exposed to the outdoors, such as but not limited to crawl spaces, service bays, wash bays, open shops and warehouses shall be hot dipped galvanized.
- E. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods; cast iron roll and stand for pipe sizes 6 inches and over.
- F. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- G. Wall Support for Pipe Sizes 4 Inches and over: adjustable steel yoke and cast iron roll.
- H. Vertical Support: Steel riser clamp.
- I. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- J. Floor Support for Pipe Sizes 6 Inches and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- K. Roof Pipe Supports and Hangers: Galvanized Steel Channel System as manufactured by Portable Pipe Hangers, Inc. or approved equal.

 For pipes 2-1/2" and smaller – Type PP10 with roller
 For pipes 3" through 8" – Type PS
 For multiple pipes – Type PSE - Custom
- L. Copper Pipe Support and Hangers: Electro-galvanized with thermoplastic elastomer cushions; Unistrut "Cush-A-Clamp" or equal. Hangers: Plastic coated; Unistrut or equal.

- M. For installation of protective shields refer to specification section 231400-3.03.
- N. Shields for Vertical Copper Pipe Risers: Sheet lead.
- O. Pipe Rough-In Supports in Walls/Chases: Provide preformed plastic pipe supports, Sioux Chief "Pipe Titan" or equal.

2.02 HANGER RODS

- A. Galvanized Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.03 INSERTS

- A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 FLASHING

- A. Metal Flashing: 20 gage galvanized steel.
- B. Lead Flashing: 4 lb./sq. ft. sheet lead for waterproofing; 1 lb./sq. ft. sheet lead for soundproofing.
- C. Caps: Steel, 20 gage minimum; 16 gage at fire resistant elements.
- D. Coordinate with roofing contractor/architect for type of flashing on metal roofs.

2.05 EQUIPMENT CURBS

- A. Fabricate curbs of hot dipped galvanized steel unless noted otherwise.

2.06 SLEEVES

- A. Sleeves for Pipes Through Non-fire Rated Floors: Form with 18 gage galvanized steel, tack welded to form a uniform sleeve.
- B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with steel pipe, schedule 40.
- C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fireproofing: Prefabricated fire rated steel sleeves including seals, UL listed.

- D. Sleeves for Round Ductwork: Form with galvanized steel.
- E. Sleeves for Rectangular Ductwork: Form with galvanized steel.
- F. Fire Stopping Insulation: Glass fiber type, non-combustible, U.L. listed.
- G. Caulk: Paintable 25-year acrylic sealant.
- H. Pipe Alignment Guides: Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted, two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

2.07 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers without disengagement of supported pipe.
- C. Design roof supports without roof penetrations, flashing or damage to the roofing material.

2.08 FINISH

- A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.01 INSERTS

- A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams. Coordinate with structural engineer for placement of inserts.
- B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- C. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
- D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

Verify with structural engineer prior to start of work.

3.02 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as follows:

<u>PIPE SIZE</u>	<u>MAX. HANGER SPACING</u>	<u>HANGER DIAMETER</u>
(Steel Pipe)		
1/2 to 1-1/4 inch	7'-0"	3/8"
1-1/2 to 3 inch	10'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
(Copper Pipe)		
1/2 to 1-1/4 inch	5'-0"	3/8"
1-1/2 to 2-1/2 inch	8'-0"	3/8"
3 to 4 inch	10'-0"	3/8"
6 to 8 inch	10'-0"	1/2"
(Cast Iron)		
2 to 3 inch	5'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
(PVC Pipe)		
1-1/2 to 4 inch	4'-0"	3/8"
6 to 8 inch	4'-0"	1/2"
10 and over	4'-0"	5/8"

- B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- C. Place a hanger within 12 inches of each horizontal elbow and at the vertical horizontal transition.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Install hangers with nut at base and above hanger; tighten upper nut to hanger after final installation adjustments.
- J. Portable pipe hanger systems shall be installed per manufactures instructions.

3.03 Insulated Piping: Comply with the following installation requirements.

- A. Clamps: Attach galvanized clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.
- B. Saddles: Install galvanized protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
- C. Shields: Install protective shields MSS Type 40 on cold and chilled water piping that has vapor barrier. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

<u>NPS</u>	<u>LENGTH</u>	<u>THICKNESS</u>
1/4 THROUGH 3-1/2	12	0.048
4	12	0.060
5 & 6	18	0.060
8 THROUGH 14	24	0.075
16 THROUGH 24	24	0.105

- D. Piping 2" and larger provide galvanized sheet metal shields with calcium silicate at hangers/supports.
- E. Insert material shall be at least as long as the protective shield.
- F. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.04 EQUIPMENT BASES AND SUPPORTS

- A. Provide equipment bases of concrete.
- B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- C. Construct support of steel members. Brace and fasten with flanges bolted to structure.
- D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.05 FLASHING

- A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Flash vent and soil pipes projecting 8 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counter flash and seal.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor shower mop sink and all other drains watertight to adjacent materials.
- E. Provide curbs for mechanical roof installations 8 inches minimum high above roofing surface. Contact architect for all flashing details and roof construction. Seal penetrations watertight.

3.06 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Extend sleeves through floors minimum one inch above finished floor level. Caulk

sleeves full depth with fire rated thermfiber and 3M caulking and provide floor plate.

- C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with U.L. listed fire stopping insulation and caulk seal air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- D. Fire protection sleeves may be flush with floor of stairways.

END OF SECTION 22 14 00

SECTION 22 19 00 SYSTEM IDENTIFICATION AND PIPE MARKING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 220500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.03 Refer to Architectural Sections for additional requirements.

PART 2 - PRODUCTS

2.01 VALVE AND PIPE IDENTIFICATION

- A. Valves:
 - 1. All valves shall be identified with a 1-1/2" diameter brass disc wired onto the handle. The disc shall be stamped with 1/2" high depressed black filled identifying numbers. These numbers shall be numerically sequenced for all valves on the job.
 - 2. The number and description indicating make, size, model number and service of each valve shall be listed in proper operational sequence, properly typewritten. Three copies to be turned over to Owner at completion.
 - 3. Tags shall be fastened with approved meter seal and 4 ply 0.018 smooth copper wire. Tags and fastenings shall be manufactured by the Seton Name Plate Company or approved equal.
 - 4. All valves shall be numbered serially with all valves of any one system and/or trade grouped together.
- B. Pipe Marking:
 - 1. All interior visible piping located in accessible spaces such as above accessible

ceilings, equipment rooms, attic space, under floor spaces, etc., shall be identified with all temperature pipe markers as manufactured by W.H. Brady Company, 431 West Rock Ave., New Haven, Connecticut, or approved equal.

2. All exterior visible piping shall be identified with UV and acid resistant outdoor grade acrylic plastic markers as manufactured by Set Mark distributed by Seton nameplate company. Factory location 20 Thompson Road, Branford, Connecticut, or approved equal.
3. Generally, markers shall be located on each side of each partition, on each side of each tee, on each side of each valve and/or valve group, on each side of each piece of equipment, and, for straight runs, at equally spaced intervals not to exceed 75 feet. In congested area, marks shall be placed on each pipe at the points where it enters and leaves the area and at the point of connection of each piece of equipment and automatic control valve. All markers shall have directional arrows.
4. Markers shall be installed after final painting of all piping and equipment and in such a manner that they are visible from the normal maintenance position. Manufacturer's installation instructions shall be closely followed.
5. Markers shall be colored as indicated below per ANSI/OSHA Standards:

<u>SYSTEM</u>	<u>COLOR</u>	<u>LEGEND</u>
Sanitary Sewer	Green	Vent Sanitary Sewer
Domestic Water	Green	Domestic Water
Domestic Hot Water Supply	Yellow	Domestic Hot Water Supply
Domestic Hot Water Re-circulating	Yellow	Domestic Hot Water Return
Fire Protection	Red	Fire Protection
Automatic Sprinkler	Red	Fire Sprinkler

C. Pipe Painting:

1. All piping exposed to view shall be painted as indicated or as directed by the Architect in the field. Confirm all color selections with Architect prior to

installation.

2. The entire fire protection piping system shall be painted red.
3. All piping located in mechanical rooms and exterior piping shall be painted as indicated below:

<u>System</u>	<u>Color</u>
Storm Sewer	White
Sanitary Sewer Waste and Vent	Light Gray
Domestic Cold Water	Dark Blue
Domestic Hot Water Supply and Return	Orange
Compressed Air	Green
Chilled Water Supply and Return	Light Blue

PART 3 - EXECUTION

- 3.01** All labeling equipment shall be installed as per manufacturers printed installation instructions.
- 3.02** All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractor's price shall include all items required as per manufacturers' requirements.
- 3.03** All piping shall be cleaned of rust, dirt, oil and all other contaminants prior to painting. Install primer and a quality latex paint over all surfaces of pipe.

END OF SECTION 22 19 00

SECTION 22 26 00 PIPING INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 220500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. Work specified elsewhere.
 - 1. Painting.
 - 2. Pipe hangers and supports.
- C. All pipes subject to freezing conditions shall be insulated.

1.03 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.
- B. Defects shall include, but not be limited to, the following:
 - 1. Mildewing.
 - 2. Peeling, cracking, and blistering.
 - 3. Condensation on exterior surfaces.

1.04 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, project variations, and accessories.

1.05 DELIVERY AND STORAGE

- A. DELIVERY: Deliver undamaged materials in the manufacturer's unopened containers. Containers shall be clearly labeled with the insulation's flame and smoke ratings.

PART 2 - PRODUCTS

2.01 It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.

2.02 The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved prior to installation.

2.03 A sample quantity of each type of insulation and each type application shall be installed and approval secured prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.

2.04 All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) fire and smoke hazard as tested by Procedure ASTM E084, NFPA 255 and UL 723 not exceeding:

Flame Spread 25
Smoke Developed 50

2.05 Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.

2.06 All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.

2.07 APPROVED MANUFACTURERS

- A. Calcium silicate materials shall be as manufactured by Johns Manville.
- B. Glass fiber materials shall be as manufactured by Johns Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer.

- C. Adhesives shall be as manufactured by Childers, Foster, HB Fuller or Armstrong, and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
- D. Armaflex elastomeric cellular thermal insulation by Armstrong.
- E. Phenolic foam insulation shall be as manufactured by PolyPhen 2500 Insulation.
- F. Polyisocyanurate insulation shall be as manufactured by Dow "Trymer 2000 XP".
- G. Metal jacketing and fitting covers shall be as manufactured by Childers or RPR Products.

2.08 MATERIALS

- A. For insulation purpose piping is defined as the complete piping system including supplies and returns, pipes, valves, automatic control valve bodies, fittings, flanges, strainers, thermometer well, unions, reducing stations, and orifice assemblies.
- B. INTERIOR DOMESTIC WATER PIPE: provide fiberglass pipe insulation with all service jackets with self sealing lap joint.
- C. EXTERIOR DOMESTIC WATER PIPE: Provide elastomeric cellular thermal, or preformed phenolic foam pipe insulation with secured metal jacketing.
- D. DRAIN BODIES AND DOWN SPOUTS: Insulate horizontal roof drain down spouts, underside of roof drain bodies, chilled water waste lines from drinking fountain to junction with main waste stacks, and branch lines including traps and exposed underside of floor drains receiving cooling coil condensate, same as water piping where exposed to building occupant view. When concealed, insulation may be same as specified for external duct wrap.
- E. CONDENSATE DRAINAGE PIPING: Fire resistant fiberglass insulation; insulation not required when piping is exposed on roof.
- F. METAL JACKETING: Utilize Childers "Strap-On" jacketing. Provide preformed fitting covers for all elbows and tees.

PART 3 - EXECUTION

- 3.01** All insulation shall be installed in accordance with the manufacturers' recommendations and printed installation instructions, including high density inserts at all hangers and pipe supports to prevent compression of insulation.

3.02 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturers requirements.

3.03 Pipes located outdoors or in crawl spaces shall be insulated **same as concealed piping**; and in addition shall have a jacket of 0.016 inch thick, smooth aluminum with longitudinal modified Pittsburgh Z-Lock seam and 2 inch overlap. Jacketing shall be easily removed and replaced without damage. All butt joints shall be sealed with gray silicone. Galvanized banding is not acceptable.

3.04 All insulated piping located over driveways shall have an aluminum shield permanently banded over insulation to protect it from damage from car antennas.

3.05 WATER PIPE INSULATION INSTALLATION

A. The insulation shall be applied to clean, dry pipes with all joints firmly butted together. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating seal shall be formed between the vapor barrier jacket and the bare pipe. The seal shall be by the applications of adhesive to the exposed insulation joint faces, carried continuously down to and along 4 inches of pipe and up to and along 2 inches of jacket.

B. Pipe fittings and valves shall be insulated with pre-molded or shop fabricated glass fiber covers finished with two brush coats of vapor barrier mastic reinforced with glass fabric.

C. All under lap surfaces shall be clean and free of dust, etc. before the SSL is sealed. These laps shall be firmly rubbed to insure a positive seal. A brush coat of vapor retarder shall be applied to all edges of the vapor barrier jacket.

3.06 FIRE RATED INSULATION

A. All pipe penetrations through walls and concrete floors shall be fire rated by applying USG Thermafiber in the space between the concrete and the pipe.

B. The fire rating shall be additionally sealed by using 3M brand model CP 25 or 303 fire barrier caulk and putty.

C. All fire rating material shall be insulated in accordance with manufacturer's printed instructions.

PART 4 - SCHEDULES

4.01 LOW TEMPERATURE SURFACES

MINIMUM INSULATION THICKNESS
BASED ON FIBERGLASS

A.	Exposed exterior domestic water pipe:	1½ inch
B.	Interior domestic cold water pipe exposed to freezing temperatures:	1 inch
C.	Condensate drain lines:	¾ inch
D.	Drains receiving condensate:	1 inch
E.	Concealed horizontal leader from roof drain:	1½ inch blanket wrap
	Exposed horizontal leader from roof drain:	1 inch thick rigid (phenolic) with all service jackets

4.02 HIGH TEMPERATURE SURFACES

MINIMUM INSULATION THICKNESS

A.	Domestic Hot Water and Hot Water Circulating Piping	1 inch
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END OF SECTION 22 26 00

SECTION 22 41 00 PLUMBING, PIPING, AND VALVES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Pipe and pipe fittings.
- B. Valves.
- C. Sanitary sewer piping system.
- D. Storm sewer piping system.
- E. Domestic water piping system.

1.02 RELATED SECTIONS

- A. Section 022220 - Excavating.
- B. Section 022230 - Backfilling.
- C. Section 022250 - Trenching.
- D. Section 221400 - Supports and Anchors.
- E. Section 221900 – System Identification and Pipe Marking.
- F. Section 232420 - Vibration Isolation.
- G. Section 222600 - Piping Insulation.
- H. Section 224400 - Plumbing Fixtures.
- I. Section 224500 - Plumbing Equipment.

1.03 REFERENCES

- A. ANSI B31.1 - Power Piping.
- B. ANSI B31.9 - Building Service Piping.
- C. ASME - Boiler and Pressure Vessel Code.

- D. ASME Sec. 9 - Welding and Brazing Qualifications.
- E. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800.
- F. ASME B16.3 - Malleable Iron Threaded Fittings.
- G. ASME B16.4 - Cast Iron Threaded Fittings Class 125 and 250.
- H. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings
- I. ASTM A47 - Ferritic Malleable Iron Castings.
- J. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.
- K. ASTM A74 - Cast Iron Soil Pipe and Fittings.
- L. ASTM B32 - Solder Metal.
- M. ASTM B42 - Seamless Copper Pipe.
- N. ASTM B306 - Copper Drainage Tube (DWV).
- O. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40, 80, and 120.
- P. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR).
- Q. ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- R. ASTM D2564 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- S. ASTM D2729 - Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- T. ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems.
- U. ASTM F493 - Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
- V. AWWA C111- Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings.
- W. AWWA C651 - Disinfecting Water Mains.

- X. CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems.
- Y. CISPI 310 - Joints for Hubless Cast Iron Sanitary Systems.

1.04 SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Product Data: Provide data on pipe materials, Pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 1.
- B. Record actual locations of valves.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 1.
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.07 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating cast or marked on valve body.
- B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.
- C. Welders Certification: In accordance with ASME Sec 9.
- D. Foreign pipe, fittings or valves are unacceptable.
- E. Piping shall be labeled along entire length indicating size, class, material specification, manufacturers name and country of origin.

1.08 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum 5 years documented experience and must be a domestic manufacturer.

- B. Installer: Company specializing in performing the work of this section with minimum 5 years documented experience.

1.09 REGULATORY REQUIREMENTS

- A. Perform Work in accordance with plumbing and building codes having jurisdiction.
- B. Conform to applicable codes for the provision and installation of all required backflow prevention devices.
- C. Provide certificate of compliance from authority having jurisdiction indicating approval of installation of backflow prevention devices.
- D. No PVC pipe or fittings will be allowed for any areas where pipe is to penetrate a fire rated assembly or to be installed in a return air plenum unless the entire length of all such piping is encased within a minimum 2 hour fire rated enclosure.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 1.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system. Tape will not be allowed as an acceptable end cover.

1.11 EXTRA MATERIALS

- A. Furnish under provisions of Division 1.
- B. Provide two repacking kits for each size valve.

PART 2 - PRODUCTS

2.01 SANITARY SOIL WASTE AND VENT PIPING, BURIED BEYOND 5 FEET OUTSIDE OF BUILDING

- A. PVC Pipe: ASTM D 1785/D 2729 schedule 40; installed per ASTM D 2321.

1. Fittings: PVC, ASTM D 3311/D 2665 drainage pattern, with bell and spigot ends. Furnished by the same manufacturer as pipe or approved equal.
2. Joints: solvent weld with ASTM D 2564 solvent cement, installed per the requirements of ASTM D 2855.

OR

B. PVC pipe: ASTM D 3034, SDR 35; installed per ASTM D 2321.

1. Fittings: ASTM F 1336 PVC, drainage pattern, with bell and spigot ends. Furnished by the same manufacturer as pipe or approved equal.
2. Joints: ASTM F 477 or F 913, elastomeric gaskets or solvent weld.

2.02 SANITARY SOIL, WASTE AND VENT PIPING, BURIED WITHIN 5 FEET OF BUILDING, BELOW GRADE

A. PVC Pipe: ASTM D 1785/D 2665 schedule 40

1. Fittings: PVC, ASTM D 3311/D 2665 drainage pattern, with bell and spigot ends to be furnished by the same manufacturer as pipe or approved equal.
2. Joints: solvent weld with ASTM D 2564 solvent cement, clear, medium bodied, for sizes 3" and smaller and gray, heavy bodied, for sizes 4" and larger, mating surfaces shall be prepared with ASTM F 656 purple primer immediately prior to cement application.

2.03 SANITARY SOIL, WASTE AND VENT PIPING, WITHIN BUILDING, ABOVE GRADE

A. Cast Iron Pipe: ASTM A 74 service weight.

1. Fittings: Cast iron, ASTM A 74 drainage pattern.
2. Joints: Hub and spigot, ASTM C 564 neoprene, compression type gaskets.

OR

B. Cast Iron Pipe: ASTM A 888, hubless, service weight.

1. Fittings: Cast iron, ASTM A 888 drainage pattern.
2. Joints: No hub, ASTM C 564 neoprene gaskets and standard stainless steel clamp and solid shield assemblies constructed of type 300 series stainless steel. Clamp assemblies shall conform to FM 1680 where required by the administrative authority.

C. Copper Tubing: ASTM B 306, DWV, sizes 2" and smaller.

1. Fittings: ASME B 16.23 cast bronze, or ASME B16.29, wrought copper.

2. Joints: ASTM B 32, solder, Grade 50B.
- D. Brass Pipe: ASTM B 43, chrome plated.
 1. Fittings: ASME B 16.23 cast bronze, chrome plated.
 2. Joints: ASTM B 32, solder, Grade 50B.
- E. Steel Pipe: ASTM A 53, Schedule 40, galvanized, sizes 2-1/2" and smaller, for waste and vent piping only, steel soil pipes not permitted.
 1. Fittings: Malleable iron, galvanized.
 2. Joints: ASME B16.3 screwed.

2.04 STORM DRAINAGE PIPING, BURIED BEYOND 5 FEET OUTSIDE OF BUILDING

- A. Pipe and fittings shall be same as specified for the sanitary soil, waste and vent piping system.

2.05 STORM DRAINAGE PIPING, BURIED WITHIN 5 FEET OF BUILDING, BELOW GRADE

- A. Pipe and fittings shall be same as specified for the sanitary soil, waste and vent piping system.

2.06 STORM DRAINAGE PIPING, WITHIN BUILDING, ABOVE GRADE

- A. Cast Iron Pipe: ASTM A74 service weight.
 1. Fittings: Cast iron, ASTM A74 drainage pattern.
 2. Joints: Hub and spigot, ASTM C564 neoprene, compression type gaskets.

2.07 DOMESTIC WATER PIPING, BURIED BEYOND 5 FEET OUTSIDE OF BUILDING

- A. PVC Pipe: ASTM D 1785 schedule 80.
 1. Fittings: ASTM D 2467 PVC.
 2. Joints: ASTM D 2855, solvent weld with ASTM D 2564 solvent cement.

2.08 DOMESTIC WATER PIPE, BURIED WITHIN 5 FEET OF BUILDING, BELOW GRADE

- A. Copper Tubing: ASTM B88, Type K, soft annealed. Provide for pipe sizes up to and including 2-1/2".
 1. Fittings: ASTM B16.22 wrought copper pressure fittings.
 2. Joints shall be as follows:
 - a. **No joints shall be permitted for pipe sizes 2" and smaller. All such piping must be run continuous below slab on grade and brought up to no less than 12" above the finished floor before any joint is provided.**

- b. For sizes larger than 2", joints between copper pipe and fittings shall be brazed and shall be made in accordance with all the applicable portions of ASTM B828, manufacturer's recommendations, and AWS requirements. Brazing filler metal shall be in accordance with AWS A5.8 and any required flux shall meet AWS A5.31, Type FB3-A or FB3-C.
 3. Beginning at no closer than the 5'-0" mark from the building, all piping buried or in contact with concrete shall be provided with one of the following, which shall also extend to a minimum of 6" above the finished floor:
 - a. AWWA C209 cold-applied, integrated primer type, elastomeric adhesive, laminate polymeric tape coating, minimum 35 mil nominal thickness, in accordance with manufacturer's installation guidelines. Chase Construction Products Tapecoat H35 or approved equivalent.
 - b. Continuous polyethylene lining, minimum 60 mil nominal thickness.
- B. Ductile Iron Pipe: Minimum pressure class 150, ANSI/AWWA C151/A21.51. Provide for pipe sizes 3" and larger.
 1. Fittings: Standard ductile iron, ANSI/AWWA C110/A21.10.
 2. Joints: Rubber-gasketed and bolted mechanical joints, ANSI/AWWA C111/A21.11. Installation shall be in accordance with ANSI/AWWA C600 and approved pipe lubricant shall be used for optimum gasket sealing and long-term performance.
 3. Note: A single fitting may be installed below slab on grade to facilitate underground pipe entry up to above floor from an immediately adjacent exterior building wall.
 4. Provide continuous polyethylene encasement for all piping buried or in contact with concrete in accordance with ANSI/AWWA C105/A21.5, beginning at no closer than the 5'-0" mark from the building and to a minimum of 6" above the finished floor.
- C. Stainless Steel Pre-Fabricated In-Building Riser (acceptable for sizes 2" through 10")
 1. Corrosion resistant Type 304 stainless steel construction single, extended 90 degree fitting.
 2. UL listed, FM approved and NFPA 24 compliant.
 3. Lead free and NSF/ANSI 61 (372) certified.
 4. Acceptable manufacturers:
 - a. Ames Fire & Waterworks Series IBR (4" through 10") and IBR2 (2", 2- 1/2", and 3")
 - b. Zurn Wilkins Model WBR (4" through 10")

5. Note: For this application, the inlet joint for larger diameter (4" through 10") piping (which **shall not** be located below a building slab or foundation) can be rubber gasketed push-on type, ANSI/AWWA C111/A21.11. Installation shall be in accordance with ANSI/AWWA C600.
6. Provide continuous polyethylene encasement for all piping buried or in contact with concrete in accordance with ANSI/AWWA C105/A21.5, beginning at no closer than the 5'-0" mark from the building and to a minimum of 6" above the finished floor.

2.09 DOMESTIC WATER PIPING, WITHIN BUILDING, ABOVE GRADE:

- A. Copper Tubing: ASTM B 88, Type L, hard drawn.
 1. Fittings: ASME B 16.18, cast bronze, or ASTM B 16.22 wrought copper alloy.
 2. Joints between copper pipe and fittings shall be made in accordance with ASTM B828 using ASTM B32 Alloy HB lead-free solder.
 3. Fittings and joints for pipe sizes 1/2" through 4" may be mechanical press-connect system joints with ASME B16.51 lead-free copper bodied fittings with integral ethylene-propylene diene monomer rubber (EPDM) sealing gaskets. All fittings, couplings, and adapters shall be the product of a single system manufacturer and only that manufacturer's approved press tools, kits, and jaws shall be used.
 - a. EPDM o-rings shall be pre-installed and lubricated with ANSI/NSF 61 listed lubricant.
 - b. All installers of copper press-connect fittings shall be trained by the fitting manufacturer's appointed representative and carry such credentials for the duration of the project.
 - c. The fitting manufacturer's representative shall conduct periodic inspections of the installation and shall provide written reports of such inspections to the Contractor and Engineer, including any observed deviations from the manufacturer's recommended installation practices.
 - d. Acceptable system manufacturers: Viega, Merit Brass, or pre-approved equal.

2.10 FLANGES AND UNIONS

- A. Drainage Applications:
 1. Provide approved listed adapter and transition fittings appropriate to the specific pipe transition and in accordance with code requirements.
 2. For dissimilar piping above ground, provide stainless steel shielded, molded elastomeric couplings and adapters meeting ASTM C564 and ASTM C1460. Applies to installations including cast iron to PVC transitions immediately adjacent

- to building slabs on grade.
3. For dissimilar underground piping not below building slab, provide shear resistant .012" thick 300 series stainless steel shielded, PVC gasketed flexible couplings and adapters meeting ASTM D5926 and ASTM C1173. For direct-bury applications, provide AWWA C209 cold-applied, integrated primer type, elastomeric adhesive, laminate polymeric tape coating, minimum 35 mil nominal thickness, in accordance with manufacturer's installation guidelines, to completely wrap the shield, banding, and screws. Chase Construction Products Tapecoat H35 or approved equivalent.
 4. Acceptable manufacturers:
 - a. Anaco-Husky/Cremco
 - b. Mission Rubber Company LLC
 - c. Fernco, Inc.
 - d. Fernco, Inc. Strong Back RC 1000 Series (underground piping, not below building slab; or readily accessible underground piping transitions in backwater valve pits, etc.)
 5. Adapters, couplings, bushings for copper DWV pipe shall be cast bronze or wrought copper, ASME B16.23/B16.29.

B. Domestic Water Applications:

1. Provide joints between various materials with approved adapter and transition fittings appropriate to the specific pipe transition and in accordance with code requirements and the manufacturer's instructions.
2. For copper tube and pipe: adapters, bushings, plugs, caps, and couplings shall be wrought copper or cast bronze; flanges (minimum class 150) and unions shall be cast bronze. Provide with solder or threaded connections as necessary and as produced to applicable ASME standards B16.15, B16.18, B16.22, B16.24, B16.50, B1.20.1. All such appurtenances shall be for use in above ground potable water systems.
3. Above slab transitions for water service entries:
 - a. 100% fusion bonded epoxy coated ASTM A536 cast ductile iron construction coupling with acrylonitrile butadiene rubber (NBR) gaskets and EPDM insulating boot for water service. 5/8 inch high strength stainless steel bolts and nuts. Coupling shall meet AWWA C219. Romac Industries, Inc. IC501 or pre-approved equivalent.
 - b. 100% fusion bonded 14 mil epoxy coated coupling with ASTM A536 cast ductile iron rings. Complete with acrylonitrile butadiene rubber (NBR) gaskets and type 304 stainless steel bridge, spacers, nuts, and bolts. Coupling shall meet AWWA C219, NSF 61, and NSF 372. Krausz USA Hymax Grip Coupling Restraint or pre-approved equivalent.

4. Dielectric connections:
 - a. For pipe sizes 2 inch and smaller, provide lead-free dielectric unions, rated to 180 F at 250 psi and compliant to ASSE 1079.
 - b. For pipe sizes larger than 2 inches, provide lead-free dielectric flanged pipe fittings, rated to 180 F at 175 psi and meeting ASME B16.1.
 - c. For grooved copper joining systems, provide grooved end dielectric transition fitting from system manufacturer, with virgin polypropylene internal lining, meeting NSF 61.
- C. General:
 1. Unions for ferrous pipe shall be ASTM B16.39 galvanized malleable iron, threaded, minimum pressure class 150.
 2. Plugs and bushings for ferrous pipe shall be ASME B16.14 galvanized malleable iron, threaded.
 3. Nipples for ferrous pipe shall be schedule 40, galvanized, ASTM A53 welded steel pipe nipples, threaded, meeting ASTM A733.
 4. Couplings for ferrous pipe shall be galvanized steel, threaded, manufactured in accordance with ASTM A865.
 5. Flanges for ferrous pipe shall be galvanized forged steel construction, either socket weld or slip-on weld type, minimum pressure class 150, manufactured to ASME B16.5.
 6. Bolts, nuts, and gaskets for flanged connections shall be appropriate to the pipe material, fluid type, temperature, and pressure. 1/16" thick pre-formed neoprene, typical.
 7. Provide flexible stainless steel connectors at pumps and other such equipment, in accordance with manufacturer's recommendations. Connectors shall have corrugated hose and braided 300 series stainless steel jacketing. Carbon steel flanged or grooved ends as appropriate. NSF 372 lead-free for all potable water applications. Metraflex Company or pre-approved equivalent.

2.11 GATE VALVES

- A. Manufacturers:
 1. Nibco No. T-111 up to 2-1/2"; F-617-O 3" and over.
 2. Other acceptable manufacturers offering equivalent products.
 - a. Crane No. 428 up to 2-1/2"; 465-1/2 3" and over.
 - b. Stockham No. B-100 up to 2-1/2"; G-623 3" and over.
 - c. Grinnell No. 3010 up to 2-1/2"; 6020A 3" and over.
- B. Up to and including 2-1/2" Inches: Bronze body, bronze trim, rising stem, handwheel, inside screw, solid wedge threaded ends.

- C. Over 3" Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, solid wedge, flanged ends.
- D. Provide bronze tee or cast iron square nut operator for all valves installed below ground.
 - 1. Valves 2-1/2" and smaller shall be equipped with ASTM B62 solid red bronze tee securely affixed to the valve stem.
 - 2. Valves 3" and larger shall be equipped with a standard 2" square combination nut/socket securely affixed to the valve stem.
 - 3. Provide owner with two extended tee handle operating wrenches for each type of valve head installed.

2.12 BALL VALVES

- A. Manufacturers:
 - 1. Nibco No. T-585-66-LF (full port) for all sizes up through 2"
 - 2. Nibco No. T-580-66-LF (conventional port) for sizes 2-1/2" and 3"
 - 3. Valves 4" and larger shall be split body stainless steel construction, 275psi cold working pressure, blow-out proof stem, PTFE seated, type 316 stainless steel trimmed, class 150 full port desing with manual gear operator. Nibco F-515-S6-F-66-FS
 - 4. Other acceptable manufacturers offering equivalent products.
 - a. Apollo 77 CLF-A series (full port) for all sizes up through 2".
 - b. Milwaukee UPBA-400S (full port) for all sizes up through 2".
 - c. Apollo 77 CLF-A series (full port) for size 2-1/2" and Apollo 70LF-140 series (standard port) for 3".
 - d. Milwaukee UPBA-100S (standard port) for sizes 2-1/2" and 3".
- B. Up to and including 2 Inches: Bronze two 600 PSI piece body full port, lead-free, stainless steel ball and stem, Teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends with union.
- C. Ball valves used for balancing shall have memory stops.

2.13 SWING CHECK VALVES

- A. Manufacturers:
 - 1. Nibco No. T-413-Y-LF up to 2"; F-918-B-LF 2-1/2" and over.
 - 2. Other acceptable manufacturers offering equivalent products.
 - a. Crane No. 37 up to 2-1/2"; 372 3" and over.
 - b. Stockham No. B-319; up to 2-1/2"; G931 3" and over.
 - c. Grinnell No. 3300 up to 2-1/2"; 6300A 3" and over.

- B. Up to and including 2-1/2 Inches: Bronze swing disc, screwed ends.
- C. Over 2-1/2 Inches: Iron body, bronze trim, swing disc, renewable disc and seat, flanged ends. Include outside lever and adjustable weight where required for quiet operation.

2.14 SPRING LOADED (SILENT) CHECK VALVES

- A. Manufacturers:
 - 1. Nibco No. W-910
 - 2. Other acceptable manufacturers offering equivalent products.
 - a. Grinnell No. 402
- B. Iron body, bronze trim, stainless steel spring, renewable composition disc, screwed, wafer, or flanged ends.

2.15 SOLDER

- A. 95.5% tin, 4% copper, 0.5% silver.
- B. Lead free, antimony free, zinc-free.
- C. Silvabrite 100, by Engelhard Corporation or approved equal.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Coordinate and verify excavations under provisions of Division 2.
- B. Verify that all excavations are to the required grade, dry, and not over-excavated.

3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale, oil and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Install, clean bank sand backfill in trench to a minimum of 6 inches below pipe, and to cover all piping a minimum of 12 inches above pipe.

3.03 INSTALLATION

- A. Install all materials in accordance with manufacturer's published instructions.
- B. All exposed sewer and water pipe in toilet rooms or other finished areas of the building shall be chromium plated.
- C. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- D. Route piping in orderly manner, parallel and perpendicular to building column grid lines, unless indicated otherwise on drawings, and maintain gradients.
- E. Install piping to conserve building space and not conflict with other trades or interfere with intended use of space.
- F. Group piping whenever practical at common elevations.
- G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- H. Provide clearance for installation of insulation and access to valves and fittings. Valves installed beyond reasonable reach shall be provided with chain operator.
- I. Provide access doors where valves and operable fittings are not exposed. Access doors shall be of approved types set in locations pre-approved by submittal to the Architect.
- J. Establish elevations of buried piping outside the building to ensure not less than 2 feet of cover, or maximum depth of frost penetration, which ever is the greater.
- K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- L. Provide encasement for and support of utility meters in accordance with requirements of utility companies.
- M. Gate valves installed below grade shall be covered with an adjustable cast iron roadway box extended to grade. Cover shall be cast iron with 'water' cast on top and set flush to finished paving or 2" above finished earthen grade. Box shall be supported from undisturbed soil or concrete base and shall not introduce any stress to piping under all traffic conditions.
- N. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting.
- O. Excavate in accordance with Division 2.

- P. Backfill in accordance with Division 2.
- Q. Install bell and spigot pipe with bell end upstream.
- R. Maintain uniformity in the installation of piping materials and joining methods. Do not mix materials types.
- S. Install valves with stems upright or horizontal, not inverted.
- T. Solder joints shall be wiped clean at each joint, remove excess metal while molten and flux residue when cooled.
- U. No PVC pipe or fittings will be allowed for any areas where pipe is installed in return air plenum unless the entire length of all such piping is encased within a minimum 2 hour fire rated enclosure.
- V. Installations of thermoplastic piping systems shall be in strict conformity to the manufacturers published instructions. Under ground drainage pipe installations shall be in conformity to ASTM D 2321.
- W. Installation of solvent cement joints for PVC piping shall be in strict conformity to the requirements outlined in ASTM D 2855.
- X. Waste nipple from wall to tapped tee shall be schedule 40 threaded galvanized steel pipe or brass or copper with threaded adapter.
- Y. Provide approved PVC slip by cast iron no hub adaptor at each transition from underground PVC piping to above ground cast iron pipe using standard or wide bodied no hub couplings for as specified elsewhere in this section. Transition shall be made as close as possible to floor for sanitary DWV piping systems and at test tee for storm drainage piping. Support vertical cast iron pipe from floor anchors with using riser clamp and galvanized all thread rod as specified in section 231400.

3.04 APPLICATION

- A. Install union downstream of all valves at equipment or apparatus connections.
- B. Install male adapters each side of threaded valves in copper piped system. Sweat solder adapters to tube prior to make-up of threaded connections.
- C. Install gate valves for shut-off and to isolate all equipment items, distinct parts of systems, or vertical risers.

- D. Each plumbing fixture shall have a shut-off valve on each hot water and cold water supply line.
- E. Each plumbing water rough-in stub out shall be fitted with a shut off valve.
- F. Install globe, ball or butterfly valves for throttling, bypass, or balancing (manual flow control) services.
- G. Ball valves installed in insulated piping shall be fitted with extended lever operators of sufficient length to raise handle above the insulation jacket material. Where valve is used for throttling service valve handle shall be equipped with adjustable memory stop device.
- H. Provide spring loaded, non-slam, check valves on discharge of water pumps.

3.05 ERECTION TOLERANCES

- A. All drainage lines in the building shall have 1/4 inch to the foot fall where possible and not less than 1/8 inch to the foot fall toward the main sewer. Pipe must be so laid that the slope will be uniform and continuous. Permission shall be secured from the Architect and Engineer before proceeding with any Work where existing conditions prevent the installation at minimum grade specified.
- B. Slope all water piping and arrange to drain at low points. Provide loose key operated, polished chrome, sill cock flush to wall where fixture stop will not suffice for this requirement.

3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, all domestic water systems shall be complete, thoroughly flushed clean and free of all foreign matter or erection residue.
- B. Ensure PH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- C. On building side of the main shut off valve, provide a 3/4" connection through which chlorine can be introduced into the water piping
- D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, in sufficient quantity to obtain 50 to 80 mg/L residual free chlorine solution throughout the entire domestic water piping systems.
- E. Bleed water from outlets as required to ensure complete distribution and test for disinfectant residual at a minimum 15 percent of total outlets.

- F. Maintain disinfectant in system for 24 hours.
- G. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- H. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- I. Take samples no sooner than 24 hours after flushing, from 5 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.07 SERVICE CONNECTIONS

- A. Provide new sanitary and storm sewer services connecting to existing building services or utility lines as shown on the drawings.
- B. Before commencing work, field verify invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover as required.
- C. Provide new domestic water service connecting to existing building services or utility lines as shown on plans. Assure connections are in compliance with requirements of the jurisdiction having authority.
- D. Extension of services to the building shall be fabricated from the same materials as the utility service lines or those materials specified herein.
- E. Should points of connection vary from those indicated on the drawings contractor shall properly allow for this in the actual connections field fabricated.

3.08 RODDING SEWERS

- A. All sanitary soil and waste lines, both in the building and out, shall be rodded out after completion of the installation.
- B. This Work shall be done, as part of the contract, to make certain that all lines are clear, and any obstruction that may be discovered shall be removed immediately. Rodding shall be accomplished by utilizing a rotary cutter, which shall be full size of pipe being cleaned.

3.09 TESTING OF PLUMBING PIPING SYSTEMS

- A. During the progress of the work and upon completion, tests shall be made as specified herein and as required by Authorities Having Jurisdiction, including Inspectors, Owner or Architect. The Architect or duly authorized Construction Inspector shall be notified in writing at least 2 working days prior to each test or other Specification requirement which requires action on the part of the Construction Inspector.

- B. Tests shall be conducted as part of this work and shall include all necessary instruments, equipment, apparatus, and service as required to perform the tests with qualified personnel. Submit proposed test procedures, recording forms, and test equipment for approval prior to the execution of testing.
- C. Tests shall be performed before piping of various systems have been covered or furred-in. For insulated piping systems testing shall be accomplished prior to the application of insulation.
- D. All piping systems shall be tested with water and proved absolutely tight for a period of not less than 24 hours. Tests shall be witnessed by the Architect or an authorized representative and pronounced satisfactory before pressure is removed or any water drawn off.
- E. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to a like new condition. Leaking pipe joints, or defective pipe, shall be removed and replaced with acceptable materials. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks.
- F. Wherever conditions permit, each piping system shall thereafter be subjected to its normal operating pressure and temperature for a period of no less than five 5 days. During that period, it shall be kept under the most careful observation. The piping systems must demonstrate the propriety of their installation by remaining absolutely tight during this period.
- G. Domestic Water:
 - 1. Provide hydrostatic pressure test at one and one half times the normal working pressure or 125 psig, which ever is the greater, for 24 hours.
- H. Sanitary Soil, Waste and Vents and Storm Sewer:
 - 1. After the rough-in soil, waste and vent and other parts of the sanitary sewer including branch laterals have been set from the lowest level, at point of connection to existing utility lines, to above the floor line, all outlets shall be temporarily plugged or capped, except as are required for testing as described herein. Ground work shall not permit the backfill of trenches to cover any joints until the completion of testing. Back fill shall be limited to mid sections of full joints of piping only. For pipe in ground the piping shall be readied as described herein and filled with water to a verifiable and visible level to 10' above the lowest portions of the system being tested.
 - 2. On multi-level buildings only one floor level shall be tested at a time. Each floor shall be tested from a level below the structure of the floor, or the outlet of the building in the case of the lowest level, to a level of 12 inches above the floor

immediately above the floor being tested, or the top of the highest vent in the case of the highest building level. The pipes for the level being tested shall be filled with water to a verifiable and visible level as described above and be allowed to remain so for 24 hours. If after 24 hours the level of the water has been lowered by leakage, the leaks must be found and stopped, and the water level shall again be raised to the level described, and the test repeated until, after a 24 hour retention period, there shall be no perceptible lowering of the water level in the system being tested.

3. Should the completion of these tests leave any reasonable question or doubt of the integrity of the installation, additional tests including peppermint smoke, or other measures shall be performed to demonstrate the reliability of these systems to the complete satisfaction of the Owner's duly authorized representative. Such tests shall be conducted and completed before any joints in plumbing are concealed or made inaccessible.

3.10 COMPLETE FUNCTIONING OF WORK

- A. All work fairly implied as essential to the complete functioning of the systems shown on the Drawings and Specification shall be completed as part of the work of this Division unless specifically stated otherwise. It is the intention of the Drawings and Specification to establish the type and function of systems but not to set forth each item essential to the functioning of any system. In case of doubt as to the work intended or in the event of amplification or clarification thereof, the Contractor shall call upon the Architect for Supplementary Instructions and Drawings, etc.

END OF SECTION 22 41 00

SECTION 22 41 10 NATURAL GAS PIPING SYSTEMS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 220500, are included as a part of this Section as if written in full in this document.

1.02 SCOPE

- A. Scope of the Work shall include the furnishing, complete installation and testing of the gas piping system, with all metering, valves, piping and auxiliaries, ready for owner's use.
- B. Coordinate with the gas company and pay all fees and permits required for a complete and operating gas service to the project.

PART 2 - PRODUCTS

2.01 All gas piping above ground shall be Schedule 40 black steel as manufactured by National Tube, Republic, Youngstown, or approved equal domestic manufacturer.

2.02 All gas piping larger than 2" shall be of welded construction. Screwed fittings will only be permitted for size 2" and smaller. Unions and valves will not be permitted above furred ceiling areas or in walls or chases.

2.03 All pipe fittings shall be of materials as follows:

- 1. All welding fittings shall be factory-made and shall be full line size, for each tee, branch, elbow, etc., with reducers after fittings, if required.
- 2. All screwed fittings shall be Crane, or approved equal, Class 150 malleable iron. Screw joints shall be made up with graphite and oil or Teflon tape. Screwed threads shall be in accordance with American Pipe Thread Standards.
- 3. All piping and fittings shall be from a domestic manufacturer.

2.04 All underground gas piping with 5 pound working pressure or less shall be as follows:

- A. The pipe shall be yellow polyethylene with socket heat fusion joints and fittings. Pipe sizes 1-1/2" and 2" shall be SDR 11, (PE 2406) and pipe sizes 3" and 4" shall be SDR 11.5 (PE 2406).

- B. All socket heat fusion fittings shall be D.O.T. approved and meet ASTM D-2513 and ANSI B31.8 codes.
 - C. All gas valves shall be polyethylene ball type, doubled union, rated for natural gas use. All valves shall be placed in a cast-iron valve box of an adequate size for accessibility and maintenance.
 - 4. All transition meter risers shall be D.O.T. approved anode-less service type, fusion coupled and PE 2406 rated.
 - E. The contractor shall take thermal expansion under consideration during installation. The contractor shall follow all requirements set by the manufacturer to protect the system from damage due to thermal expansion.
 - F. The contractor shall provide detector tape approximately 12" above all gas piping.
 - G. Wrap pipe with 18 gauge minimum copper tracer wire.
- 2.05** Gas piping installed in unventilated spaces shall be routed in properly vented continuous sleeve where required by the building code.
- 2.06** Gas valves shall be U.L. listed as follows:
- A. Ball Valves: Nibco T585-70-UL for ¼" to 1" and T580-70-UL for 1-¼" to 3".
 - B. Plug Valves: DeZurick Series 425 or 435 Eccentric valves with RS 49 plug seals.
- 2.07** Gas pressure regulators shall be capable of reducing 75 psi pressure gas to 0.5 psi gas at capacities required by Gas Demand. Install per A.G.A. Bulletin 90. Regulators shall be as manufactured by Rockwell, Fisher-Governor or approved equal.
- 2.08** All gas regulators located inside the building shall be vented to atmosphere with schedule 40 black steel pipe. This includes all regulators provided with mechanical and plumbing equipment and all other regulators provided under this contract. Vent piping shall be the full size of regulatory port opening, or as recommended by regulator manufacturer, and shall run independent of any other regulator vent through to point of termination.

PART 3 - EXECUTION

- 3.01** All piping shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- 3.02** All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.

- 3.03** All underground gas piping shall be laid on 6" of wet compact banksand approximately 24" below grade. Backfill trench with wet compacted banksand to 6" above pipe. The remainder of backfill shall be selected backfill and shall meet all compaction requirements set forth by the general trenching and backfill requirements.
- 3.04** Provide lever handle gas valve, drip leg and union to each piece of equipment and where indicated.
- 3.05** All gas lines entering building shall be valved on the exterior of the building above grade.

PART 4 - TESTING

4.01 TESTING OF GAS PIPING SYSTEMS

- A. All gas system testing shall be in compliance with local codes or as required in NFPA 54 National Fuel Gas Code whichever is the more stringent requirement.
- B. All work shall be performed by a Journeyman Plumber holding current State and local licenses.
- C. All tests shall be accomplished during normal working hours and after having given due notification to building owner, construction manager or designee, of tests to be performed. All tests shall be performed in the presence of and witnessed by the building owners representative or designee
- D. All gas system piping shall be subjected to a pneumatic test pressure of 60 psig for not less than 2 hours upon completion of all rough-in work and prior to covering. While the systems are subjected to this air pressure test, all joints shall have a soapy water solution applied and shall be observed for leaks. During test period there shall be no perceptible drop in test gage pressure
- E. A final test shall be performed after all portions of the piping system are completely installed and covered. The entire system shall be tested, with all system outlets plugged or capped, before any equipment or appliances are connected to the piping.
 - 1. Final test shall be with mercury, measured with a manometer or slope gage. Test pressures shall in no case be less than one and one half times the normal operating pressure or as listed below; which ever is the greater:
 - a. 10.5 inches mercury (5 psig) for 4 ounce system.
 - b. 21.0 inches mercury (10 psig) for 8 ounce system.
 - 2. Tests shall be for a period of not less than 30 minutes and shall prove absolutely tight, showing no perceptible drop, for the entire test period.

- F. Purge air from test piping before connecting equipment or appliances. Purge air to outdoors or to ventilated space of sufficient volume to prevent accumulation of flammable mixtures.

END OF SECTION

SECTION 22 43 00 PLUMBING SPECIALTIES

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Roof and floor drains.

1.02 RELATED WORK

- A. Section 221400 - Supports and Anchors.
- B. Section 224100 - Plumbing Piping.
- C. Section 224400 - Plumbing Fixtures.

1.03 REFERENCES

- A. ANSI/ASSE 1012 - Backflow Preventers with Immediate Atmospheric Vent.
- B. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers.
- C. ANSI/ASSE 1013 - Backflow Preventers, Reduced Pressure Principle.
- D. ANSI/ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.
- E. ANSI A112.21.1 - Floor Drains.
- F. ANSI A112.21.2 - Roof Drains.
- G. ANSI A112.26.1 - Water Hammer Arresters.
- H. PDI WH-201 Water Hammer Arresters
- I. AWWA C506 - Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.

1.04 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.05 SUBMITTALS

- A. Submit under provisions of Division 1.

- B. Submit product data under provisions of Division 1.
- C. Include component sizes, rough-in requirements, service sizes, and finishes.
- D. Manufacturer's Installation Instructions: Indicate assembly and support requirements.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 1.
- B. Record actual locations of equipment, cleanouts, and backflow preventers.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 1.
- B. Operation Data: Indicate frequency of treatment required for interceptors.
- C. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 1.
- B. Accept specialties on site in original factory packaging. Inspect for damage.

1.09 EXTRA MATERIALS

- A. Furnish under provisions of Division 1.
- B. Provide two loose keys for hose bibbs and spare hose end vacuum breakers.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - ROOF DRAINS

- A. Jay R. Smith
- B. Watts
- C. Zurn
- D. Substitutions: Under provisions of Division One.

- E. Roof Drains
 - 1. Roof Drains: ANSI A112.21.2; Galvanized cast iron body with sump, removable cast aluminum dome strainer, membrane flange and membrane clamp with integral gravel stop, with adjustable underdeck clamp roof sump receiver waterproofing flange controlled flow weir leveling frame adjustable extension sleeve (for insulation) perforated or slotted ballast guard extension for inverted roof.
 - 2. Roof Overflow Drains (OD): Galvanized cast iron body and clamp collar and bottom clamp ring; pipe extended to 2 inches above flood elevation.

2.02 ACCEPTABLE MANUFACTURERS - CLEANOUTS

- A. Zurn
- B. Watts
- C. Jay R. Smith
- D. Substitutions: Under provisions of Division 1.
- E. Cleanouts
 - 1. Exterior Surfaced Areas: Square cast nickel bronze access frame and non-skid cover;
 - 2. Exterior Unsurfaced Areas: Line type with lacquered cast iron body and round epoxy coated gasketed cover;
 - 3. Interior Finished Floor Areas: Galvanized cast iron, two piece body with double drainage flange, weep holes, reversible clamping collar, and adjustable nickel-bronze strainer, round with scored cover in service areas and round with depressed cover to accept floor finish in finished floor areas;
 - 4. Interior Finished Wall Areas: Line type with lacquered cast iron body and round epoxy coated gasketed cover, and 6" round stainless steel access cover secured with machine screw;
 - 5. Interior Unfinished Accessible Areas: Calked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.

2.03 ACCEPTABLE MANUFACTURERS - HOSE BIBBS/HYDRANTS

- A. Woodford
- B. Zurn
- C. Jay R. Smith
- D. Substitutions: Under provisions of Division 1.

E. HOSE BIBBS/HYDRANTS

1. Bronze or brass, replaceable hexagonal disc, hose thread spout, chrome plated where exposed to interior with lockshield and removable key, integral vacuum breaker in conformance with ANSI/ASSE 1011;
2. Wall Hydrant: ANSI/ASSE 1019; non-freeze, self-draining type with rough chrome plated lockable recessed box hose thread spout, lockshield and removable key, and vacuum breaker;
3. Floor Hydrant: ANSI/ASSE 1019; chrome plated lockable recessed box, hose thread spout, lockshield and removable key, and vacuum breaker;

2.04 ACCEPTABLE MANUFACTURERS - BACKFLOW PREVENTERS

A. Watts

B. Wilkins

C. Febco

D. Substitutions: Under provisions of Division 1.

E. BACKFLOW PREVENTERS

1. Reduced Pressure Backflow Preventers: ANSI/ASSE 1013; bronze body with bronze and plastic internal parts and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve which opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks;
2. Double Check Valve Assemblies: ANSI/ASSE 1012; Bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent;

PART 3 - EXECUTION

3.01 PREPARATION

- A. Coordinate cutting, forming of roof and/or floor construction to receive drains to required invert elevations.

3.02 INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

- B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- C. Encase exterior cleanouts in concrete flush with grade.
- D. Pipe relief from back flow preventer to nearest drain.

END OF SECTION 22 43 00

SECTION 23 02 01 COORDINATION DRAWINGS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions 013100 and Supplementary Conditions apply to all Work herein.

1.2 COORDINATION DRAWINGS

- A. The Contractor shall take the lead in coordinating the Mechanical, Electrical, Plumbing, Communications, Electronic Safety/Security and Fire Protection systems within the building.
- B. The General Contractor shall coordinate a three-dimensional (3D) model of the building which includes the Mechanical, Electrical, Plumbing, and Fire Protection systems. The Mechanical, Electrical, Plumbing, and Fire Protection Contractors shall prepare their work and generate 3D models which will be given to the General Contractor for coordination. The Contractor will be provided with the REVIT model that was used to generate the contract documents, this file may be used as the background file. The Contractor shall replace the systems drawn with the actual shop drawing models. The Contractor is not limited to using REVIT, but may use any 3-D software in generating and combining the coordination model.
- C. Submitting the contract drawings as coordination drawings will not be acceptable.
- D. The model shall include detailed and accurate representations of all equipment to be installed based upon the reviewed equipment submittals.
- E. The Mechanical Contractor shall hold a 3-D coordination meeting with all sub-contractors present to review the model and discuss coordination of the installation of the building systems.
- F. Upon completion of the coordination meeting, the Contractor shall submit the 3-D model and ¼" scale drawings for review.
- G. The model shall detail major elements, components, and systems in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
 - a. Wall and type locations.
 - b. Clearances for installing and maintaining insulation.
 - c. Locations of light fixtures and sprinkler heads.
 - d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - e. Equipment connections and support details.
 - f. Exterior wall and foundation penetrations.
 - g. Routing of storm and sanitary sewer piping.
 - h. Fire-rated wall and floor penetrations.
 - i. Sizes and location of required concrete pads and bases.
 - j. Valve stem movement.
 - k. Structural floor, wall and roof opening sizes and details.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.

H. Sequence of Coordination

Below is hierarchy of model elements and the sequencing by which the models will be coordinated.

1. Structural and Architectural model
2. Miscellaneous steel
3. Perform preliminary space allocation
4. Identify hard constraints (locations of access panels, lights, A/V space requirements, etc.)
5. Main and medium pressure ducts from the shaft out

6. Main graded plumbing lines and vents
 7. Sprinkler mains and branches
 8. Cold and hot water mains and branches
 9. Lighting fixtures and plumbing fixtures
 10. Smaller sized ducts and flex ducts
 11. Smaller size cold water and hot water piping, flex ducts, etc.
- I. The Contractor and Sub-Contractors shall not install any item until the coordination has been completed and reviewed by the Construction Manager, Owner, and A/E team.
- J. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
- K. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors

END OF SECTION

SECTION 23 03 00 – COMMISSIONING OF HVAC SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract Documents, including General and Supplementary Conditions and Division 01 Specifications, apply to this section.
- B. Related SECTIONS:
 - 1. SECTION 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS
 - 2. SECTION 23 95 00 - ENERGY MANAGEMENT AND CONTROL SYSTEMS.

1.2 SUMMARY

- A. The commissioning of the HVAC system and associated controls shall be performed by an impartial technical firm hired by the owner. The commissioning provider shall be certified under one or more of the following certifications:
 - 1. CxA – Certified Commissioning Authority – ACG
 - 2. CBCP – Certified Building Commissioning Professional – AEE
 - 3. CCP – Certified Commissioning Professional – BCA
 - 4. CPMP – Certified Process Management Professional – ASHRAE
 - 5. BSC – Building System Commissioning Certification – NEBB
- B. The commissioning provider (Commissioning authority) shall be responsible for leading the entire construction team through the commissioning process including, but not limited to, conducting the commissioning kick-off meeting, preparing the commissioning plan, preparing pre-functional checklists, preparing functional test scripts, participation in functional testing and preparation of required documentation and reports.

1.3 RESPONSIBILITIES

- A. Contractor: Responsibilities of the Contractor as related to the Commissioning Process include, but are not limited to the following:
 - 1. Facilitate coordination of Commissioning work by Commissioning authority.
 - 2. Attend Commissioning meetings or other meetings called by Commissioning authority to facilitate the Commissioning Process.
 - 3. Review Functional Performance Test procedures for feasibility, safety, and

- impact on warranty, and provide Commissioning authority with written comment on same.
4. Provide all documentation relating to manufacturer's recommended performance testing of equipment and systems.
 5. Provide Operations & Maintenance data to Commissioning authority for preparation of checklists and training manuals.
 6. Provide Testing and Balancing Report before Functional Testing begins.
 7. Provide As-built drawings and documentation to facilitate Testing.
 8. Assure and facilitate participation and cooperation of Sub Contractors and equipment suppliers as required for the Commissioning Process.
 9. Certify to Commissioning authority that installation work listed in Pre-Functional Checklists has been completed.
 10. Install systems and equipment in strict conformance with project specifications, manufacturer's recommended installation procedures, and Pre-Functional Checklists.
 11. Provide data concerning performance, installation, and start-up of systems.
 12. Provide copy of manufacturers filled-out start-up forms for equipment and systems.
 13. Ensure systems have been started and fully checked for proper operation prior to arranging for Testing with Commissioning authority. Prepare and submit to Commissioning authority written certification that each piece of equipment and/or system has been started according to manufacturer's recommended procedure, and that system has been tested for compliance with operational requirements.
 - a. Contractor shall carry out manufacturer's recommended start-up and testing procedures, regardless of whether or not they are specifically listed in Pre-Functional Checklists.
 - b. Contractor is not relieved of obligation for systems/equipment demonstration where performance testing is required by specifications, but a Functional Performance Test is not specifically designated by Commissioning authority.
 14. Coordinate with Commissioning authority to determine mutually acceptable date of Functional Performance Tests.
 15. Provide qualified personnel to assist and participate in Commissioning.
 16. Provide test instruments and communications devices, as prescribed by Commissioning authority, required for carrying out Testing of systems.
 17. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Test Engineer in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.
 18. Ensure deficiencies found in the Commissioning Issues Log are corrected

within the time schedule shown in the Commissioning Plan.

19. Provide Commissioning authority with all submittals, start-up instructions manuals, operating parameters, and other pertinent information related to Commissioning Process. This information shall be routed through Architect.
 20. Prepare and submit to Commissioning authority proposed Training Program outline for each system.
 21. Coordinate and provide training of Owner's personnel.
 22. Prepare Operation & Maintenance Manuals and As-Built drawings in accordance with specifications; submit copy to Commissioning authority in addition to other contractually required submissions. Revise and resubmit manuals in accordance with Design Professionals and Commissioning authority comments.
 23. Commissioning requires participation of this Division Subcontractors to ensure that systems are operating in manner consistent with Contract Documents. All costs associated with the participation of Contractor, Sub-Contractors, Design Professionals, and Equipment Vendors in the Commissioning Process shall be included as part of the Construction Contract.
- B. Subcontractors and vendors shall prepare and submit to Commissioning authority proposed Startup procedures to demonstrate proper installation of systems, according to these specifications and checklists prepared by Commissioning authority

1.4 COMMISSIONING PLAN

- A. Commissioning Process tasks and activities:
1. Commissioning kick-off meeting: Conducted by commissioning authority and attended by construction team and design team.
 2. Pre-functional checklists: Prepared by the commissioning authority and filled out by subcontractors performing the work that is applicable.
 3. Site visits to review installation of applicable systems and progress of checklist documentation performed and reported by commissioning authority.
 4. Functional testing: Commissioning authority shall conduct functional testing with assistance of applicable subcontractors and document successful results as well as deficiencies (issues). Functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing in accordance with plans and specifications. Testing shall include all modes and sequence of operation, including under full-load, part-load and emergency conditions (including all alarms). Controls system shall be tested to document that control devices, components, equipment and systems are calibrated and adjusted and operate in

accordance with the plans and specifications. Sequences shall be functionally tested to document they operate in accordance with plans and specifications.

5. Preliminary commissioning report: Commissioning authority shall issue a preliminary commissioning report to the owner that has results of the first round of functional testing including deficiencies discovered.
6. Air and hydronic system balancing: Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the contract documents. System balancing shall be performed by T.A.B. contractor as specified in the Testing, Adjusting and Balancing specification section 23 99 00.
7. Systems manual: Commissioning authority shall compile the systems manual using submittal data provided by the general contractor and applicable subcontractors.
8. Final commissioning report: Commissioning authority shall issue final commissioning report documenting the entire process and final results of functional testing. Report shall include final testing and balancing report.

B. Equipment to be tested

1. Energy Management and Control System:
 1. Graphical User Interface
 2. Automation Software
 3. Field Level Controllers
 4. Field Level Devices
 5. Control Sequences
2. Chilled Water Systems (All chillers and pumps)
3. Condenser Water Systems (All towers and pumps)
4. Heating Water Systems (All boilers and pumps)
5. Air Handling Systems (All AHU and 10% of terminal units)
6. Energy Recovery Systems (100%)
7. Water Treatment Systems (Verify vendors completion of scope)
8. Service water heating systems (100%)

C. Testing functions and conditions

1. Energy conservation programs (economizer, optimal start, etc)
2. Verify shutdown of systems when scheduled.
3. Calibration of sensors
4. Testing shall affirm winter and summer design conditions.
5. Test under full outside air conditions.
6. Confirm functionality of all specified sequences of operations.

7. Verify the functionality of all alarms.
- D. Performance criteria
1. Air and water temperatures shall be within tolerances specified in the contract documents.
 2. Space temperatures shall be maintained within 1 degree of specified set points.
 3. Space humidity shall be maintained within 5% of specified levels.

PART 2 – PRODUCTS

2.1 NO PRODUCTS SUPPLIED

PART 3 – EXECUTION

3.1 GENERAL

- A. This Division has startup responsibilities and are required to complete sub-systems so COMPLETE SYSTEMS are fully functional. Insuring they meet design requirements of Contract Documents. Commissioning procedures and testing do not relieve or lessen this responsibility or shift this responsibility, in whole or in part, to Commissioning Agent or Owner.
- B. Coordinate with other Sub-Contractors and equipment vendors to set aside adequate time to address Pre-Functional Checklists, Functional Performance Tests, Operations & Maintenance Manual creation, Owner Training, and associated coordination meetings.
- C. Commissioning authority will also conduct site inspections at critical times and issue Cx Field Reports with observations on installation deficiencies so that they may be issued by Architect as deemed appropriate.

3.2 WORK PRIOR TO COMMISSIONING

- A. Complete all phases of the work so the systems can be started, adjusted, balanced, tested, and otherwise tested.
- B. See pertinent specification sections in this Division, which outline responsibilities for start- up of equipment with obligations to complete systems, including all sub-systems so that they are fully functional.
- C. Assist commissioning authority with all information pertaining to actual equipment

and installation as required complete the full commissioning scope.

- D. Contractor shall prepare startup procedures to demonstrate compliance with pre-functional checklists, and coordinate scheduling for completion of these checklists.
- E. A minimum of 7 days prior to date of system startup, submit to Commissioning authority for review, detailed description of equipment start-up procedures which contractor proposes to perform to demonstrate conformance of systems to specifications and Checklists.

3.3 PARTICIPATION IN COMMISSIONING

- A. Attend meetings related to the Commissioning Process; arrange for attendance by personnel and vendors directly involved in the project, prior to testing of their systems.
- B. Provide skilled technicians to startup and test all systems, and place systems in complete and fully functioning service in accordance with Contract Documents.
- C. Provide skilled technicians, experienced and familiar with systems being commissioned, to assist Commissioning authority in commissioning process.

3.4 WORK TO RESOLVE DEFICIENCIES

- A. Complete corrective work in a timely manner to allow expeditious completion of Commissioning Process. If deadlines pass without resolution of identified problems, Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs thus incurred will be Contractor's responsibility.

3.5 PRE-FUNCTIONAL CHECKLISTS (PFC)

- A. Contractor shall complete Pre-Functional Checklists to validate compliance with Contract Documents installation and start-up requirements, for this Division's systems.
- B. Refer to commissioning plan for detailed list of equipment to be commissioned.

3.6 FUNCTIONAL PERFORMANCE TESTING (FPT)

- A. Contractor, in cooperation with Commissioning Agent, shall conduct Functional Performance Testing to validate compliance with Contract Documents.

- B. Refer to commissioning plan for detailed list of equipment to be commissioned.
- C. Assist Commissioning authority in Functional Testing by removing equipment covers, opening access panels, etc. Furnish ladders, flashlights, meters, gauges, or other inspection equipment as necessary.

3.7 TRAINING

- A. The following requirements are in addition to Operations & Maintenance requirements specified elsewhere in this specifications manual.
- B. Contractor shall be responsible for training coordination and scheduling, and ultimately to ensure that training is completed.
- C. The training agenda (plan) shall include, at a minimum, the following elements:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.
- D. Commissioning authority shall be responsible for overseeing and approving content and adequacy of training of Owner personnel for all installed systems. Provide Commissioning authority with training plan two weeks before planned training.

3.8 OPERATIONS & MAINTENANCE MANUALS

- A. The following requirements are in addition to Operations & Maintenance requirements specified elsewhere in this specifications manual.
- B. Sub-Contractor shall compile and prepare documentation for equipment and systems specified in this Division, and shall deliver documentation to Contractor for inclusion in Operation & Maintenance Manuals, in accordance with requirements of Division 01, prior to training Owner personnel.
- C. Provide Commissioning authority with a single, electronic copy of Operation & Maintenance Manuals for review. Commissioning authority copy of O&M manuals shall be submitted through Architect.
- D. Operation and maintenance manuals shall include, service agency contact information, maintenance requirements, controls system settings and a narrative of

how each system is intended to operate, including set points.

3.9 DOCUMENTATION

A. Commissioning authority shall provide documentation of process as follows:

1. Preliminary commissioning report including test procedures, results of testing, itemization of deficiencies, deferred tests and climatic conditions required for performance of deferred tests. Preliminary commissioning report shall be issued to owner to demonstrate the first pass of testing has occurred and to demonstrate compliance with applicable codes.
2. Final commissioning report shall include the final test and balance report, final results of functional testing, disposition of deficiencies discovered during testing, including the details of corrective measures used and functional testing procedures used for repeatability of testing in the future.

END OF SECTION 23 08 00

SECTION 23 05 00 BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.
- B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings are deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect for approval as soon as practicable. No such departures shall be made without the prior written approval of the Architect.
- C. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, such reference shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect, expressed in writing, is equal to that specified.

1.02 SCOPE OF WORK

- A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form the complete and functioning systems in all of its various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The contractor shall review all pertinent drawings, including those of other contracts prior to commencement of Work.
- B. This Division requires the furnishing and installing of all items Specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.
- C. The approximate locations of Mechanical (HVAC) and Plumbing items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the Review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.

- D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.
- E. All discrepancies between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to the bidding, where this cannot be done at least 7 working days prior to bid; the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.
- F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.
- G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".
- H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.

1.03 SCHEMATIC NATURE OF CONTRACT DOCUMENTS

- A. The contract documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the approved shop drawings.
- B. All duct or pipe or equipment locations as indicated on the documents do not indicate every transition, offset, or exact location. All transitions, offsets clearances and exact locations shall be established by actual field measurements, coordination with the structural, architectural and reflected ceiling plans, and other trades. Submit shop drawings for approval.
- C. All transitions, offsets and relocations as required by actual field conditions shall be performed by the contractor at no additional cost to the owner.
- D. Additional coordination with electrical contractor may be required to allow adequate clearances of electrical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

1.04 SITE VISIT AND FAMILIARIZATION

- A. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.
- B. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.
- C. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.05 WORK SPECIFIED IN OTHER SECTIONS

- A. Finish painting is specified. Prime and protective painting are included in the work of this Division.
- B. Owner and General Contractor furnished equipment shall be properly connected to Mechanical (HVAC) and Plumbing systems.
- C. Furnishing and installing all required Mechanical (HVAC) and Plumbing equipment control relays and electrical interlock devices, conduit, wire and J-boxes are included in the Work of this Division.

1.06 PERMITS, TESTS, INSPECTIONS

- A. Arrange and pay for all permits, fees, tests, and all inspections as required by governmental authorities.

1.07 DATE OF FINAL ACCEPTANCE

- A. The date of final acceptance shall be the date of owner occupancy, or the date all punch list items have been completed or final payment has been received. Refer to Division 1 for additional requirements.
- B. The date of final acceptance shall be documented in writing and signed by the architect, owner and contractor.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

- B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct properly protected from incidental damage and weather damage.
- C. Damaged equipment, duct or pipe shall be promptly removed from the site and new, undamaged equipment, pipe and duct shall be installed in its place promptly with no additional charge to the Owner.

1.09 NOISE AND VIBRATION

- A. The heating, ventilating and air conditioning systems, and the component parts thereof, shall be guaranteed to operate without objectionable noise and vibration.
- B. Provide foundations, supports and isolators as specified or indicated, properly adjusted to prevent transmission of vibration to the Building structure, piping and other items.
- C. Carefully fabricate ductwork and fittings with smooth interior finish to prevent turbulence and generation or regeneration of noise.
- D. All equipment shall be selected to operate with minimum of noise and vibration. If, in the opinion of the Architect, objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of the Work, the Contractor shall rectify such conditions without extra cost to the Owner.

1.10 APPLICABLE CODES

- A. Obtain all required permits and inspections for all work required by the Contract Documents and pay all required fees in connection thereof.
- B. Arrange with the serving utility companies for the connection of all required utilities and pay all charges, meter charges, connection fees and inspection fees, if required.
- C. Comply with all applicable codes, specifications, local ordinances, industry standards, utility company regulations and the applicable requirements of the following nationally accepted codes and standards:
 - 1. Air Moving & Conditioning Association, AMCA.
 - 2. American Standards Association, ASA.
 - 3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., ASHRAE.
 - 4. American Society of Mechanical Engineers, ASME.
 - 5. American Society of Plumbing Engineers, ASPE.
 - 6. American Society of Testing Materials, ASTM.
 - 7. American Water Works Association, AWWA.
 - 8. National Bureau of Standards, NBS.
 - 9. National Fire Protection Association, NFPA.
 - 10. Sheet Metal & Air Conditioning Contractors' National Association, SMACNA.

11. Underwriters' Laboratories, Inc., UL.
 12. International Energy Conservation Code, IECC.
- D. Where differences existing between the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, the more stringent or costly application shall govern. Promptly notify the Engineer in writing of all differences.
- E. When directed in writing by the Engineer, remove all work installed that does not comply with the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, correct the deficiencies, and complete the work at no additional cost to the Owner.

1.11 DEFINITIONS AND SYMBOLS

- A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 1.
- B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.
- C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.
- D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.
- E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.

- F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.
- G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.
- H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.
- I. Installer: Entity (person or firm) engaged by the Contractor or its subcontractor or Sub-contractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.
- J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor, or when so noted by other identified installers or entities.
- K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.
- L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in

Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by 1993 ASHRAE Fundamentals Handbook, chapter 34 "Abbreviations and Symbols", ASME and ASPE published standards.

1.12 DRAWINGS AND SPECIFICATIONS

- A. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.
- B. Should items be required by these Specifications and not indicated on the Drawings, they are to be supplied even if of such nature that they could have been indicated thereon. In case of disagreement between Drawings and Specifications, or within either Drawings or Specifications, the better quality or greater quantity of work shall be estimated and the matter referred to the Architect or Engineer for review with a request for information and clarification at least 7 working days prior to bid opening date for issuance of an addendum.
- C. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is equal to the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturers' standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.
- D. The Architect or Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.
- E. Products by other reliable manufacturers, other materials, and other methods, will be accepted as outlined, provided they have equal capacity, construction, and performance. However, under no circumstances shall any substitution be made without the written permission of the Architect or Engineer and Owner. Request for prior approval must be made in writing 10 days prior to the bid date without fail.
- F. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.
- G. Wherever a definite material or manufacturer's product is specified and the Specification states that products of similar design and equal construction from the specified list of manufacturers may be substituted, it is the intention of the Owner or Engineer that products of manufacturers that are specified are the only products that will be acceptable

and that products of other manufacturers will not be considered for substitution without approval.

- H. Wherever a definite product, material or method is specified and there is a statement that "OR EQUAL" product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method or an "OR EQUAL" product, material or method may be used if it complies with the specifications and is submitted for review to the Engineer as outline herein.
- I. Where permission to use substituted or alternative equipment on the project is granted by the Owner or Engineer in writing, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available which includes allowances for all required Code and maintenance clearances, and to coordinate all equipment structural support, plumbing and electrical requirements and provisions with the Mechanical (HVAC) and Plumbing Design Documents and all other trades, including Division 16.
- J. Changes in architectural, structural, electrical, mechanical, and plumbing requirements for the substitution shall be the responsibility of the bidder wishing to make the substitution. This shall include the cost of redesign by the affected designer(s). Any additional cost incurred by affected subcontractors shall be the responsibility of this bidder and not the owner.
- K. If any request for a substitution of product, material or method is rejected, the Contractor will automatically be required to furnish the product, material or method named in the Specifications. Repetitive requests for substitutions will not be considered.
- L. The Owner or Engineer will investigate all requests for substitutions when submitted in accordance with above and if accepted, will issue a letter allowing the substitutions.
- M. Where equipment other than that used in the design as specified or shown on the Drawings is substituted (either from an approved manufacturers list or by submittal review), it shall be the responsibility of the substituting Contractor to coordinate space requirements, building provisions and connection requirements with his trades and all other trades and pay all additional costs to other trades, the Owner, the Architect or Engineer, if any, due to the substitutions.
- N. The electrical design and electrical drawings are based on the equipment and/or electric motors of the type, size and electrical characteristics shown and specified on the mechanical drawings. Any change in equipment and/or motor size or type brought on directly or indirectly by a substitution or mechanical equipment having characteristics requiring a change, shall be the responsibility of the Mechanical Contractor and the entire cost of such change, including conduit, wiring, motor starting equipment, etc., shall be paid for by the Mechanical Contractor at no additional charge, unless the substitution was initiated by the Owner. Submittals must clearly show and deviations. Mechanical

Contractor is responsible for coordinating any required changes with the Electrical Contractor, prior to Electrical Contractors ordering of panels and associated equipment.

1.13 SUBMITTALS

- A. Coordinate with Division 1 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded the Contractor shall submit a minimum of eight (8) complete bound sets of shop drawings and complete data covering each item of equipment or material. The first submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain one (1) copy each of all shop drawings for their files. Where full size drawings are involved, submit one (1) print and one (1) reproducible sepia or mylar in lieu of eight (8) sets. All literature pertaining to an item subject to Shop Drawing submittal shall be submitted at one time. A submittal shall not contain information from more than one Specification section, but may have a section subdivided into items or equipment as listed in each section. The Contractor may elect to submit each item or type of equipment separately. Each submittal shall include the following items enclosed in a suitable binder:
1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
 2. An index page with a listing of all data included in the Submittal.
 3. A list of variations page with a listing all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.
 4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
 5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of $1/4" = 1'-0"$, as required to demonstrate that the alternate or substituted product will fit in the space available.
 6. Identification of each item of material or equipment matching that indicated on the Drawings.
 7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special

- requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.
8. Additional information as required in other Sections of this Division.
 9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".
- B. Refer to Division 1 for additional information on shop drawings and submittals.
- C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.
- D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.
- E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:
1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.
 2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.
 3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.
 4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.
 5. CONTRACTOR'S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required

stating the submittal meets all conditions of the contract documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.

6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified, the Contractor will automatically be required to furnish the product, material or method named in the specifications. Contractor shall not order equipment where submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.
- F. Materials and equipment which are purchased or installed without shop drawing review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.
- G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.
- H. Submittals are required for, but not limited to, the following items:
 1. Pipe Material and Specialties.
 2. Pipe Fabrication Drawings.
 3. Basic Materials.
 4. Variable Air Volume Boxes.
 5. Air Handling Units.
 6. Cooling Towers.
 7. Chillers.
 8. Air Cooled Condensing Units.
 9. Water Treatment.
 10. Expansion Compensation.
 11. Variable Frequency Drives.
 12. Noise and Vibration Controls.
 13. Plumbing Fixtures and Specialties.
 14. Plumbing Equipment.
 15. Sanitary DWV Fittings, Pipe and Accessories.
 16. Domestic Hot and Cold Water Pipe, Fittings and Accessories.
 17. HVAC Pipe and Duct Insulation.
 18. Hydronic and Plumbing Valves.
 19. Hydronic Piping and Accessories.
 20. Hydronic Pumps.
 21. Roof-Top A/C Units.
 22. Heating Water Boiler.
 23. Portable Pipe Hanger and Equipment Supports.

24. Duct Specialties.
 25. Duct Fabrication Drawings.
 26. Air Distribution Devices.
 27. Fan Coil Units.
 28. Filters.
 29. Fans.
 30. Fire Dampers and Fire Smoke Dampers.
 31. Temperature Controls and Control Sequences.
 32. Test, Adjust and Balance Reports.
 33. Testing, Adjusting and Balancing Contractor Qualifications.
 34. Coordination Drawings.
- I. Refer to other Division 23 sections for additional shop drawing requirements. Provide samples of actual materials and/or equipment to be used on the Project upon request of the Owner or Engineer.
- J. **Contractor to submit Mechanical/Electrical equipment coordination sheet with equipment submittal for all AHU's, ACCU's, and Fans. Reference chart at end of section. Provide copy to electrical subcontractor.**

1.14 COORDINATION DRAWINGS

- A. Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
 - a. Wall and type locations.
 - b. Clearances for installing and maintaining insulation.
 - c. Locations of light fixtures and sprinkler heads.
 - d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - e. Equipment connections and support details.
 - f. Exterior wall and foundation penetrations.
 - g. Routing of storm and sanitary sewer piping.
 - h. Fire-rated wall and floor penetrations.
 - i. Sizes and location of required concrete pads and bases.
 - j. Valve stem movement.
 - k. Structural floor, wall and roof opening sizes and details.
 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.
- B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
- C. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

1.15 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Special Project Requirements, in addition to the requirements specified in Division 23, indicate the following installed conditions:
1. Duct mains and branches, size and location, for both exterior and interior; locations of dampers, fire dampers, duct access panels, and other control devices; filters, fuel fired heaters, fan coils, condensing units, and roof-top A/C units requiring periodic maintenance or repair.
 2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
 3. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 4. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 5. Contract Modifications, actual equipment and materials installed.
- B. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.
- C. The Contractor shall maintain a set of clearly marked black line record "AS-BUILT" prints on the job site on which he shall mark all work details, alterations to meet site conditions and changes made by "Change Order" notices. These shall be kept available for inspection by the Owner, Architect or Engineer at all times.

- D. Refer to Division 1 for additional requirements concerning record drawings. If the Contractor does not keep an accurate set of as-built drawings, the pay request may be altered or delayed at the request of the Architect. Mark the drawings with a colored pencil. Delivery of as-built prints and reproducibles is a condition of final acceptance.
- E. The record prints shall be updated on a daily basis and shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents which are required for coordination. All dimensions shall include at least two dimensions to permanent structure points.
- F. Submit three prints of the tracings for approval. Make corrections to tracings as directed and delivered "Auto Positive Tracings" to the architect. "As-Built" drawings shall be furnished in addition to shop drawings.
- G. When the option described in paragraph F., above is not exercised then upon completion of the work, the Contractor shall transfer all marks from the submit a set of clear concise set of reproducible record "AS-BUILT" drawings and shall submit the reproducible drawings with corrections made by a competent draftsman and three (3) sets of black line prints to the Architect or Engineer for review prior to scheduling the final inspection at the completion of the work. The reproducible record "AS-BUILT" drawings shall have the Engineers Name and Seal removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

DATE:

(NAME OF GENERAL CONTRACTOR)

BY: _____
(SIGNATURE)

(NAME OF SUBCONTRACTOR)

BY: _____
(SIGNATURE)

1.16 OPERATING MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 and in addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

1.17 CERTIFICATIONS AND TEST REPORTS

- A. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and schedule date for each test. This detailed completion and test schedule shall be submittal at least 90 days before the projected Project completion date.
- B. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule submitted.
- C. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.
- D. Certifications and test reports to be submitted shall include, but not be limited to those items outlined in Section of Division 23.

1.18 MAINTENANCE MANUALS

- A. Coordinate with Division 1 for maintenance manual requirements, unless noted otherwise bind together in "D ring type" binders by National model no. 79-883 or equal, binders shall be large enough to allow $\frac{1}{4}$ " of spare capacity. Three (3) sets of all approved shop drawing submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections and labeled for easy reference and shall utilize the individual specification section numbers shown in the Mechanical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 23 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins.
- B. Prepare maintenance manuals in accordance with Special Project Conditions, in addition to the requirements specified in Division 23, include the following information for equipment items:

1. Identifying names, name tags designations and locations for all equipment.
 2. Valve tag lists with valve number, type, color coding, location and function.
 3. Reviewed shop drawing submittals with exceptions noted compliance letter.
 4. Fabrication drawings.
 5. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable, i.e., description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts.
 6. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 7. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions, servicing instructions and lubrication charts and schedules.
 8. Equipment and motor name plate data.
 9. Wiring diagrams.
 10. Exploded parts views and parts lists for all equipment and devices.
 11. Color coding charts for all painted equipment and conduit.
 12. Location and listing of all spare parts and special keys and tools furnished to the Owner.
 13. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.
- C. Refer to Division 1 for additional information on Operating and Maintenance Manuals.
- D. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer a minimum of 14 working days prior to the beginning of the operator training period.

1.19 OPERATOR TRAINING

- A. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include 12 hours of on site training in three 4 hour shifts.
- B. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
- C. Refer to other Division 23 Sections for additional Operator Training requirements.

1.20 FINAL COMPLETION

- A. At the completion of the work, all equipment and systems shall be tested and faulty equipment and material shall be repaired or replaced. Refer to Sections of Division 23 for additional requirements.
- B. Clean and adjust all air distribution devices and replace all air filters immediately prior to final acceptance.
- C. Touch up and/or refinish all scratched equipment and devices immediately prior to final acceptance.

1.21 CONTRACTOR'S GUARANTEE

- A. Use of the HVAC and Plumbing systems to provide temporary service during construction period will not be allowed without permission from the Owner in writing and if granted shall not be cause warranty period to start, except as defined below.
- B. Contractor shall guarantee to keep the entire installation in repair and perfect working order for a period of one year after its completion and final acceptance, and shall furnish free of additional cost to the Owner all materials and labor necessary to comply with the above guarantee throughout the year beginning from the date of issue of Substantial Completion, Beneficial Occupancy by the Owner or the Certificate of Final Payment as agreed upon by all parties.
- C. This guarantee shall not include cleaning or changing filters except as required by testing, adjusting and balancing.
- D. All air conditioning compressors shall have parts and labor guarantees for a period of not less than 5 years beyond the date of final acceptance.
- E. Refer to Sections in Division 23 for additional guarantee or warranty requirements.

1.22 TRANSFER OF ELECTRONIC FILES

- A. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner's risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney's fees arising out of or resulting thereof.
- B. Because data stored in electric media format can deteriorate or be modified inadvertently, or otherwise without authorization of the data's creator, the party receiving the electronic files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance

period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.

- C. When transferring documents in electronic media format, Engineer makes no representations as to the long term compatibility, usability or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.
- D. Any reuse or modifications will be Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.
- E. The Texas Board of Architectural Examiners (TBAE) has stated that it is in violation of Texas law for persons other than the Architect of record to revise the Architectural drawings without the Architect's written consent.

It is agreed that "MEP" hard copy or computer-generated documents will not be issued to any other party except directly to the Architect/Owner. The contract documents are contractually copyrighted and cannot be used for any other project or purpose except as specifically indicated in AIA B-141 Standard Form of Agreement between Architect and Owner.

If the client, Architect/Owner, or developer of the project requires electronic media for "record purposes", then an AutoCAD based compact disc ("CD") will be prepared. The "CD" will be submitted with all title block references intact and will be formatted in a "plot" format to permit the end user to only view and plot the drawings. Revisions will not be permitted in this configuration.

- F. At the Architect/Owner's request, Engineer will prepare one "CD" of electronic media to assist the contractor in the preparation of submittals. The Engineer will prepare and submit the "CD" to the Architect/Owner for distribution to the contractor. All copies of the "CD" will be reproduced for a cost of reproduction fee of Five Hundred Dollars (\$500.00) per "CD".

The "CD" will be prepared and all title blocks, names and dates will be removed. The "CD" will be prepared in a ".dwg" format to permit the end user to revise the drawings.

- G. This Five Hundred Dollars (\$500.00) per "CD" cost of reproduction will be paid directly from the Contractor to the Engineer. The "CD" will be prepared only after receipt of the Five Hundred Dollars (\$500.00). The Five Hundred Dollars (\$500.00) per "CD" cost of reproduction is to only recover the cost of the manhours necessary to reproduce the documents. It is not a contractual agreement between the Contractor and Engineer to provide any engineering services, nor any other service.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Provide materials and equipment manufactured by a domestic United States manufacturer.
- B. Access Doors: Provide access doors as required for access to equipment, valves, controls, cleanouts and other apparatus where concealed. Access doors shall have concealed hinges and screw driver cam locks.
- C. All access panels located in wet areas such as restrooms, locker rooms, shower rooms, kitchen and any other wet areas shall be constructed of stainless steel.
- D. Access Doors: shall be as follows:
 - 1. Plastic Surfaces: Milcor Style K.
 - 2. Ceramic Tile Surface: Milcor Style M.
 - 3. Drywall Surfaces: Milcor Style DW.
 - 4. Install panels only in locations approved by the Architect.

PART 3 - EXECUTION

3.01 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected via reviewed submittals.
- B. Refer to equipment specifications in Divisions 2 through 16 for additional rough-in requirements.

3.02 MECHANICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate mechanical systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with architectural action markings on submittal, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, resolve conflicts and route proposed solution to the Architect for review.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location and label.
11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified.
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
13. Provide roof curbs for all roof mounted equipment. Coordinate with roof construction for pitched roof. Provide roof curb to match roof slope. Refer to architectural drawings and details.
14. The equipment to be furnished under this Specification shall be essentially the standard product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the product of the same manufacturer.
15. The architectural and structural features of the building and the space limitations shall be considered in selection of all equipment. No equipment shall be furnished which will not suit the arrangement and space limitations indicated.
16. Lubrication: Prior to start-up, check and properly lubricate all bearings as recommended by the manufacturer.
17. Where the word "Concealed" is used in these Specifications in connection with insulating, painting, piping, ducts, etc., it shall be understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. "Exposed" shall be understood to mean the opposite of concealed.
18. Identification of Mechanical Equipment:
 - a. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Shop drawings shall include dimensions and lettering format for approval. Attachments shall be with escutcheon pins, self-tapping screws, or machine screws.
 - b. Tags shall be attached to all valves, including control valves, with nonferrous chain. Tags shall be brass and at least 1-1/2 inches in diameter.

Nameplate and tag symbols shall correspond to the identification symbols on the temperature control submittal and the "as-built" drawings.

3.03 CUTTING AND PATCHING

- A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
- B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
 - 1. Uncover Work to provide for installation of ill-timed Work.
 - 2. Remove and replace defective Work.
 - 3. Remove and replace Work not conforming to requirements of the Contract Documents.
 - 4. Remove samples of installed Work as specified for testing.
 - 5. Install equipment and materials in existing structures.
 - 6. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer/Owner's observation of concealed Work, without additional cost to the Owner.
 - 7. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers; refer to the materials and methods required for the surface and building components being patched; Refer to Section "DEFINITIONS" for definition of "Installer."
- C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, mechanical ducts and HVAC units, plumbing fixtures and trim, and other mechanical items made obsolete by the new Work.
- D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

3.04 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER

- A. The Owner will cooperate with the Contractor, however, the following provisions must be observed:
 - 1. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Sub-Contractors and the Engineer to discuss Contractor's employee parking space, access, storage of

2. During the construction of this project, normal facility activities will continue in existing buildings until renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems will have to be maintained in service within the occupied spaces of the existing building.

Mech/Elec. Equipment Coordination Sheet

Mark #	Unit Type	Manufacturer's Recomm. Fuse Size (MOCP)	Mark #	Unit Type	Manufacturer's Recomm. Fuse Size (MOCP)
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SECTION 23 05 10 STARTING OF SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Starting systems.
- B. Demonstration and instructions.
- C. Testing, adjusting, and balancing.

1.02 RELATED SECTIONS

- A. Section 014000 - Quality Control: Manufacturers field reports.
- B. Section 017000- Contract Closeout: System operation and maintenance data and extra materials.
- C. Section 239900 - Testing, Adjusting and Balancing.

1.03 STARTING SYSTEMS

- A. Coordinate schedule for start-up of various equipment and systems.
- B. Notify Architect, Engineer and Owner seven days prior to start-up of each item.
- C. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or for other conditions that may cause damage.
- D. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
- E. Adjust electrical amp draw on motors to within 80% of rated amp draw.
- F. Verify wiring and support components for equipment are complete and tested.
- G. Execute start-up under supervision of applicable manufacturer's representative in accordance with manufacturers' instructions.
- H. When specified in individual specification Sections, require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.

- I. Adjust return air to 500 fpm at each air unit inlet. Replace drive packages as necessary to achieve design airflows.
- J. Submit a written report in accordance with Section 014000 that equipment or system has been properly installed and is functioning correctly.

1.04 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of final inspection.
- B. Demonstrate Project equipment and provide instruction by a qualified manufacturers' representative who is knowledgeable about the Project.
- C. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.
- D. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owners' personnel in detail to explain all aspects of operation and maintenance.
- E. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at agreed time, at equipment location.
- F. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

1.05 TESTING, ADJUSTING, AND BALANCING

- A. Mechanical Division will secure the services of an independent firm to perform testing, adjusting, and balancing.
- B. The independent firm will perform services specified in Section 239900.
- C. Reports will be submitted by the independent firm to the Architect/Engineer indicating observations and results of tests and indicating compliance or non-compliance with the requirements of the Contract Documents.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION 23 05 10

SECTION 23 14 00 SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Pipe, and equipment hangers, supports, and associated anchors.
- B. Sleeves and seals.
- C. Flashing and sealing equipment and pipe stacks.

1.02 RELATED WORK

- A. Section 23 24 00 – Sound and Vibration Control.
- B. Section 23 26 00 - Piping Insulation.
- C. Section 23 28 00 - Equipment Insulation.
- D. Section 22 41 00 - Plumbing System.
- E. Section 23 55 10 - Hydronic Piping Above Grade.
- F. Section 23 55 11 – Hydronic Piping Below Grade.
- G. Section 23 53 00 – Refrigerant Piping

1.03 REFERENCES

- A. ANSI/ASME B31.1 - Power Piping.
- B. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- C. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.

1.04 QUALITY ASSURANCE

- A. Supports for Sprinkler Piping: In conformance with NFPA 13.
- B. Supports for Standpipes: In conformance with NFPA 14.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division 1.
- B. Indicate hanger and support framing and attachment methods.

PART 2 - PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipe Sizes 2 to 4 Inches Carbon steel, adjustable, clevis.
- C. Hangers for Pipe Sizes 6 Inches and over: Adjustable steel yoke, cast iron roll, double hanger.
- D. All hangers, supports and rods in areas exposed to the outdoors, such as but not limited to crawl spaces, service bays, wash bays, open shops and warehouses shall be hot dipped galvanized.
- E. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods; cast iron roll and stand for pipe sizes 6 inches and over.
- F. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- G. Wall Support for Pipe Sizes 4 Inches and over: adjustable steel yoke and cast iron roll.
- H. Vertical Support: Steel riser clamp.
- I. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- J. Floor Support for Pipe Sizes 6 Inches and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- K. Roof Pipe Supports and Hangers: Galvanized Steel Channel System as manufactured by Portable Pipe Hangers, Inc. or approved equal.

For pipes 2-1/2" and smaller – Type PP10 with roller
For pipes 3" through 8" – Type PS
For multiple pipes – Type PSE - Custom

- L. Copper Pipe Support and Hangers: Electro-galvanized with thermoplastic elastomer cushions; Unistrut "Cush-A-Clamp" or equal. Hangers: Plastic coated; Unistrut or equal.
- M. For installation of protective shields refer to specification section 231400-3.03.
- N. Shields for Vertical Copper Pipe Risers: Sheet lead.
- O. Pipe Rough-In Supports in Walls/Chases: Provide preformed plastic pipe supports, Sioux Chief "Pipe Titan" or equal.

2.02 HANGER RODS

- A. Galvanized Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.03 INSERTS

- A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 FLASHING

- A. Metal Flashing: 20 gage galvanized steel.
- B. Lead Flashing: 4 lb./sq. ft. sheet lead for waterproofing; 1 lb./sq. ft. sheet lead for soundproofing.
- C. Caps: Steel, 20 gage minimum; 16 gage at fire resistant elements.
- D. Coordinate with roofing contractor/architect for type of flashing on metal roofs.

2.05 EQUIPMENT CURBS

- A. Fabricate curbs of hot dipped galvanized steel unless noted otherwise.

2.06 SLEEVES

- A. Sleeves for Pipes Through Non-fire Rated Floors: Form with 18 gage galvanized steel, tack welded to form a uniform sleeve.
- B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with steel pipe, schedule 40.

- C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fireproofing: Prefabricated fire rated steel sleeves including seals, UL listed.
- D. Sleeves for Round Ductwork: Form with galvanized steel.
- E. Sleeves for Rectangular Ductwork: Form with galvanized steel.
- F. Fire Stopping Insulation: Glass fiber type, non-combustible, U.L. listed.
- G. Caulk: Paintable 25-year acrylic sealant.
- H. Pipe Alignment Guides: Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted, two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

2.07 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers without disengagement of supported pipe.
- C. Design roof supports without roof penetrations, flashing or damage to the roofing material.

2.08 FINISH

- A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.01 INSERTS

- A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams. Coordinate with structural engineer for placement of inserts.
- B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

- C. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
- D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab. Verify with structural engineer prior to start of work.

3.02 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as follows:

<u>PIPE SIZE</u>	<u>MAX. HANGER SPACING</u>	<u>HANGER DIAMETER</u>
(Steel Pipe)		
1/2 to 1-1/4 inch	6'-0"	3/8"
1-1/2 to 3 inch	10'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
(Copper Pipe)		
1/2 to 1-1/4 inch	5'-0"	3/8"
1-1/2 to 2-1/2 inch	8'-0"	3/8"
3 to 4 inch	10'-0"	3/8"
6 to 8 inch	10'-0"	1/2"
(Cast Iron)		
2 to 3 inch	5'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
(PVC Pipe)		
1-1/2 to 4 inch	4'-0"	3/8"

6 to 8 inch	4'-0"	1/2"
10 and over	4'-0"	5/8"

- B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- C. Place a hanger within 12 inches of each horizontal elbow and at the vertical horizontal transition.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Install hangers with nut at base and above hanger; tighten upper nut to hanger after final installation adjustments.
- J. Portable pipe hanger systems shall be installed per manufactures instructions.

3.03 Insulated Piping: Comply with the following installation requirements.

- A. Clamps: Attach galvanized clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.
- B. Saddles: Install galvanized protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
- C. Shields: Install protective shields MSS Type 40 on cold and chilled water piping that has vapor barrier. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

<u>NPS</u>	<u>LENGTH</u>	<u>THICKNESS</u>
1/4 THROUGH 3-1/2	12	0.048
4	12	0.060

5 & 6	18	0.060
8 THROUGH 14	24	0.075
16 THROUGH 24	24	0.105

- D. Piping 2" and larger provide galvanized sheet metal shields with calcium silicate at hangers/supports.
- E. Insert material shall be at least as long as the protective shield.
- F. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.04 EQUIPMENT BASES AND SUPPORTS

- A. Provide equipment bases of concrete.
- B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- C. Construct support of steel members. Brace and fasten with flanges bolted to structure.
- D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.05 FLASHING

- A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Flash vent and soil pipes projecting 8 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counter flash and seal.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor shower mop sink and all other drains watertight to adjacent materials.
- E. Provide curbs for mechanical roof installations 8 inches minimum high above roofing surface. Contact architect for all flashing details and roof construction. Seal penetrations watertight.

3.06 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Extend sleeves through floors minimum one inch above finished floor level. Caulk sleeves full depth with fire rated thermfiber and 3M caulking and provide floor plate.
- C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with U.L. listed fire stopping insulation and caulk seal air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- D. Fire protection sleeves may be flush with floor of stairways.

END OF SECTION 23 14 00

SECTION 23 17 00 MOTORS AND MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 230500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. WORK SPECIFIED ELSEWHERE:
 - 1. Painting
 - 2. Automatic temperature controls.
 - 3. Power control wiring to motors and equipment.

1.03 WARRANTY

Warrant the Work specified herein for one year and motors for five years beginning on data of substantial completion against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials and workmanship.

1.04 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures variations, and accessories.
- C. MOTOR NAMEPLATE INFORMATION: Manufacturer's name, address, utility and operating data.
- D. Refer to Division 1 for additional information.

1.05 DELIVERY AND STORAGE

- A. DELIVERY: Deliver clearly labeled, undamaged materials in the manufacturers' unopened containers.
- B. TIME AND COORDINATION: Deliver materials to allow for minimum storage time at the project site. Coordinate delivery with the scheduled time of installation.
- C. STORAGE: Store materials in a clean, dry location, protected from weather and abuse.

PART 2 - PRODUCTS

2.01 ELECTRIC MOTORS

- A. APPROVED MANUFACTURERS: Provide motors by a single manufacturer as much as possible.
 - 1. Baldur
 - 2. Marathon
 - 3. Siemens-Allis
 - 4. General Electric
 - 5. U.S. Motor
- B. TEMPERATURE RATING: Provide insulation as follows:
 - 1. CLASS B: 40 degrees C maximum.
 - 2. CLASS F:
 - a. Between 40 degrees C and 65 degrees C maximum.
 - b. Totally enclosed motors.
- C. STARTING CAPABILITY: As required for service indicated five starts minimum per hour.
- D. PHASES AND CURRENT: Verify electrical service compatibility with motors to be used.
 - 1. UP TO 1/2 HP: Provide permanent split, capacitor-start single phase with inherent overload protection.
 - 2. 3/4 HP AND LARGER: Provide squirrel-cage induction polyphase.
 - 3. Provide two separate windings on 2-speed polyphase motors.
 - 4. Name plate voltage shall be the same as the circuit's normal voltage, serving the motor.
- E. SERVICE FACTOR: 1.15 for multiphase; 1.35 for single phase.
- F. FRAMES: U-frames 1.5 hp. and larger.
- G. BEARINGS: Provide sealed re-graspable ball bearings; with top mounted oil mite lubrication fittings and bottom side drains minimum average life 100,000 hours typically, and others as

follows:

1. Design for thrust where applicable.
2. PERMANENTLY SEALED: Where not accessible for greasing.
3. SLEEVE-TYPE WITH OIL CUPS: Light duty fractional hp. motors or polyphone requiring minimum noise level.

H. ENCLOSURE TYPE: Provide enclosures as follows:

1. CONCEALED INDOOR: Open drip proof.
2. EXPOSED INDOOR: Guarded.
3. OUTDOOR TYPICAL: Type II. TEC.
4. OUTDOOR WEATHER PROTECTED: Type I. TEA.

I. OVERLOAD PROTECTION: Built-in sensing device for stopping motor in all phase legs and signaling where indicated for fractional horse power motors.

J. NOISE RATING: "Quiet" except where otherwise indicated.

K. EFFICIENCY: Minimum full load efficiency listed in the following table, when tested in accordance with IEEE Test Procedure 112A, Method B, including stray load loss measure.

NEMA Efficiency		
Motor Horsepower	INDEX Letter	Minimum Efficiency %
1800 RPM Synchronous Speed		
7.5-10	F	89.5
15-20	E	91.0
25-30	E	92.4
40	D	93.0
50	C	93.0
60	C	93.6
75	C	94.1
100-125	B	94.5
150-200	B	95.0
1200 RPM Synchronous Speed		
3-5	G	87.5
7.5	G	89.5
10	F	89.5
15	F	90.2
20	E	90.2
25-30	E	91.7
40-50	D	93.0

60	D	93.6
75	C	93.6
100-125	C	94.1
150-200	B	95.0

2.02 MOTOR CONTROLLERS (STARTERS)

- A. All motor controllers (for equipment furnished under Division 23) shall be furnished under Division 23 and installed under Division 26 unless otherwise noted on the plans.
- B. Motor starters shall be furnished as follows.
 1. GENERAL: Motor starters shall be Square D Company Class 8536 across-the-line magnetic type, full-voltage, non-reversing (FAVOR) starter. All starters shall be constructed and tested in accordance with the latest NEMA standards, sizes and horsepower. ICE sizes are not acceptable. Starters shall be mounted in a general purpose dead front, painted steel enclosure and surface-mounted. Provide size and number of poles as shown and required by equipment served. Provide two speed, two winding or two speed, single winding motor starter as required for two speed motors.
 2. CONTACTS: Magnetic starter contacts shall be double break solid silver alloy. All contacts shall be replaceable without removing power wiring or removing starter from panel. The starter shall have straight-through wiring.
 3. OPERATING COILS: Operating coils shall be 120 volts and shall be of molded construction. When the coil fails, the starter shall open and shall not lock in the closed position.
 4. OVERLOAD RELAYS: Provide manual reset, trip-free Class 20 overload relays in each phase conductor in of all starters. Overload relays shall be melting alloy type with visual trip indication. All 3 phase and single phase starters shall have one overload relay in each underground conductor. Relay shall not be field adjustable from manual to automatic reset. Provide 6 overload relays for two speed motor starters.
 5. PILOT LIGHTS: Provide a red running pilot light for all motor starters. Pilot lights shall be mounted in the starter enclosure cover. Pilot lights shall be operated from an interlock on the motor starter and shall not be wired across the operating coil.
 6. CONTROLS: Provide starters with HAND-OFF-AUTOMATIC switches. Coordinate additional motor starter controls with the requirements of Division 23. Motor starter controls shall be mounted in the starter enclosure cover.
 7. CONTROL POWER TRANSFORMER: Provide a single-phase 480 volt control power transformer with each starter for 120 volt control power. Connect the primary side to the line side of the motor starter. The primary side shall be protected by a fuse for each conductor. The secondary side shall have one leg fused and one leg grounded. Arrange transformer terminals so that wiring to

terminals will not be located above the transformer.

8. AUXILIARY CONTACTS: Each starter shall have one normally open and one normally closed convertible auxiliary contact in addition to the number of contacts required for the "holding interlock", remote monitoring, and control wiring. In addition, it shall be possible to field-install three more additional auxiliary contacts without removing existing wiring or removing the starter from its enclosure.
 9. UNIT WIRING: Unit shall be completely pre-wired to terminals to eliminate any interior field wiring except for line and load power wiring and HVAC control wiring.
 10. ENCLOSURES: All motor starter enclosures shall be NEMA 1, general purpose enclosures or NEMA-3R if mounted exposed to high moisture conditions. Provide NEMA 4X when located by cooling towers.
 11. POWER MONITOR: Provide a square "D" 8430 MPS phase failure and under-voltage relay, base and wiring required for starters serving motors 5 horsepower and larger. Set the under-voltage setting according to minimum voltage required for the motor to operate within its range.
- C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
1. Siemens.
 2. Square D.
 3. General Electric.
 4. Cerus.

2.03 COMBINATION MOTOR STARTERS

- A. GENERAL: Combination motor starters shall consist of a magnetic starter and a fusible or non-fusible disconnect switch in a dead front, painted steel NEMA 1 enclosure unless otherwise noted and shall be surface-mounted. Size and number of poles shall as shown and required by equipment served. Combination motor starters shall be as specified for motor starters in Paragraph 2.01/B, except as modified herein.
- B. DISCONNECT SWITCH: Disconnect switches shall be as specified in Section 264900.
- C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
1. Siemens.
 2. Square D.
 3. General Electric.
 4. Franklin-Cerus.

PART 3 - EXECUTION

3.01 All equipment shall be installed in accordance with the manufacturers' recommendations and printed installation instructions.

3.02 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractors' price shall include all items required as per manufacturers' requirements.

3.03 INSTALLATION

- A. GENERAL: Install in a professional manner. Any part or parts not meeting this requirement shall be replaced or rebuilt without extra expense to Owner.
- B. Install rotating equipment in static and dynamic balance.
- C. Provide foundations, supports, and isolators properly adjusted to allow minimum vibration transmission within the building.
- D. Correct objectionable noise or vibration transmission in order to operate equipment satisfactorily as determined by the Engineer.

END OF SECTION 23 17 00

SECTION 23 17 20 VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Variable Frequency Drive (VFD)
- B. Furnish and install a complete adjustable frequency motor speed control for the following item:
 - 1. Hydronic pumps

1.02 RELATED SECTIONS

- A. Section 23 05 00 – Basic Materials and Methods
- B. Section 23 17 00 – Motors and Motor Controllers
- C. Section 23 24 00 – Sound and Vibration Control
- D. Section 23 55 40 – HVAC Pumps
- E. Section 23 58 55 – Air Handling Unit
- F. Section 23 95 00 – Controls
- G. Section 23 99 00 – Testing, Adjusting and Balancing
- H. Section 26 07 50 – Electrical Identification

1.03 REFERENCES

- A. NEMA250
- B. EN 50178 (LVD)
- C. EN 61800-3, EN 61000-4-2(-3,-4,-5-6)/A2, EN 61000-2-1, EN 60146-1-1/A1
- D. IEEE 519
- E. UL 508C (Power Conversion)

1.04 SUBMITTALS

- A. Shop drawing shall include: Wiring diagrams, electrical schematics, front and side views of enclosures, overall dimensions, conduit entrance locations and requirements, nameplate legends, physical layout and enclosure details.

- B. Product Data: Provide data sheets showing; voltage, ratings of customer use of switching and over-current protective devices, short circuit rating, and weights.
- C. Manufacturer's Installation Instructions and Technical Manuals: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Adjustable Frequency Drive. Document the sequence of operation, cautions and warnings, trouble shooting procedures, spare parts lists and guidance.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for enclosed controllers and installed components.
 - 2. Provide manufacture's written instructions for testing and adjusting circuit breaker and Motor Circuit Protection trip settings of combination controllers.
 - 3. Provide manufacturer's written instructions for setting field-adjustable overload relays.
 - 4. Provide manufacture's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

1.06 MATERIALS MAINTENANCE SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 3. Indicating Lights: Two of each type and color installed.
 - 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 - 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.07 QUALIFICATIONS

- A. Manufacturer must have minimum of 20 years of documented experience, specializing in variable frequency drives.
- B. UL and ULc approval on all VFDs specified

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Accept VFD on site in original packing. Inspect for damage.

- B. Store in a clean, dry space. Maintain factory wrapping, or provide additional heavy canvas, or heavy plastic cover, to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully, in accordance of manufacturer's written instruction, to avoid damage to components, enclosure, and finish.

1.09 WARRANTY

- A. Provide VFD warranty, for 5 years from date of start up – Drives for variable torque applications. Warranty shall include parts, and labor at factory for repair. Servicing technician on VFD does not need factory certification to preserve warranty.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Franklin Controls/Cerus Industrial or comparable products by one of the following:
 - 1. Eaton Electrical Inc; Cutler-Hammer Business Unit.
 - 2. Square D: a brand of Schneider Electric
 - 3. ABB
 - 4. Emerson.
 - 5. Or approved equivalent by the engineer.Products manufactured by Danfoss, including those private labeled under other trade names, are not acceptable.

2.02 RATINGS:

- A. Input 380/415/440/460 VAC +/- 10%, 3 phase, 48-63 Hz or input 200/208/220/230 VAC +/- 10%, 3 phase, 48-63 Hz.
- B. Output Frequency 0 to 120 Hz
- C. Environmental operating conditions: 0 to 40°C, 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.
- D. Enclosure shall be UL listed. See section 2.40.B for ratings based on the location.
- E. Short Circuit Interrupting Rating shall be no less than 100,000A.
- F. Starting Torque: 175% starting torque shall be available from .5 Hz to 60 Hz.
- G. Must meet RFI requirements as specified by IEC STD EN 61000-2(-4)(2001) for variable frequency drives.

2.03 DESIGN

- A. All VFD must be solid state, utilizing Space Vector PWM control for lower motor operating temperature and lower THD on the output. The VFD package as specified herein shall be enclosed in a UL Type 1 enclosure, completely assembled and tested by the manufacturer.
- B. All VFD shall include a digital display, and keypad, regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus. The keypad shall be removable, capable of remote mounting, and shall have its own non-volatile memory. The keypad shall allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFD.
- C. All VFD must have adjustable carrier frequency and up to 4 programmable V/Hz points.
- D. All VFD must have BAS (Building Automation System) protocols such as Johnson Metasys N2, Modbus, and RS485 as standard and LonWorks, Profibus or BACnet as an option.
- E. All VFD shall be selectable as in both Volts/Hertz or Sensorless Vector Control mode regardless of horsepower rating.
- F. All VFD must have a motor preheat function to prevent moisture accumulation in an idle motor.
- G. All VFD shall include two independent analog inputs as standard, 0 –10VDC and 4-20mA. Both analog inputs shall be utilized as speed references, or as PID inputs. The analog inputs shall be programmed as an individual reference at a time, or as a combined reference together. A second PID loop control shall be provided for control of external equipment.
- H. All VFD shall include a minimum of 8 multi-function input terminals, capable of being programmed to a function on a change of state. These terminals shall provide up to 30 functions, including, but not limited to:
 - 1. External Trip
 - 2. Forward
 - 3. Reverse
 - 4. Three Wire Control
 - 5. Multi-step Speed Selection
 - 6. Interlock
 - 7. Jog
 - 8. Pre-excite/Motor Preheat
- I. The VFD shall provide frequency setting resolution of 0.01 Hz when its Digital Reference is utilized below 100 Hz and 0.1 Hz over 100 Hz. The VFD shall provide frequency setting resolution of 0.03 Hz / 60 Hz when Analog Reference is utilized.

- J. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable.
- K. The VFD shall be capable of both Automatic and Manual Torque Boost function to overcome sudden fluctuation of the load.
- L. The VFD shall be equipped with Auto-tuning feature for motor data analysis resulting in optimized motor performance.
- M. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to set-point without safety tripping or component damage (flying start). The VFD shall also be capable of DC injection braking at start to stop a reverse spinning motor prior to ramp.
- N. The VFD shall be equipped with an automatic extended power loss ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Typical control power loss ride-through for a fan load shall be 2 seconds minimum.
- O. All VFD shall have 1 analog output (0-10VDC) which can be programmed to function as one of the following: Output Frequency, Output Current, Output Voltage, DC Link Voltage. Default is set to Output Frequency.
- P. If the input reference (4-20mA or 0-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, or (3) hold the VFD speed based on the last good reference received. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.
- Q. The customer terminal strip shall be isolated from the line and ground.
- R. The drive shall employ current limit circuits to provide "trip-less" operation
- S. The Maximum current limit shall be fixed at 150% (minimum, instantaneous) of the VFD normal duty current rating.
- T. The overload rating of the drive shall be 120% of Rated Current for 1 Min., 150% of Rated Current for 0.5 sec.
- U. The VFD shall have 8 Step Speeds that are preprogrammed via Digital Input Terminals.
- V. The VFD shall have standard Emergency Input and Jog Input Terminals.
- W. The VFD shall provide from 0 to 6000 seconds of Acceleration and Deceleration time setting parameters. Up to 8 Acceleration and 8 Deceleration times shall be programmable.

- X. The VFD shall be optimized for various levels of carrier frequency programmable from 1 to 15 kHz (1 – 3 kHz above 40HP) to reduce motor noise and to provide high system efficiency.
- Y. The VFD must have an option to operate multiple motors with single VFD and be able to turn on/off each motors independently as well as simultaneously.
- Z. The VFD must have an Energy Saving function in auto and manual mode.
- AA. The VFD must have Bi-directional "Speed search" capability.
- BB. The VFD shall include provisions for multi-motor control as an option or as standard, enabling control of up to 4 motors.
- CC. All VFD include the following programming adjustment capabilities:
1. Directional Lock selection to prevent the unexpected motor direction.
 2. DC Injection start and stop frequency selection from Minimum output frequency to 60 Hz.
 3. Three programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.
 4. Pre-magnetization selection for the motor to build up an adequate level of flux for enhanced starting torque or programmable Volts/Hertz points selection for flexible Variable and Constant load demand curve and fluctuation.
 5. VFD Voltage-output to motor adjustment feature enabling the VFD to generate from 40% up to 110% of nominal input voltage to the VFD.
 6. Five (5) Fault Histories with detailed description of frequency, current, and other operational status at the time of each fault.
 7. Two independently adjustable acceleration and deceleration ramps. These ramp times shall be adjustable from 1 to 6000 seconds.
 8. The VFD shall Ramp or Coast to a stop, DC Injection, as selected by the user.
 9. The VFD shall have selectable 'No-Motor' parameter to facilitate startup and troubleshooting.
 10. Manual speed control adjustable by the VFD Keypad shall be available.
- DD. The VFD shall have the following protection circuits. In the case of a protective trip, the drive shall stop and announce the fault condition.
- IGBT overcurrent protection
 - Overcurrent trip on load output
 - DC overvoltage
 - Internal overtemperature
 - Ground Fault
 - Low Voltage
 - Open output phase
 - Electronic Thermal Protection. The Electronic Thermal Overload protection shall protect the motor based on speed, load curve, and motor parameters.
- EE. PC software and for parameter upload/download/graphing shall be provided at no additional

charge.

2.04 PRODUCT OPTIONS

- A. Three switch Manual Bypass shall only be provided for cooling tower VFDs. VFD and bypass components shall be mounted inside a common NEMA 1 enclosure, fully pre-wired, and ready for installation as a single UL listed device. Bypass shall include the following:
1. Output, and bypass contactors, to switch power from the VFD to bypass.
 2. UL 508E Manual Motor Starter with pad-lockable handle to isolate the drive and protect the motor while operating in the bypass mode.
 3. Control and safety circuit terminal strip.
 4. Drive/Off/Bypass selector switch and Hand/Off/Auto selector switch.
 5. Switch selectable smoke purge, auto transfer to bypass and remote transfer functions.
 6. Pilot lights (22 mm LEDs) for, "Drive Run" and "Bypass".
 7. Hand/Off/Auto selector switch shall provide the following operation:
 - Hand Position - The drive is given a start command, and the drive will run at preset speed- user adjustable.
 - Off Position - The start command is removed, all speed inputs are ignored, and power is still applied to the drive. If in bypass mode, the motor is stopped.
 - Auto Position - The drive is enabled to receive a start command and speed input from a building automation system. If in bypass mode, the motor start/stop is controlled by the building automation system
 8. Annunciation contacts for drive run, drive fault, bypass run and motor OL/safety fault.
 9. VFD operator/keypad selection, LCD multi-line display.
- B. Enclosure:
1. NEMA 1 extended enclosure, to house additional equipment within the VFD enclosure for VFDs not requiring Bypass.
 2. NEMA 12 FVFF (Forced Ventilation inlet Filter and outlet Filter) enclosures with filters and blower. (For dusty or industrial environments.)
 3. NEMA 3R enclosures for outdoor installations.
 - a. For installation in ambient temperature environment above 104°F, de-rate VFD 20% to increase ambient temperature rating to 122°F.
 - b. For installation in sustained ambient temperature environment below 14°F, include panel space heater.
- C. Integral Disconnect: Motor Circuit Protector (MCP) The MCP shall be a UL listed 508 current limiting manual motor starter with magnetic trip elements only. The breaker shall carry a UL 508F rating (up to 100A frame size) with a minimum interrupting rating of 30,000 AIC.
- D. Minimum 3% Line reactors shall be provided on the input side of the drive for harmonic suppression and input rectifier protection. DC Link Reactors or Bus Chokes are not acceptable substitute.

- E. Surge suppression shall be provided to protect the drive from input power disturbances.
- F. Output Filtering:
 - 1. For long VFD to motor lead lengths provide self contained, installation appropriate enclosed output reactor or filter:
 - a. Provide output line reactor when lead is greater than 50 ft. at 460V input line power application.
 - b. Provide output line reactor when lead is greater than 200 ft. at 208/230V input line power application.
 - c. Provide output dual element filter when lead is greater than 100 ft. at 460V input line power application.
 - d. Provide output dual element filter when lead is greater than 400 ft. at 208/230V input line power application.
- G. Engraved cabinet nameplates shall be provided.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.
- B. Power wiring shall be completed by the electrical contractor. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 START-UP

- A. Remote VFD Start-up assistance and training shall be available by factory and/or VFD provider at no additional charge. Start-up technician is not required to be factory certified to preserve factory warranty. A factory supplied start-up form shall be filled out for each drive with a copy provided to the owner, and a copy sent to be kept on file at the manufacturer.

3.03 PRODUCT SUPPORT

- A. Factory trained application engineering and service personnel that are thoroughly trained with the supplied VFD and optional packages shall be available via factory remote technical assistance at both the specifying and installation locations. Additional local support to be available through VFD supplier or referred technician for hire or pre-negotiated service terms. Servicing technician does not need to be factory certified to preserve warranty.

END OF SECTION

SECTION 23 19 00 SYSTEM IDENTIFICATION AND PIPE MARKING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 220500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.03 Refer to Architectural Sections for additional requirements.

PART 2 - PRODUCTS

2.01 VALVE AND PIPE IDENTIFICATION

- A. Valves:
 - 1. All valves shall be identified with a 1-1/2" diameter brass disc wired onto the handle. The disc shall be stamped with 1/2" high depressed black filled identifying numbers. These numbers shall be numerically sequenced for all valves on the job.
 - 2. The number and description indicating make, size, model number and service of each valve shall be listed in proper operational sequence, properly typewritten. Three copies to be turned over to Owner at completion.
 - 3. Tags shall be fastened with approved meter seal and 4 ply 0.018 smooth copper wire. Tags and fastenings shall be manufactured by the Seton Name Plate Company or approved equal.
 - 4. All valves shall be numbered serially with all valves of any one system and/or trade grouped together.
- B. Pipe Marking:

1. All interior visible piping located in accessible spaces such as above accessible ceilings, equipment rooms, attic space, under floor spaces, etc., shall be identified with all temperature pipe markers as manufactured by W.H. Brady Company, 431 West Rock Ave., New Haven, Connecticut, or approved equal.
2. All exterior visible piping shall be identified with UV and acid resistant outdoor grade acrylic plastic markers as manufactured by Set Mark distributed by Seton Nameplate Company. Factory location 20 Thompson Road, Branford, Connecticut, or approved equal.
3. Generally, markers shall be located on each side of each partition, on each side of each tee, on each side of each valve and/or valve group, on each side of each piece of equipment, and, for straight runs, at equally spaced intervals not to exceed 75 feet. In congested area, marks shall be placed on each pipe at the points where it enters and leaves the area and at the point of connection of each piece of equipment and automatic control valve. All markers shall have directional arrows.
4. Markers shall be installed after final painting of all piping and equipment and in such a manner that they are visible from the normal maintenance position. Manufacturer's installation instructions shall be closely followed.
5. Markers shall be colored as indicated below per ANSI/OSHA Standards:

<u>SYSTEM</u>	<u>COLOR</u>	<u>LEGEND</u>
Chilled Water	Green	Chilled Water Supply
Chilled Water Return		
Sanitary Sewer	Green	Vent
Sanitary Sewer		
Storm Drain	Green	Storm Drain
Domestic Water	Green	Domestic Water
Domestic Hot Water Supply	Yellow	Domestic Hot Water Supply
Domestic Hot Water Re-circulating	Yellow	Domestic Hot Water Return
Fire Protection	Red	Fire Protection

Automatic Sprinkler	Red	Fire Sprinkler
Compressed Air	Blue	Compressed Air

C. Pipe Painting:

1. All piping exposed to view shall be painted as indicated or as directed by the Architect in the field. Confirm all color selections with Architect prior to installation.
2. The entire fire protection piping system shall be painted red.
3. All piping located in mechanical rooms and exterior piping shall be painted as indicated below:

<u>System</u>	<u>Color</u>
Storm Sewer	White
Sanitary Sewer Waste and Vent	Light Gray
Domestic Cold Water	Dark Blue
Domestic Hot Water Supply and Return	Orange
Compressed Air	Green
Chilled Water Supply and Return	Light Blue

PART 3 - EXECUTION

- 3.01** All labeling equipment shall be installed as per manufacturers printed installation instructions.
- 3.02** All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractor's price shall include all items required as per manufacturers' requirements.
- 3.03** All piping shall be cleaned of rust, dirt, oil and all other contaminants prior to painting. Install primer and a quality latex paint over all surfaces of pipe.

END OF SECTION 23 19 00

SECTION 23 24 00 SOUND AND VIBRATION CONTROL

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Vibration and sound control products.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract including General and Supplementary Conditions and Division One specification sections, apply to work of this section
- B. This section is Division 23 Basic Materials and Methods section, and is part of each Division 23 section making reference to vibration control products specified herein.

1.03 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products, of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Vibration and sound control products shall conform to ASHRAE criteria for average noise criteria curves for all equipment at full load conditions.
- C. Except as otherwise indicated, sound and vibration control products shall be provided by a single manufacturer.

1.04 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Amber/Booth Company, Inc.
- B. Mason Industries, Inc.
- C. Kinetics Noise Control, Inc.

2.02 GENERAL

- A. Provide vibration isolation supports for equipment, piping and ductwork, to prevent transmission of vibration and noise to the building structures that may cause discomfort to the occupants.
- B. Model numbers of Amber/Booth products are included for identification. Products of the additional manufacturers will be acceptable provided they comply with all of the requirements of this specification.

2.03 FLOOR MOUNTED AIR HANDLING UNITS

- A. Provide Amber/Booth CAL-2, style C aluminum housed isolators sized for 2" static deflection. Cast iron or steel housings may be used provided they are hot-dip galvanized after fabrication
- B. If floor mounted air handling units are furnished with internal vibration isolation option, provide 2" thick Amber/Booth type NRC ribbed neoprene pads to address high frequency breakout and afford additional unit elevation for condensate drains. Ribbed neoprene pads shall be located in accordance with the air handling unit manufacturer's recommendations.

2.04 SUSPENDED AIR HANDLING UNITS

- A. Provide Amber/Booth type BSWR-2 combination spring and rubber-in-shear isolation hanger sized for 2" static deflection.
- B. If suspended air handling units are furnished with internal vibration isolation option, furnish Amber/Booth type BRD rubber-in-shear or NR AMPAD 3/8" thick neoprene pad isolation hangers sized for approximately 1/2" deflection to address high frequency break-out.

2.05 SUSPENDED FANS AND FAN COIL UNITS

- A. Provide Amber/Booth type HS spring hangers sized for 1" static deflection.

2.06 BASE MOUNTED PUMPS AND CHILLERS

- A. Amber/Booth type SP-NR style E flexplate pad isolators consisting of two layers of 3/8" thick alternate ribbed neoprene pad bonded to a 16 gage galvanized steel separator plate.
- B. Pads shall be sized for approximately 40 PSI loading and 1/8" deflection.
- C. Provide Amber/Booth CPF, 8" concrete inertia base. The base shall be welded steel construction with concrete in-fill supplied by the contractor on site and shall incorporate

standard rebar reinforcement, spaced a maximum of 12" on center. Provide Amber/Booth AWH, floor mounted spring isolators sized for 1" static deflection.

- D. Provide inertia bases for all base mounted pump applications in which the pumps are to be installed on any floor level other than the ground floor or grade level. Inertia bases shall also be provided for base mounted pump applications in which the associated mechanical room where they are housed is in a noise sensitive location, regardless of floor level.

2.07 PIPING

- A. Provide spring and rubber-in-shear hangers, Amber/Booth type HRS in mechanical equipment rooms, for a minimum distance of 50 feet from isolated equipment for all chilled water and hot water piping 1-1/2" diameter and larger. Springs shall be sized for 1" deflection.
- B. Floor supported piping is required to be isolated with Amber/Booth type AW-1 open springs sized for 1" deflection.
- C. Furnish line size flexible connectors at supply and return of pumps, Amber/Booth style 2800 single sphere EPDM construction, connector shall include 150 lb. cadmium plated carbon steel floating flanges.

2.08 CORROSION PROTECTION

- A. All vibration isolators shall be designed and treated for resistance to corrosion.
- B. Steel components: PVC coated or phosphated and painted with industrial grade enamel. Nuts, bolts, and washers: zinc-electroplated.

PART 3 - EXECUTION

- 3.01** All equipment shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- 3.02** All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturers requirements.
- 3.03** If internal isolation option is used on air handling units, the mechanical contractor shall verify proper adjustment and operation of isolators prior to start-up. All shipping brackets and temporary restraint devices shall be removed.
- 3.04** The vibration isolation supplier shall certify in writing that he has inspected the installation and that all external isolation materials and devices are installed correctly and functioning properly.

END OF SECTION

SECTION 23 26 00 PIPING INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 230500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. Work specified elsewhere.
 - 1. Painting.
 - 2. Pipe hangers and supports.
- C. All pipes subject to freezing conditions shall be insulated.

1.03 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.
- B. Defects shall include, but not be limited to, the following:
 - 1. Mildewing.
 - 2. Peeling, cracking, and blistering.
 - 3. Condensation on exterior surfaces.

1.04 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, project variations, and accessories.

1.05 DELIVERY AND STORAGE

- A. DELIVERY: Deliver undamaged materials in the manufacturer's unopened containers. Containers shall be clearly labeled with the insulation's flame and smoke ratings.

PART 2 - PRODUCTS

- 2.01** It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
- 2.02** The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved prior to installation.
- 2.03** A sample quantity of each type of insulation and each type application shall be installed and approval secured prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
- 2.04** All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) fire and smoke hazard as tested by Procedure ASTM E084, NFPA 255 and UL 723 not exceeding:

**Flame Spread 25
Smoke Developed 50**

- 2.05** Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.
- 2.06** All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.
- 2.07 APPROVED MANUFACTURERS**

- A. Calcium silicate materials shall be as manufactured by Johns Manville.
- B. Glass fiber materials shall be as manufactured by Johns Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer.

- C. Adhesives shall be as manufactured by Childers, Foster, HB Fuller or Armstrong, and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
- D. Armaflex elastomeric cellular thermal insulation by Armstrong.
- E. Phenolic foam insulation shall be as manufactured by Kooltherm Insulation (Koolphen).
- F. Polyisocyanurate insulation shall be as manufactured by Dow "Trymer 2000 XP".
- G. Metal jacketing and fitting covers shall be as manufactured by Childers or RPR Products.

2.08 MATERIALS

- A. For insulation purpose piping is defined as the complete piping system including supplies and returns, pipes, valves, automatic control valve bodies, fittings, flanges, strainers, thermometer well, unions, reducing stations, and orifice assemblies.
- B. INTERIOR DOMESTIC WATER PIPE: provide fiberglass pipe insulation with all service jackets with self sealing lap joint.
- C. EXTERIOR DOMESTIC WATER PIPE: Provide elastomeric cellular thermal, or preformed phenolic foam pipe insulation with secured metal jacketing.
- D. DRAIN BODIES AND DOWN SPOUTS: Insulate horizontal roof drain down spouts, underside of roof drain bodies, chilled water waste lines from drinking fountain to junction with main waste stacks, and branch lines including traps and exposed underside of floor drains receiving cooling coil condensate, same as water piping where exposed to building occupant view. When concealed, insulation may be same as specified for external duct wrap.
- E. CONDENSATE DRAINAGE PIPING: Fire resistant fiberglass insulation; insulation not required when piping is exposed on roof.
- F. REFRIGERANT PIPING: Refrigerant pipe insulation shall be model "AP-2000", fire rated for use in environmental air plenums. Apply manufacturers recommended finish and sealant for exterior applications.
- G. METAL JACKETING: Utilize Childers "Strap-On" jacketing. Provide preformed fitting covers for all elbows and tees.

PART 3 - EXECUTION

- 3.01** All insulation shall be installed in accordance with the manufacturers' recommendations and printed installation instructions, including high density inserts at all hangers and pipe supports to prevent compression of insulation.
- 3.02** All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturers requirements.
- 3.03** Pipes located outdoors or in crawl spaces shall be insulated same as concealed piping; and in addition shall have a jacket of 0.016 inch thick, smooth aluminum with longitudinal modified Pittsburgh Z-Lock seam and 2 inch overlap. Jacketing shall be easily removed and replaced without damage. All butt joints shall be sealed with gray silicone. Galvanized banding is not acceptable.
- 3.04** All insulated piping located over driveways shall have an aluminum shield permanently banded over insulation to protect it from damage from car antennas.

3.05 WATER PIPE INSULATION INSTALLATION

- A. The insulation shall be applied to clean, dry pipes with all joints firmly butted together. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating seal shall be formed between the vapor barrier jacket and the bare pipe. The seal shall be by the applications of adhesive to the exposed insulation joint faces, carried continuously down to and along 4 inches of pipe and up to and along 2 inches of jacket.
- B. Pipe fittings and valves shall be insulated with pre-molded or shop fabricated glass fiber covers finished with two brush coats of vapor barrier mastic reinforced with glass fabric.
- C. All under lap surfaces shall be clean and free of dust, etc. before the SSL is sealed. These laps shall be firmly rubbed to insure a positive seal. A brush coat of vapor retarder shall be applied to all edges of the vapor barrier jacket.

3.06 FIRE RATED INSULATION

- A. All pipe penetrations through walls and concrete floors shall be fire rated by applying USG Thermafiber in the space between the concrete and the pipe.
- B. The fire rating shall be additionally sealed by using 3M brand model CP 25 or 303 fire barrier caulk and putty.
- C. All fire rating material shall be insulated in accordance with manufacturer's printed instructions.

PART 4 - SCHEDULES

4.01 LOW TEMPERATURE SURFACES

MINIMUM INSULATION THICKNESS BASED ON FIBERGLASS

- | | | |
|----|------------------------------|---------|
| A. | Condensate drain lines: | ¾ inch |
| B. | Drains receiving condensate: | 1 inch |
| C. | Chilled Water Piping: | |
| | (1) Located outdoors: | 2 inch |
| | (2) Located indoors: | |
| | (a) 4 inch and smaller: | 1½ inch |
| | (b) Larger than 4 inch: | 2 inch |
| D. | Refrigerant Piping | |
| | (1) 1½" and smaller | 1 inch |
| | (2) Larger than 1½ inch | 1 inch |

4.02 HIGH TEMPERATURE SURFACES

MINIMUM INSULATION THICKNESS

- | | | |
|----|--|--------|
| A. | Hot Water Piping: | |
| | (1) Operating temperature 105°F or less: | 1 inch |
| | (2) Operating temperature higher than 105°F
and pipe size 1½ inch or smaller | 1 inch |
| | (3) Operating temperature higher than 105°F
and pipe size larger than 1½ inch | 2 inch |

END OF SECTION

SECTION 23 28 00 EQUIPMENT INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 230500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. Work specified elsewhere.
 - 1. Basic materials and methods.
 - 2. Piping systems.
 - 3. Air distribution equipment.

1.03 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.
- B. Defects shall include, but not be limited to, the following:
 - 1. Mildewing.
 - 2. Peeling, cracking, and blistering.
 - 3. Condensation on exterior surfaces.

1.04 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

1.05 DELIVERY AND STORAGE

- A. DELIVERY: Deliver undamaged materials in the manufacturer's unopened containers clearly labeled with flame and smoke ratings.

PART 2 – PRODUCTS

- 2.01** It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
- 2.02** The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved before any insulation is installed.
- 2.03** A sample quantity of each type of insulation and each type of application shall be installed and approval secured prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
- 2.04** Glass fiber materials as manufactured by Owens/Corning, PPG, CSG, or Johns Manville will be acceptable, if they comply with the specifications.
- 2.05** All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) fire and smoke hazard as tested by Procedure ASTM E084, NFPA 255 and UL 723 not exceeding:

**Flame Spread 25
Smoke Developed 50**

- 2.06** Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.
- 2.07** All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.

PART 3 - EXECUTION

- 3.01** All insulation shall be installed in accordance with the manufacturers recommendations and printed installation instructions.

- 3.02 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturers requirements.

3.03 CHILLED WATER PUMPS

- A. Shall be insulated with Certain-Teed IB-600 rigid insulation board, 2" thick, cut and formed into a box and secured in place with 3/4" wide x .020 galvanized bands spaced on 9" centers. Bands shall be pulled snug over sheets of insulation board. All joints shall be well and neatly fitted and so arranged that the assembly may be dismantled with ease permitting access to the pump. All voids on the interior of box shall be filled with glass fiber blanket insulation. Exterior shall be finished with a trowel coat of Foster's 30-35 vapor barrier mastic, a layer of 1" mesh galvanized wire, and a coat of J.M. #352 cement. Final finish shall be an eight ounce canvas jacket, pasted and sealed in place with Foster's 30-36 Seafas.
- B. Pipe insulation shall be extended over all cold parts of chilled water pumps not directly over drainage basin of pump base.

END OF SECTION 23 28 00

SECTION 23 29 00 DUCT INSULATION

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Ductwork system insulation.

1.02 RELATED SECTIONS

- A. Section 230500 - Basic Materials and Methods
- B. Section 231700 - Motors and Motor Controllers

1.03 QUALITY ASSURANCE

- A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
- B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.
 - 1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
- C. Duct and plenum insulation shall comply with minimum R-value requirements of 2015 International Energy Conservation Code.
- D. Adhesive and other material shall comply with NFPA and NBFU Standards No. 90A and 90B.

1.04 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories. **Provide 8x11 sample of product along with submittal.**

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened

containers with manufacturer's stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.

- B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.01 GENERAL DESCRIPTION

- A. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved before any insulation is installed.
- B. A sample quantity of each type of insulation and each type of application shall be installed and approval secured prior to proceeding with the main body of the work.

2.02 ACCEPTABLE MANUFACTURERS

- A. Glass fiber materials shall be as manufactured by Knauf, Certain-Teed, Johns-Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer.
- B. Adhesives shall be as manufactured by Minnesota Mining, Arabol, Benjamin-Foster, Armstrong or Insulmastic, Inc., and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
- C. Ceramic fiber materials shall be as manufactured by Primer Refractories, A.P. Green Refractories or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

- A. All insulation shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.

3.02 EXTERNAL DUCT INSULATION

- A. Fasten all longitudinal and circumferential laps with outward clinching staples 3" on

center. On rectangular ducts over 24" wide apply as above and hold insulation in place on bottom side with mechanical pins and clips on 12" centers.

- B. Seal all seams and joints, fastener penetrations and other breaks in vapor barrier with 3 inch wide strips of white glass fabric embedded between two coats of vapor barrier mastic, Childers CP-30 or approved equal.
- C. All external duct insulation shall be Knauf Insulation Atmosphere Duct Wrap with ECOSE Technology, Johns Manville Microlite EQ duct wrap insulation with reinforced aluminum facing or approved equal.
- D. External duct wrap is required on all outside air ducts, supply and return air ducts that are not internally insulated. External duct wrap is also required on all exhaust and relief air ducts that are used in airside energy recovery systems. Any exhaust ductwork located in an unconditioned space shall also be provided with external duct wrap. Duct wrap shall be provided as follows:
 - 1. A minimum installed R-value of 6 when ducts are located in unconditioned spaces, such as ceiling plenum space.
 - 2. A minimum installed R-value of 12 when ducts are located outside of the building.
- E. Any ductwork located in an air plenum that is comprised of materials that do not comply with the 25/50 flame and smoke rating per ASTM E 84 testing requirements shall be provided with a single layer of duct wrap to establish a noncombustible rating per ASTM E 136. Duct wrap products which are approved for such non-compliant combustible duct materials located in air plenums shall be 3M Fire Barrier Plenum Wrap 5A+ or Unifrax FyreWrap 0.5 Plenum. Insulation products for this application shall be installed in strict accordance with the manufacturer's instructions.

3.03 DUCT LINER

- A. Duct liner shall be kept clean and dry during transportation, storage, installation, and throughout the construction process care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.
- B. All portions of duct designed to receive duct liner shall be completely covered with liner as specified. The smooth, black, mat facing or acrylic-coated surfaces with flexible glass cloth reinforcement shall face the airstream. All duct liner shall be cut to assure tight, overlapped corner joints. The top pieces shall be supported by the sidepieces. Duct liner shall be installed following the guidelines in the NAIMA "Duct Liner Installation Standard".
- C. The duct liner shall be tested according to erosion test method in ASTM C 1071 and

shall be guaranteed to withstand velocities in the duct system up to 6000 fpm without surface erosion.

- D. Duct liner shall be adhered to the sheet metal with full coverage of an approved adhesive that conforms to ASTM C 916, and all exposed leading edges and transverse joints shall be coated with Permacote factory-applied or field-applied edge coating and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with Johns Manville SuperSeal[®] duct butter and Edge Treatment or approved adhesive.
- E. Metal nosings shall be securely installed over transversely oriented liner edges facing the airstream at forward discharge and at any point where lined duct is preceded by unlined duct.
- F. When velocity exceeds 4000 fpm (20.3 m/sec), use metal nosing on every leading edge. Nosing may be formed on duct or be channel or zee attached by screws, rivets or welds.
- G. The liner shall further be secured with Graham welding pins and washers on not more than 18 inch centers both vertical and horizontal surfaces, and the pins and washers shall be pointed up with adhesive.
- H. Duct liner shall be Knauf Insulation Atmosphere Duct Liner with ECOSE Technology, Johns Manville Linacoustic RC duct liner with factory-applied edge coating and acrylic coating on the mat surface of airstream side or approved equal. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B, FHC 25/50 and Limited Combustibility and the air stream surface coating should contain an immobilized, EPA-registered, anti-microbial agent so it will not support microbial growth as tested in accordance with ASTM G21 and G22. The duct liner shall conform to the requirements of ASTM C 1071, UL 2824, with an NRC not less than .70 as tested per ASTM C 423 using a Type "A" mounting, and a thermal conductivity no higher than 0.24 BTU•in/(hr•ft²•°F) at 75°F mean temperature.
 - I. Line supply and return ductwork at connection of HVAC unit to a point of 15 feet upstream and downstream of the equipment and in return air boots. Attach with full cover coat of cement, duct dimensions up to 16 inches; provide stick clips or screws and cap for dimensions over 16 inches, spaced 16 inches o.c. maximum. Provide sheet metal liner cap over all leading edges of internal insulation exposed to air stream.
 - J. Duct liner shall be provided as follows:

- A. Minimum installed R-value of 6 when ducts are located in conditioned spaces.
- B. Minimum installed R-value of 6 when ducts are located in unconditioned spaces, such as ceiling plenum space.
- C. Minimum installed R-value of 12 or greater when ducts are located outdoors.

3.04 EXPOSED DUCTWORK LOCATED INDOORS

- A. Round duct routed exposed shall be double wall with solid inner liner and R-6 thermal layer of fiberglass insulation as manufactured by United McGill Company model no. Acousti-27 or approved equal.

3.05 AIR DEVICE AND MISCELLANEOUS DUCT INSULATION

- A. The backside of all supply air devices shall be insulated with taped and sealed with external duct wrap equivalent to the insulation specified.
- B. The contractor shall install an additional layer of 2 inch thick external fiberglass duct wrap on any portion of the supply air, return air, outside air, or exhaust air system that has condensation forming during any period of operation. The insulation shall be taped and sealed and located until all evidence of the condensation had been eliminated at no additional cost to the owner.

END OF SECTION 23 29 00

SECTION 23 51 21 EXPANSION COMPENSATION

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Flexible pipe connections.
- B. Expansion joints and compensators
- C. Pipe loops, offsets, and swing joints.

1.02 RELATED WORK

- A. Section 231400 - Supports and Anchors.
- B. Section 235300 - Refrigerant Piping.

1.03 PERFORMANCE REQUIREMENTS

- A. Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
- B. Expansion Calculations:
 - 1. Installation Temperature: 50 degrees F (10 degrees C).
 - 2. Hot Water Heating: 210 degrees F (99 degrees C).
 - 3. Domestic Hot Water: 140 degrees F (60 degrees C).
 - 4. Safety Factor: 30 percent.
- C. Pipe sizes indicated are to establish a minimum quality of compensator. Refer to manufacturers' literature for model series for different pipe sizes.

1.04 SUBMITTALS

- A. Submit shop drawings under provisions of Division 1.
- B. Product Data:
 - 1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot (meter) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 - 2. Expansion Joints: Indicate maximum temperature and pressure rating, and

maximum expansion compensation.

- C. Design Data: Indicate selection calculations.
- D. Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 1.
- B. Record actual locations of flexible pipe connectors, expansion joints, anchor, and guides.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 1.
- B. Maintenance Data: Include adjustment instructions.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years documented experience.
- B. Design expansion compensation system under direct supervision of a Professional Engineer experienced in design of this work and licensed in the state where the project is located.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, project and handle products to site under provisions of Division 1.
- B. Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.
- C. Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.09 WARRANTY

- A. Provide five year warranty under provisions of Division 1.
- B. Warranty: Include coverage for leak free performance of packed expansion joints.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Division 1.

PART 2 - PRODUCTS

2.01 FLEXIBLE PIPE CONNECTORS

- A. Steel Piping (Based on 2" Pipe):
1. Manufacturers:
 - a. Amber/Booth Metal-Flex, Model Type SS-PM or FW
 - b. Triplex, Model Flexonics Series 400M
 - c. Mercer Rubber Company, Model BSS-EM (Mason Industries)
 2. Inner Hose: Type 321, stainless steel, corrugated metal.
 3. Exterior Sleeve: Type 321, single braided stainless steel.
 4. Pressure Rating: 350 psig WOG and 70 degrees F. For 4 inch pipe - 200 psig WOG and 70 degrees F.
 5. Joint: Schedule 40 steel, threaded with male nipple and hex boss each end and Union. Flanged joints for pipe sizes 2½ inch and larger.
 6. Size: Use pipe sized units.
 7. Maximum offset: 1/2 inch on each side of installed center line.
 8. Application: Air handling units cooling and heating coils.
- B. Copper Piping (Based on 2" Pipe):
1. Manufacturers:
 - a. Amber/Booth Metal-Flex, Model Type BR-SM
 - b. Triplex, Model Flexonics Series 300
 - c. Mercer Rubber Company, Type BFF (Mason Industries)
 2. Inner Hose: Corrugated Bronze
 3. Exterior Sleeve: Braided bronze.
 4. Pressure Rating: 250 psig WOG and 70 degrees F.
 5. Joint: Threaded with male nipple and hex boss each end with Union. Flanged joints for pipe sizes 2½ inch and larger.
 6. Size: Use pipe sized units.
 7. Maximum offset: 1/2 inch on each side of installed center line.
 8. Application: Air handling units cooling and heating coils.

2.02 EXPANSION JOINTS

- A. Bellows Type (Based on 4" Pipe):
1. Manufacturers:
 - a. Amber/Booth, Style EB
 - b. Triplex, Model Resistoflex R6905

- c. Mercer Rubber Company, Style 803 or 805 (Mason Industries)
- 2. Body: Monel wire reinforced molded TFE teflon bellows, multiple arch.
- 3. Pressure Rating: 70 psig WSP and 250 degrees F (66 degrees C).
- 4. Maximum Compression: 1 inch.
- 5. Maximum Extension: 1 inch.
- 6. Maximum Offset: 1/2 inch.
- 7. Joint: ASA standard ductile iron flanges, integral molded gasket.
- 8. Size: Use pipe sized units.
- 9. Accessories: Control rod limit bolts.
- 10. Application: Steel piping 8 inch and under.

2.03 FLEXIBLE COUPLINGS:

- A. Bellows Type (Based on 4" Pipe):
 - 1. Manufacturers:
 - a. Amber/Booth, Style EA
 - b. Triplex, Model Resistoflex R6904
 - c. Mercer Rubber Company, Style 802 (Mason Industries)
 - 2. Body: Monel wire reinforced, molded TFE Teflon, bellows, multiple arch.
 - 3. Working Pressure: 110 psi.
 - 4. Maximum Temperature: 250 degrees F.
 - 5. Maximum Compression and Elongation: 1/2 inch.
 - 6. Maximum Offset: 1/4 inch.
 - 7. Joint: ASA standard ductile iron flanges, integral molded gasket.
 - 8. Size: Use pipe sized units, not pump connection size.
 - 9. Accessories: Control rod limit bolts.
 - 10. Application: All water pumps.

2.04 ACCESSORIES

- A. Pipe Alignment Guides to Direct Axial Movement:
 - 1. Manufacturers:
 - a. Triplex, Model Flexonics
 - b. Metraflex, Style II
 - 2. Two piece welded steel with shop paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inch travel.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

- B. Construct spool pieces to exact size of flexible connection for future insertion.
- C. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
- D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- E. Provide miscellaneous metals to rigidly anchor pipe to building structure. Provide pipe guides so that movement takes place along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
- F. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Prepare and start systems under provisions of Division 1.
- B. Provide inspection services by flexible pipe manufacturer's representative for final installing and certify installation is in accordance with manufacturer's recommendations and connectors are performing satisfactorily.

END OF SECTION 23 51 21

SECTION 23 55 10 HYDRONIC PIPING ABOVE GRADE

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Pipe and pipe fittings.
- B. Valves.
- C. Chilled water piping system.

1.02 RELATED WORK

- A. Section 235121 - Expansion Compensation.
- B. Section 231400 - Supports and Anchors.
- C. Section 231900 – System Identification & Pipe Marking
- D. Section 232400 – Sound & Vibration Control.
- E. Section 232600 - Piping Insulation.
- F. Section 235515 - Hydronic Specialties.
- G. Section 235511 - Hydronic Piping Below Grade.

1.03 REFERENCES

- A. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.
- B. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.
- C. ANSI/ASME B31.9 - Building Services Piping.
- D. ANSI/AWS A5.8 - Brazing Filler Metal.
- E. ANSI/AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids.
- F. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

- G. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses.
- H. ASTM B32 - Solder Metal.
- I. ASTM B88 - Seamless Copper Water Tube.

1.04 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME B31.9.

1.05 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9. and applicable state labor regulations.
- C. Welders Certification: In accordance with ANSI/ASME SEC 9.

1.06 SUBMITTALS

- A. Submit product data under provisions of Division 1.
- B. Include data on pipe materials, pipe fittings, valves, and accessories.
- C. Include welders certification of compliance with ANSI/ASME SEC 9.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 1.
- B. Store and protect products under provisions of Division 1.
- C. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS

2.01 CHILLED WATER PIPING

- A. Steel Pipe: ASTM A53 or A120, Schedule 40, black.
 - 1. Fittings: ANSI/ASTM B16.3, malleable iron or ASTM A234, forged steel

welding type fittings.

2. Joints: Screwed, or ANSI/AWS D1.1, welded.

*** OR ***

- B. Copper Tubing: ASTM B88, Type K, hard drawn.

1. Fittings: ANSI/ASME B16.23 cast brass or ANSI/ASME B16.29 solder wrought copper.
2. Joints: ANSI/AWS A5.8, BCuP silver braze.

2.02 EQUIPMENT DRAINS AND OVERFLOWS

- A. Steel Pipe: ASTM A53 or A120, Schedule 40 galvanized.

1. Fittings: Galvanized cast iron, or ANSI/ASTM B16.3 malleable iron.
2. Joints: Screwed, or grooved mechanical couplings.

*** OR ***

- B. Copper Tubing: ASTM B88, Type L, hard drawn.

1. Fittings: ANSI/ASME B16.23 cast brass, or ANSI/ASME B16.29 solder wrought copper.
2. Joints: ASTM B32, solder, Grade 95TA.

2.03 FLANGES, UNIONS, AND COUPLINGS

- A. Pipe Size 2 Inches and Under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
- B. Pipe Size Over 2 Inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; 1/16 inch thick preformed neoprene bonded gasket.
- C. Grooved and Shouldered Pipe End Couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; C-shape elastomer composition sealing gasket for operating temperature range from -30 degrees F (-34 degrees C) to 230 degrees F (110 degrees C); steel bolts, nuts, and washers; galvanized couplings for galvanized pipe. Can be utilized only in mechanical rooms or cooling tower areas.

2.04 ACCEPTABLE MANUFACTURERS - GATE VALVES

- A. Crane.

- B. Dezurik.
- C. Nibco.
- D. Substitutions: Under provisions of Division 1.

2.05 GATE VALVES

- A. Up to 2 Inches: Bronze body, bronze trim, rising stem, handwheel, inside screw, single wedge or disc, threaded ends.
- B. Over 2 Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, single wedge, flanged ends.

2.06 ACCEPTABLE MANUFACTURERS - GLOBE VALVES

- A. Nibco.
- B. Stockham.
- C. Dezurik.

2.07 GLOBE VALVES

- A. Up to 2 Inches: Bronze body, bronze trim, rising stem and handwheel, inside screw, renewable stainless steel disc, screwed ends, with back seating capacity.
- B. Over 2 Inches: Iron body, bronze trim, rising stem, hand wheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc.

2.08 ACCEPTABLE MANUFACTURERS - BALL VALVES

- A. Nibco.
- B. Jamesbury.
- C. Dezurik.

2.09 BALL VALVES

- A. Up to 2 Inches: Bronze two piece body, 600 PSI full port, stainless steel ball and stem, teflon seats and stuffing box ring, lever handle, and balancing stops, threaded ends.

- B. Over 2 Inches: Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, or gear drive hand wheel for sizes 10 inches (250 mm) and over, flanged.
- C. Ball valves installed in insulated lines shall have stem extensions compatible with up to 2" of insulation. Extensions shall be non-metallic equal to Nibco "nib-seal".

2.10 ACCEPTABLE MANUFACTURERS - PLUG COCKS

- A. Nibco.
- B. Jenkins.
- C. Dezurik.

2.11 PLUG COCKS

- A. Up to 2 Inches: Bronze body, bronze tapered plug, non-lubricated, teflon packing, threaded ends, with one wrench operator for every ten plug cocks.
- B. Over 2 Inches: Cast iron body and plug, pressure lubricated, teflon packing, flanged ends, with wrench operator with set screw.

2.12 ACCEPTABLE MANUFACTURERS - BUTTERFLY VALVES

- A. Nibco.
- B. WECO.
- C. Dezurik.
- D. Substitutions: Under provisions of Division 1.

2.13 BUTTERFLY VALVES

- A. Iron body, aluminum bronze disc with a resilient replaceable seat for service up to 180 degrees F°, lug ends, extended neck, and an infinite position lever handle with memory stop. Valve shall be rated at full working pressure with downstream flange removed in either direction.

2.14 ACCEPTABLE MANUFACTURERS - SWING CHECK VALVES

- A. Nibco.

- B. Stockham.
- C. Dezurik.
- D. Substitutions: Under provisions of Division 1.

2.15 SWING CHECK VALVES

- A. Up to 2 Inches: Bronze 45 degree swing disc, screwed ends.
- B. Over 2 Inches 50 mm: Iron body, bronze trim, 45 degree swing disc, renewable disc and seat, flanged ends.

2.16 ACCEPTABLE MANUFACTURERS - SPRING LOADED CHECK VALVES

- A. Nibco.
- B. Mueller.
- C. Dezurik.
- D. Substitutions: Under provisions of Division 1.

2.17 SPRING LOADED CHECK VALVES

- A. Iron body, bronze trim, stainless steel spring, aluminum bronze disc, screwed, wafer or flanged ends.

2.18 ACCEPTABLE MANUFACTURERS - RELIEF VALVES

- A. Nibco.
- B. Jenkins.
- C. Dezurik.
- D. Substitutions: Under provisions of Division 1.

2.19 RELIEF VALVES

- A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems.
- E. Provide extended necks for all vents, thermometer wells, pressure gauge wells, pet cocks and pete's plugs.

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- B. Install piping to conserve building space, and not interfere with use of space and other work.
- C. Group piping whenever practical at common elevations.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 235121.
- E. Provide clearance for installation of insulation, and access to valves and fittings.
- F. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08305.
- G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- I. Prepare pipe, fittings, supports, and accessories for finish painting.
- J. Install valves with stems upright or horizontal, not inverted.

3.03 APPLICATION

- A. Use grooved mechanical couplings and fasteners only in accessible locations.
- B. Install unions downstream of valves, and at equipment or apparatus connections.
- C. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.
- D. Install gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E. Install plug or butterfly valves for throttling, bypass, or manual flow control services.
- F. Provide spring loaded check valves on discharge of condenser and chilled water pumps.
- G. Use plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- H. Use only butterfly valves in condenser water systems for throttling and isolation service.
- I. Use lug end butterfly valves to isolate equipment.
- J. Provide 3/4 inch ball (drain) valves equal to Nibco T-585-70-HC at main shut-off valves, low points of piping, bases of vertical risers, and at equipment and pipe to nearest drain.
- K. Provide automatic air vents at all high points and air pockets in the system.

3.04 CONDENSATE DRAIN PIPING

- A. Drain piping from each unit shall be extended to the nearest floor drain or condensate drainage system. Drains shall be of the size indicated but not less than the full size of the drain pan connections.
- B. Use plugged tees in lieu of elbows.
- C. Pipe shall be Schedule 40 galvanized with malleable iron screwed or type "L" copper fittings.
- D. Slope all drain lines 1/8" per foot, minimum.
- E. Provide auxiliary drain pan on all AHU's above ceiling with auxiliary drain line routed to discharge in visually prominent area.

3.05 PIPE FABRICATION AND INSTALLATION

- A. All pipes shall be cut accurately to measurements established at the site and shall be worked into place without springing or forcing.
- B. Piping layout and installation shall be made in the most advantageous manner possible with respect to headroom, valve access, opening and equipment clearance, and clearance, from other work. Particular attention shall be given to piping in the vicinity of equipment; layout shall be made in such manner as to preserve maximum access to the various equipment parts for maintenance.
- C. All changes in directions shall be made with fittings; field bending and mitering of pipe is prohibited.
- D. Foreign made pipe, valves and fittings will not be acceptable.
- E. Air vents and air chambers shall be installed as hereinafter specified.

3.06 OFFSETS AND FITTINGS

- A. Due to the small scale of the drawings, it is not possible to indicate all offset fittings, etc. which may be required. The Contractor shall carefully investigate structural and finish conditions affecting the work, and shall take such steps as may be required to meet such conditions.
- B. All piping shall be installed close to walls, ceilings and columns, (consistent with the proper space for covering, removal of pipe and special clearances), so as to occupy the minimum of space, and all offsets, fittings, etc., required shall be provided.

3.07 SECURING AND SUPPORTING

- A. All piping shall be adequately supported to line and grade, with due provisions for expansion and contraction.
- B. Piping shall be supported on approved clevis type, split ring, or trapeze type hangers properly connected to the structural members of the building.
- C. All insulated piping shall be fitted with suitable steel protection saddles.
- D. Perforated bar hangers, straps, wire or chains will not be permitted.

3.08 ISOLATION VALVES

- A. All piping systems shall be provided with line size shut-off valves located at risers, at branch connections to mains and at other locations as indicated and required.

3.09 TESTING OF PIPING SYSTEMS

- A. During the progress of the work and upon completion, tests shall be made as specified herein and as required by Authorities Having Jurisdiction, including Inspectors, Owner or Architect. The Architect or duly authorized Construction Inspector shall be notified in writing at least 2 working days prior to each test or other Specification requirement which requires action on the part of the Construction Inspector.
- B. Tests shall be conducted as part of this work and shall include all necessary instruments, equipment, apparatus, and service as required to perform the tests with qualified personnel. Submit proposed test procedures, recording forms, and test equipment for approval prior to the execution of testing.
- C. Tests shall be performed before piping of various systems have been covered or furred-in. For insulated piping systems testing shall be accomplished prior to the application of insulation.
- D. All piping systems shall be tested and proved absolutely tight for a period of not less than 2 hours at a pressure of 150 psi(g) or 150% of design pressure, whichever is greater. Tests shall be witnessed by the Architect or an authorized representative and pronounced satisfactory before pressure is removed or any water drawn off.
- E. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to a like new condition. Leaking pipe joints, or defective pipe, shall be removed and replaced with acceptable materials. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks.
- F. Wherever conditions permit, each piping system shall thereafter be subjected to its normal operating pressure and temperature for a period of no less than five 5 days. During that period, it shall be kept under the most careful observation. The piping systems must demonstrate the propriety of their installation by remaining absolutely tight during this period.

3.10 PIPE CLEANING AND STERILIZATION

- A. After piping systems have been pressure tested and approved for tightness, they shall be thoroughly cleaned and flushed using an approved pipe cleaning compound.
- B. All temporary connections required for cleaning, purging and circulating are included in this Section. Provide suitable pipe bypasses at each coil and heat exchanger during this cleaning operation. All air vents, gauges, strainers, etc., valve connections in piping systems shall be blown clean after cleaning operation is completed.

- C. After cleaning, drain the system, fill with fresh water and flush thoroughly until clear water is obtained. Purge all air from the system with the installed manual and automatic air vents.

END OF SECTION 23 55 10

SECTION 23 55 15 HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Expansion tanks.
- B. Air vents.
- C. Air separators.
- D. Strainers.
- E. Pump suction fittings.
- F. Combination fittings.
- G. Flow indicators, controls, meters.
- H. Relief valves.

1.02 RELATED WORK

- A. Section 235121 - Expansion Compensation.
- B. Section 235510 - Hydronic Piping Above Grade
- C. Section 231400 - Supports and Anchors.

1.03 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks.

1.04 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.05 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Division 1.

- B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 1.
- B. Store and protect products under provisions of Division 1.

1.07 EXTRA STOCK

- A. Provide one extra 45 gallon drum of propylene glycol under provisions of Division 1.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - DIAPHRAGM-TYPE EXPANSION TANKS

- A. Bell and Gossett.
- B. TACO.
- C. Wessels Co.
- D. John Wood

2.02 DIAPHRAGM-TYPE EXPANSION TANKS

- A. Construction: Welded steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code; supplied with National Board Form U-1, rated for working pressure of 125 psig, with flexible EPDM diaphragm sealed into tank, and steel legs or saddles.
- B. Accessories: Pressure gage and air-charging fitting, tank drain; pre-charge to 12 psig.

2.03 ACCEPTABLE MANUFACTURERS - AIR VENTS

- A. Armstrong.
- B. ITT.
- C. Bell and Gossett.

2.04 AIR VENTS

- A. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- B. Float Type: Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
- C. Washer Type: Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.05 ACCEPTABLE MANUFACTURERS - AIR SEPARATORS

- A. Bell and Gossett.
- B. McDonald Miller.
- C. TACO.

2.06 AIR SEPARATORS

- A. Dip Tube Fitting: For 125 psig operating pressure; to prevent free air collected in boiler from rising into system.
- B. In-line Air Separators: Cast iron for sizes 1-1/2 inch and smaller, or steel for sizes 2 inch and larger; tested and stamped in accordance with Section 8D of ANSI/ASME Code; for 125 psig operating pressure.
- C. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.
- D. Combination Air Separators/Strainers: Steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code, for 125 psig operating pressure, with galvanized steel integral strainer with 3/16 inch perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

2.07 ACCEPTABLE MANUFACTURERS - STRAINERS

- A. Armstrong.
- B. Bell and Gossett.
- C. Mueller Steam Specialty.

2.08 STRAINERS

- A. Size 2 inch and Under: Screwed brass or iron body for 175 psig working pressure, Y

pattern with 1/32 inch stainless steel perforated screen.

- B. Size 2-1/2 inch to 4 inch: Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.
- C. Size 6 inch and Larger: Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.09 ACCEPTABLE MANUFACTURERS - PUMP SUCTION FITTINGS

- A. Bell and Gossett.
- B. TACO.

2.10 SUCTION FITTINGS

- A. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.
- B. Accessories: Adjustable foot support, blowdown tapping in bottom, gage tapping in side.

2.11 ACCEPTABLE MANUFACTURERS - COMBINATION PUMP DISCHARGE VALVES

- A. Bell and Gossett.
- B. TACO.

2.12 COMBINATION PUMP DISCHARGE VALVES

- A. Valves: Straight or angle pattern, flanged cast-iron valve body with bolt-on bonnet for 175 psig (1200 kPa) operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

2.13 ACCEPTABLE MANUFACTURERS - FLOW INDICATORS

- A. Bell and Gossett.
- B. Watson McDaniel.

2.14 FLOW INDICATORS

- A. Brass construction, threaded for insertion into piping system, packless, with paddle with removable segments, vapor proof electrical compartment with switches.

2.15 ACCEPTABLE MANUFACTURERS - FLOW CONTROLS

- A. Bell and Gossett.
- B. ITT Hoffman.
- C. TACO.

2.16 FLOW CONTROLS

- A. Construction: Brass or bronze body with union on inlet, and outlet, temperature and pressure test plug on inlet and outlet blowdown/backflush drain.
- B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times the minimum pressure required for control, maximum minimum pressure 3.5.
- C. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.
- D. Accessories: In-line strainer on inlet and ball valve on outlet.

2.17 ACCEPTABLE MANUFACTURERS - FLOW METERS

- A. Bell and Gossett.
- B. ITT Hoffman.
- C. TACO.

2.18 FLOW METERS

- A. Orifice principle by-pass circuit with direct reading gage, soldered or flanged piping connections for 125 psig working pressure, with shut off valves, and drains and vent connections.
- B. Cast iron, wafer type, orifice insert flow meter for 250 psig working pressure, with read-out valves equipped with integral check valves with gasketed caps.
- C. Calibrated, plug type balance valve with precision machined orifice, readout valves equipped with integral check valves and gasketed caps, calibrated nameplate and

indicating pointer.

- D. Cast iron or bronze, globe style, balance valve with handwheel with vernier type ring setting and memory stop, drain connection, readout valves equipped with integral check valves and gasketed caps.
- E. Portable meter consisting of case containing two, 3 percent accuracy pressure gages with 0-135 inches and 0-60 feet pressure ranges for 500 psig (3 450 kPa) maximum working pressure, color coded hoses for low and high pressure connections, and connectors suitable for connection to read-out valves.

2.19 ACCEPTABLE MANUFACTURERS - RELIEF VALVES

- A. Bell and Gossett.
- B. McDonnell-Miller.
- C. TACO.

2.20 RELIEF VALVES

- A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

PART 3 - EXECUTION

3.01 INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions to permit intended performance.
- B. Support tanks inside building from building structure in accordance with manufacturer's instructions.
- C. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- D. Provide manual air vents at system high points and as indicated on details and drawings.
- E. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- F. Provide air separator on suction side of system circulation pump and connect to expansion tank.

- G. Provide drain valve and hose connection on strainer blow down connection.
- H. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.
- I. Provide combination pump discharge valve on discharge side of base mounted centrifugal pumps.
- J. Support pump fittings with floor mounted pipe and flange supports.
- K. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- L. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- M. Pipe relief valve outlet to nearest floor drain.
- N. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION 23 55 15

SECTION 23 55 40 HYDRONIC PUMPS

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Close coupled pumps.
- B. Base mounted pumps.

1.02 RELATED WORK

- A. Section 231700 – Motors and Motor Controllers
- B. Section 232400 – Sound & Vibration Control.
- C. Section 232600 - Piping Insulation.
- D. Section 235510 - Hydronic Piping Above Grade

1.03 REFERENCES

- A. ANSI/UL 778 - Motor Operated Water Pumps.

1.04 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum five years experience.
- B. Alignment: Base mounted pumps shall be aligned by qualified millwright and alignment certified.
- C. Impellers: All impellers shall be dynamically balanced.
- D. The mechanical contractor shall be responsible for accurately checking all pumping heads, based upon the actual piping and equipment installation. The contractor shall be responsible for furnishing pumps and motors of proper sizes suitable for the actual installation. Do not provide pumps with capacities less than the amount indicated on the drawings.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division 1.

- B. Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
- C. Submit manufacturer's installation instructions under provisions of Division 1.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Division 1.
- B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 1.
- B. Store and protect products under provisions of Division 1.

1.08 EXTRA PARTS

- A. Provide one set of replacement mechanical seals for each size of pump. After the pumps are in operation for ninety days, the Contractor shall check the seals and replace any that are defective. If the replacement seals are not used during the 90 day operational period, they shall be delivered to the Owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Taco.
- B. Aurora.
- C. Bell and Gossett.
- D. Armstrong
- E. Substitutions: Under provisions of Division 1.

2.02 GENERAL CONSTRUCTION REQUIREMENTS

- A. Balance: Rotating parts, statically and dynamically.

- B. Construction: To permit servicing without breaking piping or motor connections.
- C. Pump Motors: Operate at 1750 rpm unless specified otherwise. Provide totally enclosed motors when mounted outdoors. Refer to Section 231700.
- D. Pump Connections: Flanged, for pipe size two inches and larger. Provide union for pipe sizes less than two inches.
- E. Critical speed of each pump shall be at least 115% of the running speed listed in the schedule.

2.03 CLOSE COUPLED PUMPS

- A. Type: Horizontal shaft, single stage, close coupled, radially split casing, for 125 psig maximum working pressure.
- B. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed to motor shaft extension.
- D. Shaft: Stainless steel.
- E. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F (110 degrees C) maximum continuous operating temperature.

2.04 BASE MOUNTED PUMPS

- A. Type: Horizontal shaft, single stage, direct connected, radially split casing, for 125 psig maximum working pressure.
- B. Motors: Indoor applications shall have open drip proof motors. Outdoor applications shall have TEFC motors.
- C. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- D. Impeller: Bronze, fully enclosed, keyed to shaft.
- E. Bearings: Grease or Permanently lubricated roller or ball bearings, 40,000 hour minimum life.
- F. Shaft: Alloy steel with stainless steel shaft sleeve.

- G. Seal: Carbon rotating against a stationary ceramic seat, 225 degrees F maximum continuous operating temperature.
- H. Drive: Flexible coupling with coupling guard.
- I. Baseplate: Cast iron or fabricated steel with integral drain rim. Galvanized when located outdoors.
- J. For pumps driven by motors 25 horsepower and larger, the steel base shall be fabricated of structural shapes and formed steel sections. The main structural member and formed steel section shall have a depth of at least 1/12 the overall length of the base but not less than 4 inches. The base shall be filled with concrete or grout after installation.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install pumps in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
- C. 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.
- D. Pumps shall be free of flashing and cavitation at all flow rates from 25% to 125% of design flow under the suction conditions of the pump installation.
- E. The impeller selected for compliance with design requirements shall not exceed 85% of cutwater diameter for the selected pump casing size. This shall be clearly certified on the Shop Drawing submittal.
- F. 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. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge lines.
- G. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- H. Provide air cock and drain connection on horizontal pump casings.

- I. Provide drains for bases and seals, piped to and discharging into floor drains.
- J. Lubricate pumps before start-up.
- K. Install close coupled and base mounted pumps on concrete base, with anchor bolts, set and level, and grout in place.
- L. Qualified millwright shall check, align, and certify base mounted pumps prior to start-up.

END OF SECTION 23 55 40

SECTION 23 55 46 HYDRONIC WATER TREATMENT SYSTEMS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 230500, are included as a part of this Section as though written in full in this document.

1.02 SCOPE

Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.03 DESCRIPTION OF WORK

- A. Work Included: Perform water analysis and provide all water treatment products, holding reservoirs, equipment and labor for testing, cleaning, flushing and dispensing products to control water quality for each system specified hereinafter as follows:
 - 1. Chilled water system.
- B. Chemicals: Provide, at no additional cost to the Owner, all chemicals required for operating and testing all water treatment systems prior to and for three months after acceptance by the Owner.
- C. Instructions: Provide operating and maintenance instructions for each water treatment system; include one set in each Owner's Manual and deliver one set to Owner's operating personnel.
- D. Testing Equipment and Reagents: Furnish suitable water treatment testing equipment for each system, complete with apparatus and reagents necessary for operation prior to and for three months after acceptance by the Owner.
- E. Service Representative: Furnish the services of a qualified service representative to instruct Owner's operating personnel in proper operation and maintenance of water treatment equipment, systems and tests required. Service representative shall return to the site bi-weekly during first 2 months of operation and monthly during the remainder of the guarantee period. At such time, service representative shall check and adjust water treatment system operation, check efficiency of chemicals and chemical applications, and instruct and advise operating personnel.

- F. Replacement and Rework: Replace defective or nonconforming materials and equipment with new materials and equipment at no additional cost to the Owner for 1 year after successful start-up of the system. All warranty work shall be FOB as installed at the project site.
1. Guarantee: Provide system produced by manufacturer who is willing to execute the required guarantee.
 2. Agreement to Maintain: Provide system produced by manufacturer who is willing to execute (with the Owner) the required agreement for continued maintenance of the system.

1.04 QUALITY ASSURANCE

- A. Qualifications: The Contractor for work under this Section shall have:
1. Research and development facilities.
 2. Regional laboratories capable of making water analysis.
 3. A service department and qualified technical service representative located within a reasonable distance of the project site.
 4. Service representatives who are Registered Engineers or factory-certified technicians with not less than 5 years of water treatment experience with the water treatment system manufacturer.
- B. Packaging and Labeling: Supply water treatment chemicals in metal drums, fiber drums with plastic liners, or plastic lined "liqui-paks" as best suited to the materials. Paper bags or unlined cardboard cartons will not be acceptable. Use only chemicals in domestic water systems, and all coincides regardless of where used, which are registered with the U.S. Department of Agriculture (USDA) or the U.S. Environmental Protection Agency (EPA) and which are labeled as required by law.
- C. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters Laboratories (UL) and which comply with National Electrical Manufacturers' Association (NEMA) standards.
- D. Chemical Standards: Provide chemical products acceptable under state and local pollution control or other governing regulations.

1.05 SUBMITTALS

- A. Test reports: Submit test reports certified by an officer of the firm, on water treatment company letterheads, of samples of each treated water system specified. Comply with ASTM D 596 for reporting. Indicate the ASTM best methods for each test.

- B. Shop Drawings: Submit shop drawings for each water treatment system. Show wiring, piping and tubing sizes, fittings, accessories, valves and connections.
- C. Guarantee: Submit written guarantee signed by the Manufacturer and countersigned by the Installer and Contractor, agreeing to adjust or replace the chemicals in the systems as required to achieve the required performance, during a 1-year period following the final start-up or the continued operation of the chillers.
- D. Agreement to Maintain: Prior to the time of final acceptance, the Manufacturer of the chilled water treating system shall submit four copies of an "Agreement for Continued Service and the Owner's possible acceptance." Offer terms and conditions for furnishing chemicals and providing continued testing and equipment for a 1-year period with option for renewal of the Agreement by Owner.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Water Analysis: Determine which chemicals to use from the results of a water sample analysis taken from the building site by the system manufacturer. Provide ingredients necessary to achieve the desired water conditions.
- B. Pre-Treatment: Treat water piping systems with chemicals to remove and permit flushing of mill scale, oil, grease and other foreign matter. Chemicals shall be equal to Nalco 2578 prepping compound.
- C. FDA and USDA Approval: Use only FDA and USDA-approved products in system with direct connection to domestic water systems.
- D. Governing Laws: Ensure that neither products, waste, blow-down nor other effluents violate local, state, EPA, or other agency regulations in effect in the project area.

2.02 CHILLED AND HOT WATER SYSTEMS

- A. Chemicals: Provide water treatment products which contain inhibitors that perform the following:
 - 1. Form a protective film to prevent corrosion and scale formation;
 - 2. Scavenge oxygen and protect against scale;
 - 3. Remain stable throughout operating temperature range, and;
 - 4. Are compatible with pump seals and other elements in the system.
 - 5. The inhibitor shall be a boron-nitrate corrosion inhibitor compound, equal to Nalco 2534.

- B. Equipment: For each system, provide a 5-gallon filter feeder constructed of materials which are impervious to the products dispensed. Feeder shall be designed for not less than 200-psig operating pressure. Filter feeder shall be as manufactured by efficiency Dynamics Model FF-50 or approved equal.
- C. Test Kit: Provide test kit and reagents for determining proper water conditions.

PART 3 - EXECUTION

3.01 PIPING SYSTEMS PREPARATION

- A. General: After piping systems are erected and proven free of leaks, administer chemicals required for preparation treatment and flushing. Apply chemicals for the time period and in the concentration recommended by the water treatment manufacturer for this portion of the work.
- B. Testing: Perform test procedures and submit a written report of test conditions and results to the Engineer. If test results are unsatisfactory, repeat preparation treatment as necessary to achieve test results approved by the Owner's insurance carrier and the Engineer.

3.02 FLUSHING

- A. Drain preparation and boil out products from the systems. Flush with clean water until system tests prove systems are free of preparation and boil out products and other contaminants prior to administering system water treatment as specified hereinbefore.

3.03 CHILLED AND HOT WATER SYSTEMS

- A. Treatment: Treat initial water charge to water system, after system has been flushed and prepped, to achieve a water quality as specified.
- B. Start-up Procedures: During water system start-up, operate water treating system (after charging with specified chemicals) to maintain the required steady-state characteristics of water. Demonstrate system operation to Owner's operating personnel.
- C. Reports: Prepare certified test report for each required water performance characteristic. Comply with the following ASTM standard, where applicable:
 - 1. D859 - Tests for Silica in Water and Water Waste.
 - 2. D1067 - Tests for Acidity or Alkalinity of Water.
 - 3. D1068 - Tests for Iron in Water and Waste Water.
 - 4. D1126 - Tests for Hardness in Water.

5. D1128 - Identification of Types of Microorganisms and Microscopic Matter in Water and Waste Water.
 6. D3370 - Sampling Water.
- D. Water Chemistry: Where water chemistry substantiates that pH control is not necessary, chemical fee shall be based on water makeup qualities. Water analysis shall be based on the full parameters of operation, and all possible water supplies. Total hardness and "M" alkalinity of the makeup water will be the determining factor along with the technical limitations of the inhibitors.

3.04 PERSONNEL TRAINING

- A. Operator Training: Train Owner's personnel in use and operation of chilled water treating systems including preparation of chemical solution reservoir. A Program Administration Manual shall be furnished encompassing all systems in this section of the Specifications.

END OF SECTION

SECTION 23 57 60 HVAC ROOF CURBS AND EQUIPMENT SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Roof curbs for conventional and pre-engineered metal buildings
 - 2. Equipment supports
 - 3. Adapters
 - 4. Structural platforms
 - 5. Isolation roof curbs and rails
- B. Related Sections
 - 1. Division 23 - Mechanical
 - 2. Division 26 - Electrical
- C. This section specifies curbs for mechanical equipment specified by Division 23. These curbs are designed and fabricated as welded single piece units that are structurally designed to span structural framing. They require structural calculations from manufacturer.
- D. Manufactured curbs are designed, engineered, and fabricated for exact mechanical units selected after bid, and can be designed for compound slopes and difficult roofing conditions. There are designs to accommodate each type of roofing condition including standing seam metal roofing.
- E. Field-fabricated curbs except under special conditions are not acceptable.
- F. Top of roof curb shall be a minimum of 12 inches above the roofing insulation. Provide sloped curbs to match roof slope
- G. Structural calculations required for work and for production of required submittals shall be signed and sealed by a structural engineer licensed in the state of Texas.
 - 1. Curbs, equipment rails and supports, and similar items shall be designed in compliance with the applicable building code and the latest additions of ASCE 7, by a structural engineer registered in the state of Texas.
 - 2. Curbs shall meet windstorm standards for Inland zone 1 for 120mph winds at a 3 second gust.
- H. Provide provisions for wind attachment devices, anchorages and equipment shall be designed and included as integral parts of the products.
 - 1. Coordinate with mechanical equipment manufacturers for requirements, and specific items to be supplied with equipment.

1.2 REFERENCES

- A. Reference Standards: Most recent edition at time of Bid

- B. American Society for Testing and Materials (ASTM): ASTM A 653 – Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron

1.3 SUBMITTALS

- A. Submit under provisions of Division 01
- B. Shop Drawings: Dimensioned drawings showing overall layout details, jointing connections, and fasteners. Show adjacent construction including roof deck, roofing system, and equipment.
- C. Product Data: Published data indicating product characteristics.
- D. Structural Calculations: Signed and sealed by structural engineer.
- E. Manufacturer Instructions: Include installation instructions, rough-in dimensions, special procedures, and perimeter conditions requiring special attention.
- F. Overlay Coordinating Drawing: Show interface between Architectural, Structural, and Mechanical Drawings with applicable roof curbs.

1.4 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Design, fabricate, and furnish roof curbs and equipment supports to accurate dimensions, configuration, and structural rigidity to meet requirements for watertight systems, and spanning capacity between structural members at openings in roof deck.

1.5 QUALIFICATIONS

- A. Manufacturer:
 - 1. Able to document minimum 10 years continuous experience designing, manufacturing, and supplying work for this Section.
 - 2. Maintain engineering and design capabilities to furnish customized curbs, and equipment supports.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Comply with provisions of Division 01 and manufacturer's instructions.
- B. Deliver on pallets or protective packaging with manufacturer's identifying labels legible and intact.
- C. Store on pallets above water, mud, and dirt, protected from soiling and damage.
- D. Handle to prevent permanent warping and racking of frame.

1.7 WARRANTY

- A. Comply with Warranty provisions specified Division 01.

- B. Manufacturer: Standard 5 year limited Warranty against defects in labor and workmanship.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Roof Products, Inc. (RPI) Chattanooga, TN and Phoenix, AZ
 - 1. Tel 1-800-262-6669, Fax: (423) 892-2107, Email: rpicurbs@comcast.net
 - 2. Web Site <http://www.rpicurbs.com>.
- B. Curb Technologies, LLC
 - 1. Tel 1-334-8826-9538
- C. ThyCurb
 - 1. Tel 1-972-416-6220

2.2 ROOF CURBS AND EQUIPMENT SUPPORTS AND MISC. ROOF CURBS (for conventional buildings)

- A. Frame:
 - 1. Material: ASTM A 653 G90 hot-dipped Galvanized steel
 - a. Minimum 18 gauge or as engineered by manufacturer
 - b. Minimum 18 gauge for curbs supporting HVAC units
 - 2. Corners: Mitered and welded (welds are micro-sealed and prime painted after fabrication). Bolted connections not accepted.
 - 3. Internally reinforced with Galvanized 1 inch by 1 inch by 12 gauge angles for curbs exceeding 3 feet in length. Reinforced internal bulkhead at equipment curbs to support lateral loads.
 - 4. Wood Nailers: Factory installed, pressure treated. Size and width as suitable for support of items installed on curbs.
- B. Insulation: Factory installed 1-1/2 inch thick three-pound density fiberglass insulation.
- C. Curb Height: minimum 18 inch (12 inches above finished roof surface).
- D. Construct curbs to match roof slope with plumb and level top surface for mounting mechanical equipment.
- E. Gasket: 1 / 4 inch thick, 1" wide at roof top units and exhaust fans.
- F. Counter Flashing: 18 gauge Galvanized steel.
- G. Cants: wood or fiber for built-up or modified bitumen roofing systems (not required for single ply roofing)
 - 1. RPC-1 / RPES-1 (raised cant style) installs on top of metal decks with insulation.
 - 2. RPC-2 / RPES-2 (canted style) installs on wood roofs without insulation.
- H. Fabricate platform curbs, adapters, pipe curbs, curb covers, square to round, column and tube counter flashings as necessary for complete watertight systems at roof penetrations.

- I. All roof curbs are structural and shall include calculations signed and sealed by a registered Structural Engineer. Refer to installation drawings for any additional requirements. If curbs do not span a minimum of two bar joists, only two angles will be required. Coordination with Architect's Structural Engineer for mechanical equipment weight loading on the roof structure shall be by the Contractor and Architect based on approved equipment submittals.

2.3 ACCESSORIES

- A. Screws: Fasteners as instructed by manufacturer for pre-engineered metal buildings.

2.4 PLATFORM CURBS

- A. Structural Platform curbs
 1. Material: ASTM A 653 G90 hot-dipped Galvanized steel.
 - a. Minimum 18 gauge or as engineered by manufacturer
 2. Corners: Mitered and welded. Bolted and connections are not accepted.
 3. Internally reinforced with Galvanized 1 inch by 1 inch by 12 gauge angles for curbs exceeding 3 feet in length. Reinforced internal bulkhead at wider curbs to support lateral loads.
 4. Wood Nailers: Factory installed, pressure treated. Size and width as suitable for support of items installed on curbs.
 5. Provide $\frac{3}{4}$ " plywood top with support channels as required.
- B. Insulation: Factory installed 1-1/2 inch thick three-pound density fiberglass insulation.
- C. Curb Height: Minimum 12 inch above finished roof.
- D. Construct curbs to match roof slope with plumb and level top surface for mounting mechanical equipment.
- E. Counter Flashing: 18 gauge Galvanized steel.
- F. Cants: Wood or fiber for built-up or modified bitumen roofing systems (not required for single ply roofing)
 1. RPPF-1 (raised cant) roof curb installs on top of metal decks with installation.
 2. RPPF-2 (canted) roof curb installs on roofs without insulations.

2.5 PIPE CURBS

- A. Provide 18 gage Galvanized steel shell, base plate, and counter flashing, with internal reinforcement and factory-installed treated-wood perimeter nailer at top; welded construction.
- B. Design Basis: "Model RPVP-3"; pipe curb with side outlets.
- C. 90-degree pipe chase: standard model of Roof Products, Inc.; size as required with mounting flange.
- D. Cant strip shall be provided and installed by roofing Contractor.

- E. Pleated and bellows- Type boot flashing; manufacturer's standard products of pleated or stepped EPDM rubber or silicone material; one piece construction sized as necessary for the penetrating work. Acceptance manufactures are:
 - 1. "Dektite"; by ITW Buildex
 - 2. "Deckmate"; by Portal Plus
 - 3. "Alumi-Flash"; by Portal Plus
- F. Miscellaneous work:
 - 1. Provide all manufacturer's additional items, such as but not limited to platforms, adapters, pipe curbs, curb covers, square to round, column and tube counter flashings as required for a complete and weather-tight installation at each roof accessory.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Verify conditions ready to receive work of this Section. Do not work until unsatisfactory conditions are corrected. Beginning work constitutes acceptance of existing conditions.
- B. Ensure that all curbs, equipment supports and rails are installed prior to the installation of the steel roof deck.

3.2 INSTALLATION

- A. Install in accordance with Contract Document provisions and manufacturer's instructions. Where in conflict, follow the requirements that are more stringent, and verify with Architect before beginning work.
- B. Anchor products securely to structural substrates, as required by structural design, adequate to withstand imposed loading and lateral and thermal stresses as well as inward and outward loading pressures.
- C. Equipment Supports: Span minimum two structural members.
- D. Do not apply load to cantilever exceeding 2 foot length, for equipment supports.
- E. Coordinate with installation of roof system as required to ensure that each element of the work performs properly, and that combined elements are waterproof and weather-tight.
- F. Isolation: where metal surfaces of units are installed in contact with dissimilar metal or corrosive substrates, including wood, apply Bituminous coating on concealed metal surfaces, or provide other permanent separation as recommended by metal producer.
- G. Clean up exposed metal surfaces in accordance with manufacturer's instructions. Touch up damaged metal coatings.
- H. Do not apply load to cantilever exceeding 4 foot lengths for roof curbs.

3.3 ADJUSTING

- A. Replace or repair installations not conforming to specified requirements including installations out of level and out of plumb.

3.4 CLEANING

- A. Leave installation clean, free of debris and residue resulting from work of this Section.

END OF SECTION 23 57 60

23 68 30 AIR-COOLED SCROLL WATER CHILLERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes design, performance criteria, refrigerants, controls, and installation requirements for air-cooled rotary scroll packaged chillers.

1.02 REFERENCES

- A. AHRI 550/590 - Standard for Water Chilling Packages using the Vapor Compression Cycle
- B. AHRI 370 - Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
- C. ASHRAE 15 - Safety Code for Mechanical Refrigeration
- D. ASHRAE 90.1 - Energy Efficient Design of New Buildings
- E. UL 1995 - Central Cooling Air Conditioners
- F. ASTM B117 - Standard Method of Salt Spray (Fog) Testing
- G. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- H. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products
- I. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments
- J. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings.
- K. ISO 9001
- L. California Administrative Code - Title 24

1.03 SUBMITTALS

- A. Submit dimensional plan and elevation view drawings, weights and loadings, required clearances, location and size of all field connections, electrical requirements and wiring diagrams.
- B. Submit product data indicating rated capacities, accessories and any special data.

- C. Submit manufacturer's installation instructions.

1.04 REGULATORY REQUIREMENTS

- A. Comply with codes and standards specified.
- B. Chiller must be built in an ISO 9001 classified facility.

1.05 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.

1.06 DELIVERY, HANDLING AND STORAGE

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting chillers.
- B. Chiller shall be capable of withstanding -40°F (-40°C) to 158°F (70°C) storage temperatures for an indefinite period of time.

1.07 WARRANTY

- A. Provide entire unit parts, compressors, labor and refrigerant warranty for Five (5) years from start-up.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Daikin AGZ
- B. Approved equals by Trane, and JCI must have scroll compressor and meet the specification including all scheduled performance.

2.02 CHILLER DESCRIPTION

- A. The contractor shall furnish and install air-cooled water chiller with scroll compressors as shown as scheduled on the contract documents. The chillers shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.03 CHILLER OPERATION

- A. Chiller shall be able to start and operate in ambient conditions from 0°F to 125°F. Wide ambient operation is accomplished with factory installed and tested protection. If field installed wide ambient solution is used, this shall be purchased and installed at contractor expense and shall be field verified by manufacturer during winter conditions with a factory start-up report.
- B. Chiller shall be capable of operating with a leaving solution temperature range 40°F to 65°F without glycol.
- C. Chiller shall be capable of starting up with 95°F entering fluid temperature to the evaporator. Maximum water temperature that can be circulated with the Chiller not operating is 125°F.
- D. Chiller shall provide evaporator freeze protection and low limit control to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. Whenever this control is in effect, the controller shall indicate that the chiller is in adaptive mode. If the condition exists for more than 30 seconds, a limit warning alarm relay shall energize.
- E. Rapid Restart™ after power restoration. The Chiller shall be capable of starting in 45 seconds.

2.04 COMPRESSORS

- A. Construct chiller using fully hermetic scroll type compressors with R410A optimized and dedicated scroll profile.
- B. Provide direct drive motor cooled by suction gas with only three major moving parts and a completely enclosed compression chamber that leads to increased efficiency.
- C. Each compressor shall have overload protection internal to the compressor.

- D. Each compressor shall include: centrifugal oil pump, oil level sight glass and oil charging valve.
- E. Each compressor will have crankcase heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

2.05 EVAPORATOR

- A. The evaporator shall be a high efficiency, brazed plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material.
- B. The water side working pressure shall be rated at 150 psig and tested at 1.5 times maximum allowable water side working pressure.
- C. The refrigerant side working pressure shall be rated at 460 psig and tested at 1.1 maximum allowable refrigerant side working pressure.
- D. The evaporator shall be insulated with 1.5" (38mm) (K=02.28) thick CFC and HCFC-free closed-cell flexible elastomeric foam insulation material with 100% adhesive coverage. Suction piping to the compressors shall be insulated with similar foam insulation material of 0.75" (19 mm) thickness. The insulation shall have an additional outer protective layer of 3mm thick PE embossed film to provide superior damage resistance. Insulation without the protective outer film shall not be acceptable. UV resistance level shall meet or exceed a rating of 'Good' in accordance with the UNI ISO 4892 - 2/94 testing method. This combination of a heater plate and insulation shall provide freeze protection down to -20°F (-29°C) ambient air temperature. If the insulation is field installed, the additional money to cover material and installation costs in the field should be included in the bid.

- E. Evaporator heaters shall be factory installed and shall protect chiller down to minus -20°F. Contractor shall wire separate power to energize heat tape and protect evaporator while chiller is disconnected from the main power.
- F. Provide water drain connection, vent and fittings. Factory installed leaving water temperature control and low temperature cutout sensors.
- G. Water connections shall be grooved pipe.
- H. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

2.06 FANS

- A. Low sound fans shall be dynamically balanced and direct driven.
- B. All condenser fan TEAO motors have permanently lubricated ball bearings and external overload protection.

2.07 CONDENSER

- A. The condenser coils shall consist of microchannel all aluminum brazed fin construction.
- B. The condenser coils shall have an integral sub-cooling circuit and shall be designed for at least 650 psig (44.8 bar) working pressure. Leak tested at 650 psig (44.8 bar).
- C. Condenser coils shall include a coating providing 10,000+ hour salt spray resistance per ASTM B117-90 (Marine applications), ASTM G85, and UV Weathering ASTM D 4587/4141 and ISO 1134/11507 applied to the coil at the factory. The coating shall be Energy Guards DCC Green or approved equal. Condenser coils are made of aluminum fins (plate fins) mechanically bonded to internally finned copper tubes. The condenser box is then submerged in an epoxy polymer bath where an electrostatic charge is used to uniformly deposit the epoxy

onto the coil. This option resists bimetallic corrosion and allows for operation in coastal environments.

- D. Provide louvered, condenser coil hail guard painted to match the unit. This is required regardless of the orientation of the condenser coil. Wire guards are not acceptable.

2.08 ENCLOSURES/CHILLER CONSTRUCTION

- A. Units shall be constructed of a galvanized steel frame with galvanized steel panels and access doors.
- B. Chiller panels, base rails and control panels shall be finished with a baked on powder paint. Control panel doors shall have door stays.
- C. Mount starters and Terminal Blocks in a UL 1995 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of chiller indicating if power is on or off.
- D. The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B117. Additional corrosion coatings shall be applied to the cabinet, casing, and exposed refrigerant lines to provide 10,000+ hour salt spray protection. Coating shall be equivalent to Energy Guards DCC Cabinet Casing coating or approved equivalent.

2.09 CHILLER MOUNTED STARTER

- A. The starter shall be across-the-line configuration, factory-mounted and fully pre-wired to the compressor motor(s) and control panel.
- B. Unit shall have a single point power connection.
- C. A control power transformer shall be factory-installed and factory-wired to provide unit control power.

- D. Control panel shall be dead front construction for enhanced service technician safety
- E. Unit wiring shall run in liquid-tight conduit.
- F. A molded case standard interrupting capacity circuit breaker shall be factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, making it available to disconnect the chiller from main power.
- G. High short circuit current rating (SCCR) of 65kA chillers with selection of high fault protection device.

2.10 REFRIGERANT CIRCUIT

- A. All chillers shall have 2 independent refrigeration circuits.
- B. Provide for refrigerant circuit:
 - 1. Liquid line shutoff valve
 - 2. Discharge service valve
 - 3. Filter
 - 4. Liquid line sight glass.
 - 5. Electronic expansion valve sized for maximum operating pressure
 - 6. Charging valve
- C. Full operating charge of R410A and oil.

2.11 CONTROLS

- A. Factory-mounted to the control panel door, the operator interface has an LCD touch-screen display
- B. Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor, evaporator, and motor information as well as associated diagnostics.
- C. The chiller control panel shall provide password protection of all set-points

- D. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer.
- E. 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. Saturated evaporator and condenser refrigerant temperatures.
 - 8. Evaporator and condenser refrigerant pressure.
 - 9. Differential oil pressure.
 - 10. Phase reversal/unbalance/single phasing and over/under voltage protection.
 - 11. Low chilled water temperature protection.
 - 12. High and low refrigerant pressure protection.
 - 13. Load limit thermostat to limit compressor loading on high return water temperature.
 - 14. Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize chiller efficiency.
 - 15. Display diagnostics.

16. Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.
- F. On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer.
 - G. The chiller controller shall utilize a microprocessor that will automatically take action to prevent chiller shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.
 - H. Provide the following safety controls with indicating lights or diagnostic readouts.
 1. Low chilled water temperature protection.
 2. High refrigerant pressure.
 3. Loss of chilled water flow.
 4. Contact for remote emergency shutdown.
 5. Motor current overload.
 6. Phase reversal/unbalance/single phasing.
 7. Over/under voltage.
 8. Failure of water temperature sensor used by controller.
 9. Compressor status (on or off).
 - I. Provide the following operating controls:
 1. A variable method to control capacity in order to maintain leaving chilled water temperature based on PI algorithms. Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start, or greater than 2 minute stop-to-start timer is

included, hot gas bypass shall be provided to insure accurate chilled water temperature control in light load applications.

2. Chilled water pump output relay that closes when the chiller is given a signal to start.
 3. Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance trip outs.
 4. High ambient unloader pressure controller that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
 5. Compressor current sensing unloader chiller that unloads compressors to help prevent current overload nuisance trip outs.
 6. Low ambient lockout control with adjustable setpoint.
 7. Condenser fan sequencing which adjusts the speed of all fans automatically in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing chiller efficiency.
- J. Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:
1. Leaving chilled water setpoint adjustment from LCD input
 2. Entering and leaving chilled water temperature output
 3. Pressure output of condenser
 4. Pressure output of evaporator
 5. Ambient temperature output
 6. Voltage output
 7. Current limit setpoint adjustment from LCD input.

- K. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.
- L. Digital Communications to BAS system shall consist of a BACnet MS/TP interface via a single twisted pair wiring.

2.12 SOUND

- A. Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels. Sound pressure data per AHRI 370 must be provided at full load. A weighted sound power level shall not exceed 92 dBA.
- B. Include compressor blankets and low noise fans.
- C. If manufacturer cannot meet the noise levels, contractor shall install sound attenuation devices and/or barrier walls to meet this performance level at no cost to the owner.

2.13 ACCESSORIES

- A. Chiller shall ship with elastomeric isolators.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's requirements.
 - 1. Level the chiller using the base rail as a reference. The chiller must be level within 1/2" in over the entire length and width. Use shims as necessary to level the chiller.

3.02 SERVICE AND START-UP

- 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. A certificate of completion for the manufacturer's instructed maintenance and operation, and service and troubleshooting courses must be submitted and approved by the owner and engineer of record prior to start up. The technician performing the startup shall be named on the certificate.

- 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 manufacturers 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. The service agent must be current on manufacturer's training requirements for access to factory support. A certificate of completion for the manufacturer's instructed service and troubleshooting courses must be submitted and approved by the owner prior to project completion.
- E. The service provider shall employ a minimum of (3) full time, competent HVAC and automation system servicepersons on staff, whose office in which they operate from is within (50) miles of the job site and who have been within their employment for a minimum of (3) years.
- F. During the first 12 months of operation, a factory-trained technician from the original equipment manufacturer (OEM) shall perform quarterly on-site operating inspections to confirm the chiller's operational performance. The manufacturer shall provide the owner with a report describing the condition of the equipment, current operating log, any issues found needing to be addressed, and recommended corrective actions. A certificate of completion for the

manufacturer's maintenance and operation course must be submitted and approved by the owner prior to project completion.

END OF SECTION 23 68 30

SECTION 23 89 00 METAL DUCTWORK

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Low pressure ductwork.
- B. Medium and high pressure ductwork.
- C. Casings.
- D. Duct cleaning.

1.02 RELATED SECTIONS

- A. Section 230500 - Basic Material and Methods.
- B. Section 231400 - Supports and Anchors.
- C. Section 232900 - Duct Insulation.
- D. Section 239100 - Ductwork Accessories.
- E. Section 238810 - Air Distribution Devices.
- F. Section 239900 - Testing, Adjusting and Balancing.

1.03 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.
- C. Codes and Standards:
 - 1. SMACNA Standards: Comply with latest SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork.

2. ASHRAE Standards: Comply with ASHRAE Handbook, Equipment Volume, Chapter 1 "Duct Construction", for fabrication and installation of metal ductwork.
3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems", NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems", and NFPA 96 Standard.
4. IECC 2015: Comply with the 2015 International Energy Conservation Code.

1.04 GENERAL DESCRIPTION

- A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

1.05 SUBMITTALS

- A. Submit shop drawings, duct fabrication standards and product data under provisions of Division 1.
- B. Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work.
- C. The contract documents are schematic in nature and are to be used only for design intent. The contractor shall prepare sheet metal shop drawings, fully detailed and drawn to scale, indicating all structural conditions, all plumbing pipe and light fixture coordination, and all offsets and transitions as required to permit the duct to fit in the space allocated and built. All duct revisions required as a result of the contractor not preparing fully detailed shop drawings will be performed at no additional cost.

1.06 DEFINITIONS

- A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain indicated clear size inside lining. Where offsets or transitions are required, the duct shall be the equivalent size based on constant friction rate.
- B. Low Pressure: Three pressure classifications: ½ inch WG positive or negative static pressure and velocities less than 1,000 fpm; 1 inch WG positive or negative static pressure and velocities less than 1,500 fpm, and 2 inch WG positive or negative static pressure and velocities less than 2,000 fpm. Low pressure ductwork shall be defined as all return, exhaust, and outside air ducts associated with constant volume air handling units with a scheduled external static pressure of less than 1.5", and all supply ductwork downstream of terminal units in variable volume systems.
- C. Medium Pressure: Three pressure classifications: 3 inch WG positive or negative static pressure and velocities greater than 2,000 fpm but less than 3,000 fpm, 4 inch WG

positive static pressure and velocities greater than 3,000 fpm but less than 4,000 fpm, and 6 inch WG positive static pressure and velocities greater than 4,000 fpm. Medium pressure ductwork shall be defined as all supply ducts extending from variable volume air handling units to terminal units in variable volume systems with air handling units having a scheduled external static pressure of less than 4". The supply ductwork of constant volume air handling units having scheduled external static pressure greater than 2" and less than 4" shall be rated for medium pressure.

- D. High Pressure: 10 inch WG positive static pressure and velocities greater than 6,000 fpm.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings, use sheet metal end caps on any lined duct exposed to the weather and use 3 mil vinyl wrap with duct tape on end pieces where stored inside.
- B. Storage: Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.01 DUCTWORK MATERIALS

- A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.
- B. Sheet Metal.: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality, with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations.
- C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A167; Type 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.
- D. Aluminum Sheet: Where indicated, provide aluminum sheet complying with ASTM B 209, Alloy 3003, Temper H14.

2.02 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Non combustible and conforming to UL 181, Class 1 air duct materials.
- B. Flexible Ducts: Flexmaster U.S.A., Inc. Type 8M or approved equal, corrosive resistant galvanized steel formed and mechanically locked to inner fabric with factory wrapped insulation blanket with aluminum vapor barrier and an R-6 thermal conductance. Flexible duct shall have reinforced metalized outer jacket comply with UL 181, Class 1 air duct. Equivalent manufactures are Thermaflex.
- C. Sealants: Hard-Cast "iron grip" or approved equal, non-hardening, water resistant, fire resistive and shall not be a solvent curing product. Sealants shall be compatible with mating materials, liquid used alone or with tape or heavy mastic.
- D. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
 - 1. For exposed stainless steel ductwork, provide matching stainless steel support materials.
 - 2. For aluminum ductwork, provide aluminum support materials.

2.03 LOW PRESSURE DUCTWORK

- A. Fabricate and support in accordance with latest SMACNA Low Pressure Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by approved shop drawings. Obtain engineer's approval prior to using round duct in lieu of rectangular duct.
- C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
- D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.
- E. Use crimp joints with bead for joining round duct sizes 6 inch smaller with crimp in direction of airflow.

- F. Use double nuts and lock washers on threaded rod supports.

2.04 MEDIUM AND HIGH PRESSURE DUCTS

- A. Fabricate and support in accordance with SMACNA High Pressure Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Construct T's, bends, and elbows with radius of not less than 1½ times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-turning vanes. Where acoustical lining is required, provide turning vanes of perforated metal with glass fiber insulation. Weld in place.
- C. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence.
- D. Fabricate continuously welded medium and high pressure round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Joints shall be minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.
- E. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

2.05 CASINGS

- A. Fabricate casings in accordance with SMACNA Low Pressure Duct Construction Standards and SMACNA High Pressure Duct Construction Standards and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of 18 gage galvanized expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.
- C. Reinforce doorframes with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection. Provide clear wire glass observation ports, minimum 6 X 6 inch size.
- D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gage back facing and 22 gage perforated front facing with 3/32 inch diameter holes on 5/32 inch centers. Construct panels 3 inches thick packed with 4.5 lb./cubic foot minimum glass fiber media, on inverted channels of 16 gage.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

- A. Obtain manufacturer's inspection and acceptance of fabrication and installation of ductwork at beginning of installation.
- B. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- D. Connect terminal units to medium or high pressure ducts with four feet maximum length of flexible duct. Do not use flexible duct to change direction.
- E. Connect diffusers or troffer boots to low pressure ducts with 6 feet maximum, 4 feet minimum, length of flexible duct. Hold in place with strap or clamp.
- F. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- G. The interior surface of all ductwork shall be smooth. No sheet metal parts, tabs, angles, or anything else may project into the ducts for any reason, except as specified to be so. All seams and joints shall be external.
- H. All ductwork located exposed on roof shall be "crowned" to prevent water from ponding. Ref: Insulation for additional requirements.
- I. Where ducts pass through floors, provide structural angles for duct support. Where ducts pass through walls in exposed areas, install suitable sheet metal escutcheons as closers.
- J. All angles shall be carried around all four sides of the duct or group of ducts. Angles shall overlap corners and be welded or riveted.
- K. All ductwork shall be fabricated in a manner to prevent the seams or joints being cut for the installation of grilles, registers, or ceiling outlets.

3.02 INSTALLATION OF FLEXIBLE DUCTS

- A. Determine the minimum length of flexible duct needed for each connection. Excess flex causing tight bends and increased pressure drops are not acceptable. Do not exceed 6'-0" extended length.
- B. Install in accordance with Section III of SMACNA's, "HVAC Construction Standards, Metal and Flexible".
- C. Cut outer vapor barrier and insulation. Fold back insulation and outer vapor barrier to expose inner core. Using sheet metal snips, cut the inner core.
- D. Connect the inner core to the tap or collar by pulling it a minimum of 1" over the collar.
- E. Where collars are less than 1" in length, i.e. diffusers, connect a separate collar to the existing collar and proceed as described in 3.02.C above.
- F. Wrap the core twice with UL181 Tape over the collar. Secure the connection by placing a clamp over the tap or collar, UL listed Panduit clamps for collars with beads and Stainless Steel clamps for collars without beads are acceptable.
- G. Roll the insulation and vapor barrier back over the collar or tap as described in 3.02.C above and wrap twice with UL181 Tape.
- H. Secure the outer vapor barrier with a clamp as described in 3.02.F above if desired.
- I. For Medium to High Pressure applications, use duct sealer for 3.02.F and 3.02.G in lieu of UL181 Tape.
- J. Flexible duct shall be hung with proper support to minimize sagging and snaking between supports. Maximum of 4'-0" between supports. Hanger material will be a minimum of 1 1/2" wide.
- K. Supports will be used before all vertical 90° bends to prevent sagging and ensure a 1.5 center line turn radius of flexible duct.

3.03 REQUIREMENTS FOR UNIT CASINGS

- A. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

3.04 DUCTWORK APPLICATION SCHEDULE

AIR SYSTEM

MATERIAL

Low Pressure Supply	Steel
Return and Relief	Steel
General Exhaust	Steel
Outside Air Intake	Steel
Combustion Air	Steel

3.05 DUCTWORK HANGERS AND SUPPORTS

- A. All ductwork shall be properly suspended or supported from the building structure. Hangers shall be galvanized steel straps or hot-dipped galvanized rod with threads pointed after installation. Strap hanger shall be attached to the bottom of the ductwork, provide a minimum of two screws one at the bottom and one in the side of each strap on metal ductwork. The spacing, size and installation of hangers shall be in accordance with the recommendations of the latest SMACNA edition.
- B. All duct risers shall be supported by angles or channels secured to the sides of the ducts at each floor with sheet metal screws or rivets. The floor supports may also be secured to ducts by rods, angles or flat bar to the duct joint or reinforcing. Structural steel supports for duct risers shall be provided under this Division.

3.06 DUCT JOINTS AND SEAMS

- A. Seal all non-welded duct joints and seams with duct sealant as indicated. All longitudinal and transverse joints, seams and connections in metallic and non-metallic ducts shall be constructed as per specified in SMACNA HVAC Duct Construction Standards-Metal and Flexible. All longitudinal and transverse joints, seams and connections shall be sealed in accordance with the International Energy Conservation Code 2018 edition.

3.07 AIR DUCT LEAKAGE: (From SMACNA Duct Standards 3rd Edition) Test all ductwork (designed to handle over 1000 CFM) as follows:

- A. Test apparatus

The test apparatus shall consist of:

- 1. A source of high pressure air--a portable rotary blower or a tank type vacuum cleaner.
- 2. A flow measuring device consisting of straightening vanes and an orifice plate

mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.

B. Test Procedures

1. Test for audible leaks as follows:
2. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - a. Start the blower with its control damper closed.
 - b. Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
 - c. Survey all joint for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
3. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
 - a. Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
 - b. Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
 - c. Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
 - d. Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which, must be corrected.
4. Test Witness
 - a. Air duct leakage test shall be witnessed by Owner/Engineer.
 - b. The Architect or duly authorized construction inspector shall be notified in writing at least 2 working days prior to each test.

END OF SECTION 23 89 00

SECTION 23 91 00 DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Volume control dampers.
- B. Round Duct Taps.
- C. Fire dampers.
- D. Combination fire and smoke dampers.
- E. Back draft dampers.
- F. Air turning devices.
- G. Flexible duct connections.
- H. Duct access doors.
- I. Duct test holes.

1.02 RELATED WORK

- A. Section 232400 – Sound & Vibration Control.
- B. Section 238900 – Metal Ductwork.

1.03 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- B. SMACNA - Low Pressure Duct Construction Standards.
- C. UL 33 - Heat Responsive Links for Fire-Protection Service.
- D. UL 555 - Fire Dampers and Ceiling Dampers.

1.04 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division 1.

- B. Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers duct access doors duct test holes. Provide product data for hardware used.
- C. Submit manufacturer's installation instructions under provisions of Section 01300, for fire dampers and combination fire and smoke dampers.

PART 2 PRODUCTS

2.01 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated.
- B. Fabricate splitter dampers of material same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.
- C. Fabricate splitter dampers of double thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/2 inch diameter rod in self aligning, universal joint, action flanged bushing, with set screw.
- D. Fabricate single blade dampers for duct sizes to 9-1/2 x 24 inch.
- E. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inch.
 - 1. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
 - 2. On outside air, return air, and all other dampers required to be low leakage type, provide galvanized blades and frames, seven inches wide maximum, with replaceable vinyl, EPDM, silicone rubber seals on blade edges and stainless steel side seals. Provide blades in a double sheet corrugated type construction for extra strength. Provide hat channel shape frames for strength and blade linkage enclosure to keep linkage out of the air stream. Construction leakage not to exceed 1/2%, based on 2,000 fpm and 4 inch static pressure.
- F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- G. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Where rod lengths exceed 30 inches provide regulator at both ends.
- H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.02 ROUND DUCT TAPS

- A. Taps to trunk duct for round flexible duct shall be spin-in fitting with locking quadrant butterfly damper, model no. FLD-B03 by Flexmaster or approved equal.

2.03 ACCEPTABLE MANUFACTURERS - FIRE DAMPERS AND COMBINATION FIRE AND SMOKE DAMPERS

- A. Greenheck
- B. Louvers and Dampers Inc.
- C. Ruskin.
- D. Nailor Industries.

2.04 FIRE DAMPERS

- A. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- B. Provide curtain type dampers of galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream.
- C. Fabricate multiple blade fire dampers per U.L. with 16 gauge minimum galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- D. Fusible links, UL 33, shall separate at 160 degrees F. Provide adjustable link straps for combination fire/balancing dampers.

2.05 COMBINATION FIRE AND SMOKE DAMPERS

- A. Fabricate in accordance with NFPA 90A, UL555 and UL 555S, and as indicated.
- B. Provide factory sleeve for each damper. Install damper operator on exterior of sleeve and link to damper operating shaft.
- C. Fabricate with multiple blades with 16 gauge galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.

1. Operators shall be spring return electric type suitable to operate on 120 V AC, 60 cycle.
 2. Operators shall be UL listed and labeled.
- D. See smoke dampers for details and accessories to be included

2.06 SMOKE DAMPERS

- A. Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.
- B. Motorized Smoke Dampers: normally open with power on, close automatically when power is interrupted, UL-listed and labeled damper and damper operator. Unit shall close upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices ensure positive closure for units mounted horizontally.
- C. Electro thermal Link: Fusible link which melts when subject to local heat of 165 degrees F and from external electrical impulse; UL listed and labeled.
- D. Each smoke damper and combination fire/smoke damper shall be equipped with end position indicators for remote indication of damper blade position.
- E. Furnish each smoke damper with a duct mounted smoke detector and sensing tube for proper operation of smoke damper. Duct smoke detectors shall be of the photoelectronic type. Sensing tube shall run the entire width of the duct and comply with manufactures instructions. Smoke detector and sensing tube shall be furnished and factory installed by the damper manufacture.

2.07 ACCEPTABLE MANUFACTURERS - BACKDRAFT DAMPERS

- A. Greenheck
- B. American Warming and Vent.
- C. Louvers and Dampers Inc.
- D. Ruskin.
- E. Substitutions: Under provisions of Division 1.

2.08 BACKDRAFT DAMPERS.

- A. Gravity back draft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturers standard construction.

- B. Fabricate multi-blade, parallel action gravity balanced back draft dampers of 16 gauge galvanized steel, or extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.09 ACCEPTABLE MANUFACTURERS - AIR TURNING DEVICES

- A. Young Regulator.
- B. Titus.
- C. Tuttle and Bailey.
- D. Substitutions: Under provisions of Division 1.

2.10 AIR TURNING DEVICES

- A. On duct sizes less than 12 x 12, multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades, mounting straps.
- B. Multi-blade device with radius blades attached to pivoting frame and bracket, steel or aluminum construction, with worm drive mechanism with 18 inch long removable key operator.

2.11 ACCEPTABLE MANUFACTURERS - FLEXIBLE DUCT CONNECTIONS

- A. Metaledge.
- B. Ventglass.
- C. Substitutions: Under provisions of Division 1.

2.12 FLEXIBLE DUCT CONNECTIONS TO AIR MOVING EQUIPMENT

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated.
- B. UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 20 oz per sq yd, approximately 6 inches wide, crimped into metal edging strip.

2.13 ACCEPTABLE MANUFACTURERS - DUCT ACCESS DOORS

- A. Greenheck
- B. Ruskin.
- C. Titus.
- D. Substitutions: Under provisions of Division 1.

2.14 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.
- B. Review locations prior to fabrication.
- C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover. Insulation shall be replaceable without field cutting or patching.
- D. Access doors smaller than 12 inches square may be secured with sash locks.
- E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.
- F. Access doors with sheet metal screw fasteners are not acceptable.

2.15 DUCT TEST HOLES

- A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions.
- B. Balancing Dampers

1. Provide at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing. Use splitter dampers only where indicated.
 2. All regulators mounted on externally insulated ductwork shall have 16 gauge elevated platforms at least 1/8 inch higher than the thickness of the insulation. Damper shaft shall have Ventlock No. 607 bearing mounted on ductwork within elevated platform. If duct is inaccessible the operating handle shall be extended and the regulator installed on the face of the wall or ceiling. Where regulators are exposed in finished parts of the building, they shall be flush type, Ventlock No. 666. All regulators shall be manufactured by Ventlock, or approved equal.
 3. All dampers in lined ductwork shall have bushing to prevent damper damage to liner.
 4. Provide cable extensions with adjustable regulators and cover plate for dampers located in locations not accessible such as behind sheetrock ceilings. Regulators shall be equivalent to Young's Regulator.
- C. Provide fire dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- D. Demonstrate re-setting of fire dampers to authorities having jurisdiction and Owner's representative.
- E. Provide back draft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- F. Provide flexible duct connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Provide at least one inch slack at all flexible duct connections.
- G. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated.
- H. Provide duct test holes where indicated and required for testing and balancing purposes.

END OF SECTION 23 91 00

SECTION 23 95 00 ENERGY MANAGEMENT AND CONTROL SYSTEM (EMCS)

PART 1 - GENERAL

1.1 GENERAL

- A. The Energy Management and Control System (**EMCS**) shall be comprised of a Local Area Network (**LAN**) infrastructure, Operator Workstations (**OWS**), Engineering Workstations (**EWS**), a Primary Network Server (**PNS**), Network Area Controllers (**NAC**), Application Specific Controllers (**ASC**), Unitary System Controllers (**USC**), and Field Devices installed within the facility.
- B. The Workstations, Primary Network Server, and Network Area Controllers shall be connected by a EMCS Contractor supplied and installed Local Area Network. The LAN shall comply with all IEEE Standards as outlined in: IEEE STD 802-1990: IEEE Standards for Local and Metropolitan Networks, Overview and Architecture.
- C. If the EMCS contractor wishes to connect to the Owner's Wide Area/Local Area Network as part of the control system network, the EMCS contractor shall acquire permission in writing and include the letter in the submittal. Any system that requires connection to the owner's network for communication between NAC, ASC, USC and/or field devices that is submitted without the written permission from the owner shall be rejected. The EMCS Contractor shall coordinate with the Owner and supply all required information.
- D. Access to the system, either locally in the building, or remotely from a central site or sites, shall be accomplished through standard web browsers, via the Internet and/or a local area network.
- E. All EMCS controllers and workstations shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2010, latest revision. Management level TCP/IP Ethernet network speeds shall be 1 Gbps minimum and the Automation Level MS/TP network speeds shall be 76.8 Kbps minimum.
- F. The Server shall gather data from the system and generate HTML pages accessible through a conventional web browser from all personal computers (PCs) connected to the network. System shall include any and all software and hardware to support at least 50 simultaneous users. The EMCS shall be compatible with all common web browsers.
- G. Facility Operators shall be able to view and configure systems through the standard web browser and all graphical/data representations shall appear identical, whether the user is on site or viewing via the Internet at a remote location. Standard operator functions such as control point manipulation, configuration and viewing of trends, schedules and alarms shall be performed through the standard browser. Each mechanical system and building floor plan shall be depicted on the operator workstation by point-and-click

graphics.

- H. The EMCS shall directly control HVAC equipment as specified in the Sequence of Operations. Furnish Energy Conservation features such as Optimal Start/Stop, Night Setback, Setpoint Reset logic, and Demand Control Ventilation.
- I. The EMCS vendor shall provide the following additional services as part of this specification: warranty and service during the warranty period; submittals, samples and record documentation; comprehensive startup and testing of the EMCS with documentation; training services for the owner and facility operators; coordination with other contractors and suppliers; operator and technician training program, and shall cooperate fully with the Project Commissioning Agent.
- J. Products furnished under this specification but installed by other.
 - 1. Mechanical devices installed under Division 23 by the mechanical contractor or other suppliers: temperature sensing thermowells; automatic control valves; pipe taps for flowmeters; water pressure sensors and switches; automatic control dampers not installed in air handling unit mixing boxes or louver schedules; damper actuators for variable air volume (VAV) terminal units; mounting cost of controller and actuator for VAV terminal units.
 - 2. Electrical devices installed under Division 26 by the electrical contractor:
 - a. 120 VAC power to controllers and control panels at locations indicated on the drawings. Review and verify that these locations are adequate for the proposed EMCS.
 - b. Interlock wiring to duct mounted smoke detector or fire alarm shutdown relays to HVAC equipment motor starters and variable frequency drives (VFD).
- K. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

1.2 RELATED DOCUMENTS & REFERENCES

- A. Drawings and general provisions of the contract documents, apply to this section including:
 - 1. Division 01 for General Conditions and Supplementary Conditions.
 - 2. Division 21 for fire protection equipment.
 - 3. Division 22 for plumbing equipment and domestic water systems.
 - 4. Division 23 for mechanical equipment, ductwork, and piping systems.
 - 5. Division 26 for electrical equipment, lighting control, and fire alarm systems.
- B. The latest edition of the following standards and codes in effect as approved by the

authority having jurisdiction and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:

1. ANSI MC85.1 - Terminology for Automatic Control.
2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
3. ANSI/ASHRAE Standard 135-2010, BACnet.
4. BTL Mark by the BACnet Testing Laboratories.
5. Uniform Building Code (UBC), including local amendments.
6. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
7. National Electrical Code (NEC).
8. FCC Part 15, Subpart J, Class A.
9. National Institute of Standards and Technology (NIST).
10. IEEE STD 802-1990: IEEE Standards for Local and Metropolitan Networks, Overview and Architecture.

1.3 RELATED WORK IN OTHER SECTIONS

- A. Refer to Division 00 and Division 01 for allowances and related contractual requirements.
- B. Refer to Division 21 for General Fire Protection Provisions and fire suppression pump.
1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP acceptable if IP interface is not available from equipment manufacturer.
 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.
- C. Refer to Division 22 for General Plumbing Provisions, domestic water heating systems, domestic water pumping systems, natural gas meter and domestic water metering.
1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP acceptable if IP interface is not available from equipment manufacturer.
 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.
- D. Refer to Division 23 for General Mechanical Provisions for equipment such as chillers, cooling towers, boilers, pumps, air-handling units, terminal units, ventilation fans,

variable frequency drives, unitary AC units, etc.

1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP acceptable if IP interface is not available from equipment manufacturer.
 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.
- E. Refer to Section 26 for General Electrical Provisions for equipment such as electrical switchgear control, electrical power monitoring, emergency generators, lighting control system, etc.
1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP acceptable if IP interface is not available from equipment manufacturer.
 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.

1.4 ELECTRICAL POWER PROVISIONS

- A. Primary power will be provided under Division 26 by the electrical contractor to the panel locations indicated on the mechanical & electrical drawings. Provide step down transformers within panel enclosures. Provide all necessary fuses and circuit protection devices
- B. Power will be provided to the controllers serving fan powered terminal units with electric heat via the control transformer provided with the unit.
- C. All components of the EMCS shall be powered from the sources above. Provide final terminations from the locations indicated on the Division 23 Drawings.
- D. The EMCS Contractor shall provide any additional control power that is required as part of this contract and not indicated by other. This shall include all conduit, cabling, circuit breakers, etc.

1.5 CONTRACTOR QUALIFICATIONS

- A. The EMCS Contractor shall:
1. Have a local staff of trained personnel capable of giving instructions and providing routine and emergency maintenance on the EMCS, all components and software/firmware and all other elements of the EMCS.

2. Have a proven record of experience in the supply and installation of equivalent BACnet systems over a minimum period of five years. Provide documentation of at least three equal and complexity, if so requested by the Owner's Representative.
3. Be a factory certified representative of the native BACnet EMCS manufacturer for design, installation, and service of the proposed system.
4. Have comprehensive local service, training and support facilities for the total EMCS as provided. Maintain local, supplies of essential expendable parts.

1.6 SUBMITTALS

A ALL DOCUMENTS SUBMITTED SHALL BE IN NATIVE PDF FORMAT. NO SCANS.

B Shop Drawings:

1. The following information shall be included on the cover page for each shop drawing and equipment documentation submittal:
 - a. Project name with date. Refer to the applicable specifications by name and number.
 - b. Provide submittal number and re-submittal number and date as applicable.
 - c. Provided name and address of Consulting Engineer, Mechanical Contractor, General Contractor
2. Shop drawings shall be CAD generated, plot size of 8-1/2" x 11" or 11" x 17". Drawings shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all aspects of the system to be installed.
3. Provide schematic of systems indicating instrumentation locations, all interconnecting cables between supplied cabinets on a mechanical floor plan.
4. Software specifications and descriptions including operating sequences.
5. Provide a bill of material that indicates specific manufacturer, part number, part description and quantity of each device for all system components.
6. Provide a list of the wire labels to be installed on each end of the control wiring, at the device and the control panel terminal. Labels shall be machine generated, typed and legible with a maximum of 17 characters. The label description "AHU-1 SAT" shall indicate the supply air temperature of AHU-1.
7. Equipment Schematic: Provide an electronic equipment schematic for each piece of mechanical equipment. The schematic shall display all mechanical equipment characteristics including fans, dampers, valves, sensors and other applicable control devices. The schematic shall show wiring terminations to each control device as shown in the submittal and as-build documentation. Control devices shall be labeled by a symbol that can easily be identified in a bill of material that is shown on this graphic. The bill of material shall show the

- device symbol, description, manufacture and part number.
8. Sequence of Operations: The control sequences shall be viewable for each piece of mechanical equipment and be in a text format as shown in the as built documentation. The sequence of operations shall be selectable at the applicable location for the control program.

C. Control component submittals:

1. Component technical data sheets with mounting and installation details.
2. The documentation shall include comprehensive and complete details of the BIBB and automation level documentation including address, associated controller type, etc. as required and for the interface to the EMCS.
3. Details of networks/communications equipment, cabling and protocols proposed. Provide schedule of cabling including details of proposed cable types.
4. Module Drawing: Provide an electronic wiring diagram of each control module (as shown in submittal documentation). Diagram shall display wiring schematic and terminations to end devices. Diagram shall display each input and output terminals and label those that are used for the control application. Diagram shall display module type/name and network address.
5. Field sensor and instrumentation specification sheets. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.
6. Schedule and specification sheets for dampers, valves and acutators.
7. Design and provide layout of all components of panel mounted control devices, terminal strips and power supplies.

- D. Colorgraphics: Provide sample layout of color graphic representations of the systems for review. The submittal shall indicate the quality of the graphic to be provided with the system with a sample of the specific control points to be included. Control points shall as a minimum include points indicated in the input/output summary, control schematic and primary controlling points defined in the sequences of operation. Provide a sample of a floor plan layout, typical AHU, terminal unit, outside air pretreatment unit, variable frequency drive, exhaust/supply fan, chiller plant and hot water plant. For control points to be provided by equipment BACnet integration provide sample of the control points, up to 25 total.

- E. Verification Reports. The submittal shall include a sample of the verification reports to be utilized during the verification section of this specification. Sample reports shall be approved as submitted or be modified by the engineer or owner's representative. The verification reports shall be included in the final Operation & Maintenance Manuals. Reports shall be provided in electronic PDF format.

1. Project Systems Verification Form for each controller.

- a. General information for each form shall include: project name; associated equipment with mark number; control panel number and location; controller number and model number; controller device instance number (address); MS/TP LAN segment number; verifying technician and date.
 - b. Each connected control point and device shall contain the following columns with a separate line for each connected physical point: point description (same as device label); input/output number for each connected control device (AI-XX, AO-XX, DI-XX, or DO-XX).
 - c. Check boxes confirming that the verification tasks have been completed: device location, proper termination at device; proper termination at control panel; sequence is verified; point trend is enabled.
 - d. Data entry boxes indicating measured/confirmed values: preliminary control point value on the graphic; observed control point value; calibration or adjustment value to correct offset; final displayed point value on the color-graphic; date of verification; engineer or owner's representative verification.
 2. Control Panel Verification Form for each control panel.
 - a. General information: panel location and identification number; panel dimensions and NEMA rating; panel properly installed; Class 1 and Class 2 wiring are properly separated; correct voltage to the panel; no shorts or grounds in panel; no induce voltages in panel wiring; point to point termination match submittal; devices are mounted in the correct location; controller software revision number; address of controllers; panel device checkout is complete; panel startup is complete.
 3. **Sequence of Operation Verification Form** per piece of equipment (AHU, VAV, chiller, boiler, etc.).
 - a. General information: project name; system identifier; building area served; control panel and controller numbers; controller model number and instance number (address); MS/TP LAN segment number; name of verifying technician and date.
 - b. Each step of the sequence of operation for each piece of equipment shall be documented shall include a "description of test", "input to trigger test" and "expected outcome". A pass/fail checkbox shall indicate each of these actions. Provide space for technician approval with associated date.
- F. Operating and Maintenance (O&M) manuals: Provide O&M manual with full information to allow the owner to operate, maintain and repair installed products. Include trade names with model numbers, color, dimensions and other physical characteristics.
1. Format: Produce on 8-1/2 x 11-inch pages, and bind in 3-ring/binders with

durable plastic covers. Label binder covers with printed title "OPERATION AND MAINTENANCE MANUAL", title of project, and subject matter and "Number _ of _" of binder. Provide substantial dividers tabbed and titled by section/component number.

2. Table of Contents for each volume:

- a. Part 1: Directory with name, address and telephone number of Designer, Contractor and Subcontractors and Suppliers for each Project Manual section.
- b. Part 2: Operation and maintenance instructions, arranged by Project Manual Section number where practical and where not, by system. Include:

3. Product design criteria, functions, normal operating characteristic and limiting conditions. Installation, alignment, adjustment, checking instructions and troubleshooting guide. Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown. Test data and performance curves.
4. Spare parts list for operating products, prepared by manufacturers including detailed drawings giving location of each maintainable part, lists of spares recommended for user- service inventory and nearest source of in-stock spares.

G. Record Documentation:

1. Details of all alarm, diagnostic, error and other messages. Detail the Operator action to be taken for each instance.
2. Detail special programs provided and provide a complete programming instruction manual. Detail operation of all software applications.
3. Detailed list of the database for all installed devices.
4. Record drawings shall be CAD generated and shall include final locations and point ID for each monitored and controlled device.
5. In addition to the required hard-copies, provide a CD-ROM with all of the record documentation in PDF format and a CD-ROM containing backup copies of all installed software and graphics.
6. Online as-built documentation: provide digital replications of as-builts that shall be accessible from each equipment graphic controlled or monitored by the EMCS.

1.7 WARRANTY

- A. Warranty work and the equipment provided under this contract shall be for a period of one year from the date of Substantial Completion. Warranty shall cover all components, system software, parts and assemblies supplied by this contractor and shall be guaranteed against defects in materials and workmanship for one (1) year from the

date of Substantial Completion. Labor to troubleshoot, repair, reprogram or replace system components that have failed due to defects in materials and workmanship shall be provided by this contractor at no charge to the owner during the warranty period. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks. All warranty work shall be performed by the EMCS contractor's local service group.

- B. Warranty shall not include routine maintenance, e.g., equipment cleaning, mechanical parts lubrication, pilot lamp replacement, operational testing, etc. Warranty shall not cover repair or replacement of equipment damaged by under- or over-voltage, misuse, lack of proper maintenance, lightning, water damage from weather or piping failure.
- C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the EMCS contractor. The maximum acceptable response time to provide this service at the site shall be 24 hours, during normal working hours.

1.8 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration that includes hands-on demonstration of the manipulation of setpoints, schedules and other adjustable elements of the system.
 - 7. The demonstration shall be on the actual, completed graphic interface pages for the specific project.
- B. Provide a second training session 3 months after initial session for any follow-up or additional training requested by owner's personnel. Allow 3 hours for the second training session.

1.9 OPERATOR WORKSTATION (OWS)

- A. The Operator Workstation shall be any personal computer, connected to the LAN, with appropriate web browser software installed.

1.10 ENGINEERING WORKSTATION (EWS)

- A. The Engineering Workstation shall be any personal computer, connected to the LAN, with a registered copy of the EMCS contractor supplied engineering and/or programming software installed. The EMCS contractor shall provide at least one copy of all required software(s), to enable the Owner complete editing/programming functions of all controllers, graphics, and control logic.
- B. The EMCS shall provide one personal computer (PC) which is compatible with the performance required by the EMCS Engineering Software if an engineering workstation is specified for the system.

PART 2 - PRODUCTS

2.1 THE ACCEPTABLE EMCS VENDORS ARE, each shall be submitted as alternates.

- A. SCHNEIDER ELECTRIC – Branch Office
- B. JOHNSON CONTROLS – Branch Office
- C. SIEMENS – Branch Office

2.2 PRIMARY NETWORK SERVER (PNS)

- A. The EMCS Contractor shall provide and install the Primary Network Server as part of this system. The PNS shall utilize the Internet and provide efficient integration of standard open protocols. The PNS shall maintain comprehensive database management, alarm management and messaging services, and graphical user interface as follows:
 - 1. Support an unlimited number of users over the Internet/intranet with a standard web browser to access alarms, trend logs, graphics, schedules and configuration data. Access to the PNS shall be password protected utilizing authentication and encryption techniques. An audit trail of database changes indicating user, time stamp, and audit action shall be provided.
 - 2. Enterprise level information exchange using an SQL database and HTTP/HTML/XML text formats.
 - 3. Synchronize controller databases, database storage scheduling, control and energy management routines
 - 4. Alarm processing and routing which includes email, SMS text messages and paging.
 - 5. HTML based help system that includes comprehensive online system documentation.
 - 6. Support of multiple Network Area Controllers (NAC) connected to a Local Area Network.

B. Server Functions

1. It shall be possible to access all Network Area Controllers (NAC) via a single connection to the server through the Ethernet LAN. In this configuration, each Network Area Controller can be accessed from a single user login.
2. The PNS shall provide the following functions, at a minimum:
 - a. The server shall provide complete access to distributed global data. The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.
 - b. The server shall include a master clock service for its subsystems and provide time synchronization for all NACs.
 - c. The server shall provide scheduling for all NACs and their underlying field control devices.
 - d. The server shall provide demand limiting control that operates across all NACs. The network server shall be capable of multiple demand limiting programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
 - e. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to NACs. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
 - f. The server shall provide central alarm management for all NACs supported by the server. Alarm management shall include: routing of alarms to a video display, a printer, an email and pager; view and acknowledge alarms; query alarm logs based on user-defined parameters
 - g. The server shall provide central management of logged data for all NACs supported by the server. Logged data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include: viewing and printing log data; exporting log data to other software applications; query log data based on user-defined parameters
3. The Primary Network Server shall be capable of supporting the following open system drivers;
 - a. BACnet/IP
 - b. Modbus TCP

C. Network Server Platform Requirements

1. Rack-Mounted Server Computer Hardware: DELL PowerEdge R220 or equal, Intel Pentium Core 2 Duo 2.0 GHz or higher, 8GB RAM, 500GB harddrive, video

- card, 22" color monitor, and Ethernet adapter 1Gbps or higher.
2. Operating system software shall be Microsoft Windows 7 Professional or higher.

2.3 NETWORK AREA CONTROLLER (NAC)

- A. Provide one or more Network Area Controllers (NAC) to meet the sequence of operations and the type and quantity of devices being integrated into the system. The NAC shall provide the interface between the local area network and the field controllers. The NAC shall provide global supervisory control functions over the associated controllers and shall be capable of executing application control programs to provide: calendar functions; scheduling; trending; alarm monitoring and routing; time synchronization; integration of controller data for each applicable protocol; network management functions for all network devices. The user may view real-time information via web-based data.
- B. The Network Area Controller shall provide the following hardware features as a minimum: Ethernet Ports 100Mbps or higher, BACnet MS/TP ports, battery backup, DDR RAM memory, flash memory for long term data backup.
- C. Provide an uninterruptible power source (UPS) per network controller to maintain operation for 1 hours.
- D. The NAC shall be capable of operation over a temperature range of 32 to 122 °F and operation over a humidity range of 5 to 95% RH, non-condensing; storage temperatures of between 32 and 158 °F.
- E. The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- F. The NAC shall be capable of supporting the following open system drivers;
 1. BACnet/IP
 2. BACnet MS/TP
 3. Modbus TCP
 4. Modbus RTU
- G. Event Alarm Notification and actions: The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. Alarm conditions shall be routed to any defined user location whether connected to a local or wide-area network.
 1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to: alarm; return to normal; fault.

2. Provide for the creation of a minimum of eight alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc. Allow timed routing of alarms by class, object, group, or node.
 3. Provide alarm generation from binary object “runtime” and/or event counts for equipment maintenance (i.e. filter status, fan run status). Authorized users shall be able to reset runtime or event count values with appropriate password control.
 4. Control equipment and network failures shall be treated as alarms and annunciated.
 5. Alarms shall be annunciated in any of the following manners as defined by the user: screen message text; e-mail of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on: day of the week, time of day and recipient.
 6. Color-graphic shall have flashing alarm object(s). Printed message may be routed directly to a dedicated alarm printer.
 7. The following shall be recorded by the NAC for each alarm (at a minimum): time and date; location (building, floor, zone, office number, etc.); associated equipment. Upon acknowledgement of the alarm the NAC shall document the time, date and authorized user. The number of alarm occurrences since the last acknowledgement shall be recorded.
 8. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user. Alarm actions may be initiated by user defined programmable objects created for that purpose.
 9. Alarm archiving: A log of all alarms shall be maintained by the NAC and/or a server and shall be available for review by the user. Provide a “query” feature to allow review of specific alarms by user defined parameters. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- H. Data Collection and Storage: The NAC shall have the ability to collect data for any property of any object and store this data for future use.
1. The user shall designate the log as an interval log or deviation log. For an interval log, the object shall be configured for time of day, day of week and the sample collection interval. For deviation log, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
 2. All log data shall be stored in a relational database in the NAC and the data shall be accessed from the server or a standard web browser. All log data, when accessed from the server, shall be capable of being manipulated using standard SQL statements.

3. All log data shall be available to the user in the following data formats: HTML, XML, plain text, comma separated values, as a minimum.
 4. The NAC shall have the ability to archive its log data either locally or remotely to the server or other NAC on the network.
- I. Local Access: The NAC shall provide redundancy of system access to the local controllers at the remote building if the Primary Network Server should lose communication or be off-line. The NAC shall maintain setpoint and scheduling features, access to the color-graphic displays, maintain trend logs and reports. Upon restoration of communication with the PNS the archived information shall be transmitted to the server for archiving.

2.4 SOFTWARE FOR THE NAC

- A. The distributed architecture of the operating system for the PNS and NACs shall provide the operator a comprehensive interface to allow the operator to configure and customize the EMCS to optimize the HVAC system to save energy, schedule and maintain equipment and provide occupant comfort. The provided graphical toolset shall allow the operator to create applications in a drag and drop environment.
1. Input/output capability shall allow the operator to request the current value or status of the control point; command/override equipment to a specific state; add, change or delete control points, alarm limits and controllers; change descriptors to control points and equipment; modify parameters; create or modify DDC loops.
- B. Operator System Access: Via software password with five access levels at workstations and at each control unit.
- C. Color graphic tools shall allow the user to create equipment and floor plan graphics from a standard library of symbols; allow custom generation of symbols; utilize over 64 or more colors; create real-time dynamic data for the graphics. Up to 60 control points may be displayed on each graphic.
1. Provide a link between compatible graphics to minimize the paths to additional information. For example provide the link from the zone sensor to the VAV terminal to the air handling unit and to the central plant. Web pages shall be provided to allow the operator to zoom into specific areas of the facility and then link the space to the floor plan to the overall building and then to the facility site plan.
 2. Graphical tools shall allow the creation of bar graphs, pie graphs and other tools to visualize control information such as run time hours, energy consumed and occupant comfort.
- D. Alarm processing tools shall allow the operator to create alarm messages that include as a minimum: time of alarm, point descriptor, alarm condition and remote annunciation.

Critical alarms shall be displayed, archived to a storage device or printed on a alarm printer. Alarms shall be displayed in order of occurrence and have an optional audible alarm indicator.

1. Print alarm messages, up to 60 characters in length, for each alarm point specified.
 2. Alarms may be routed to other devices including web-enabled cell phones, pagers, tablet PCs and designated personal computers on the network or Internet.
 3. Operator specifies when alarm requires acknowledgment. Continue to indicate unacknowledged alarms after return to normal. An alarm log shall be maintained to archive alarms for future reference with the above specified parameters as well as indicating the person acknowledging the alarm.
 4. The graphical display shall indicate the number of the current unacknowledged alarms by individual building site or by sum of all campus-wide facilities.
 5. The operator may create and forward an e-mail message to another user directly from the graphical interface so that the message can be read when the second user logs on to the system.
- E. Upon a power failure to equipment in the facility, the EMCS shall automatically start equipment upon the restoration of power. Program a time delay between individual equipment restart on a schedule to minimize demand charges from the utility company.
- F. Custom reports may be created by the operator with a requested time and date manually or automatically. All reports may be logged to a storage device for future reference. The data reports shall allow customization and scaling of the X-Y coordinates; plotting of tabular reports; provide multi-point graphical reports with not less than eight variables on the same report. Print reports on daily, weekly, monthly, yearly or scheduled basis as scheduled.
- G. The network server current operating system, database, color-graphics, custom reports shall be backed up automatically to a remote server or storage device as directed by the owner's representative.
- H. Maintenance Management capability shall allow the system to monitor and log the run-time for HVAC equipment; schedule maintenance reports that include recommended material and labor for the assigned task.

2.5 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. All devices required for single loop control shall be terminated on a single controller. (for example, CHW loop pressure control. The differential pressure sensor and the pump VFD ramp signal.)
- B. ASCs shall be capable of implementing control strategies for the system based on information from any or all connected inputs. The AC shall utilize factory pre-

programmed global strategies that may be modified by field personnel on-site. Global control algorithms and automated control functions should execute via a 32-bit processor

- C. Programming shall be object-oriented using control program blocks that will support a minimum of 500 Analog Values and 500 Binary Values. Analog and binary values shall support standard BACnet priority arrays. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing.
- D. Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1 year (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium type. The onboard, battery-backed real time clock must support schedule operations and trend logs.
- E. The base unit of the ASC shall host various I/O combinations including universal inputs, binary outputs, and switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.
- F. All binary outputs shall have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. The position of each HOA switch shall be available system wide as a BACnet object.
- G. Controller shall be capable of BACnet communication. BACnet Conformance:
 - 1. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. All necessary tools shall be supplied for working with proprietary information.
- H. Schedules: Each ASC shall support a minimum of 10 BACnet schedule objects.
- I. Logging Capabilities: Each controller shall support a minimum of 100 trend logs. Sample time interval shall be adjustable at the operator's workstation. Controller shall periodically upload trended data to system server for long term archiving if desired. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
- J. Alarm Generation: Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures. Alarm logs shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects – system

destination and actions individually configurable.

2.6 UNITARY SYSTEM CONTROLLERS (USC)

- A. All devices required for single loop control shall be terminated on a single controller. (for example, cooling coil control valve control. The temperature sensor and the valve control signal.)
- B. The EMCS Contractor shall provide all Unitary System Controllers. USCs shall be fully programmable or applications specific controllers with pre-packaged operating sequences maintained in Flash RAM.
- C. The USC shall be a node on the automation network and shall control its own communications so that the failure of any one node, shall not inhibit communications on the network between the remaining nodes. USCs shall be totally independent of other network nodes for their monitoring and control functions.
- D. Provide each USC with a battery back-up for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a seven year life.
- E. All associated applications programs shall reside at the USC. The USC shall not require communication to any other panel for normal operating sequences other than time scheduled base commands.
- F. Control shall be based on algorithms, i.e. proportional plus integral plus derivative (PID), proportional plus integral (PI), or proportional to comply with the sequences of operation PID algorithms shall maintain the system operation within +/- 2% of setpoint.
- G. The USC shall be configured with sufficient input/output capacity to achieve the required control points to meet the sequence of operations.

2.7 VAV TERMINAL UNIT CONTROLLER (TUC)

- A. All devices required for single loop control shall be terminated on a single controller. (for example, terminal unit air valve control. The flow sensor and the actuator control signal.)
- B. The EMCS Contractor shall provide all controllers required for all variable air volume (VAV) terminal units. The number and location of terminal units and airflow rates shall be as indicated on the mechanical drawings.
- C. The TUC shall be capable of monitoring and controlling the following parameters for VAV terminal units per the sequences of operation and input/output summary: space temperature; primary air flow rate; damper modulation; heating coil stage control,

heating valve control, heating SCR control (as applicable); fan on/off control; supply air sensor; occupancy sensor; carbon dioxide sensor or humidity sensor.

- D. Furnish primary damper actuators, for factory mounting, meeting the following requirements: direct shaft mounting; adequate torque, to properly operate the damper from fully open to fully closed without binding; locking "V" groove or similar means to prevent slippage between actuator and shaft.
- E. The EMCS Contractor shall field install the following components for each terminal unit: space temperature sensor; supply air temperature sensor; occupancy sensor, and carbon dioxide sensor as indicated on the Mechanical Drawings.
- F. The EMCS Contractor shall furnish to the terminal unit manufacturer the following components for factory installation and wiring for each terminal unit: VAV controller with integral differential pressure transducer and damper actuator.
- G. The terminal unit manufacturer may provide the following components for each terminal unit for interface and mounting of the TUC: primary air dampers; enclosure to house the TUC and associated components including suitable mounting brackets shall be NEMA 1 rating and located outside the terminal unit; multi-point averaging type flow sensor at the primary air inlet to the terminal unit; 24 VAC control transformer; 24 VAC fan control relay interface; 24 VAC heater control relay interface (up to two stages); 24 volt SCR heater input as scheduled (0-10 Vdc or 4-20 mA).
- H. Any items required for proper operation but not provided by TU vendor, shall be provided under this section.

2.8 AIR HANDLING UNIT CONTROLLER

- A. All devices required for single loop control shall be terminated on a single controller. (for example, AHU static pressure control. The differential pressure sensor and the VFD ramp signal.)
- B. The EMCS Contractor shall provide controllers required for chilled/hot water and DX/electric heat air handling units and fan coil units. Provide an enclosure to house the controller and associated components including suitable mounting brackets shall be NEMA 1 rated and located outside the FCUs.
- C. The controller shall be capable of monitoring and controlling the following parameters per the sequences of operation and input/output summary; space temperature; space relative humidity sensor ; cooling/heating stage control or modulating valve control; fan on/off control and status; supply air sensor; occupancy sensor; carbon dioxide sensor; VFD control and monitoring.

2.9 EMCS CONTROLLER LEVEL NETWORK

- A. EMCS Automation Level Network shall consist of BACnet MS/TP (76.8 Kbps minimum). Data transfer rate and data throughput as required to meet the alarm annunciation requirements.

2.10 SOFTWARE OVERVIEW

- A. **Dynamic Colored Floor plans:** Dynamic colored floor plans that compare actual space conditions to setpoints shall be provided on all floorplan graphics displayed on the front-end. Floorplan enlargements shall also use the thermographs to display space conditions. Zones within the set point range shall appear transparent white. As the space gets warmer the zone color shall gradually modulate from transparent white to transparent red to identify a hot zone. As the space conditions get cooler the zone color shall gradually modulate from transparent white to transparent blue to identify a cold zone. Each zone shall indicate the current actual zone temperature within the zone. The floor plans shall use a dynamic scheduling icon to indicate schedule occupancy for each zone and provide direct one-click access to that zones unique schedule. Provide a designated icon or symbol indicating that the zone is in the occupied/unoccupied condition. From the floorplan graphic, the operator shall be able to click on any zone and go directly to the graphic for the piece of equipment controlling that zone. All dynamic floor plans shall be visible via web interface as well as on the LAN. The authorized system operator shall be able to change the zone or system identifier (or name) on the graphic and that change shall be distributed to other associated graphics and to the equipment controller.
- B. **Pop up Trends:** Provide trend logs that automatically pop up when the operator mouse clicks on the point from the graphic. Provide pop up trends for all dampers, control valves, temperature sensors, carbon dioxide sensors, humidity sensors, airflows, static pressures, flow meters, VFD speeds, etc. The EMCS contractor shall set up all trends for the owner. The pop-up trend shall include a trend tool that allows the operator to modify the trend time scale and sample interval for up to 10 sample values. The trends shall be graphical on the computer screen but shall provide an output as an .xls, .csv, .pdf, HTML, r text file.
- C. **Interactive Maps:** Implement JAVA SCRIPT API 3.0 or newer, such as Google Interactive maps depicting the facility location to indicate the site plan. This is not a static image and must be completely interactive.
- D. **Custom User HTML applications:** The EMCS shall utilize HTML applications as an extra feature. At minimum, provide 7-day forecast, weather radar, traffic map and hurricane tracker. All of these features shall be imbedded into the EMCS system.
- E. Provided a web-based EMCS platform; contractor shall provide an Open License software. Licenses that are not open are not acceptable. There shall be no per seat or

per user licensing fee charged to the owner by the contractor.

- F. System shall use the **BACnet** protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, setpoints, trends, and alarms shall be BACnet Objects.
- G. **User access** shall include 50 assigned operators that shall include five levels of access within the web system. Each operator log-in shall have an expiration date to allow for temporary access to the system. The operator's access description shall include his e-mail address and cell/phone numbers. The operator access can be limited from 5 minutes to permanent access. The user shall be limited to eight bad login attempts before being locked out of the system.
- H. **Global modification:** Provide the capability for global modification of user definable parameters of all points shall be provided. Global modification is defined as the mass adjustment of user definable parameters across a defined group, area, facility, campus, or network. Parameters shall include, but not be limited to temperature set point (VAV boxes, AHU Discharge, VAV AHU Static Pressure Setpoints etc.), equipment start/stop, equipment status, valve output signal, VFD speed control signal, and damper position signal. User shall be able to lock the definable parameter to a set value, or adjust a set point to an operator adjustable value. This function shall be accomplished through the standard graphical user interface/workstation and is to be selectively applicable by the user to all controllers on the network, all controllers in a specific facility or all controllers in a specific zone within a specific facility.
- I. The system operator shall be able to override the output signal to the valves, dampers, variable frequency drives, etc. with the use of the PC mouse click on the device. The system override shall include a **Hand-Off-Auto (HOA)** capability. If the output is commanded to the hand position the operator shall designate an output value of 0-100% in 1% increments. The hand override position shall be permanent or expire after a designated time period and revert to the auto position. The color-graphic shall indicate the device that has been overridden by a color change of the output value.
- J. For non-emergency in-warranty events the system operator may submit a **Service Request** directly from the floor plan or system graphic. The web interface shall include the EMCS suppliers contact information including phone numbers and e-mail address. The service request will be logged into the EMCS suppliers service department. A non-response by the assigned technician shall elevate the request to the next highest manager or supervisor until the system operator receives an response that their request has been received and is scheduled for a resolution. All requests for service shall be maintained in the customer's database for future reference. The service request capability may be extended after the expiration of the warranty as part of a service agreement.
- K. The web-based system shall be accessible from **Tablet PCs** and provide the same

functionality that is available from personal computers connected through the LAN or WAN to the system operator. The tablet PCs as a minimum shall include an Apple iPad and Google Android based tablet PC. Operation shall include touch screen capability and use of the tablet keyboard screen. The operator shall be able to view color-graphics, system trends, override setpoints, change time schedules, and override damper and valve positions.

2.11 ENERGY SAVING PROGRAMS

- A. Demand Limiting: Monitor total power consumption for each power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
- B. Duty Cycling: Periodically stop and start loads, based on space temperature, and according to various on/off patterns.
- C. Automatic Time Scheduling: Self-contained programs for automatic start/stop/scheduling of building loads. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary schedules.
- D. Optimal Start/Stop: Perform optimized start/stop as function of outside conditions, inside conditions, or both. Optimization shall be adaptive and self-tuning, adjusting to changing conditions by modifying occupancy period based upon the desired temperature at beginning and end of the occupancy period. Base optimization on occupancy schedules, outside air temperature, seasonal requirements, and interior room temperature. Employ adaptive model prediction for how long building takes to warm up or cool down under different conditions.
- E. Night-Setback Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours in conjunction with scheduled start/stop and optimum start/stop programs.
- F. Setpoint Reset: Setpoints for control of variable load systems shall be reset based on load demand, as described in the Sequence of Operations.
- G. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.
- H. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.
- I. Holiday Scheduling
- J. Direct Digital Control: Furnish software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms

and choosing optimum loop parameters.

- K. Trend logging shall be provided for all points per the input/output summary where there is a change in the analog or binary signal. Each controller shall be capable of storing trend values and then automatically transfer data to the NAC or the NS hard disk. Trend data shall be updated continuously per the operator assigned interval at intervals as low as one minute. Collect samples at intervals specified in minutes, hours, days, or month. Output trend logs as line-graphs or bar graphs. Binary points (input and output) shall only be logged upon a change of value (COV). Display trend samples on workstation in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time versus data.

2.12 FIELD INSTRUMENTATION

- A. Temperature Sensors: All temperature sensors shall be thermistor type, factory-calibrated to within 0.5 °F, interchangeable with housing appropriate for application. Sensors shall have a temperature curve rated for the application. Sensor wiring terminations shall be in a galvanized box.
 - 1. Outside air temperature sensors shall be installed in weather proof enclosure with ventilated sun-shield
 - 2. Duct mounted temperature sensors shall be averaging type for supply air, mixed air and low temperature applications for air handling units. Duct probe temperature sensor shall be acceptable for terminal units.
 - 3. Space temperature sensors shall contain a backlit LCD digital display and user function keys along with temperature sensor, setpoint adjustment and after-hours override use. Override time may be set in one-hour increments.
 - 4. Thermowell temperature sensors shall be stainless steel probe of length that is equivalent to a minimum of 50% of the pipe diameter. End-to-end accuracy shall be ± 0.5 deg. F. Connection box shall be moisture/water proof with conduit fitting. Furnish the stainless steel thermowell to the mechanical contractor for installation. A thermal conducting grease shall be installed in the thermowell to provide uniform temperature sensing.
 - 5. Provide flat plate stainless steel space temperature sensors with no local setpoint adjustment as indicated on the drawings.
- B. Carbon Dioxide Sensors: The sensor shall be capable of monitoring carbon dioxide concentration with an accuracy of ± 30 parts per million (PPM). The sensor shall produce a linear 0-10 VDC or 4-20 mA signal over the range of 0 to 2000 PPM. The sensor shall measure using non-dispersed infrared (NDIR) technology to measure carbon dioxide gas and shall be;
 - 1. Wall mounted carbon dioxide sensors shall be Veris CWE series or equivalent.
 - 2. Duct mounted carbon dioxide sensor shall be Veris CWD series or equivalent.

3. The EMCS contractor shall utilize the required calibration devices to properly commission and calibrate the sensors per the manufacturer's requirements.
- C. Relative Humidity Sensors: relative humidity sensors shall be a two-wire type, 4-20 mA output proportional to the relative humidity range of 0-100%. The accuracy of the sensors shall be +3% over a range of 5-95% RH.
1. Outdoor relative humidity sensors: provide non-corroding outdoor shield to minimize wind effects and solar heating. Install wall-mount weather proof enclosure with conduit fitting. Sensor shall be Veris HO series, or equivalent.
 2. Wall-mounted relative humidity sensor: sensor shall be installed in a wall-mounted enclosure with white cover. Sensor shall be Veris HEW series or equivalent.
 3. Duct-mounted relative humidity sensor: sensor shall be provided with a moisture resistant enclosure with conduit fitting. The probe length shall be 8" minimum. Sensor shall be Veris HED series or equivalent.
- D. Pressure Transducers:
1. Air pressure sensor: The pressure sensors shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 VDC or 4-20 mA. Sensor shall be SETRA Model 264 or equivalent.
 2. Water pressure sensors: The pressure sensors shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 VDC or 4-20 mA. Sensor shall be SETRA Model 230 or equivalent. Sensor shall be installed with a valved piping bypass and bleed off for each port.
- E. Freezestat: Provide freezestats for all chilled water air handling systems that receive more than 10% untreated outside air. Freezestats shall provide vapor tension elements, which shall serpentine the inlet face on all coils. Provide additional sensors, wired in series, to provide one linear foot per square foot of coil surface area. Freezestat shall be manually reset at the switch. Interlock to the associated fan so that fan will shut down when HOA switch is in hand or auto position. Provide time delay relays with a 0-10 minute time delay relay duration to minimize nuisance freezestat trips. Time delay relay shall be adjustable at the associated control panel.
- F. Air differential pressure switch: For fan shutdown, provide air differential pressure switches for all fans controlled by a variable frequency drive (VFD) to shut down the associated fan in the event of sensing high differential pressure. Air differential pressure switches shall have an adjustable setpoint with a range of 0-10 inches w.g. with manual reset at the switch. Provide ¼ inch copper tubing with compression fittings to mount to the side of the duct. Sensor shall be DWYER Series 1620 or equivalent.

- G. Momentary control relays: Provide momentary control relays as indicated. . Relays shall have coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application. Contact ratings shall be 10 amp. Provide complete isolation between the control circuit and the digital output. Relays shall be located in the UC or other local enclosures and have pin-type terminals. Relays shall have LED indication of status.
- H. Current sensing relay: Current sensing relays shall be rated for the applicable load. The output relay shall have an accessible trip adjustment over its complete operating range. Enclosure shall have an LED to indicate relay status.
- I. Photocell: Ambient light level shall by a photocell in a non-corroding in a weatherproof housing with sun shield suitable for exterior installation. The control signal output shall be 4-20 ma or binary contact closure as specified in the sequences of operation. Mount the photocell on the north side of the building on the roof. The sensor reading shall be 0- 750 foot-candles.
- J. Occupancy Sensors
 - 1. The dual-technology occupancy ceiling mounted sensor shall be capable of detecting presence in the control area by via Doppler shifts in transmitted ultrasound and passive infrared (PIR) heat changes. Sensor shall utilize Dual Sensing Verification Principle for coordination between ultrasonic and PIR technologies. Detection verification of both technologies must occur in order to activate lighting systems. Sensor shall have a retrigger feature in which detection by either technology shall retrigger the lighting system on within 5 seconds of being switched off. The sensor shall operate at 24 VDC/VAC. WattStopper DT- 300 or approve equal.
 - 2. Sensors shall have a time delay that is adjustable with configuration software or shall have a fixed time delay of 5 to 30 minutes, set by a DIP switch. Sensors shall feature a walk-through mode, where lights turn off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.
 - 3. The sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options. The sensor shall have an LED indicator that remains active at all times in order to verify detection within the area to be controlled.

2.13 WATER FLOW METERS

- A. Insertion Turbine Flow Meters shall be provided for HVAC applications in piping larger than 2 inches. The flow meter shall have a stainless steel insertion probe with non-metallic rotors; 2.0 % accuracy of actual reading from 0.4 to 20 ft/s; turndown ratio of 30:1; pulse outputs proportional to flow rate. The flow meter shall be single turbine type on applications with 20 diameters of pipe upstream and 5 diameters of pipe downstream. The flow meter shall be a dual turbine type on applications with less than

20 diameters of pipe upstream and 5 diameters of pipe downstream. Provide full port valve to allow for removal and re-insertion without disruption to the water service, to be installed by Division 23. Meter shall be ONICON F-1200 series or pre-approved substitution.

- B. Inline nutating-disk type flow meters shall be provided for domestic water and cooling tower metering applications. The meter shall include a pulse output for monitoring by the EMCS. Provide meter to be installed by Division 23. Meter shall be Badger RCDL series or approved substitution.

2.14 AIRFLOW MEASURING STATIONS (AFMS)

- A. Duct mounted airflow measuring stations with combination airflow and air temperature measurement devices shall have the following features:
 - 1. Multi-point sensors in one or more probe assemblies with a maximum of one to sixteen sensor nodes per location, and a single remotely mounted microprocessor-based transmitter for each measurement location. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Each sensing point shall independently determine the airflow rate and temperature at each node, which shall be equally weighted in calculations by the transmitter prior to output as the cross-sectional average. Each ducted sensor probe shall have an integral, U.L. Listed, plenum rated cable. Each independent temperature sensor shall have a calibrated accuracy of $\pm 0.14^{\circ}\text{F}$ (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C), and be calibrated at 3 temperatures against standards that are traceable to NIST. Acceptable manufacturer shall be EBTRON, Inc. GTx116-PC.
 - 2. Each transmitter shall have a display capable of simultaneously displaying both airflow and temperature. Airflow rate shall be field configurable to be displayed as velocity or volumetric rates, selectable as IP or SI units. Each transmitter shall operate on 24 VAC and be fused and protected from over voltage, over current and power surges.
 - 3. Each independent airflow sensor shall have a laboratory accuracy of $\pm 2\%$ of Reading over the entire calibrated airflow range of 0 to 5,000 fpm (25.4 m/s), and be wind tunnel calibrated at 16 points against air velocity standards that are traceable to NIST.

2.15 DAMPERS:

- A. Provide motorized volume control and shutoff dampers as detailed in 23 33 00 Ductwork Accessories.

2.16 DAMPER ACTUATORS:

- A. Outside and exhaust air damper actuators shall be mechanical spring return. The

actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.

- B. Outside and return air modulating actuators shall utilize analog (proportional) control 0-10 VDC. Actuators shall be driven in both the open and closed directions.
- C. Electric damper actuators shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
- D. Single section dampers shall have one electronic actuator direct shaft mounted.
- E. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section.
- F. Damper actuators shall be BELIMO or equivalent.

2.17 CONTROL VALVES

- A. Furnish all valves controlled by the EMCS as shown on the Mechanical Drawings. Furnish all automated isolation valves as shown on the Mechanical Drawings. Control valves shall be factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. EMCS contractor to size control valve with a maximum of three psi pressure drop. 2- position isolation valves shall be full-line size.
 - 1. All chilled water, condenser water, and hot water valves shall meet, at minimum, the following ANSI Class 150 ratings. Valves 0.5 inch to 2 inches shall have NPT female screwed ends. Valves 2.5 inches and larger shall have flanged ends.
 - 2. Equal Percentage control characteristic shall be provided for all water coil control valves.
- B. Pressure Independent Characterized Control Ball Valves ½" to 6", for **two-way modulating applications** shall have equal percentage characteristics and control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSI across the valve. The pressure independent control valve shall be provided and delivered from a single manufacturer as a complete assembly. The actuator shall be integrally mounted to the valve at the factory with a single screw on a direct coupled DIN mounting-base. All valve actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow and/or temperature control. Programming using actuator mounted switches or multi-turn actuators are not acceptable. The control

valves shall be sized for the scheduled flow and not pressure drop. Calibrated Balancing Valves and Automatic Flow-Control Valves shall be prohibited from use at coil circuit piping where pressure independent control valves are installed. Contractor shall provide a section of straight pipe five times the pipe diameter with respect to the nominal valve size upstream of the control valve assembly where utilizing integral flow sensor to guarantee sensor accuracy.

1. NPS 3/4" and Smaller: Belimo PIQCV or equal. Forged brass body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, characterizing disc integral to ball, PTFE ball seat, dual EPDM lubricated O-rings, and female NPT union ends. Close off pressure rating of 100 psi. Integral pressure regulator located upstream of ball to maintain a constant pressure differential. Replaceable cartridge type regulators are not permitted.
 2. NPS 1" through 2": Belimo ePIV or equal. Forged brass, nickel-plated body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, PTFE ball seat, dual EPDM lubricated O-rings, stainless steel or TEFZEL characterizing disc, and female NPT union ends. Close off pressure rating of 200 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.
 3. NPS 2-1/2" through 6": Belimo ePIV or equal. GG25 cast iron body according to ANSI 125, Class B, stainless steel ball and blowout-proof stem, PTFE ball seat, with a dual EPDM lubricated O-rings and a stainless steel flow characterizing disc. End connection pattern to match ANSI 125 flange. Close off pressure rating of 100 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.
- C. Characterized Control Ball Valves (CCV) for 1/2' to 2": for **3-way modulating applications** shall have equal percentage characteristics. Manufacturer shall be Belimo or approved equal.
1. Valve housing shall consist of forged brass rated at no less than 400 psi at 250 °F. Three-way valves shall have EPDM O-rings behind ball seals to allow for a minimum close-off pressure of 40 psi with an actuator that provides 35 in-lbs torque for 1/2 to 2 in. sizes. Three-way valves shall be installed in a "tee" configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.
- D. Globe Valves 2-1/2" to 6": for **3-way modulating applications** shall have equal percentage characteristics. Manufacturer shall be Belimo G7 series or approved equal.
1. Valve housing shall consist of cast iron rated at no less than 125 psi at 300 °F. Valve shall have stainless steel stem, plug and seat. Three-way valves shall be installed in a "tee" configuration with actuator perpendicular to the shaft.

Confirm mixing or diverting application for correct valve selection.

- E. Butterfly valves: For chiller and cooling tower isolation control valves, butterfly control valves may be provided.
 - 1. Butterfly Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats. Butterfly valves shall have ductile iron body, 304 stainless steel disc and EPDM seat. The valve body close- off pressure rating shall be 150 psi over a range of -20 F to 250 F. The flange shall be ANSI 125/250. Belimo F6 and F7 series or approved manufacturer.
- F. Actuators for characterized control valves and globe valves: Provide electric actuators for all control valves that are furnished as part of the EMCS contract. Two-way and three- way control valve actuators shall meet, at minimum, the following requirements:
 - 1. Motor driven type with gear assembly made of hardened steel. Actuator shall have an input voltage of 24 VAC. Interior actuator housings shall be NEMA-2 rated. Exterior housings shall require a weather shield or shall be NEMA-4 rated. Provide visual mechanical position indication
 - 2. Valves shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head. Actuators shall control against system maximum working pressures.
 - 3. Normal and failure positions shall be as indicated in the operating sequences. Provide spring return action per the sequences.
 - 4. Manual declutch lever to enable manual operation of the valve. It shall be possible for an operator to manually modulate valves located in mechanical rooms in the event of loss of power.
 - 5. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
 - 6. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
 - 7. Electric actuators shall be Belimo, compatible with the valves furnished.
- G. Butterfly Valve Industrial Actuators
 - 1. Enclosure shall be NEMA 4 (weatherproof) enclosure and will have an industrial quality coating.
 - 2. Actuator shall have a motor rated for continuous duty. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on a

- 120 VAC, 1 phase, 60 Hz supply. Two adjustable cam actuated end travel limit switches shall be provided to control direction of travel. A self-resetting thermal switch shall be imbedded in the motor for overload protection.
3. Reduction gearing shall be designed to withstand the actual motor stall torque. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
 4. Actuator shall have a 6 ft wiring harness provided for ease in field wiring (above 1500 in-lbs). Two adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC shall be provided for indication of open and closed position. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
 5. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator and when in manual operation electrical power to the actuator will be permanently interrupted. The hand wheel will not rotate while the actuator is electrically driven.
 6. The actuator shall be analog, floating, or two position as called out in the control sequence of operation. All analog valves shall be positive positioning, and respond to a 2-10 VDC, 4-20 mA, or adjustable signal as required. Analog actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.
 7. Butterfly valve actuators shall be Belimo furnished with specified butterfly valves.

2.18 PANELS AND ENCLOSURES

- A. Provide panels and enclosures for all components of the EMCS, which are susceptible to physical or environmental damage.
- B. Interior panels and enclosures shall meet be NEMA 1 rated painted steel panels with locking door.
- C. Exterior mounted panels and enclosures shall be NEMA 4 painted steel panels with locking door.
- D. Panels for USCs shall be mounted on the outside of all unit ventilators and fan coil units with three feet of wall clearance in front of them and no higher than 7 feet to the bottom of the panel.

2.19 LABELING and WARNING NOTICES

- A. Provide labeling for all control panels and enclosures.

- B. Provide labeling of all control wires and input/output points at the controller and at the control device; the label at each end of the wire shall be the same. Labels shall be machine generated, typed and clearly legible with a maximum of 17 characters. Hand written labels or labels written on the control wire jacket will not be acceptable. Each label shall be unique to its function and shall reference the applicable system. For example "AHU-1 SAT" will indicate the supply air temperature sensor for AHU-1. Improper labeling shall be removed and shall require re-commissioning of the control device and controller to document correct functionality.
- C. Provide high voltage warning notices at all equipment controlled by the EMCS and at all associated motor starters when used by equipment controller.

2.20 TUBING AND PIPING

- A. Provide tubing and piping as required for the field instrumentation.
- B. Tubing within equipment rooms, vertical risers, and penetrations to ductwork shall be either copper pipe or shall be plastic tubing within conduit. Tubing for all water-based instrumentation shall be copper pipe. Identify the type of tubing proposed in the shop drawing submittal.
- C. Provide suitable bulk head fittings for duct and panel penetrations.
- D. Tubing in plenum rated areas may be plastic tubing. Polyethylene tubing shall meet, at minimum, the following requirements: flame retardant; crack resistant; 300 psi burst pressure.

2.21 CONDUIT AND FITTINGS

- A. Provide all conduits, raceways and fittings for the EMCS monitoring, communication and control cabling. All work shall meet all applicable codes.
- B. Conduit, where required, shall meet, the requirements specified within Division 26.
- C. EMCS monitoring and control cable shall not share conduit with cable carrying voltages in excess of 90 VAC.

2.22 CABLING

- A. Provide all cables for the EMCS. Cable shall meet, at minimum, the following requirements:
 - 1. Minimum 98% conductivity stranded copper.

2. Proper impedance for the application as recommended by the EMCS component manufacturer.
 3. Monitoring and control cable shall be #18 AWG or larger, dependent on the application. Analog input and output cabling shall be shielded.
 4. Management Level Network cable shall be CAT 6, 24 gauge unshielded.
 5. Automation Level Network cable shall be #24 AWG shielded.
 6. Shield shall be grounded at the CCP, UC, or control panel. Ground at one end only to avoid ground loops.
 7. Identification of each end at the termination point. Identification should be indicated on and correspond to the record drawings.
- B. 120 VAC power wiring shall be of #12 AWG solid conductor or larger as required.

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION

- A. The EMCS supplier shall provide a pre-construction coordination meeting with the affected trades to ensure a cooperative efficient process of installation. The invited trades shall include the general contractor, mechanical contractor, electrical contractor, test and balance contractor, owner's representative, consulting engineer and others with a direct interest in the coordination of the affected systems. The EMCS contractor shall provide an outline of the meeting agenda highlighting the construction schedule, coordination with mechanical and electrical trades. Provide a sign-in sheet and submit it through the attendees along with a summary of the meeting notes for future reference.

3.2 INSPECTION DURING INSTALLATION

- A. Provide a technician to assist the Engineer or Owner's Representative with inspections made during the installation period that are required to review the progress and quality of ongoing work. The engineer/owner's representative shall generate field observation reports on the findings of the inspection. The engineer or owner's representative shall advise the EMCS contractor during the inspection of any concerns noted with respect to the installation and shall repeat the concerns in writing as soon as possible after the inspection is completed. The EMCS contractor shall take corrective action to meet the requirements of the specifications. Upon correction, the EMCS contractor shall submit written documentation through the contractors to the engineer.

3.3 INSTALLATION OF COMPONENTS

- A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with specification Division 26 and all national, state and local electrical codes.
- B. Provide wire and wiring techniques recommended by equipment manufacturers.

Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in. Provide auxiliary pilot duty relays on motor starters as required for control function.

- C. Electrical Contractor shall provide 120 or 277 volt power at a junction box within 48" of the controller. The BAS Contractor shall coordinate with the Electrical Contractor to identify locations of power requirements prior to the installation of the controls.
- D. Conduit for control wiring shall be provided whenever one of the following conditions exists:
 - 1. Conduit is indicated on the drawings or specifically required by the specifications.
 - 2. Cabling runs through inaccessible areas such as within partitions/walls, above closed in ceilings, under floor; within trenches and underground; on the exterior of the building; exposed on the surface of the building; when encased in concrete or other material that makes the cable inaccessible or when located such that access to the cable is not readily obtained.
 - 3. Cable within mechanical, telecommunications and electrical equipment rooms and control rooms.
 - 4. Conduit shall be installed, inside wall from sensor box to above the wall, for all wall mounted temperature, humidity and CO2 sensors.
- E. Control wiring located above an accessible ceiling space may be plenum rated cable. Plenum rated wire shall be bundled and routed at right angles to the building lines and secured to the building structure every 15 feet.
- F. Control wiring located in underground conduits shall be provided with direct-burial-rated insulation.
- G. When communication bus enters or exits a building, a surge suppressor shall be installed. The surge suppressor shall be installed according to the controls manufacturer's instructions.
- H. Provide sleeves for all cable and conduit passing through walls, partitions, structural components, floors and roof
- I. All sensor wiring shall be labeled to indicate the origination (at the device) and destination of data (at the control panel). The description shall indicate the type and location of the control device such as "AHU-1 SA temp" or "VAV 1-1 space temp".
- J. Wall temp sensors at 48" above the finished floor to comply with ADA requirements and

to match the height of the light switches. Mount humidity sensor at equal height to wall temperature sensor.

3.4 VERIFICATION REQUIREMENTS

- A. Verification shall be provided by the EMCS contractor to demonstrate and confirm that the installed system complies with the specifications and the control sequences of operation herein specified. upon completion of the verification process the EMCS contractor shall demonstrate to the engineer or owner's representative the functionality of the control system devices are in compliance with the contract documents.
- B. Technicians provided by the EMCS contractor shall be factory trained and qualified in the operation of the provided control system. The EMCS contractor shall provide, if requested, the factory training certificates of the individuals providing the verification services on this project.
- C. Verification tools, applicable to the system provided, shall be utilized by the factory-trained technicians for proper verification of system operation and functionality. Temperature verification sensors shall be NIST certified within the last 12 months. Meters such as Fluke 52 series or better shall be utilized. Use of non-certified meters may require the system to be re-verified with certified meters at no cost to the owner.
- D. Documentation of the verification process shall be provided per the project general conditions in electronic PDF format as required. Documentation shall include the following forms:
 - 1. **Project System Verification Forms** for each controller provided on the project to verify the proper function of each controller, control device and system component provided.
 - 2. **Panel Verification Forms** for each control panel to document the proper installation and function of each control panel provided.
 - 3. **Sequence of Operation Verification Forms** for each piece of controlled equipment to confirm compliance of the control system with the specified sequences of operation.
 - 4. Not providing proper documentation for each control devices, panel, or system, upon request by the engineer or owner's representative, may require the EMCS contractor to re-verify the applicable systems at no additional cost to the owner.
- E. After completion of the verification, the EMCS contractor shall be able to demonstrate the sequence of operations for each system to the engineer and the owner's representative.
- F. Equipment checkout sheets are to be produced by this contractor showing checkboxes and compliance with the following procedures for each piece of equipment and turned

over to the owner and/or mechanical engineer.

3.5 COLORGRAPHICS

- A. The colorgraphics shall be provided for the EMCS system prior to system acceptance and owner training.
- B. The colorgraphics provided shall include the following as a template. Provide forward and backward links on the graphic.
 - 1. Site plan with link to overall building plan including detached buildings. The site plan shall be referenced to an automatically updated aerial view or map view of the area such as Google Maps or Bing Maps. Provide link to proceed to the overall building floor plan.
 - 2. The overall building plan shall indicate space temperature conditions referenced by the color of the zone. Specific details of the zone temperatures and equipment are not required. Provide a link to the floor plan wings, upper floors and remote buildings.
 - 3. The floor plan colorgraphics shall indicate the space temperatures by color references. Additional information shall indicate the space temperature, the occupancy of the zone, air handling units, VAV terminals and ductwork with diffusers. A link at each terminal unit or AHU shall automatically connect the system operator to the equipment colorgraphic.
 - 4. The colorgraphics for the equipment shall as a minimum be equal to the points from the input/output summary or control schematic. Primary control devices as required by the sequences of operation shall also be provided.
 - 5. Control points from equipment that are integrated into the EMCS via BACnet shall be provided to convey the operating conditions of the attached equipment. Coordination of the integration points shall be accomplished during the submittal phase. The EMCS contractor shall provide a list of all integrated points on their submittal.

3.6 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- A. Startup testing documentation: Prepare the checklist documenting startup testing of each input and output device, with technician's initials and date certifying each device has been tested and calibrated prior to acceptance testing. This document shall indicate proof that the following functions have been commissioned and shall be included in the as-built documentation: short to ground check, configuration of trends, confirmation that color- graphics are accurately representing actual systems, point to point checkout, all damper and valve actuators respond to input change, control modules are addressed and have functional descriptors, specified interlocks are functional, calibration report of all sensors, discrete outputs respond to time schedule or manual enable command.

- B. Demonstration. Prior to acceptance, demonstrate the following performance tests to demonstrate system operation and compliance with specifications.
1. Engineer, owner's representative and mechanical contractor shall be invited to observe and review system demonstration. Provide attendees at least 10 days notice.
 2. Demonstration shall follow process approved as part of the submittal and shall include complete checklists and forms for each system as part of system demonstration.
 3. Demonstrate actual field operation of each sequence of operation as specified. Demonstrate calibration and response of any input and output points requested by engineer or owner's representative.
 4. Demonstrate complete operation of operator interface including review of color- graphics, time schedules, trend logs, alarm notification, functionality of tablet PC operation.
 - a. PID loop response. Supply graphical trend data output showing each PID loop's response to a set point change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be selectable from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values.
 - b. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand limiting setpoint, and status of set points and other affected equipment parameters.
 - c. Trend logs for each system. Trend data shall indicate set points, operating points, valve positions, and other data as specified. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.
 5. Alarms and Interlocks. Check each alarm with an appropriate signal at a value that will trip the alarm. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction. Alarm verification shall include temperatures exceeding alarm threshold (high and low), fan failure safety, duct high static pressure switch, freeze stat, and smoke detector shutdown.
 6. Tests that fail to demonstrate proper system operation to the engineer shall be repeated after contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.
- C. Owner Acceptance.
1. After tests described in this specification are performed to the satisfaction of

both engineer and owner's representative, the engineer shall accept the control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond EMCS contractor's control. Engineer shall provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved by the engineer.

3.7 DEMONSTRATION AND OWNER TRAINING

- A. Furnish basic operator training for multiple persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 16 hours: 8 hours instructor time for onsite training and 8 hours of hands on class environment training. Training sessions may be provided in 4-hour increments as approved by the owner's representative.
 1. Change/modify temperature setpoints.
 2. Change/modify time of day, holiday and override schedules.
 3. Display, create, and modify trends of system points.
 4. Update room numbers on the color-graphics.
- B. Demonstrate complete and operating system to Owner. Provide written documentation listing the attendees of the specified training with sign-in sheet and training time and date.

PART 4 - SEQUENCE OF OPERATIONS

- 4.1 Refer to the Section 23 95 01 for project sequence of operations.

END OF SECTION 23 95 00

SECTION 23 95 01 CONTROLS SEQUENCES OF OPERATION

SEQUENCE OF OPERATIONS

AHU – VARIABLE AIR VOLUME

Building Automation System Interface:

The Building Automation System (BAS) shall send the controller Occupied Bypass, Morning Warm-up/Pre-Cool, Occupied/Unoccupied and Heat/Cool modes. The BAS shall also send the discharge air temperature setpoint and the duct static pressure setpoint. If a BAS is not present, or communication is lost with the BAS, the controller shall operate in the occupied mode using default modes and setpoints.

Occupied:

During occupied periods, the supply fan shall run continuously, and the outside air damper shall open to maintain minimum ventilation requirements. If the discharge air temperature sensor fails, the chilled water valve shall close and electric heat shall be disabled and an alarm shall be annunciated at the BAS. When enabled, the unit shall control to the communicated building automation system discharge air temperature setpoint and if communication is lost the local discharge air temperature setpoint shall be used.

Unoccupied:

When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.), the supply fan shall start, the outside air damper shall remain closed, and the electric heat shall be enabled. Unoccupied:

When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.), the supply fan shall start and the electric heat shall be enabled.

When the space temperature rises above the unoccupied cooling setpoint 80.0 deg. F (adj.) plus 4.0 deg. F, the supply fan will start and the cooling shall be enabled.

Optimal Start:

The BAS shall monitor the scheduled occupied time, occupied space setpoints, and space temperature to calculate when the optimal start occurs.

Morning Warm-Up Mode:

During optimal start, if the average space temperature is below the occupied heating setpoint a morning warm-up mode shall be activated. When morning warm-up is initiated, the unit shall enable the supply fan and heating. The outside air damper shall remain closed. When the space temperature reaches the occupied heating setpoint (adj.), the unit shall transition to the occupied mode.

Pre-Cool Mode:

During optimal start, if the average space temperature is above the occupied cooling setpoint, pre-cool mode shall be activated. When pre-cool is initiated the unit shall enable the fan and

cooling. The outside air damper shall remain closed. When the space temperature reaches occupied cooling setpoint (adj.), the unit shall transition to the occupied mode.

Optimal Stop:

The BAS shall monitor the scheduled unoccupied time, occupied setpoints and space temperature to calculate when the optimal stop occurs. When the optimal stop mode is active, the space temperature is allowed to drift a few degrees from occupied setpoint and disabling heating/cooling, but still controlling to maintain the space temperature offset setpoint. Outside air damper shall remain enabled to provide minimum ventilation.

Occupied Bypass:

The BAS shall monitor the status of the “on” and “cancel” buttons of the space temperature sensor. When an occupied bypass request is received from a space sensor and the current mode is unoccupied or occupied standby, the unit shall transition into occupied bypass mode and the unit shall maintain the space temperature to the occupied setpoints (adj.). The controller remains in the occupied bypass mode until the occupied bypass timer (120 minutes, adj.) or until the cancel button is pressed.

Heat/Cool Mode:

When the space temperature rises above the occupied cooling setpoint the mode shall transition to cooling. When the space temperature is above the occupied cooling setpoint or below the occupied heating setpoint the mode shall remain in its last state.

Supply Air Temperature Reset Control:

The supply air temperature setpoint shall be reset to the optimal setpoint communicated by the BAS. The BAS shall reset the supply air temperature setpoint based on the current outside air temperature, but shall override this reset function and return the supply air temperature setpoint to 55.0 deg. F (adj.) if more than two (adj.) zones begin to overheat.

If the return air relative humidity is greater than 50%(adj.), the chilled water valve shall modulate to maintain a supply air temperature setpoint of 52.0 deg. F (adj.).

Return CO2 is for monitoring purposes only.

Supply Fan:

The fan shall be off in the unoccupied mode. A hardwired, high static pressure cut-off switch shall be electrically interlocked with the variable speed drive. If the high static pressure cut-off switch is tripped, the fan shall stop, the outside air damper shall close, all heating/cooling shall be disabled, and an alarm shall be annunciated at the BAS.

Mixed Air Low Limit:

The initial damper opening rate shall be limited to 2% per minute (adj.) until the damper has reached its minimum ventilation position. The outside air damper shall modulate to a position less than the minimum damper position if the mixed air temperature drops below 50.0 deg. F

(adj.). When the mixed air temperature sensor fails, an alarm shall be annunciated at the BAS and the outdoor air damper shall return to the minimum position.

If the low limit temperature switch is tripped 38.0 deg. F (adj.), the supply fan shall be disabled, the outside air damper shall close, all valves shall open to 100% (adjust per climate), the electric heat shall be disabled and an alarm shall be annunciated at the BAS. If the low limit temperature switch is tripped 38.0 deg. F (adj.), the supply fan shall be disabled, the outside air damper shall close, all valves shall open to 100% (adjust per climate), the gas heat shall be disabled and an alarm shall be annunciated at the BAS. A manual reset of the low limit temperature switch shall be required to restart the fan.

Smoke Detector Shutdown: The unit shall shut down in response to a signal from either smoke detector indicating the presence of smoke. The smoke detectors shall be interlocked to the unit through the dry contacts of the smoke detectors. A manual reset of the smoke detectors shall be required to restart the unit.

Filter Status:

A differential pressure sensor shall monitor the differential pressure across the filter when the fan is running. If the differential pressure increases above the setpoint (adj.) during normal, operation a dirty filter alarm shall be annunciated at the BAS.

AHU – SINGLE ZONE VARIABLE AIR VOLUME.

Building Automation System Interface:

The Building Automation System (BAS) shall send the controller Occupied Bypass, Morning Warm-up/Pre-Cool, Occupied/Unoccupied and Heat/Cool modes. The BAS shall also send the discharge air temperature setpoint and the duct static pressure setpoint. If a BAS is not present, or communication is lost with the BAS, the controller shall operate in the occupied mode using default modes and setpoints.

If the discharge air temperature sensor fails, the chilled water valve shall modulate and electric heat shall stage to maintain the active space temperature setpoint and an alarm shall be annunciated at the BAS. The discharge air temperature setpoint shall be dynamically reset to maintain space temperature 0.5 deg. F above the heating setpoint and 0.5 deg. F below the cooling setpoint. If the discharge air temperature sensor and the space temperature sensor fail, the chilled water valve shall close and electric heat shall be disabled and an alarm shall be annunciated at the BAS.

Unoccupied:

When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.), the supply fan shall start, the outside air damper shall remain closed, and the electric heat shall be enabled.

Optimal Start:

The BAS shall monitor the scheduled occupied time, occupied space setpoints, and space temperature to calculate when the optimal start occurs.

Morning Warm-Up Mode:

During optimal start, if the space temperature is below the occupied heating setpoint a morning warm-up mode shall be activated. The outside air damper shall remain closed. When the space temperature reaches the occupied heating setpoint (adj.), the unit shall transition to the occupied mode.

Pre-Cool Mode:

During optimal start, if the space temperature is above the occupied cooling setpoint, pre-cool mode shall be activated. When pre-cool is initiated the unit shall enable the fan and cooling. The outside air damper shall remain closed. When the space temperature reaches occupied cooling setpoint (adj.), the unit shall transition to the occupied mode.

Optimal Stop:

The BAS shall monitor the scheduled unoccupied time, occupied setpoints and space temperature to calculate when the optimal stop occurs. When the optimal stop mode is active, the space temperature is allowed to drift a few degrees from occupied setpoint and disabling heating/cooling, but still controlling to maintain the space temperature offset setpoint. Outside air damper shall remain enabled to provide minimum ventilation.

Occupied Bypass:

The BAS shall monitor the status of the “on” and “cancel” buttons of the space temperature sensor. When an occupied bypass request is received from a space sensor and the current mode is unoccupied or occupied standby, the unit shall transition into occupied bypass mode and the unit shall maintain the space temperature to the occupied setpoints (adj.). The controller remains in the occupied bypass mode until the occupied bypass timer (120 minutes, adj.) or until the cancel button is pressed.

Heat/Cool Mode:

When the space temperature rises above the occupied cooling setpoint the mode shall transition to cooling. When the space temperature falls below the occupied heating setpoint the mode shall transition to heating. If the space temperature sensor fails an alarm shall be annunciated at the BAS. When the space temperature is above the occupied cooling setpoint or below the occupied heating setpoint the mode shall remain in its last state.

Supply Air Temperature Reset Control:

At the zone’s design cooling load, the supply fan shall operate at maximum speed (design airflow) and the cooling capacity shall modulate to maintain the discharge air temperature at setpoint (55.0 deg. F, adj.).

As the zone cooling load decreases, the supply fan VFD shall decrease fan speed to maintain the space temperature at cooling setpoint plus 0.5 deg. F , while the cooling capacity shall modulate to maintain the discharge air temperature reset minimum setpoint (55.0 deg. F, adj.). When the zone cooling load has decreased to the point that the supply fan VFD has reached its minimum speed, the discharge air temperature setpoint shall be gradually reset upward toward the space cooling setpoint, attempting to keep the space temperature 0.5 deg. F below the cooling setpoint. The supply fan shall operate at minimum speed while the cooling capacity shall

modulate to maintain this reset discharge air temperature setpoint. If the supply fan begins to modulate upward from the minimum speed to maintain space cooling setpoint plus 0.5 deg. F, the discharge air setpoint reset shall be bypassed and the discharge air setpoint shall be set to minimum (55.0 deg. F, adj.). The supply fan will continue to modulate between the minimum and maximum speed to maintain space cooling setpoint plus 0.5 deg. F, while the cooling capacity will modulate to maintain the discharge air temperature at the minimum limit (55.0 deg. F, adj.).

When the space temperature is in the deadband between the cooling and heating setpoints, the fan shall operate at minimum speed with either cooling capacity or heating capacity modulating as needed based on mode. If the supply fan begins to modulate upward from the minimum speed to maintain the space temperature heating setpoint minus 0.5 deg. F, the discharge air setpoint reset shall be bypassed and the discharge air setpoint shall be set to maximum (95.0 deg. F, adj.). The minimum fan speed shall be incremented upward based on number of stages installed and number of stages operating to maintain enough airflow for the heat exchanger or strip heat.

If the return air relative humidity is greater than 50%(adj.), the chilled water valve shall modulate to maintain a supply air temperature setpoint of 52.0 deg. F (adj.).

Return CO2 is for monitoring purposes only.

Supply Fan:

The supply fan shall be enabled while in the occupied mode and cycled on during the unoccupied mode. A hardwired, high static pressure cut-off switch shall be electrically interlocked with the variable speed drive. If the high static pressure cut-off switch is tripped, the fan shall stop, the outside air damper shall close, all heating/cooling shall be disabled, and an alarm shall be annunciated at the BAS.

Mixed Air Low Limit:

The initial damper opening rate shall be limited to 2% per minute (adj.) until the damper has reached its minimum ventilation position. The outside air damper shall modulate to a position less than the minimum damper position if the mixed air temperature drops below 50.0 deg. F (adj.). When the mixed air temperature sensor fails, an alarm shall be annunciated at the BAS and the outdoor air damper shall return to the minimum position.

If the low limit temperature switch is tripped 38.0 deg. F (adj.), the supply fan shall be disabled, the outside air damper shall close, all valves shall open to 100% (adjust per climate), the electric heat shall be disabled and an alarm shall be annunciated at the BAS. A manual reset of the low limit temperature switch shall be required to restart the fan.

Smoke Detector Shutdown: The unit shall shut down in response to a signal from either smoke detector indicating the presence of smoke. The smoke detectors shall be interlocked to the unit through the dry contacts of the smoke detectors. A manual reset of the smoke detectors shall be required to restart the unit.

Filter Status:

A differential pressure sensor shall monitor the differential pressure across the filter when the fan is running. If the differential pressure increases above the setpoint (adj.) during normal, operation a dirty filter alarm shall be annunciated at the BAS.

AHU – CONSTANT VOLUME

Building Automation System Interface:

The Building Automation System (BAS) shall send the controller Occupied Bypass, Morning Warm-up/Pre-Cool, Occupied/Unoccupied and Heat/Cool modes. If a BAS is not present, or communication is lost with the BAS, the controller shall operate in the occupied mode using default modes and setpoints.

Occupied:

During occupied periods, the supply fan shall run continuously, and the outside air damper shall open to maintain minimum ventilation requirements. If the discharge air temperature sensor fails, the chilled water valve shall modulate and electric heat shall stage to maintain the active space temperature setpoint and an alarm shall be annunciated at the BAS. The discharge air temperature setpoint shall be dynamically set by heat/cool mode, neutral air setpoint determined from occupied discharge air temperature cool minimum & heat maximum, and space temperature deadband deviation(1.5 deg. F, adj.). If the discharge air temperature sensor and the space temperature sensor fail, the chilled water valve shall close and electric heat shall be disabled and an alarm shall be annunciated at the BAS.

Unoccupied:

When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.), the supply fan shall start, the outside air damper shall remain closed, and the electric heat shall be enabled.

When the space temperature rises above the unoccupied cooling setpoint 80.0 deg. F (adj.) plus 4.0 deg. F, the supply fan will start and the cooling shall be enabled.

Optimal Start:

The BAS shall monitor the scheduled occupied time, occupied space setpoints, and space temperature to calculate when the optimal start occurs.

Morning Warm-Up Mode:

During optimal start, if the space temperature is below the occupied heating setpoint a morning warm-up mode shall be activated. The outside air damper shall remain closed. When the space temperature reaches the occupied heating setpoint (adj.), the unit shall transition to the occupied mode.

Pre-Cool Mode:

During optimal start, if the space temperature is above the occupied cooling setpoint, pre-cool mode shall be activated. When pre-cool is initiated the unit shall enable the fan and cooling. The outside air damper shall remain closed. When the space temperature reaches occupied cooling setpoint (adj.), the unit shall transition to the occupied mode.

Optimal Stop:

The BAS shall monitor the scheduled unoccupied time, occupied setpoints and space temperature to calculate when the optimal stop occurs. When the optimal stop mode is active, the space temperature is allowed to drift a few degrees from occupied setpoint and disabling heating/cooling, but still controlling to maintain the space temperature offset setpoint. Outside air damper shall remain enabled to provide minimum ventilation.

Occupied Bypass:

The BAS shall monitor the status of the “on” and “cancel” buttons of the space temperature sensor. When an occupied bypass request is received from a space sensor and the current mode is unoccupied or occupied standby, the unit shall transition into occupied bypass mode and the unit shall maintain the space temperature to the occupied setpoints (adj.). The controller remains in the occupied bypass mode until the occupied bypass timer (120 minutes, adj.) or until the cancel button is pressed.

Heat/Cool Mode:

When the space temperature rises above the occupied cooling setpoint the mode shall transition to cooling. When the space temperature falls below the occupied heating setpoint the mode shall transition to heating. If the space temperature sensor fails an alarm shall be annunciated at the BAS. When the space temperature is above the occupied cooling setpoint or below the occupied heating setpoint the mode shall remain in its last state.

If the return air relative humidity is greater than 50%(adj.), the chilled water valve shall modulate to maintain a supply air temperature setpoint of 52.0 deg. F (adj.).

Return CO2 is for monitoring purposes only.

Supply Fan:

The fan shall be off in the unoccupied mode.

Building Pressure Control:

After the fan startup delay expires, building static pressure will be controlled by modulating the Outside Air Damper.

Mixed Air Low Limit:

The initial damper opening rate shall be limited to 2% per minute (adj.) until the damper has reached its minimum ventilation position. The outside air damper shall modulate to

a position less than the minimum damper position if the mixed air temperature drops below 50.0 deg. F (adj.). When the mixed air temperature sensor fails, an alarm shall be annunciated at the BAS and the outdoor air damper shall return to the minimum position.

Freeze Protection:

A hardwired, low limit temperature switch shall be electrically interlocked with the motor starter. If the low limit temperature switch is tripped 38.0 deg. F (adj.), the supply fan shall be disabled, the outside air damper shall close, all valves shall open to 100% (adjust per climate), the electric heat shall be disabled and an alarm shall be annunciated at the BAS. A manual reset of the low limit temperature switch shall be required to restart the fan.

Smoke Detector Shutdown: The unit shall shut down in response to a signal from either smoke detector indicating the presence of smoke. The smoke detectors shall be interlocked to the unit through the dry contacts of the smoke detectors. A manual reset of the smoke detectors shall be required to restart the unit.

Filter Status:

A differential pressure sensor shall monitor the differential pressure across the filter when the fan is running. If the differential pressure increases above the setpoint (adj.) during normal, operation a dirty filter alarm shall be annunciated at the BAS.

VAV – NON FAN POWERED TERMINAL UNITS

Building Automation System Interface:

The Building Automation System (BAS) shall send the controller Occupied and Unoccupied commands. The BAS may also send a Heat/Cool mode, priority shutdown commands, space temperature and/or space temperature setpoint. If communication is lost with the BAS, the VAV controller shall operate using its local setpoints.

Occupancy:

The occupancy mode shall be communicated or hardwired to the controller via a binary input. When the unit is in the occupied mode the VAV shall maintain the space temperature at the active occupied heating or cooling setpoint. Applicable ventilation and airflow setpoints shall be enforced. The occupied mode shall be the default mode of the VAV.

Unoccupied:

Normal operating mode for unoccupied spaces or nighttime operation. When the unit is in unoccupied mode the VAV controller shall maintain the space temperature at the stored unoccupied heating or cooling setpoint regardless of the presence of a hardwired or communicated setpoint. When in the Unoccupied Mode, the controller shall disable the electric heat, and close the ventilation air damper, unless unoccupied cooling or heating is needed. When the space temperature drops below its Unoccupied Heating Setpoint, the controller shall modulate the air damper and the SCR heat until the zone temperature rises back to 2.0 deg. F above the Unoccupied Heating Setpoint. When the space temperature exceeds the active unoccupied setpoint the electric heat shall modulate off and the air damper shall modulate fully closed.

Heat/Cool Mode:

The Heat/Cool mode shall be set by a communicated value or automatically by the VAV controller. In standalone or auto mode the VAV controller shall compare the primary air temperature with the configured auto changeover setpoint to determine if the air is "hot" or "cold". Heating mode implies the primary air temperature is hot. Cooling mode implies the primary air temperature is cold.

Heat/Cool Setpoint:

The space temperature setpoint shall be determined either by a local (e.g., thumbwheel) setpoint, the VAV default setpoint or a communicated value. The VAV shall use the locally stored default setpoints when neither a local setpoint nor communicated setpoint is present. If both a local setpoint and communicated setpoint exist, the VAV shall use the communicated value.

Cooling Mode:

When the unit is in cooling mode, the VAV controller shall maintain the space temperature at the active cooling setpoint by modulating the VAV damper (between the active cooling minimum and maximum airflow setpoints). The outputs will be controlled based on the unit configuration and the requested cooling capacity.

Heating Mode:

When the unit is in heating mode, the VAV controller shall maintain the space temperature at the active heating setpoint by modulating the VAV damper (between the active heating minimum and maximum airflow setpoints). Based on the VAV controller occupancy mode, the active heating setpoint shall be one of the following:

Setpoint	Default Value
Occupied Heating Setpoint	71.0 deg. F
Unoccupied Heating Setpoint	60.0 deg. F
Occupied Standby Heating Setpoint	67.0 deg. F
Occupied Min Heating Airflow Setpoint	See VAV Schedule
Occupied Max Heating Airflow Setpoint	See VAV Schedule

During reheat the VAV damper and electric heat shall operate as follows:

Silicon Controlled Rectifier (SCR):

The VAV controller shall modulate the air damper and the SCR electric heater to maintain space temperature at the active heating setpoint.

If the discharge air temperature reaches the design heating discharge air temperature setpoint of 90.0 deg. F (adj.), the VAV controller shall modulate the air damper between the minimum and maximum fan airflow setpoints to maintain space temperature at the active heating setpoint and modulate the SCR electric heater to maintain discharge air temperature at the design heating discharge air temperature setpoint.

When the unit is in occupied mode, the ventilation airflow setpoint shall equal the design outdoor airflow (see VAV schedule).

The current ventilation airflow setpoint shall be communicated to the BAS for control of the system outdoor-air intake.

Space Sensor Failure:

If there is a fault with the operation of the zone sensor an alarm shall be annunciated at the BAS. Space sensor failure shall cause the VAV to drive the damper to minimum air flow if the VAV is in the occupied mode, or drive it closed if the VAV is in the unoccupied mode.

VAV - FAN POWERED TERMINAL UNITS

Building Automation System Interface:

The Building Automation System (BAS) shall send the controller Occupied and Unoccupied commands. The BAS may also send a Heat/Cool mode, priority shutdown commands, space temperature and/or space temperature setpoint. If communication is lost with the BAS, the VAV controller shall operate using its local setpoints.

Occupancy:

The occupancy mode shall be communicated or hardwired to the controller via a binary input. When the unit is in the occupied mode the VAV shall maintain the space temperature at the active occupied heating or cooling setpoint. Applicable ventilation and airflow setpoints shall be enforced. The occupied mode shall be the default mode of the VAV.

Unoccupied:

Normal operating mode for unoccupied spaces or nighttime operation. When the unit is in unoccupied mode the VAV controller shall maintain the space temperature at the stored unoccupied heating or cooling setpoint regardless of the presence of a hardwired or communicated setpoint. When in the Unoccupied Mode, the controller shall disable the electric heat, and close the ventilation air damper, unless unoccupied cooling or heating is needed. When the space temperature is between the active unoccupied setpoint the VAV shall modulate fully closed, and the fan shall turn off.

Heat/Cool Mode:

The Heat/Cool mode shall be set by a communicated value or automatically by the VAV controller. In standalone or auto mode the VAV controller shall compare the primary air temperature with the configured auto changeover setpoint to determine if the air is "hot" or

"cold". Heating mode implies the primary air temperature is hot. Cooling mode implies the primary air temperature is cold.

Heat/Cool Setpoint:

The space temperature setpoint shall be determined either by a local (e.g., thumbwheel) setpoint, the VAV default setpoint or a communicated value. The VAV shall use the locally stored default setpoints when neither a local setpoint nor communicated setpoint is present. If both a local setpoint and communicated setpoint exist, the VAV shall use the communicated value.

Cooling Mode:

When the unit is in cooling mode, the VAV controller shall maintain the space temperature at the active cooling setpoint by simultaneously modulating both the VAV damper (between the active cooling minimum and maximum airflow setpoints) and the fan (between the minimum and maximum fan airflow setpoints). Based on the VAV controller occupancy mode, the active cooling setpoint shall be one of the following:

Setpoint	Default Value
Occupied Cooling Setpoint	74.0 deg. F
Unoccupied Cooling Setpoint	85.0 deg. F
Occupied Standby Cooling Setpoint	78.0 deg. F
Occupied Min Cooling Airflow Setpoint	See VAV Schedule
Occupied Max Cooling Airflow Setpoint	See VAV Schedule
Min Fan Airflow Setpoint	See VAV Schedule
Max Fan Airflow Setpoint	See VAV Schedule

The VAV controller shall use the measured space temperature and the active cooling setpoint to determine the requested cooling capacity of the unit. The outputs will be controlled based on the unit configuration and the requested cooling capacity.

Heating Mode:

When the unit is in heating mode, the VAV controller shall maintain the space temperature at the active heating setpoint by simultaneously modulating both the VAV damper (between the active heating minimum and maximum airflow setpoints) and the fan (between the minimum and maximum fan airflow setpoints). Based on the VAV controller occupancy mode, the active heating setpoint shall be one of the following:

Setpoint	Default Value
Occupied Heating Setpoint	71.0 deg. F
Unoccupied Heating Setpoint	60.0 deg. F
Occupied Standby Heating Setpoint	67.0 deg. F
Occupied Min Heating Airflow Setpoint	See VAV Schedule
Occupied Max Heating Airflow Setpoint	See VAV Schedule
Min Fan Airflow Setpoint	See VAV Schedule

Max Fan Airflow Setpoint

See VAV Schedule

Continuous Fan Control:

The VAV fan shall operate continuously in all occupied modes. The terminal fan and heat shall cycle as needed to maintain a reduced space temperature.

During reheat the VAV damper, fan, and electric heat shall operate as follows:

Silicon Controlled Rectifier (SCR):

The VAV controller shall operate the fan at the minimum fan airflow setpoint and modulate the SCR electric heater to maintain space temperature at the active heating setpoint. If the discharge air temperature reaches the design heating discharge air temperature setpoint of 90.0 deg. F (adj.), the VAV controller shall modulate the fan between the minimum and maximum fan airflow setpoints to maintain space temperature at the active heating setpoint and modulate the SCR electric heater to maintain discharge air temperature at the design heating discharge air temperature setpoint. If the fan reaches the maximum fan airflow setpoint, the VAV controller shall modulate the SCR electric heater to maintain space temperature at the active heating setpoint while the fan continues to operate at the maximum fan airflow setpoint.

When the unit is in occupied mode, the ventilation airflow setpoint shall equal the design outdoor airflow (see VAV schedule).

The current ventilation airflow setpoint shall be communicated to the BAS for control of the system outdoor-air intake.

Space Sensor Failure:

If there is a fault with the operation of the zone sensor an alarm shall be annunciated at the BAS. Space sensor failure shall cause the VAV to drive the damper to minimum air flow if the VAV is in the occupied mode, or drive it closed if the VAV is in the unoccupied mode. The series fan shall be enabled and the reheat will be disabled.

END OF SECTION 23 95 01

SECTION 23 99 00 TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. Conditions of the contract and general requirements in Division 1 apply to work specified in all section of Division 23.
- B. All Division 23 specification sections, drawings, and general provisions of the contract apply to work of this section, as do other documents referred to this section.
- C. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- D. Requirements for submittals, shop drawings, and substitutions, Division 1, Section 013000 and 016000, apply to work specified in all sections of Division 23.
- E. The basic Materials and Methods, Section 230500, are included as a part of this Section as though written in full in this document.

1.02 REFERENCES AND STANDARDS

- A. The publications listed below from a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASSOCIATED AIR BALANCE CONCIL (AABC)

(2002) National Standards for Testing Adjusting Balancing of Environmental Systems

NATIONAL EVROMENTAL BALANCING BUREAU (NEBB)

(1998) National Standards for Testing Adjusting Balancing of Environmental Systems

(1994) Procedural Standards for the Measurement and Assessment of Sound and Vibration

- B. TAB shall be preformed in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC or NEBB procedural standards, unless otherwise specifies herein. All recommendations and suggested practices contained in the TAB standard shall be considered mandatory. The provisions of the TAB

Standard, including checklists, report forms, etc. Shall, as nearly as practical, be used to satisfy the Contract requirements. The TAB standard shall be used for all aspects of TAB, including qualifications, for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, the manufacture’s recommendations shall be adhered to. All quality assurance provisions of the TAB Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the TAB standard TAB procedures shall be developed by the TAB Specialist. Where new procedures, requirements, etc. applicable to the Contact requirements have been published or adopted by the body responsible for the TAB Standard used (AABC or NEBB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

- C. The TAB contractor shall submit all questions regarding interpretations and questions regarding these standards in writing or as required by documents to the A/E team who shall provide formal reply in ka reasonable time. Decisions of the A/E team shall be final.

1.03 DEFINITIONS AND SIMILAR TERMS

- A. In some instances, terminology differs between the Contract TAB Standard primarily because the intent of this section is to use the industry standards specified, along with the additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent the corresponding AABC or NEBB where differences.

<u>CONTRACT TERM</u>	<u>AABC TERM</u>	<u>NEBB TERM</u>
TAB Standard	National Standard Testing and Balancing Heating, Ventilating, and Air Conditioning System	Procedural Standards for Testing Adjusting Environmental System
TAB Specialist	TAB Engineer	TAB Supervisor
System Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures

1.04 QUALIFICATIONS

- A. The TAB of the air conditioning systems will be performed by an independent, impartial technical firm whose operations are limited only to the field of professional TAB, and is not a part or subsidiary of any other project contractor or subcontractor, to include, but not limited to General Contractor, and Mechanical; Contractor. The TAB work

will be done under the direct supervision of qualified Professional Engineer employed as a full time employee of TAB firm.

- B. The TAB agency shall be either a member of AABC or certified by the NEBB and certified in all categories and functions where measurements or performance are specified on the plans and specifications.
- C. QUALIFICATIONS OF CONTRACTOR PERSONAL: Submit evidence to show that the people who shall be in charge of correcting deficiencies for balancing the systems are qualified. The Owner and Engineer reserve the right to require that the originally approved personal be replaced with other qualified personnel if, in the Owner and Engineer's opinion, the original personnel are not qualified to properly place the system in condition for balancing.
- D. QUALIFICATIONS OF TAB FIRM

The certification shall be maintained for the entire duration of specified herein. If, for any reason, the firm losses subject certification during this period, the Contractor shall immediately execute each certifying agency's applicable Performance Guaranty, then immediately notify the Contracting Officer and submit another TAB firm for approval, at no additional cost to Project Owner, Architect, Engineer, or their designated representatives. Any firm that has been the subject to disciplinary action by either the AABC or the NEBB within the five years preceding the contract award shall not be eligible to perform any duties related to the HVAC systems including TAB. All work specified in this section and in other related sections to be performed by the TAB firm shall be considered invalid if the TAB firm losses its certification prior to contract completion and must be performed by an approved successor, at no additional cost to Project Owner, Architect, Engineer, or their designated representative. The TAB firm shall have an occupied office within 100 miles of the project site.

E. QUALIFICATIONS OF TAB FIRM PERSONAL:

- 1. A minimum of one registered Professional Engineer, licensed in the State the work is performed, is required to be in permanent employment of the firm.
- 2. The TAB Specialist shall be either a member of AABC or an experienced technician of the firm certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason the Specialist losses subject certification during this period, the Contractor shall immediately execute each certifying agency's applicable Performance Guaranty, then immediately notify the Contracting Officer and submit another TAB Specialist for approval, at no additional cost to Project Owner, Architect, Engineer, or their designated representatives. Any individual that has been the subject of disciplinary action by

either the AABC or the NEBB within the five years preceding the contract award shall not be eligible performed any duties related to the HVAC systems, including TAB. All work specified in this section and other related sections to be performed by the TAB Specialist shall be considered invalid if the TAB Specialist loses certification prior to the contract completion and must be performed by an approved successor, at no additional cost to the Project Owner, Architect, Engineer, or their designated representatives.

3. Personal used on the job site shall be either Professional Engineers or technicians, who shall have been permanent, full time employees of the firm for a minimum of six months prior to the start of work for that specified project.
4. Evidence shall be submitted to show that the personal who actually balanced the systems are qualified. Evidence showing that the personnel have passed the tests required by the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) shall be required.

F. ACCEPTABLE TAB FIRMS SHALL INCLUDE:

1. PHI Service Agency (361-248-4861)
2. Engineering Air Balance Company (210-736-9494)
3. Testing Specialties (210-492-8885)
4. TCx Synergy (361-960-3475)

1.05 SCOPE OF WORK

- A. The Contractor will contract with a professional TAB firm under the provisions of paragraph 1.04 of this section.
- B. The TAB firm will be responsible for inspecting, adjusting, balancing, and logging the data on the performance of fans, dampers in the duct system, and air distribution devices. The Contractor and the various subcontractors of the equipment installed shall cooperate with the TAB firm to furnish necessary data on the design and proper applications of the system components and provide labor and material required to eliminate deficiencies or poor performance.
- D. The work included in this section consists of furnishing labor, instruments, and tools required in testing, adjusting, and balancing the HVAC systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking specified measurements, recording and reporting the

results. The items requiring testing, adjusting, and balancing include the following (as applicable to contract drawings):

AIR SYSTEMS

Air Handling Units
Packaged Units
Exhaust Fans
VAV Terminal Units
Diffusers, Registers, & Grilles
Coils (Air Temperature)

HYDRONIC SYSTEMS

Chill Water Pumps
Heating Water Pumps
Chill Water Coils
Heating Water Coils

PLUMBING SYSTEMS

Recirc Pumps
Mixing Valves
Circuit Setters

1.06 SUBMITTALS AND RELATED DOCUMENTS:

- A. The name of the selected AABC or NEBB certified firm shall be submitted to the Engineer for approval within 30 days after contract award.
- B. Within 30 days after the award of contract, the TAB firm shall submit for approval an organizational chart and proof of current certification which shall identify all AABC or NEBB certified Supervisors or Specialist. The TAB firm shall submit a company resumes listing personal and project experience in air and hydronic system balancing. TAB firm will also provide information showing successful completion for three similar scope projects for which the firm is being contracted.
- C. Within 30 days after the award of contract, the TAB firm will submit for approval the name of the TAB Specialist and/or Professional Engineer, who will have direct supervision of all TAB related labor through completion of project.
- D. Within 30 days after the award of contract the TAB firm shall submit TAB procedures and agenda proposed to be used.
- E. Within 30 days after the award of contract, but prior to TAB field measurements, the TAB firm shall submit sample report forms, sample report forms, which shall include minimum data required by either the AABC or NEBB National Standards.

- F. Within 15 days of notification of approval of TAB firm and TAB Specialist by engineer, TAB firm shall conduct a Design Review of contract drawings and submit a Design Review report.
- G. Proposed date and time for execution of Systems Readiness Inspection shall be submitted no later than 7 days prior to inspection. A copy of the Systems Readiness Inspection Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.
- H. Proposed date and time to begin field measurements, making adjusting, ext., for the TAB report, shall be submitted with the Systems Readiness Inspection Report.
- I. Six (6) copies of the completed TAB Report shall be submitted for approval no later than 7 days after the execution of TAB. All copies of TAB Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.
- J. Proposed date and time to begin TAB Completion Verification, shall be submitted with the TAB Report. Six (6) copies of TAB Completion Verification Report shall be submitted no later than 7 days after execution of TAB verification.
- K. Proposed date and time for execution of Opposite Season Inspection shall be submitted no later than 7 days prior to inspection.

1.07 INSTRUMENTATION

- A. All instruments used for measurements shall be accurate and calibrated. TAB firm shall submit list of all instruments, to include gauges, thermometers, flow measuring hoods, and other balancing devices to be used in balancing the system. The list will indicate name of equipment, function, model number, serial number, date of the last calibration, and date calibration is due. TAB firm shall submit copies of calibration certificates for all test instruments used showing all devices were properly calibrated before proceeding with system balancing. All instruments will be within one year of calibration for duration of the project. If duration of project exceeds the tenure of instrument calibration, then said instrument must be recalibrated, and copy of calibration certificate sent to Engineer, before the instrument is placed into continued use.

1.08 TAB PREPARATION AND COORDINATION

- A. It is the intent of this specification section to provide for a completely tested, adjusted, and balanced (TAB) installation without overlaps or omissions between the installing contractor and the TAB contractor. The installing contractors are those who perform the installation of

this work and make all preparations for the TAB contractor who performs the testing, adjusting, and balancing described herein.

- B. The contactor Manager or General Contractor performing the General construction work shall coordinate the work of the contractors performing the Mechanical, Electrical, Automatic Temperature Control, and TAB work to provide complete properly tested, adjusted, and balanced systems. The Construction Manager or General Manager shall require and provide a start-up report for each piece of equipment furnished.
- C. The contractor performing the HVAC work shall coordinate all Mechanical work, including Sheet Metal work and Automatic Temperature Controls, to provide a complete, properly tested adjusted and balanced system throughout. He shall furnish progress reports regarding this phase of the work on a regular basis as directed. At such time as the systems are started up, the Contractor performing the Mechanical work shall provide TAB Contractor with documentation that the duct systems have been tested to the satisfaction of the Duct Leak Test Specifications. The Mechanical Contractor shall insure that all comments are installed and operating, and the major components such as fans, pumps, refrigeration machines, and the like are capable of producing the scheduled capacity requirements. The requirement does not relieve the Mechanical Contractor of any other requirements specified elsewhere. Should any of these components or systems not be capable of producing these requirements, he shall make corrections within the limits of his responsibility or as otherwise authorized and shall certify in writing that the systems are ready for final testing and balancing by the Tab contractor.
- D. The contractor performing the Electrical work shall work coordinate all electrical work to provide complete, properly tested, adjusted and balanced mechanical systems throughout the project. He shall furnish progress reports on a regular basis as directed. He shall certify in writing when each system is electrically operable, including the check for proper rotation of equipment.
- E. The Contractor performing the Automatic Temperature Controls work shall coordinate all controls work to provide complete, properly tested, adjusted and balanced mechanical systems throughout the project. He shall furnish progress reports on a regular basis as directed. He shall certify in writing when each system is operational from an Automatic Temperature Controls standpoint. This contractor shall also provide to TAB contractor all necessary submittal information, software, and/or personal complete, properly tested, adjusted and balanced mechanical systems.
- F. The TAB contractor shall from the award of contract, begin preparation.

PART 2-PRODUCTS (NOT USED)

PART 3- EXECUTION

3.01 SERVICES OF THE CONTRACTOR

- A. The drawing and specifications have indicated valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, install these devices in a manner that leaves them accessible, provide access as requested by the TAB firm.
- B. Have systems complete and in operational readiness prior to notifying the TAB firm the project is ready for their services, and certify in writing to the Construction Manager that such a condition exists.
- C. As a part of the Work of this Section, make changes in the sheaves, belts, and dampers or the addition of dampers required for correct balance of new work as required by TAB firm, at no additional cost to owner.
- D. Fully examine the existing system to be balanced, to determine, whether or not sufficient volume dampers, balancing valves, thermometers, gauges, pressure in the duct systems, means of determining water flow, and other means of taking data needed for proper water and air balancing are existing. Submit to the Engineer in writing a listing of omitted items considered necessary to balance existing systems. Submit the list and proposal as a cost add item.
- E. Verify that fresh air louvers are free of blockage, coils are clean and fresh air ducts to each air handling unit has individually adjustable volume regulating dampers.
- F. Provide correct, repair, or replace deficient items or conditions found during the testing, adjusting, and balancing period.
- G. In order that systems may be properly tested, balanced, and adjusted as specified, operate the systems at no expense for the Owner at the length of time necessary to properly verify their completion and readiness for TAB period.
- H. Project Contract completion schedules shall allow time for allowance to permit the successful completion of TAB services to Owner's final inspection and expectance. Complete, operational readiness, prior to commencement of TAB services, shall include the following services of the Contractor:
 - 1. Construction status of building shall permit the closing of doors, window, ceilings, installed and penetrations complete, to obtain project operating conditions.
 - 2. AIR DISTRIBUTION SYSTEMS:
 - a. Verify installation for conformity to design. Supply, return, and exhaust ducts terminated and pressure tested for leakage as specified.
 - b. Volume and fire dampers properly located and functional. Dampers serving requirements of minimum and maximum outside air, return and relief shall provide tight closure and full opening, smooth and free operation.

- c. Supply return, exhaust and transfer grilles, registers and diffusers.
 - d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, ect., shall be blanked and sealed to eliminate excessive bypass or leakage of air.
 - e. Fans (supply and exhaust) operating and verified for freedom from vibrations, proper fan rotation and belt tension; overload heater elements shall be of proper size and rating ; record motor amperage and voltage and verify that these functions do not exceed nameplate ratings.
 - f. Furnish or revise fan drives or motors as necessary to attain the specified air volumes.
3. WATER CIRCLULATING SYSTEMS
- a. Position valves pertinent to system design and require operation to permit full flow of water through system components. Operate systems under full flow conditions until circulating water is clean. Remove and clean strainers as required during this cycle of operation.
 - b. Record each pump motor amperage and voltage. Readings shall not exceed nameplate rating.
 - c. Verify, on new equipment, electrical starter overload heater elements to be of proper size and rating.
 - d. Ensure that water circulating systems shall be full of water and free of air; expansion tanks set for proper water level, and air vents installed at high points of systems and operating freely. Advise Owner of deficiencies.
 - e. Check and set operating temperatures of heat exchangers to design requirements.
4. AUTOMATIC CONTROLS
- a. Verify that control components are installed in accordance with project documents and functional, electrical interlocks, damper sequences, air and water resets, fire and freeze stats.
 - b. Controlling instruments shall be functional and set for design operating conditions. Factory pre-calibration of room thermostats and pneumatic equipment will not be acceptable.
 - c. The temperature shall be regulation shall be adjusted for proper relationship between the controlling instruments and calibrated by the TAB Contractor. Advise Owner of deficiencies or malfunctions.

3.02 SERVICES OF THE TAB FIRM

- A. The TAB firm will act as liaison between the Owner, Engineer, and Contractor and inspect the installation of mechanical piping system, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems being retrofitted, repaired, or added under this Contract. The re-inspection of the Work will cover that part related to proper arrangement and adequate provision for the testing and balancing and will be done when the Work is 80 percent complete.

- B. Upon completion of the installation and start –up of the mechanical equipment, to check, adjust, and balance system components to obtain optimum conditions in each conditioned space in the building. Prepare and submit to the Owner complete reports on the balance and operations of the systems.
- C. Measurements and recorded readings of air, water and electricity that appear in the TAB reports will be done by the permanently employed technicians or engineers of the TAB firm.
- D. Make an inspection in the building during the opposite season from that in which the initial adjustments were made. At the time, make necessary modifications to the initial adjustments required to produce optimum operation of system components to effect the proper conditions as indicated on the Drawings. At time of opposite season check-out, the Owner's representative will be notified before readings and adjustments are made.
- E. In fan systems, the air quantities indicated on the Drawings may be varied as required to secure a maximum temperature variation of two degrees with each separately controlled space, but the total air quantity indicated for each zone must be obtained. It shall be the obligation of the Contractor to furnish or revise fan drive and motors if necessary, without cost to the Owner, to attain the specified air volumes.
- F. The various existing water circulating systems shall be cleaned, filled, purged, of air, and put into operation before hydronic balancing.

3.03 PROFESSIONAL REPORT

- A. Before the final acceptance of the report is made the TAB will furnish the Owner the following data to be approved by the Owner and Engineer.
 - 1. Summary of main supply, return and exhaust duct pilot tube traverses and fan settings indicating minimum value required to achieve specified air volumes.
 - 2. A listing of the measured air quantities at each outlet corresponding to the temperature tabulation as developed by the Engineer and TAB firm.
 - 3. Air quantities at each return and exhaust air handling device.
 - 4. Static pressure readings entering and leaving each supply fan exhaust fan, filter, coil, balancing dampers and other components of the systems included in the retrofit Work. These readings will be related to performance curves in terms of the CFM handled if available,
 - 5. Motor current readings at each equipment motor on load side of capacitors. The voltages at the time of the reading shall be listed.
 - 6. The final report shall certify test methods and instrumentation used, final velocity reading obtained, temperatures, pressure drops, RPM of equipment, amperage of motors, air balancing problems encountered, recommendations and uncompleted punch list items. The test results will be recorded on standard forms.

7. A summary of actual operating conditions shall be included with each system outlining normal and ventilation cycles of operation. The final report will act as a reference of actual operating conditions for the Owner's operating personal.

3.03 BALANCING AIR CONDITIONING SYSTEM

A. GENERAL

1. Place all equipment into full operation, and shall continue the operating during each working day of balancing and testing. If the air conditioning system is balanced during OFF-Peak cooling seasons Balancing Contractor shall return to rebalance air side system as required to put system in proper balance at that time.
2. The contractor shall submit detailed balancing and recording forms for approval. After the approval by the Architect, prepare complete set of forms for recording test data on each system. All Work shall be done under the supervision of Registered Professional Engineer. All instruments used shall be accurately calibrated to within 1% of scale and maintained in good working order.
3. Upon completion of the balancing and testing, the Balancing Contractor shall compile the test data in report forms, and forward five copies to the Architect for evaluation
4. The final report shall contain logged results of all tests, including such data as
 - a. Tabulation of air volume at each outlet.
 - b. Outside dry bulb and wet bulb temperature.
 - c. Inside dry bulb and wet bulb temperature in each conditioned space room or area.
 - d. Actual fan capacities and static pressures. Motor current and voltage readings at each fan.

B. AIR SYSTEMS: Perform the following operations as applicable to system balance and test:

1. Check fan rotation.
2. Check filters (balancing shall be done with clean filters).
3. Test and adjust blower rpm to design requirements.
4. Test and record motor full load amperes.
5. Test and record system static pressures, suction and discharge.
6. Test and adjust system for design cfm, return air and outside air (+2%). Change out fan sheaves as required to balance system.
7. Test and record entering air temperatures, db and wb.
8. Test and record leaving air temperature, db and wb
9. Adjust all zones to design cfm (+2%).
10. Test and adjust each diffuser, grille, and register to within 5% of design.

C. WATER SYSTEMS: Perform the following operations as applicable to system balance and test:

1. Check pump operation
2. Check operation of all mixing valves.
3. Test water flow rate at all pumps. Adjust balancing valves as required.

4. Record water temperature entering and leaving the pump and water heater.
 5. Record pump suction and discharge pressures.
- D. DX SYSTEMS:
1. Test and record suction and discharge pressures at each compressor and record ambient air temperature entering the condensing coils.
 2. Test and record unit full load amps and voltage.
 3. Test and record staging and unloading of unit required by sequence of operation or drawing schedule.
- E. Automatic temperature controls shall be calibrated and all thermostats and dampers, adjusted so that the control system is in proper operating condition, subject to approval of the Architect.
- F. The Air Balance Contractor shall report to Engineer all air distribution devices or other equipment that operate noisily so that corrective measures may be implemented by the Contractor at no additional cost to the owner.
- 3.04 AIR DUCT LEAKAGE:** (From SMACNA Duct Standards 3rd Edition) Test 50% of all ductwork (from VAV Air Handler to terminal unit) as follows:
- A. Test apparatus
- The test apparatus shall consist of:
1. A source of high pressure air--a portable rotary blower or a tank type vacuum cleaner.
 2. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.
- B. Test Procedures
1. Test for audible leaks as follows:
 2. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - a. Start the blower with its control damper closed.
 - b. Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
 - c. Survey all joint for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
 3. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:

- a. Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
 - b. Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
 - c. Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
 - d. Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which, must be corrected.
4. Test Witness
- a. Air duct leakage test shall be witnessed by Owner/Engineer.
 - b. The Architect or duly authorized construction inspector shall be notified in writing at least 2 working days prior to each test.

END OF SECTION 23 99 00

SECTION 26 01 00
ELECTRICAL GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE:

- A. The Contractor shall execute all work as hereinafter specified, as shown on the drawings or as necessary to provide complete and functioning systems. All items of labor, material or equipment not required in detail by the specifications or drawings, but incidental to or necessary for the complete installation and proper operation of all phases of work described herein, or reasonably implied in connection therewith, shall be furnished as if called for in detail by the specifications or drawings.

1.02 LAWS AND ORDINANCES:

- A. All work and materials shall conform to the requirements of the federal, state, and local laws and ordinances having jurisdiction at the jobsite. The installation shall be in strict accordance with the latest edition of the National Electrical Code (NEC). The Contractor at no increase in contract price shall make all modifications to the work, which may be required by an authority having legal jurisdiction over the work.

1.03 LICENSES, FEES AND PERMITS:

- A. The Contractor shall have a Master Electrician license issued by or acceptable to the city in which the work is to be performed. Additionally, and at all times while work is being performed, for every five or less craftsman working on the project site, at least one craftsman shall have a Journeyman Electrician license issued by or acceptable to the city in which the work is to be performed. A city electrical construction permit will not be required for this project.

1.04 THE DRAWINGS AND SPECIFICATIONS:

- A. The drawings and specifications shall be interpreted together, and any and all work included in either, though not in both, shall be part of the contracted work. The drawings are diagrammatic but shall be followed as closely as actual construction of the project and existing job site conditions will permit. Any changes due to equipment supplied, conflict with the work of other trades or to make this work conform to the National Electrical Code shall be made by the Contractor at no increase in contract price.

1.05 SITE CONDITIONS:

- A. Before submitting his bid, the Contractor shall visit the site and familiarize himself with all existing conditions and his bid shall be based on accepting conditions as they exist.

1.06 MATERIALS AND EQUIPMENT:

- A. All materials and equipment furnished by the Contractor shall be new. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such materials and equipment. Where two or more units of the same item are required, they shall be products of a single manufacturer. The Contractor shall unload and properly store all electrical materials and equipment delivered to the jobsite.

1.07 UTILITY CONNECTIONS AND SERVICE:

- A. The Contractor shall make arrangements for connection with the electrical utility company that will serve the jobsite and shall comply with all the rules, regulations and requirements of the utility company. The Contractor shall examine the site, confer with the utility company and verify the requirements for connections prior to bidding the work. The Contractor shall verify with the utility company the exact location of service tie-in points, cable routes, etc. Failure of the Contractor to contact the utility company and obtain such information prior to bidding the work shall not be considered as a basis for additional compensation. Where outages to existing electrical service are required, the Contractor shall coordinate the timing and duration of such outages with Owner's representative.
- B. The Contractor shall furnish and install a meter enclosure for the utility company meter. The enclosure and installation shall be in accordance with utility company requirements.

1.08 SAFETY:

- A. It shall be the responsibility of the electrical Contractor to initiate, maintain, and supervise all safety precautions required by local, state, and federal laws, including OSHA.

1.09 SUBMITTALS:

- A. Submittals for Approval:
 - 1. Submit in accordance with Section 013000 except as otherwise stated herein.
 - 2. Within 30 calendar days after award of contract, the Contractor shall furnish seven (7) sets of drawings and data as described herein for Engineer approval. No item of equipment or material shall be ordered or shipped to the job site until the Engineer has given written approval of the submittal data.
 - 3. The submittal data shall be bound in a 3-ring binder with dividers. The binder shall include a cover and a table of contents with the contractors name as well as the name of the project. All data shall be divided by specification section.

4. The submittal data for each item shall include descriptive literature, performance data, shop drawings technical literature and any other necessary data to readily identify that the equipment will meet the requirements of the drawings and specifications.
5. One complete submittal of drawings and data shall be made for all required items. Partial or incomplete submittals will be returned without comment. All copies furnished shall be manufacturer's original copies of good quality, legible photocopies or blue line prints. Copies transmitted by facsimile machine are not acceptable.
6. Submittal documents shall be job specific. Where manufacturer's standard drawings or catalog sheets are provided, they shall be marked to show specifically what is being furnished. Drawings shall be marked to show Owner's name, plant location, project description and equipment designation.
7. Substitutions for specified products shall be in compliance with Paragraph 1.10.
8. The Contractor shall review all manufacturers' submittals for completeness, accuracy and compliance with project specifications before submitting to Engineer.
9. The Engineer will review the complete submittal package and return five (5) sets to the Contractor with individual items marked in one of the following three forms:

Reviewed as submitted
Reviewed with comments
Disapproved

Items that are disapproved shall be corrected as required and shall be resubmitted to the Engineer for approval.

- B. Approval of submittals, etc. shall not be construed as releasing the Contractor from further responsibility, but rather as a means to coordinate the work and to aid in the proper selection and installation of the materials and equipment. All materials and equipment shall be subject to final acceptance by the Engineer at completion of the project.

- C. Submittal of Record Data:

1. Record Data: Provide seven (7) sets of record data books containing information listed below. The material shall be bound into appropriately sized 3 ring binders, organized with dividers and index sheets. The binders shall be appropriately labeled with the Owner's name, project name and location. The data books shall include:
 - a. Certified as-built shop drawings for all fabricated equipment.
 - b. Approved product data for all items required in Paragraph 1.09A.
 - c. Spare parts lists
 - d. Test records.

2. Record Drawings: Provide one (1) set of project drawings marked neatly and legibly in colored pencil to show any significant deviation between actual conditions and original design layout.
3. Operation and Maintenance Data: Provide seven (7) sets of manufacturer's operation and maintenance data on equipment and components. The data shall be organized into loose-leaf binders with dividers and master index.

1.10 SUBSTITUTIONS:

- A. Requirements for Substitutions: It is the intention of the drawings and specifications to establish a definite standard when a particular manufacturer's product is mentioned. Written request for substitutions of equivalent products will be considered provided all the following conditions are met. Substitutions for specified products will not be permitted unless all of the following conditions are met:
 1. Written request shall be received in the Engineer's office ten (10) days prior to the day of bid opening. Requests after ten days prior to the day of bid opening will not be considered.
 2. Request shall include complete technical data, i.e. product data sheets, curve, ratings, etc.
 3. Request shall include a complete written comparison of differences and similarities between the proposed and specified product. Provide a written comparison for each substitution being requested.
 4. Space and clearance requirements are adequate for products mentioned. It is the responsibility of the Contractor to verify space and clearance requirements for products proposed for substitution.
 5. If modifications to the drawings and specifications are necessary for the proper installation of a product proposed for substitution, the request shall explain such in detail, accompanied by drawings if necessary.
- B. Approval: If the above has been complied with, and in the Engineer's opinion the product proposed for substitution is equivalent to that mentioned, the product will be approved for substitution and all prospective bidders will be so notified.

1.11 PROTECTION:

- A. All new work, equipment and materials shall be protected at all times to prevent damage or breakage, either in transit, storage, installation or testing. All openings shall be closed with caps or plugs during installation. All materials and equipment shall be covered and protected against dirt, water, chemical or mechanical injury. This shall include the erection of all required temporary shelters, cribbing of any apparatus above floor construction and covering of apparatus in incomplete buildings with

tarpaulins or other protective covering. Temporary electric heaters shall be installed to keep apparatus dry. All rotating equipment and/or machinery shall be properly lubricated and rotated on a regular basis. All electrical materials and equipment damaged during handling, storage, and installation, until the Owner has accepted the project, shall be repaired or replaced by the Contractor with no increase in contract price.

1.12 COORDINATION:

- A. The Contractor shall not hinder and/or delay any work being accomplished by other construction companies at or near the general construction site; nor shall the Contractor impede normal operation of the Owner at any time except as otherwise indicated.

1.13 WORKMANSHIP:

- A. All labor shall be performed in the best and most workmanlike manner by mechanics skilled in their particular trades. All installations shall be complete in both effectiveness and appearance whether finally enclosed or left exposed. The Engineer reserves the right to direct the removal or replacement of any item which, in his opinion, does not present a reasonably neat or workmanlike appearance, providing that same can be properly installed in an orderly way by usual methods for such work. All specialties and appurtenances shall be installed to conform to the manufacturer's recommendations unless otherwise specified.

1.14 EQUIPMENT BY OTHERS:

- A. This Contractor shall make electrical connections to equipment installed by other trades. The mechanical contractor shall install all motor driven equipment and motors furnished under this contract.
 - 1. The Contractor shall verify the electrical requirements of equipment and appliances furnished by others with data provided by the successful vendor or vendors. The Contractor shall provide the proper sized circuits, circuit breakers, starters, disconnect switches, receptacles, etc. as required to connect this equipment. If changes are required to electrical systems shown on the drawings, the Contractor shall make these changes at no additional cost to Owner.

1.15 CUTTING AND REPAIRING:

- A. The Contractor shall coordinate the work to eliminate cutting of the construction except as specified. Where it becomes necessary to cut through the construction to permit the installation of work or the repair of defective work, it shall be done by mechanics skilled in the trade of erecting the type of work involved. The Contractor without additional compensation shall pay the cost of cutting and repairing. No cutting shall be

done to any structural members unless the Engineer grants specific permission, in writing.

1.16 SLEEVES, INSERTS, SUPPORTS, ANCHOR BOLTS, FLASHING AND FOUNDATIONS:

- A. Furnish and install all sleeves, inserts, supports, anchor bolts, flashing, counter flashing and foundations required for the proper installation of the proposed work.

1.17 CLEANING:

- A. All debris resulting from the construction shall be removed from the project site daily. Upon completion of the project, unused materials and equipment shall be removed from the project site. All visible labels, dirt overspray, paint, grease, and stains shall be removed from all electrical equipment. Labels indicating testing laboratory approval or giving parts numbers shall be left in place.

1.18 TESTING:

- A. The Contractor shall test the entire wiring system for proper voltage level and balance, and for short circuits and grounds in accordance with established methods upon completion of work. The system shall operate satisfactorily in every respect. This Contractor shall make all corrections to accomplish such.

1.19 INSPECTIONS:

- A. The Contractor shall cooperate with and provide assistance to the Engineer or the Engineer's Inspector in making periodic and final inspections of the work. This assistance shall include, but not necessarily be limited to, the furnishing of labor, tools, etc. to operate equipment and demonstrate its proper functioning. Also included shall be the removal of outlet, junction box and panel covers, etc. as necessary for the Engineer to inspect the work.

1.20 GUARANTEE:

- A. Any defects from imperfect or improper materials or faults arising from improper workmanship that may appear within a period of twelve (12) months from the date of final acceptance of the system shall be amended and made good by the Contractor at his own cost. Any defects or faults shall be attended to within ten (10) days after receiving written notice from the Engineer. Failure to promptly attend to said defects or faults shall be sufficient cause for the Owner to correct the problem with the Owner's forces or the forces of others and invoice the Contractor for any and all charges, including management and overhead, related to correcting said problem.

END OF SECTION 26 01 00

SECTION 26 02 01
COORDINATION DRAWINGS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions 013100 and Supplementary Conditions apply to all Work herein.

1.2 COORDINATION DRAWINGS

- A. The Contractor shall take the lead in coordinating the Mechanical, Electrical, Plumbing, and Fire Protection systems within the building.
- B. The General Contractor shall coordinate a three-dimensional (3D) model of the building which includes the Mechanical, Electrical, Plumbing, and Fire Protection systems. The Mechanical, Electrical, Plumbing, and Fire Protection Contractors shall prepare their work and generate 3D models which will be given to the General Contractor for coordination. The Contractor will be provided with the REVIT model that was used to generate the contract documents, this file may be used as the background file. The Contractor shall replace the systems drawn with the actual shop drawing models. The Contractor is not limited to using REVIT, but may use any 3-D software in generating and combining the coordination model.
- C. Submitting the contract drawings as coordination drawings will not be acceptable.
- D. The model shall include detailed and accurate representations of all equipment to be installed based upon the reviewed equipment submittals.
- E. The Contractor shall hold a 3-D coordination meeting with all sub- contractors present to review the model and discuss coordination of the installation of the building systems.
- F. Upon completion of the coordination meeting, the Contractor shall submit the 3-D model and 1/4" scale drawings for review.
- G. The model shall detail major elements, components, and systems in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
 - 1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
 - a. Wall and type locations.
 - b. Clearances for installing and maintaining insulation.

- c. Locations of light fixtures and sprinkler heads.
 - d. Panel and transformer locations.
 - e. Conduits 1-1/2" and larger.
 - f. Fire Alarm Panels and Devices.
 - g. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - h. Equipment connections and support details.
 - i. Exterior wall and foundation penetrations.
 - j. Routing of storm and sanitary sewer piping.
 - k. Fire-rated wall and floor penetrations.
 - l. Sizes and location of required concrete pads and bases.
 - m. Valve stem movement.
 - n. Structural floor, wall and roof opening sizes and details.
- 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 - 3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 - 4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.

H. Sequence of Coordination

Below is hierarchy of model elements and the sequencing by which the models will be coordinated.

- 1. Structural and Architectural model
- 2. Miscellaneous steel
- 3. Perform preliminary space allocation
- 4. Identify hard constraints (locations of access panels, lights, A/V space requirements, etc.)
- 5. Main and medium pressure ducts from the shaft out
- 6. Main graded plumbing lines and vents
- 7. Sprinkler mains and branches
- 8. Cold and hot water mains and branches
- 9. Lighting fixtures and plumbing fixtures

10. Smaller sized ducts and flex ducts
11. Smaller size cold water and hot water piping, flex ducts, etc.

- I. The Contractor and Sub-Contractors shall not install any item until the coordination has been completed and reviewed by the Construction Manager, Owner, and A/E team.
- J. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
- K. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

END OF SECTION

SECTION 26 06 00 GROUNDING

PART 1 GENERAL

1.01 SUMMARY:

A. Section Includes:

1. Solid grounding of electrical systems, equipment, machine frames, enclosures, appliances and structures.
2. Basic requirements for grounding for protection of life, equipment, circuits, and systems.
3. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

1.02 REFERENCES:

A. American Society for Testing and Materials (ASTM):

1. B3 Standard Specification for Soft or Annealed Copper Wire.
2. B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
3. B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

B. National Fire Protection Association (NFPA):

1. 70 National Electrical Code
2. 78 Lightning Protection Code

C. Underwriters Laboratories Inc. (UL)

1. 467 UL Standard for Safety Grounding and Bonding Equipment.

1.03 SUBMITTALS – FOR APPROVAL:

- ##### **A. Procedure:** Submit in accordance with Section 013000 and 260100.

- B. Product Data: Submit for grounding conductors, ground rods, clamps, connectors, wells and insulating materials.

1.04 SUBMITTALS – RECORD DATA:

- A. Submit in accordance with Section 013000.
- B. Product Data: Approved, as furnished data as listed above.
- C. Test Reports

1.05 QUALITY ASSURANCE:

- A. Items provided under this Section shall be listed or labeled by UL.
- B. Regulatory Requirements:
 - 1. National Electrical Code (NEC): Provide components and installation as required by National Fire Protection Association (NFPA) 70, Article 250.

PART 2 PRODUCTS

2.01 GENERAL:

- A. Provide products in quantities, sizes and ratings to comply with the NEC or the design drawings, whichever requirements are more stringent.
- B. Conductor Materials: Copper
- C. Connector Materials: Copper or bronze, tin-plated where required for corrosion resistance.

2.02 CONDUCTORS:

- A. Grounding Electrode Conductor: Soft drawn copper, Class B stranded per ASTM B-8, 600 volt TW, THW or THWN insulation. Size per NEC 250.
- B. Equipment Grounding Conductor: Soft drawn copper, Class B stranded per ASTM B-8 except that conductor sizes Nos. 12 and 10 AWG used in lighting and receptacle branch circuits may be solid conductor. All conductors shall have 600 volt, TW, THW or THWN insulation.

- C. Grounding Grid Conductor: Medium hard drawn bare copper, Class B stranded per ASTM B-8, No. 2/0 AWG or as otherwise indicated on the drawings.
- D. Color Code: Insulation color shall be green, except that sizes No. 2 AWG and larger may be black with green colored tape spirally applied over all visible surfaces within enclosures.

2.03 WIRE CONNECTORS:

- A. Terminal Lugs: Copper alloy, tin-plated, compression type, Burndy type, YA, NEMA 1 hole for sizes No. 6 through No. 1/0 AWG. Burndy type YGHA, NEMA 2 hole pad for sizes No. 2/0 AWG and larger.
- B. Split Bolt Connectors: Burndy SERVIT, type KS
- C. Taps and Splices:
 - 1. Grounding Grid below Grade: Exothermic type (Cadweld) or compression type (Burndy Hyground).
 - 2. Above Grade: Compression type.

2.04 CONDUIT CONNECTORS:

- A. Conduit Clamps: Burndy type GAR or GD.
- B. Grounding Bushings: 0-Z/GEDNEY

2.05 GROUNDING ELECTRODES:

- A. Ground Rods: $\frac{3}{4}$ inch diameter, 10 feet long, copper clad steel with high strength sheath, molten welded to core.
- B. Rod Connectors:
 - 1. Exothermic type: Cadweld
 - 2. Mechanical type: Burndy type GAR or GD
- C. Test Wells: (Not Required)

2.06 INSULATING MATERIALS:

- A. Tape: Scotch 33+ vinyl plastic.
- B. Mastic Pads: Scotch EZ – Seal

PART 3 EXECUTION

3.01 INSTALLATION:

- A. General:
 - 1. Provide grounding of systems, equipment and structures in accordance with NEC Article 250, the requirements of the authority having jurisdiction and the design drawings.
- B: Service Entrance:
 - 1. Not applicable.
- B. Building Steel and Piping:
 - 1. Not applicable.
- E. Equipment Grounding:
 - 1. Provide a green insulated equipment grounding conductor in all branch circuits and feeder conduits. Size conductor in accordance with NEC 250 unless otherwise indicated on the drawings.
 - 2. Connect the equipment grounding conductor to panelboard or switchgear ground bus and to all metallic raceways, outlet boxes, lighting fixtures, equipment enclosures, appliances and motor frames.
 - 3. Where metallic raceways are installed, both the raceway and the internal equipment grounding conductor shall be utilized for equipment grounding.
- F. Grounding Grid:
 - 1. Not applicable
- G. Conduit:
 - 1. Provide grounding bushings where metallic conduits connect to non-metallic enclosures or stub-up into open-bottom, floor-mounted enclosures.

2. Provide conduit grounding clamps where metallic conduit stub-ups are connected to non-metallic underground conduits.

END OF SECTION 26 06 00

**SECTION 26 07 50
ELECTRICAL IDENTIFICATION**

PART 1 GENERAL

1.01 SUMMARY:

A. Section Includes:

1. Equipment nameplates and labels
2. Warning and caution signs
3. Operational instruction signs
4. Identification labeling of conduits, cables

B. Related Sections:

1. Additional identification requirements are specified in other Sections of Division 26.

1.02 REFERENCES:

A. Code of Federal Regulations (CFR)

1. 29CFR1910.145 Specification for Accident Prevention Signs

B. National Fire Protection Association (NFPA)

1. 70 National Electrical Code

1.03 SUBMITTALS FOR APPROVAL:

A. Procedure: Submit in accordance with Section 013000 and 260100.

B. Product Data: Submit for each type of product used on project.

C. Schedules: Nameplate engraving schedule.

PART 2 PRODUCTS

2.01 ELECTRICAL IDENTIFICATION PRODUCTS:

A. Engraved Nameplates and Signs:

1. Material: 3 ply plastic laminate, matte-finish, 0.125 inch thickness, white with black center core except that material used for warning signs shall be red with white center core. Provide punched mounting holes for mechanical fasteners.
2. Size: Minimum size to be 1 inch by 2.5 inches, rectangular shape with square corners.
3. Engraving: Accurately align lettering and engrave into center core. Lettering shall be normal block style. Character size shall be 3/8 inch high for grouped equipment and load designation and 1/4 inch for individual equipment, loads and devices.

B. Warning Signs:

1. Fiberglass reinforced polyester, non-adhesive backed, indoor-outdoor with punched mounting holes, Brady B-120.
2. Polyester overlaminated with plastic coating, adhesive-backed, indoor-outdoor, Brady B-302.
3. High Voltage warning signs to read "Danger-High Voltage-Keep Out."
4. Provide identical signs for each application.

PART 3 EXECUTION

3.01 INSTALLATION:

A. General:

1. Provide labels and signs in accordance with NEC requirements.
2. Install labels and signs at locations for best convenience of viewing without interference with operation and maintenance of equipment.
3. All nameplates and signs used on the project shall be of similar size, style and appearance.

B. Equipment Nameplates:

1. Provide engraved identification nameplates for each of the following:
 - a. Panelboards
 - b. Circuit breakers
 - c. Switches
 - d. Contactors

- e. Pull and junction boxes
- 2. Nameplate legends shall include the equipment identification number as indicated on the design drawings and an appropriate service description.
- 3. Nameplates for switchgear assemblies, panelboards, and separately enclosed breakers, switches, starters and contactors shall include the operating voltage.
- 4. Attach engraved nameplates to equipment with self-tapping, stainless steel, round head screws. Use adhesive attachment only where the substrate material is not suitable for screw attachment.

C. Warning Signs:

- 1. Voltage warning signs where required by the NEC, where indicated on drawing and as follows:
 - a. Equipment Rooms: On all doors to equipment rooms containing equipment or circuits over 600 volts or containing exposed live parts. Minimum size shall be 7 inches x 10 inches.
 - b. Pull Boxes: On removable covers for all pull and junction boxes containing circuits over 600 volts.
 - c. Equipment: On front and rear compartment access doors and covers enclosing live parts. Signs provided as part of equipment that meet these requirements are acceptable.
 - d. Fences: On each gate and on each side of fences that enclose equipment or circuits over 600 volts or exposed live parts. Minimum size shall be 10 inches by 14 inches. Locate at intervals not exceeding 30 feet.
- 2. Multiple Source Signs:
 - a. Where enclosures contain voltages from more than one source which are not interrupted by opening the local unit disconnecting means, provide an engraved nameplate bearing the following (or similar) legend:

“WARNING – MULTIPLE ELECTRICAL SOURCES EXIST WITHIN THIS ENCLOSURE”

OR

“WARNING – VOLTAGE MAY BE PRESENT WITH DISCONNECT SWITCH OPEN”

3. Hazardous Operation:
 - a. Where operation of an electric switch or control device may create an unsafe or undesirable operating condition, provide an engraved plastic sign with appropriate warning statement.
- D. Multiple Services:
 1. Where multiple services exist, provide each service disconnect with an additional sign which states the name and location of other service disconnects.
- E. Conduits:
 1. Identify conduits at each termination and at all transitions from exposed to concealed or underground installation.
 2. Mark conduits legibly with a permanent marker pen to indicate conduit per circuit number.
- F. Cables:
 1. Identify cables in pull and junction boxes, vaults, manholes and where entering switchgear panelboard assembly.
 2. Provide an engraved plastic nameplate or other suitable permanent tag for each cable or cable assembly. Attach with self-locking nylon cable tie.
 3. Cable identification shall include circuit number and phase as indicated on drawings.

END OF SECTION 26 07 50

SECTION 26 09 13
ELECTRICAL POWER MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for an Electrical Power Management System (also identified as EPMS, EMS, Energy Management System or Energy and Power Management System) as required for the complete performance of the Work, as shown on the Drawings and as herein specified.
- B. The Work specified in this Section includes but shall not be limited to the following:
 - 1. Hardware—such as device communication interface hardware; servers; mobile or workstation devices; and ancillary equipment.
 - 2. Software—such as on premise installed software and cloud based software-as-a-service (SaaS) applications.
 - 3. Services, support, and training.
- C. The EPMS shall be provided by a qualified EPMS system supplier. The Contractor shall ultimately be responsible for the EPMS and shall supplement the system supplier's Work as necessary to provide a complete and operable system. The Contractor shall coordinate the equipment and systems provided by others that interface with the EPMS to ensure necessary interconnections and compatibility are provided for the required functionality of the EPMS.
- D. Related Sections: Related sections include, but shall not be limited to, the following:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
 - 2. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.
 - 3. Refer to the following specifications of system connected devices for additional requirements:
 - a. Section 26 27 13 – Power and Energy Meters
 - 4. Refer to the following specifications of system connected equipment for additional requirements:
 - a. Section 26 24 13.11 – Switchboards - Integrated
 - b. Section 26 24 16 – Panelboards
 - 5. Refer to the following specifications for additional requirements related to the integration and interface with the Electrical Power Management System:
 - a. Section 23 95 00 – Energy Management & Control System

1.2 REFERENCES

- A. General Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The

edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. Canadian Standards Association (CSA)
 - a. CSA C282, "Emergency Electrical Power Supply for Buildings"
 - b. CSA Z32, "Electrical Safety and Essential Electrical Systems in Health Care Facilities"
2. European Engineering Standards (CSN EN):
 - a. CSN EN 16247-1, "Energy Audits - Part 1: General Requirements"
 - b. CSN EN 50160, "Voltage Characteristics in Public Distribution Systems"
3. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE 519, "Recommended Practice and Requirements for Harmonic Control in Electric Power Systems"
 - b. IEEE 1159.3, "Recommended Practice for the Transfer of Power Quality Data"
 - c. IEEE 1588, "Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems"
4. International Electrotechnical Commission (IEC):
 - a. IEC 60364-7-710, "Electrical installations of Buildings - Part 7-710: Requirements for Special Installations or Locations - Medical Locations"
 - b. IEC 61000-4-30, "Electromagnetic Compatibility (EMC) - Part 4-30: Testing and Measurement Techniques - Power Quality Measurement Methods"
 - c. IEC TS 62443-1-1, "Industrial communication networks - Network and system security - Part 1-1: Terminology, concepts and models"
 - d. IEC 62443-2-1, "Industrial communication networks - Network and system security - Part 2-1: Establishing an industrial automation and control system security program"
 - e. IEC TR 62443-2-3, "Security for industrial automation and control systems - Part 2-3: Patch management in the IACS environment"
 - f. IEC 62443-2-4, "Security for industrial automation and control systems - Part 2-4: Security program requirements for IACS service providers"
 - g. IEC PAS 62443-3, "Security for industrial process measurement and control - Network and system security"
 - h. IEC TR 62443-3-1, "Industrial communication networks - Network and system security - Part 3-1: Security technologies for industrial automation and control systems"
 - i. IEC 62443-3-3, "Industrial communication networks - Network and system security - Part 3-3: System security requirements and security levels"
 - j. IEC 62443-4-1, "Security for industrial automation and control systems - Part 4-1: Secure product development lifecycle requirements"
5. International Organization for Standardization (ISO):
 - a. ISO 9001, "Quality Management Systems - Requirements"
 - b. ISO 50001, "Energy Management Systems"
6. National Fire Protection Agency (NFPA)
 - a. NFPA 70, "National Electrical Code (NEC)"
 - b. NFPA 110, "Standard for Emergency and Standby Power Systems"

1.3 DEFINITIONS

- A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.
 - 1. PQ: Power Quality
 - 2. Smart Mobile Device: Smart phone or tablet compatible with iOS or Android OS capable of running apps used for specified functionality

1.4 SUBMITTALS

- A. General: Submittals shall be in accordance with the requirements of Section 01 33 00 Submittals and Section 26 01 00 Electrical Requirements, in addition to those specified herein.
 - 1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
 - 2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.
- B. EPMS Software Configuration Standards and Conventions. A "Software Configuration Standards and Conventions" document shall be prepared and submitted by the System Supplier after the first EPMS Software Configuration Review Meetings to document decisions made within the meeting. The document shall be submitted for review and approval before software configuration commences. All copies of this submittal shall be provided in color to ensure the accuracy of each item. No black and white copies will be accepted. The colors used in the printed submittal shall accurately depict the colors and shapes proposed for use on the final system.
- C. Product Data: EPMS product catalog sheets and technical data sheets specifying physical data and electrical performance, electrical characteristics, and connection requirements of each device shall be supplied under the EPMS scope of work.
- D. Shop Drawings
 - 1. EPMS drawings shall show elementary and interconnection diagrams for all relevant field-monitoring devices and networking components including power, signal, control, communications wiring and network addresses. Drawings shall identify network connections and protocols. Drawings shall identify device room locations and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installation contractor. Where LV Switchgear interconnection is specified, drawings shall not be typical, but shall be provided for each Switchgear and Breaker furnished.
 - 2. Sequence of operation (for control applications such as automatic transfer schemes, load control, etc.), layout drawings, as-built wiring diagrams, bill of material, spare parts list, and component catalog information shall be included in a final documentation package that will be delivered to the owner prior to training.

- E. Operation & Maintenance (O&M) manuals shall be provided in accordance with the minimum requirements specified in Section 01 78 23 Operation and Maintenance Data, Section 26 01 00 Electrical Requirements and additional requirements specified herein.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of ten years.
 - 1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
 - 2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.
- B. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.
- B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.7 WARRANTY

- A. General: Refer to Section 01 77 00 - Closeout Procedures.
- B. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.8 SPECIAL TOOLS AND SPARE PARTS

- A. Any manufacturer specific special tool, not normally found in an electrician's toolbox, required to remove and install recommended or furnished spare parts shall be furnished. At a minimum the following shall be provided:

1. If available from manufacturer, provide PC-based configuration software tool and a minimum of one (1) communication interface cable for each type of cable required to connect a PC-based computer to the devices specified herein for configuration and programming.
 2. Electronic configuration files, in a media format acceptable by the Owner (e.g. CD, USB stick, etc.), updated to an as-installed and commissioned state.
- B. Spare parts shall be properly marked and packaged for long term storage. Printed circuit boards shall be provided in separate anti-static containers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide EcoStruxure™ Power and supporting products and services by Schneider Electric.
- B. Acceptable Products and supporting services: The Electrical Power Management System (EPMS) specified herein shall be the products and supporting services of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date:
1. EcoStruxure™ Power and supporting products and services by Schneider Electric
 2. Powermanager/WinPM.net by Siemens

2.2 GENERAL REQUIREMENTS

- A. The EPMS shall provide data and analytics functionality for (a) energy performance optimization, (b) power reliability and availability, and (c) sustainability metrics. Features like real-time monitoring, alarming and event management, energy, power, and sustainability data analytics and visualization will facilitate the following functions at a high level:
1. Analyze energy usage and uncover savings opportunities.
 2. Meet and exceed energy efficiency and sustainability standards and certifications.
 3. Measure return on investment of energy capital projects.
 4. Allocate and bill energy costs accurately to processes, tenants, cost centers, and departments.
 5. Decrease the frequency and duration of unplanned outages.
 6. Improve workplace safety by minimizing exposure to electrical hazards.
 7. Provide accurate and automated documentation for regulatory compliance.
 8. Improve the effectiveness of equipment maintenance activities.
 9. Manage multiple power generation sources effectively.
 10. Increase the return on electrical distribution assets.
 11. Measure and achieve sustainability targets.

- B. Data and analytics provided by the EPMS system for centralized display, analysis, logging, alarming, event recording, and other EPMS operations shall be accessible from a computer workstation with supported operating system and interface software.
- C. EPMS Software Configuration Review Meetings. Proposed screens and report formats shall be reviewed with the Owner and Engineer throughout the configuration process. The System Supplier's programming personnel shall attend the initial review meeting. A second review meeting shall be held at approximately 50 percent completion. Both meetings shall be held at the Owner's facilities. A "Software Configuration Standards and Conventions" document shall be prepared and submitted by the System Supplier after the first EPMS Software Configuration Review Meeting to document decisions made at the meeting.
- D. Software License. All software programs supplied as a standard part of system supplier's products for this project shall be licensed to Owner for use on the system specified herein. Such license shall not restrict Owner from using the software on the system provided hereunder or its replacement. Owner shall have the right to make copies of the software for use on the system provided. Specific requirements of System Supplier's software license are subject to review and approval by Owner and Engineer.
- E. Computers / Servers: Computers systems including servers, workstations, etc. required for the EPMS system shall be as depicted on the Drawings. Computer hardware shall be provided by the EPMS supplier to meet the specified performance of the system. Computer systems shall use current generation PC based architectures using Microsoft operating systems. Computers shall be provided with 50% additional capacity for system expansion.

2.3 ELECTRICAL DISTRIBUTION MONITORING & ALARMING

- A. The EPMS in conjunction with compatible connected power monitoring devices shall provide screens displaying real-time data from the electrical infrastructure, such as incoming utility feeds, medium voltage, and low voltage distribution. Relevant real-time data from energy meters and other facility metadata, such as water, air, gas, electric, and steam meters (WAGES), industrial process data, weather, occupancy, etc. shall be displayed from the connected devices, equipment and systems compatible with the EPMS. Real-time data shall also be organized and displayed along with other analytics functions of the EPMS software to provide logical views for the health of the system and to support EPMS applications specified herein.
- B. Electrical single line diagrams: The EPMS shall provide a set of screens showing the electrical single line diagram for the facility. The following minimum functionality shall be provided.
 - 1. Links to navigate between various levels of the single line diagram.
 - 2. Electrical parameters for equipment components on the single line (such as MV switchgear, MV transformers, generators, unit substations, LV switchboards, UPS, isolated panel system).
 - 3. Link to power equipment details screens.
- C. Equipment details: The EPMS shall include a set of screens showing equipment details including:
 - 1. Details pertaining to each piece of equipment. This includes a picture of the equipment (if provided to EPMS supplier), local single line (if applicable), information for each electrical section (for example, breaker and disconnect switch), and all alarm points.
 - 2. Measured peak demand and loading of equipment (e.g. breakers, UPSs, transformers, generators)

3. A link to each of the default diagrams of each meter/protection device that apply to the piece of equipment.
- D. Floor plans: The EPMS shall include a set of screens showing floor plans overlaid with relevant real-time data. The Engineer or Owner will provide digital image files in a timely manner to the EPMS supplier for this purpose. Navigation links to summary screens, equipment details screens, etc. shall be provided.
- E. Status: The EPMS shall include a summary status screen for alarm indication for major power equipment components of the electrical distribution system.
- F. Alarms: Abnormal electrical conditions, events and group related incidents shall be organized logically using good alarm management practices for quick and easily situational awareness and actionable intelligence. The EPMS shall also notify appropriate staff members of alarms through email or SMS text messages.

2.4 POWER QUALITY MONITORING

- A. The EPMS in conjunction with connected compatible power quality monitoring devices shall monitor electrical disturbances such as harmonics, unbalance, flicker, over/under voltage conditions, etc. to assist in the reporting, analysis of conditions and diagnoses of events.
- B. The EPMS software shall provide power quality specific screens and reports including but not limited to the following.
 1. Device Level Power quality summary screen—the data collected by any compliant PQ-capable metering device shall be summarized to show:
 - a. Voltage disturbances, including the date and time of the last disturbance, the count of the number of transient events, and the count of the number of sag/swell events.
 - b. Harmonic measurements, including a link to the harmonics log for the particular device.
 - c. Real-time Harmonic Distortion measurements: Total Harmonic Distortion (THD) content and the maximum THD.
 - d. Flicker measurements.
 - e. Logged events, including a link to the event log for the particular device.
 - f. Waveform logs, including a link for waveforms captured during transients and sag/swell events.
 - g. Detailed waveform analysis tools.
 2. System Level Power Quality summary screen—the power quality report shall display all power quality events collected in the EPMS for one or more metered points within a given time period.
 - a. The report shall show a summary table of all the events within a given time period and provide the means to see further details (power quality details report) for any given event.
 - b. The summary report shall contain a plot of the Information Technology Industry Council (ITI) (also known as ITIC or CBEMA) curve that displays the worst disturbance from each event listed in the summary table. The summary table shall contain the following components for each event:
 - 1) Event identifier.
 - 2) Source.
 - 3) Event timestamp.

- 4) Phase identifier for the worst disturbance during this event (ex., "V1").
 - 5) Voltage magnitude for the worst disturbance during this event in % of nominal (for example, "68.80%").
 - 6) Voltage magnitude maximum and minimum on phases V1, V2 and V3 for the worst disturbance during this event in % of nominal.
 - 7) Duration for the worst disturbance during this event in seconds (for example, "0.084s").
 - 8) Disturbance type for the worst disturbance during this event (for example, "sag").
 - 9) ITI (ITIC, CBEMA) tolerance curve violations (for example, "outside tolerance").
 - 10) Link to the details report for this event.
 - 11) Link to waveform report for the worst disturbance during this event.
- c. Each entry in the summary table shall include a link that provides further details for the given event. The details to be shown are:
- 1) Disturbance event timestamp.
 - 2) Phase identifier.
 - 3) Voltage magnitude in % of nominal (for example, "68.80%")
 - 4) Voltage magnitude maximum and minimum on phase V1, V2 and V3 in percentage of nominal.
 - 5) Duration in seconds.
 - 6) Disturbance type.
 - 7) ITI (CBEMA) tolerance curve violations (for example, "outside tolerance").
 - 8) Link to waveform report.
- d. Each entry in the summary table shall include a link that shows the waveforms of the given event (if any exist). The waveforms shown shall be for both the voltage and current readings of the measuring point.
3. One hundred (100)-millisecond Power Quality Report
- a. This report shall display data recorded at 100 millisecond intervals, with a data table for the measured point and selected measurement containing columns labeled: Timestamp, Source Label, Measurement Label, Measurement Unit, and Data Value.
4. IEEE1159.3 Power Quality Data Interchange Format (PQDIF) Support
- a. The system shall provide a mechanism to export power quality data to the non-proprietary standard PQDIF format with support for the following default templates:
- 1) Flicker: Short-term and long-term flicker disturbance data on the voltage inputs.
 - 2) Sag/Swell: Sag/swell disturbance data for voltage inputs, including minimum, maximum and average values.
 - 3) Sag/Swell Waveforms: Waveform data for voltage sag/swell.
 - 4) Steady-state: Steady-state (RMS) data for trending.
 - 5) Steady-state Waveforms: Waveform data for steady-state data.
5. Disturbance Direction Detection
- a. For power quality compliant devices, the system will indicate the direction of the disturbance within the electrical distribution system in event logs, with associated confidence or certainty rating (for example, "Upstream: Confidence Rating - High", or "Downstream: Confidence Rating - Medium" etc.).
- C. The EPMS software shall provide the following specific Power Quality Compliance Reports:
1. EN50160 Edition 4 Compliance Report

- a. The EN50160 voltage characteristics of public distribution systems compliance report shall display a summary of EN50160 compliance for a set of metered points in the system within a given time period for the following components:
 - 1) Power frequency.
 - 2) Supply voltage variations.
 - 3) Flicker severity.
 - 4) Supply voltage unbalance.
 - 5) Harmonic voltage.
 - 6) Inter-harmonic voltages.
 - 7) Mains signaling voltages.
 - 8) Interruptions of supply voltage.
 - 9) Supply voltage dips and swells.
 - b. Additionally, the report shall allow for detailed drill-down for a given measuring point and measurement period.
2. IEC61000-4-30 Report
- a. The IEC61000-4-30 compliance report shall display a summary of the IEC61000-4-30 compliance for a set of metered points in the system within a given period. The report shall:
 - 1) Include the following IEC61000-4-30 components: frequency, supply voltage magnitude, flicker, supply voltage unbalance and supply voltage THD.
 - 2) Provide a means to manually enter a baseline value for each component.
 - 3) Display a series of trends for each component listed with each component's manually entered baseline.
 - 4) Include a data table that displays all the power quality-related events for the given report period including voltage dips, voltage swells, and voltage interruptions.
3. IEEE 519 Harmonics Compliance Report
- a. The IEEE519 harmonics compliance report shall have the following capabilities:
 - b. Provide a mechanism to report on IEEE519 limits.
 - c. Provide a mechanism to report on user defined limits.
 - d. Ability to determine voltage and $I_{sc}/I-I$ ratio directly from the device, where I_{sc} is the maximum short circuit current at the point of common coupling (PCC), and the $I-I$ is the maximum fundamental frequency demand current.
 - e. For both individual and total harmonic voltage distortion, display the following:
 - 1) The allowable IEEE519 limits.
 - 2) The % time out of compliance.
 - 3) The number of non-compliant three-second intervals.
 - 4) The number of total measured intervals.
 - 5) Number of missing or invalid intervals.
 - 6) Compliance levels of Warning, Out of compliance, or Compliant.
 - 7) A maximum value with a time-stamp of when that distortion was measured.
 - f. For both individual and total harmonic distortion for current, display all the values specified in the previous section for every range of harmonic orders.
 - g. For each phase, voltage, and current provide a graphical plot of THD versus time stamp. On the same plot, plot the allowable limit to allow for visual comparison of compliance.

- h. Provide a graphical plot of “average value of voltage per harmonic” and “average value of current per harmonic” as a percentage of fundamental frequency, versus harmonic order to allow for visual identification of the worst harmonic problems.
 - i. For each phase voltage and current, provide a graphical plot of harmonic content versus time stamp with simultaneous plot lines for a set of harmonic orders (for example, $h \leq 11$). This allows the user to identify the harmonic orders associated with the worst problems to enable mitigation measures such as active filtering.
- D. The EPMS software shall provide power quality analytics functionality, delivered through dashboards and reports.
 - 1. PQ Analytics Key Performance Indicators (KPIs)
 - a. PQ Downtime Impact – display current count (and trend over time), of PQ events (both grid and within-facility), electrical system downtime (in hours) from these events with associated cost.
 - b. Power Factor Impact – display current value (and trend over time), for average power factor and estimated penalties or surcharges incurred
 - c. PQ Index – display an overall health indicator (and trend over time) representing a baseline for the overall PQ of the facility, based on analysis of PQ events and limits and/or thresholds defined by established PQ standards. This index shall be calculated over various time periods, and be represented on a scale of “A” to “F”, with “A” representing optimal, and “F” representing poor.
 - d. PQ Event Categorization – display event type (sags, swells, etc.), likely origin (external/within facility) and potential impact to operations per thresholds recommended by recognized PQ standards. Display shall support flexible time periods and trending over time periods.
 - 2. PQ Disturbance Indicator Analytics:
 - a. The EPMS shall calculate and display a summary screen with high-level health indicators (red, yellow, green) for each type of PQ event/disturbance, based on appropriate industry best practices or standards.
 - b. Evaluated PQ events/disturbances are:
 - 1) PQ Events - voltage sags/dips, voltage swells, voltage transients, voltage interruptions, over/under voltages
 - 2) PQ Disturbances and other phenomena - harmonic distortion, voltage/current unbalance, frequency variation, flicker
 - c. The EPMS shall provide aggregate count or maximum/average values (depending on event/disturbance type).
 - d. The EPMS shall provide the capability to drill down into each PQ event/disturbance type to view the following data (as relevant to the particular event type) – source of event (device), timestamp, potential impact, duration, and magnitude.
- E. Integration with Power Quality Mitigation Equipment
 - 1. The system shall natively support interfaces with compatible power quality mitigation equipment for power factor correction, harmonic filtering, voltage sag mitigation (UPS), and transient

protection to provide end-to-end solutions for monitoring, correction and optimization of power quality. This shall include the capabilities to

- a. Monitor key electrical and operational parameters (real-time data & alarm status)
- b. Identify operational anomalies easily through color-coded indicators (red, yellow, green)

2.5 POWER EVENTS RECORDING AND ANALYSIS

- A. The EPMS in conjunction with compatible connected power monitoring devices shall provide event aggregation and analysis tools to gather time-stamped events from compatible connected devices to provide a consolidated system event view, showing a date/time ordered list of events, event priority and the name of the reporting device.
- B. The EPMS shall automatically acquire on-board event data and associated waveforms from compatible connected power quality monitoring devices without additional software configuration or data upload scheduling.
- C. The EPMS shall automatically retrieve onboard, high resolution timestamps without degradation or modification even for devices that support clock synchronization via GPS, IRIG-B, NTP or PTP (Precision Time Protocol).
- D. High Accuracy and Resolution (1 ms.) Event Recording. System-wide events associated with critical status points shall be time-stamped to an accuracy of one millisecond (1 ms.). The following implementation details shall be specified in the "Software Configuration Standards and Conventions" document.
 1. The "critical status point list" and mechanism of integration with the EPMS. All points shall support the 1 ms. requirement and shall include but not be limited to the following.
 - a. Utility distribution switchgear—multifunction electronic relays, power quality meters, and breaker open/closed/tripped position.
 - b. Generator paralleling switchgear—multifunction electronic relays, power quality meters, and breaker open/closed/tripped position.
 - c. Substations and low voltage switchgear/switchboards—power quality meters and breaker open/closed/tripped position.
 - d. UPS, distribution panels and PDUs— power quality meters and breaker open/closed/tripped position.
 2. Mechanism of time synchronization: external GPS time signal or PTP (IEEE 1588) over Ethernet within 100 microseconds.
- E. Sequence of Events Recording (SER) Hardware. SER recording (high accuracy) hardware needed to implement the 1 ms. requirement shall comprise an integrated collection of devices and components to provide synchronized time-stamp signals, and record events with an accuracy of one millisecond. The devices chosen shall be compatible and natively supported by the EPMS software.
 1. The hardware shall include all necessary components to record the most critical system events as defined in the "critical status point list", such as
 - a. PTP master clock.
 - b. GPS antenna, cable and lightning arrestor (provided by EPMS vendor).
 - c. Clock signal distribution hardware and cabling (for legacy protocols).

- d. Event recorders.
 - e. Power quality meters.
 - f. Multifunction electronic relays.
 - g. Data network components.
 - h. Enclosures.
 - i. Computer equipment.
2. Time stamping and event recording shall be implemented at the local (field) device level where the event occurs (event recorders, meter I/O, or relays), rather than at the EPMS computer server. For instance, a breaker trip event shall be time-stamped by I/O at the local meter or at an event recorder point local to the switchboard location. The use of software to scan, poll, and time-stamp events through a PLC or on a server is not permissible, because this introduces scan time and network communication delays.
 3. Hardware requirements for any dedicated sequence-of-events recorders (for 1-millisecond event recording of discrete inputs, such as breaker open/close and trip status) shall include the following key features:
 - a. Onboard clocks time-synchronized to 1 ms. accuracy.
 - b. Precision time synchronization input per PTP (IEEE 1588), IRIG-B, DCF77 and other time synchronization standards.
 - c. Thirty-two (32) high-speed digital inputs each with configurable filter, debounce, and chatter functions
 - d. Onboard data logs for storing events: event log capacity to store 8000 events accessible from multiple masters. Each event record shall contain descriptive information for root-cause analysis, such as time/date stamp, input number, event type, input status, time quality, and unique sequence number.
 - e. The discrete output from the SER may be used to trigger waveform capture in a power quality meter. This output shall be wired to the designated power quality meter(s) and shall be prewired within connected equipment by the manufacturer.
 - f. Modbus RTU or Modbus/TCP interface.
 - g. GPS time synchronization input per the IRIG-B time synchronization standard.
 - h. Event log capacity to store 8000 events accessible from multiple masters. Each event record shall contain descriptive information for root-cause analysis, such as time/date stamp, input number, event type, input status, time quality, and unique sequence number.
 - i. Ethernet network interface supporting Modbus TCP/IP and embedded web server for setup and monitoring.
 - j. Capability to customize embedded web pages.
 - k. Non-volatile memory to store setup and event data.
 - l. A built-in, standard SD flash memory card to store user setup values and other user files.
 - m. Ability to export event data in .CSV format directly from the device without the need for additional software.
 - n. Ability to serve as a "time distribution hub" for other devices, accepting PTP precision time sync IN (over Ethernet) and outputting the required "legacy" protocol: IRIG-B, DCF77, ASCII/RS-485, etc.
 4. For multifunction electronic relays with time synchronization capabilities, ANSI function codes of events with one millisecond time stamp shall be accessible for software integration, using a Modbus RTU or Modbus/TCP interface.

5. For power quality meters having time synchronization and waveform capability, the time stamps (one millisecond accuracy) of the waveform shall match the events that initiated the waveform capture.

2.6 POWER RESTORATION

- A. The EPMS in conjunction with connected intelligent circuit breakers with compatible embedded functionality shall provide diagnosis of power loss events and assist in the efficient restoration of power. The following shall be provided at a minimum:
 1. EPMS and circuit breaker annunciation in case of a circuit breaker trip, opening or loss of power.
 2. Within a safe working distance from the circuit breaker a smart mobile device shall be able to wirelessly access with Bluetooth the circuit breaker for access to key data, recovery assistance and control.
 3. With no power to the breaker, a smart mobile device shall be able to wirelessly access with NFC the circuit breaker for key data, trip cause and recovery assistance.
 4. Access to Key data prior to tripping, root cause explanation and power recovery information including:
 - a. Health status, protection settings, trip cause, trip history, load measurements and waveform capture (waveform capture accessible with Bluetooth only) of a trip event.
 - b. Potential trip cause(s) and suggestions for additional investigations needed to determine if power can be restored
 - c. Step-by-step circuit breaker reclosing recommendations and power restoration information

2.7 BACKUP POWER TESTING

- A. The EPMS in conjunction with compatible connected power monitoring devices shall provide an Emergency Power Supply System (EPSS) Test Automation mechanism to document backup generator system testing for a written record of generator system inspection, performance, testing, and repairs.
- B. Mechanisms of EPMS integration with the generator system, report formats and dashboard layouts shall be specified in "Software Configuration Standards and Conventions" document. The following functionality shall be provided at a minimum.
 1. Fully configured Generator Test and Generator Activity report(s) that can be scheduled per a user-defined interval.
- C. The EPMS shall include screens relating to generator system testing displaying the following information:
 1. General Information—Generator name, Nameplate ratings, and Description.
 2. Testing Evaluation Data—Test Load and Test Duration.
 3. Generator Status—Starting, Running, Stopped.
 4. Engine Data—Oil Pressure, Coolant Temperature, and other user defined measurements (if available).
 5. Exhaust Gas Data—Exhaust Gas Temperature (left/right).
 6. Electrical Data—Voltage, Current, Power (Active, Reactive, Apparent), Power Factor, Load Percentage and Frequency.

- D. The EPMS shall provide a Generator Test (EPSS) Report showing the following sections:
1. Devices Summary Section—ATS and generator descriptions, and indication if the device was excluded from the report.
 2. ATS Summary Section— Lead ATS, Required Transfer Time (Sec), Transfer Time (Sec). Detail with priority level and transfer time for each ATS in the test.
 3. Generator summary section— overall grade (pass/fail) of the test and the test evaluation method used.
 4. Generator Load Summary section.
 - a. Load graph:
 - 1) Load evaluation method: the graph shall compare recorded test data to the required load threshold.
 - 2) Exhaust gas temperature evaluation method: the graph shall compare recorded test data to the minimum required exhaust gas temperature.
 - 3) Load bank testing method: the graph shall compare applicable acceptable power load thresholds with the respective test data.
 - b. Minimum, maximum, and average table - when using the load evaluation method, the minimum, maximum, and average table shall contain corresponding values for active power, apparent power, current per phase, L-N, and L-L voltages. When using the load bank testing method, the minimum, maximum, and average table shall contain corresponding values for each of the applicable stages.
 5. Generator exhaust temperature summary section: display the beginning and end date/time (HH:MM:SS) for the longest continuous temperature (LCT) at or above the manufacturer recommended minimum exhaust gas temperature. In addition, display the manufacturer recommended minimum exhaust gas temperature, the required run duration (minutes) and the pass/fail status based on the LCT.
 6. Exhaust temperature graph: display the required manufacturer recommended minimum exhaust gas temperature and the actual recorded exhaust gas temperature data.
 7. Minimum, maximum, and average exhaust temperature table - display the minimum, average, and maximum exhaust temperature readings for longest continuous temperature at or above the minimum acceptable exhaust temperature.
 8. Report Behavior: if the test solution has not been configured to collect exhaust temperature data, the entire Generator Exhaust Temperature Summary section shall not be shown and no warning message shall be shown.
- E. Generator Test (EPSS) Configuration.
1. Device Grouping.
 - a. The system shall provide a mechanism to group generators and ATS's functionally or logically for subsequent report generation based on these groups.
 2. Evaluation Method.
 - a. The system shall support specifying one of the following five methods to evaluate a generator test: (1) Load, (2) Exhaust Gas Temperature, (3) Load Bank, (4) Load or Exhaust Gas Temperature, (5) Load and Exhaust Gas Temperature.

- b. The system shall support setting pass/fail criteria based upon the exhaust gas temperature, and/or the electrical load, or load bank criteria.
- 3. The system shall support user configuration of the following:
 - a. Minimum manufacturer recommended exhaust gas temperature in degrees C or degrees F, when testing using Exhaust Gas mode.
 - b. Minimum required load as a percentage of generator nameplate rating, when testing using Load Test mode.
 - c. Load percentage and run duration for each applicable stage, when testing with Load Bank mode.
- 4. For each generator, the system shall support user assignment of a monitoring device or transducer measurement and an active value (logical 0 or 1) to the logical device start, running, and stopped engine parameters. This also includes other engine parameters such as oil pressure, battery voltage, tank level, etc.
 - a. ATS Device Configuration - for each ATS, the system shall support user configuration of individual priority level, permissible transfer time, and a text description. The system shall also support:
 - 1) Logical ATS measurement configuration, i.e., the ability to map logical ATS's to device or transducer based parameters.
 - 2) Assigning a monitoring device measurement and an active value (logical 0 or 1) to the test, emergency and normal parameters.
 - 3) Capturing and mapping the "Utility Power Available."
 - b. Generator Test (EPSS) Report Configuration - the system shall support user configurability to:
 - 1) Add an EPSS Report Group to include in the test report.
 - 2) Exclude a subset of devices from the report group.
 - 3) Choose "Reason for Running Report," to differentiate reporting on a test versus a real power outage.
 - 4) Change report layout to selectively enable or disable displaying parameters such as the exhaust gas temperature graph, minimum/maximum, average voltage, current, power, frequency, and exhaust gas temperature data.
 - c. If data quality issues (for example, missing data) are encountered, the report shall display a warnings table with relevant information.
- F. The EPMS shall provide a Generator Capacity Planning report customizable to accommodate the site's redundancy with the following features:
 - 1. Display available capacity before the designed redundancy is compromised, or show if the system is oversubscribed and by how much.
 - 2. Graphically display the level of redundancy of generator equipment during a user-selected time period.
 - 3. Display the redundancy design limit.
 - 4. Display the peak system load.
 - 5. Display the calculated difference between the redundancy design limit and the peak system load.
- G. When integrated with generator testing system, the EPMS shall be capable of Generator Fuel Monitoring and displaying fuel facility data including:

1. Volume of fuel is left in the tank.
 2. Available run time available based on fuel levels and tank temperature.
 3. Alarms shall also be set for leaks, low fuel levels, and water presence.
- H. The EPMS shall provide a Generator Activity Report to list each instance the generator was run, categorize the reason (test, emergency etc.), and a cumulative total of emergency and non-emergency run time. The EPMS shall show a comparison of the number of non-emergency hours compared with the allowable threshold (for example, 100 hours as per EPA in the US) for the reporting period for each generator.
- I. The EPMS shall present a Generator Load Summary showing the electrical data captured during the run of a generator including a load graph with kW and kVA as well as a min/max/average summary table. Optionally, the user can include a table containing the electrical details.

2.8 CAPACITY MANAGEMENT

- A. The EPMS in conjunction with compatible connected power monitoring devices shall provide service and circuit load management with capacity planning compliant with NEC 220.87. The EPMS shall provide sufficient information for operations and management decision-making for site expansion and modification planning in the form of dashboards, trending and reporting.
- B. The relevant circuits identified for capacity management reporting, report formats and dashboard layouts shall be specified in the "Software Configuration Standards and Conventions" document. The following functionality shall be provided as a minimum:
1. Monitor or aggregate measurements to monitor source capacity to indicate degree of source loading.
 2. For each circuit measured monitor maximum load and compare to equipment capacity to indicate the degree of equipment loading.
 3. Identify when a user configurable threshold (for example, 80%) is exceeded.
 4. Provide historical trending and reporting for loading on power sources and power distribution equipment such as automatic transfer switches, medium and low voltage switch gear, transformers, power distribution panels, uninterruptible power supply, etc.
 5. Show the peak load provided by the transfer switch or other equipment during a time period and compare the peak load to equipment capacity.
 6. Provide a summary of all transfer switches or equipment in a group or daily information for each piece of equipment in the group.
- C. The EPMS in conjunction with compatible connected power monitoring devices shall include a report to compare current state of the UPS system with thresholds for redundancy design. The report shall help assess the available capacity of the UPS system(s) in relation to both UPS module de-rating and intended redundancy design (ex., N+1, N+2, 2N, 2(N+1), 2(N+2)). This report shall:
1. Report available capacity before designed redundancy is compromised, or show if the system is oversubscribed and by how much.
 2. Graphically display UPS equipment in its redundancy configuration.
 3. Show both graphically and in tabular format during the user-selected time period.
 4. Show the redundancy design limit.

5. Show the peak system load.
6. Show the calculated difference between redundancy design limit and peak system load.
7. Show the information rolled-up to a system level, but also in increasingly more granular detail down to each UPS itself.

2.9 UTILITY BILL VERIFICATION

- A. The EPMS in conjunction with compatible connected revenue grade power and energy monitoring devices shall provide verification of utility energy costs through internally generated "shadow bills" for various types of utility sources (water, air, gas, electrical, steam etc.).
- B. Billing determinants and billing report formats shall be specified in the "Software Configuration Standards and Conventions" document. The following minimum functionality shall be provided.
 1. Fully configured shadow energy billing report(s) that can be scheduled per a user-defined interval.
- C. The EPMS shall provide a billing rate engine with the following capabilities.
 1. Pre-engineered rate files for common utility rate structures.
 2. Support for rate schedule configuration and business logic through configuration files without custom programming
 3. Support for common rate determinants including:
 - a. Energy usage (kWh, kVARh, kVAh)
 - b. Demand (kW, kVAR)
 - c. Power factor penalties
 - d. Co-incident demand
 - e. Time of use rates (off-peak, on-peak, etc.)
 - f. Seasonal rates (summer, winter, etc.)
 - g. Daily charges
 - h. Tiered or block energy rates (kWh)
 - i. Taxes
 - j. Dynamic rate formulas
 4. Web based interface for rate schedule editing.

2.10 ENERGY COST ALLOCATION

- A. The EPMS in conjunction with compatible connected power and energy monitoring devices shall provide energy cost allocation features to encourage energy efficient behavior and support cost accounting by accurately allocating direct and indirect energy costs to departments / processes.
- B. Energy cost determinants, report formats and dashboard layouts shall be specified in the "Software Configuration Standards and Conventions" document. The following functionality shall be provided at a minimum.
 1. Fully configured shadow energy cost allocation report(s) that can be scheduled per a user-defined interval.
 2. Relevant cost allocation parameters represented in dashboard screens.

- C. The EPMS shall provide cost allocation features to allow
1. Reporting on energy costs for all energy sources - WAGES (Water, Air, Gas, Electrical and Steam)
 2. Aggregating energy costs up to any point in the organizational hierarchy (business units, departments, areas, floor or buildings, cost centers, tenants etc.)
 3. Configurable start and end dates for energy cost reporting.
 4. Calculated apportionment by creating virtual measurements allocating percentages of physical meters, for example, 20% (Meter 2) + 80% (Meter 3).
 5. Calculated net metering by creating summed or subtracted physical meters, for example, Meter 1 + Meter 2 – Meter 3.
 6. Common area allocation to allocate calculated values to various entities in the organization hierarchy
 7. Allocation of cost by standard time intervals, such as daily, weekly, monthly, yearly, or by specified time intervals like production shift
 8. Data integrity checks including warnings for data gaps or duplicates.
 9. Customization of energy cost reports to allow for custom logos and headers.
- D. The EPMS shall provide the following user-configurable report templates to facilitate energy cost allocation.
1. Billing Report: Billing report for any entity in the hierarchy with
 - a. configurable time-periods and rate structures
 - b. Itemized entries with each item in the rate structure and associated costs clearly specified
 2. Billing Summary Report: Billing Report for multiple entities in the hierarchy with
 - a. Energy costs per entity represented as a subtotal section
 - b. Grand Total for all entities
 3. Multiple Billing Report: Billing Report for multiple entities in the hierarchy with
 - a. Each individual entity represented as a distinct section
 - b. Itemized entries with each item in the rate structure and associated costs clearly specified
- E. The EPMS shall be capable of exporting energy cost data, along with pertinent metadata, to integrate with external billing systems. The export mechanisms must be flexible with
1. Support for common data file formats such as xml, csv and multiple files
 2. Support for XSLT transformations to customize format to match systems for billing, accounting, SAP, ERP etc.
- F. The EPMS shall support customizing the cost allocation reporting to different environments such as:
1. Building Environment:
 - a. Energy cost while building occupied versus empty.
 - b. Energy cost per occupant.
 2. Data Centers:
 - a. Energy cost by colocation tenant.
 - b. Energy cost by PDU, rack etc.
 3. Industrial Environment:

- a. Energy cost while in operation versus shut down, by shift etc.
 - b. Energy cost per unit of production.
4. Provide above comparisons in graphical format such as bar and pie charts.

2.11 ENERGY USAGE AND BENCHMARKING

- A. The EPMS in conjunction with compatible connected power and energy monitoring devices shall provide energy analysis and benchmarking features to isolate the factors contributing to energy usage, analyze energy usage patterns, and implement energy conservation measures. The features must support common analysis and benchmarking activities such as
 - 1. Categorize energy usage by load types to identify where to focus energy conservation initiatives
 - 2. Compare energy usage across various entities such as buildings, departments, plants, and processes.
 - 3. Compare energy usage across multiple sites.
 - 4. Analyze factors contributing to energy usage, usage patterns and isolate energy waste
 - 5. Compare energy usage by normalizing consumption with respect to area, production volume or other energy drivers
- B. The following information shall be specified in the "Software Configuration Standards and Conventions" document.
 - 1. Energy usage determinants
 - 2. Report formats and dashboard layouts.
 - 3. Data import mechanisms to integrate normalization data from external systems like building management systems, production systems etc. when relevant.
 - 4. Data import mechanisms to integrate operating state information from external systems like HVAC, production systems etc. when relevant.
- C. The following functionality shall be provided at a minimum.
 - 1. Fully configured energy analysis report(s) that can be scheduled per a user-defined interval.
 - 2. Relevant energy analysis parameters, model and other performance parameters represented in dashboard screens.
 - 3. Relevant energy analysis parameters represented in dashboard screens.
- D. The EPMS shall provide the following report templates to support benchmarking initiatives to drive improved energy efficiency.
 - 1. Energy Comparison report to display and compare the normalized energy consumption.
 - 2. Energy Dashboards to compare the normalized energy consumption between sites or other organizational entities such as buildings, plants and processes.
 - 3. Calendar Trend: Display energy data in interactive calendar views (monthly, weekly) with overlaid target lines.
 - 4. Duration Curve: Display data organized by order of magnitude (rather than chronological) with overlaid target lines.
- E. At a minimum, the EPMS shall support importing and logging the following parameters for normalization calculations.
 - 1. Area (ft² or m²)

2. Outdoor temperature
 3. Humidity
 4. Building occupancy
 5. Manufacturing productivity (number of devices produced)
- F. The EPMS shall provide the following functionality to support energy usage per-operating-state analysis to facilitate energy efficiency initiatives for operational systems such HVAC and industrial processes.
1. Calculate and display equipment energy and power consumption including percentages for water, air, gas, electricity and steam (WAGES) per operating state (e.g. Off, Normal, High, Free Cooling, etc.).
 2. Calculate and display operational equipment statistics including hours of operation in each state/mode, percentage (%) hours in each state/mode, activations per each state/mode, and average duration operating in each state/mode.
 3. The supplied report templates shall support
 - a. Configurable reporting/aggregation time periods, and state annotation.
 - b. Flexible output formats such as pie, stacked column, data table etc.

2.12 ENERGY PERFORMANCE ANALYSIS AND VERIFICATION (MODELING)

- A. The EPMS in conjunction with compatible connected power and energy monitoring devices shall provide modeling and analysis tools to determine the factors contributing most to energy usage, find energy usage patterns, and implement energy conservation measures. At a minimum, the EPMS shall support importing of the following energy driver data.
1. Outdoor temperature,
 2. Humidity
 3. Building occupancy
 4. Manufacturing productivity (number of devices produced)
- B. The following information shall be specified in the "Software Configuration Standards and Conventions" document.
1. Energy usage determinants
 2. Report formats and dashboard layouts.
 3. Data import mechanisms to integrate energy driver information such as temperature, occupancy etc. when relevant.
- C. The following functionality shall be provided at a minimum.
1. Fully configured energy modeling report(s) that can be scheduled per a user-defined interval.
 2. Relevant energy model & performance parameters represented in dashboard screens.
- D. The EPMS will facilitate energy analysis through the following capabilities.
1. Model data using linear regression or "best-fit" functions for assessing the relationship of two variables to find anomalies and track performance.
 2. Plot single or broken "best-fit" line and trend actual values against expected values based on linear regression calculations.

- E. The EPMS shall provide the following user-configurable report template to facilitate energy modeling and verification.
1. Represent the relationship between any measurement datasets through:
 - a. X-Y scatter plot with overlay best-fit or broken-line regression lines
 - b. Model summary table with model output variables - slope, Y-Intercept, R2, RMSE etc.
 2. Display measured values vs. expected (model output) values
 3. Plot cumulative summation report to show cumulative deviation between measured values and expected values.
 4. Support the following X Axis Calculation methods - Cooling Degree Days (CDD), Heating Degree Days (HDD), Average, Sum, Delta
 5. Support the following Y Axis Calculation Methods – Average, Sum, Delta
 6. Support data quality checks and optionally exclude missing data

2.13 CONDITION BASED MAINTENANCE

- A. The EPMS in conjunction with compatible connected equipment shall provide Low Voltage (LV) Breaker Aging Monitoring to provide an estimate of electrical and environmental aging data (for all supported breakers) that can then be used for preventive maintenance planning for LV switchgear. The relevant circuits identified for LV Breaker Aging Monitoring, report formats and dashboard layouts shall be specified in the "Software Configuration Standards and Conventions" document.
1. The system will provide a breaker aging report providing maintenance information related to:
 - a. Electrical aging in percent (%)
 - b. Environmental aging in percent (%)
 - c. Classification of breakers by group and aging status
 2. The aging algorithm will use the following electrical and environmental parameters to estimate aging percentages for supported devices.
 - a. Overload tripping
 - b. Short circuit tripping
 - c. Operation
 - d. Commissioning date
 - e. Ambient temperature
 - f. Vibration
 - g. Humidity
- B. The EPMS in conjunction with compatible connected equipment shall provide a report to provide UPS health and status information. This report shall provide additional diagnostics outside data collected during typical annual preventive maintenance. For each (typically monthly) UPS test, the report will display the start date/time, end date/time and status (pass/fail). In addition, the report shall outline the following events with date and time:
1. Load Protection Status changing
 2. General Alarms and Major Faults
 3. Overload Events
 4. In battery backup Indication
 5. Low Battery Indication

6. Battery end of life Indication
 7. Battery test results: pass /failed Indication
 8. UPS Battery Health Report: For unsupported UPS systems that do not provide a compatible "Auto Test" feature, the EPMS shall monitor the UPS Battery Health by capturing the UPS battery voltage signatures during transfer from utility power to battery power. By comparing these voltage signatures, the system shall provide predictive maintenance insight into when the batteries need to be replaced.
- C. The EPMS in conjunction with compatible connected equipment shall monitor the Generator Battery Health by capturing battery voltage signatures during generator starts. By comparing signatures, the system can provide predictive maintenance insight into when the batteries need to be replaced or other related equipment (such as the starter motor) needs to be serviced.

2.14 CONNECTED DEVICES

- A. Connected Devices shall be connected to the EPMS network for power monitoring, equipment status, alarms, etc. and to provide the required functionality of the EPMS. Connected Devices shall be integrated with the EPMS network and system as required to support the specified EPMS applications. Additional Connected Devices shall be integrated with the EPMS as shown on drawings or as specified within the device's specification.

B. METERS

1. Utility Revenue: The revenue grade metering device used to monitor incoming utility medium voltage mains for grid revenue, substation automation, network management, energy cost allocation, power quality analysis, asset management, operational efficiency, and compliance reporting, shall be a Utility Revenue Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.
2. Transfer Switches: The metering device used to monitor transfer switches for purposes of automated generator test documentation such as Emergency Power Supply System (EPSS) Test Automation, shall be a Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.
3. Generators: The metering device used to monitor generators for purposes of automated generator test documentation, Emergency Power Supply System (EPSS) Test Automation, shall be an Advanced Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.
4. LV Mains: The metering device used to monitor the medium voltage mains for network management, energy cost allocation, power quality analysis, asset management, operational efficiency, and compliance reporting, shall be a Power Quality Meter as specified in Section 26 27 13.16 Power Quality Meters.
5. LV Feeders: The metering device used to monitor the medium voltage mains for network management, energy cost allocation, power quality analysis, asset management, operational efficiency, and compliance reporting, shall be a Power Meter as specified in Section 26 27 13 Power and Energy Meters.
6. LV Sub Metering Individual Circuits: The metering device used to monitor circuits for purposes of network management, energy cost management, energy allocation, and operational efficiency shall be shall be an Energy Meter as specified in Section 26 27 13 Power and Energy Meters.

7. LV Sub Metering Multiple Circuits: The metering device used to monitor branch circuits for network management, energy cost allocation and compliance reporting, shall be a Multi-Circuit Meter as specified in Section 26 27 13 Power and Energy Meters.
8. Additional application requirements and modifications to existing equipment for connected devices such as protective relays, circuit breakers, active harmonic filters, power factor correction equipment, voltage regulation equipment, RTUs and controllers, power event recorders, etc. can be specified here.

C. OTHER CONNECTED DEVICES

1. Non-Electric Power Utilities: The device used to interface with metering for non-electric utilities - water, air, gas, electricity, and steam shall be an Energy Server as specified in Section 26 27 13 Power and Energy Meters.

2.15 CONNECTED EQUIPMENT

- A. Connected Equipment shall contain one or more Connected Devices (e.g. meters, circuit breakers, gateways, sensors, etc.). Connected equipment shall include an internal inter-wired communications network for a singular connection to the EPMS network for power monitoring, equipment status and alarms.
- B. Connected Equipment (e.g. switchgear, motor control centers, motor controllers, switchboards, panelboards, automatic transfer switches, multi-meter enclosures, etc.) shall be integrated with the EPMS network and system as required to support the specified EPMS applications. Additional Connected Equipment shall be integrated with the EPMS as shown on drawings or as specified within the device's specification.

2.16 EPMS SOFTWARE

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: EcoStruxure™ Power Monitoring Expert by Schneider Electric or WinPM.net by Siemens.
- B. General:
 1. Furnish a dedicated, edge control, software platform (The Software Platform) purpose-built to be the operational interface for an EPMS to manage safe, reliable and efficient power within buildings and facilities. The Software Platform shall have specialized data acquisition, visualization, analysis and reporting tools specifically designed for Power Management applications such as:
 - a. Electrical Distribution System Monitoring and Alarming.
 - b. Electrical System Capacity Management.
 - c. Power Quality (PQ) Monitoring and Compliance.
 - d. Continuous Electrical Thermal Monitoring.
 - e. Breaker Setting Monitoring.
 - f. Backup Power Testing.
 - g. Power Events Analysis.
 - h. Energy Usage Analysis and Energy Benchmarking.
 - i. Utility Bill Verification and Cost Allocation.

- j. Energy Performance Analysis and Verification.
 - 2. The Software Platform shall natively support (without additional installation or configuration) at least 75 devices specifically designed for power distribution and PQ monitoring including: programmable power analyzers, power meters, branch and multi-circuit meters, smart panels with communicating circuit breakers, protective relays, uninterruptible power supplies, active harmonic filters, capacitor bank controllers, and electrical distribution thermal sensors. Native device support shall include
 - a. All registers pre-mapped to standard measurement names without requiring additional register mapping.
 - b. A comprehensive set of factory device graphical screens without requiring additional graphics creation or installation.
 - c. Fully factory-tested support.
 - 3. The Software Platform shall be designed to comply with cybersecurity standard IEC62443 at the component level: IEC62443-4-1 and IEC62443-4-2 (SL1).
 - 4. The Software Platform shall be designed to streamline the process of checking and maintaining EN50160 and IEEE 519 Power Quality compliance.
 - 5. The Software Platform shall be certified for use as a part of an ISO50001/50002 program and verifiably support compliance. In addition, the functionality shall support ongoing ISO50001 programs per the following areas of Section 4 of the ISO standard:
 - a. Energy review.
 - b. Energy baseline.
 - c. Energy performance indicators.
 - d. Monitoring, measurement, and analysis.
 - e. Input to management review.
 - 6. The Software Platform shall natively support the vendor's continuous electrical thermal monitoring system with the ability to detect abnormal bus bar or cable temperatures due to loose or faulty connections and to prevent equipment damage and fire.
- C. Real Time Monitoring:
- 1. The Software Platform shall support the creation of diagrams representing the Power Monitoring system, including electrical one-line diagrams, facility maps, plan views, floor layouts, equipment representations, and mimic displays. The EPMS shall have a graphic library with standard electrical one-line symbols to simplify the creation of single line diagrams.
 - 2. The Software Platform shall have the capability to graphically trend in real-time any measurements supported by metered connected electrical equipment.
 - 3. The Software Platform shall allow users to easily create interactive side-by-side visualizations of any real-time measurements to:
 - a. Display tabular & trend line views to compare readings from multiple devices.
 - b. Create, modify, view and share table views directly, without additional software.
 - c. Support both physical and virtual devices defined in the system.
 - d. Support exporting real time data into Excel formats, without additional software.

4. The Software Platform shall support the Automatic Network Diagram Creation feature, whereby a comprehensive set of linked hierarchical graphical diagrams can be automatically created for any supported connected device.
 5. The Software Platform shall support Advanced Power Quality meters with onboard high speed Power Analysis and Disturbance Direction Detection (DDD) capabilities, and include a set of real-time graphical indicators for use in electrical diagrams indicating
 - a. the type of Power Quality Disturbance (sag, swell, transient).
 - b. the direction of PQ Disturbance relative to the reporting DDD device (upstream, downstream).
 6. The Software Platform shall provide real-time indication of aggregated demand measured by one or more devices in a predefined zone, with the following capabilities.
 - a. Zone demand expressed using either Kilowatts or normalized Kilowatts/Area.
 - b. Visual indication of how present zone demand compares with four (4) configurable limits / targets using a color scale.
 - c. Configurable limits to allow different values during On-Peak & Off-Peak periods.
- D. Alarm and Event Analysis & Notification:
1. The Software Platform shall support acquiring specialized, high speed power disturbance data directly from advanced PQ meters for Power Events Analysis, including:
 - a. Timestamped Power Events with Disturbance Direction Detection (DDD).
 - b. Timestamped high speed (1/2 cycle sample rate) pre/post event RMS data.
 - c. Pre/post event waveform captures (Voltage and Current all phases).
 2. The Software Platform shall include an alarm annunciator displaying the total number of unacknowledged alarms with categorization into high, medium and low priority, and easy navigation to the alarm viewer.
 3. The Software Platform shall support analysis of cascading power events with the following capabilities.
 - a. Automatic, intelligent clustering of events into grouped alarms, and multiple alarms from multiple devices into "incidents".
 - b. Automatic categorization of alarms and incidents into predefined categories such as Power Quality, Power Availability, Diagnostics and Other.
 - c. Predefined views for events, alarms and incidents with intuitive navigation and configurable filters based on priority, status, source and categories.
 - d. Ability to create private or shared views with custom filters.
 - e. Ability to drill into details about location, time and nature of the alarm or incident, with associated information including Power Disturbance and Power Quality data.
 - f. Clear graphical indication of the direction (arrow) of a Power Disturbance for alarms and incidents captured by Disturbance Direction Detection (DDD) compliant devices.
 4. The Software Platform shall provide a graphical timeline view of alarms and events constituting an "incident" in the electrical distribution network, with the capability to
 - a. Display alarms/events stacked by order of time for sequence of events analysis.
 - b. Display the start and end of alarms/events.
 - c. Indicate the direction of the incident with any associated, captured waveforms.

- d. Display pre- and post-event high speed RMS data from supported PQ meters.
- 5. The Software Platform shall provide the capability to send email notifications based on recent changes to the system which will be used to formulate notification types including:
 - a. Communication Loss – sent on loss of communication with selected devices
 - b. Alarm Summary – sent regularly to indicate changes in the average amount of high, medium, and low priority alarms
 - c. Power Quality Event – sent regularly to indicate changes in the average amount, duration, and magnitude of Sag, Swell and Transient power disturbances.
 - d. Energy Usage – sent when energy usage exceeds the normal usage range for the current day and time.
- E. Data Analytics and Visualization:
 - 1. The Software Platform shall include an interactive, web-based Dashboard application supporting all water, air, gas, electric, and steam (WAGES) data, historical data trends, power quality, images, and external content from any accessible URL address.
 - 2. Users shall be able to create, modify, view, and share dashboards (including graphics, labels, scaling, measurements, date ranges, etc.) without additional software.
 - 3. The Software Platform shall support kiosk slideshow displays to run in unattended mode, scrolling through designated dashboards at a configurable time interval. Any number of kiosk slideshow displays may be created and configured to run independently on any computer using a browser.
 - 4. The Dashboard application shall provide a library of standard graphical objects (gadgets) including Bar, Pie, Trend, Real Time and Web Portal
 - 5. The Dashboard application shall provide a library of specialized energy usage graphical objects (gadgets) including Period Over Period Comparison, Pareto Charts, Heat Map / Carpet Plot and Sankey Diagrams
 - 6. The Dashboard application shall provide a library of specialized Power Quality graphical objects (gadgets) including PQ Downtime Impact, PQ Rating, PQ Incident Breakdown and Location.
 - 7. The Software Platform shall provide an interactive, web-enabled Reports application, allowing users to generate, modify, save and manage reports based on pre-engineered report templates for:
 - a. Energy Billing, Verification and Allocation.
 - b. Energy Management and Performance.
 - c. Power Quality Performance and Compliance (EN50160 and IEEE 519).
 - d. Electrical Equipment Operation and Performance.
 - 8. The reporting tool shall support automatic distribution (via email or shared folder) on a scheduled basis or based on event or manual export using the following output formats: .csv, .xlsx, .pdf, .tiff, .html, .xml.
- F. Technical Infrastructure:
 - 1. The Software Platform shall support installation on a physical computer or virtual machine and shall support a variety of Windows operating systems including Server and non-Server class Windows operating systems.

2. The Software Platform shall support a variety of SQL Server Editions including Enterprise, Standard and Express Editions.
3. The Software Platform shall only require SQL Server Database Engine Services and Basic Management Tools, and not require additional SQL components such as Analysis Services or Reporting Services.
4. The Software Platform shall support the following cybersecurity features:
 - a. Encrypted transmission of data between the Software Platform Server and its Web Clients using Transport Layer Security (TLS) version 1.2.
 - b. Secure authentication between the Software Platform Server and its Web Clients using Certification Authority (CA) certificates.
 - c. Encryption & hashing of system credentials using AES256 & SHA-512 respectively.
 - d. Installation in a Federal Information Processing Standard (FIPS) compliant environment.
5. The Software platform shall support the integration of Windows Active Directory for users and groups across multiple domains to facilitate the following:
 - a. Login using Windows credentials.
 - b. Enforce password policies via Windows (complexity and expiration).
 - c. Role-Based Access Control (RBAC).
6. The Software Platform shall automatically acquire on-board data (including events, trends and waveforms) from natively-supported device types without additional software configuration or data upload scheduling. Onboard, high resolution timestamps (1ms) shall be retrieved without degradation or modification even for devices that support clock synchronization via GPS, IRIG-B, NTP or PTP (Precision Time Protocol).
7. The Software Platform shall support logical device definitions based on inputs/outputs or channels on devices representing downstream circuits, with the following features:
 - a. User interface for device and measurement mapping.
 - b. Bulk-import capability to create large numbers of logical devices without manual single-device configuration
8. The Software Platform shall support real-time and historical data aggregation within defined hierarchy views (e.g. Tenants/Racks/Circuits, PDUs/RPPs/Panels, Buildings/Floors/Rooms, or any user defined view) with the following capabilities:
 - a. Web-based, end user interface.
 - b. Automatic, intelligent data aggregation across all nodes in the hierarchy for data visualization in dashboards, trends and reports.
 - c. Creation of virtual devices to enable net metering, common area allocation and apportionment.
 - d. Update node names and associated time ranges in the hierarchy to accurately represent & report on facility changes (e.g. tenant move in – move out).
 - e. Bulk-import capability to create and edit large hierarchies without manual per-device setup.
9. The Software Platform shall support device-level Modbus integration with the following capabilities:
 - a. Modbus master to read/write registers in Modbus devices for monitoring and control applications.

- b. User interface to create and manage Modbus device definitions (device drivers) and association of device graphic template screens.
- 10. The Software Platform shall support OPC DA Server 2.01 with the following capabilities:
 - a. Provide default OPC Server tag mappings for all natively supported device types without the need for manual mapping of device registers to OPC tags.
 - b. Add or change OPC mappings, or add custom measurements.
- 11. The Software Platform shall support OPC DA Client 2.01 with the following capabilities:
 - a. User Interface to create and manage OPC device definitions (device drivers) and association of device graphic template screens.
 - b. Built in OPC Test Client.
- 12. The Software Platform shall support Web Services interoperability with the following capabilities:
 - a. Web Services Server to share real-time, historical (i.e. timestamped trend data), and alarm data (i.e. timestamped event strings) to other Web Services Client applications.
 - b. User interface for Web Services configuration and mapping.
 - c. Ability to acknowledge alarms by authenticated and authorized clients.
- 13. The Software Platform shall have an Extract, Transform, and Load (ETL) engine to exchange data between files, databases and systems with the following capabilities:
 - a. User Interface to specify connection information, data formats, measurement mappings and schedules.
 - b. Support for importing data from .csv and .xml data files, Wonderware Historian databases and other 3rd party databases via OleDb connections.
- 14. The Software Platform shall support system-wide programming extensibility, using a graphical, object-oriented application engine capable of logic & arithmetic functions, database queries, XML data import, complex logic-based alarming and data logging, email & text notifications.
- 15. The Software Platform shall remain online during all system administration functions (including communications, logging, and alarming) and not require an operator to take the system offline.
- 16. The Software Platform shall support internationalization and regional settings, with factory support for the following languages: Chinese (Simplified), Chinese (Traditional), English, French, German, Italian, Russian, Spanish, Polish, Czech, and Swedish. The Software Platform shall support the ability to change its default language at any time without the need for additional installation or advanced software configuration.
- 17. The Software Platform shall support offline software configuration management for efficient system deployments and upgrades with a dedicated user interface for creating, copying and deploying software configuration projects.

2.17 EPMS ADVISORY SERVICES

- A. Provide the following specified product, services and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: EcoStruxure™ Power Advisor by Schneider Electric or WinPM.net by Siemens.
- B. Provide 2 years of EPMS Advisory Services to commence at Substantial Completion. Submit a quotation for yearly renewals of EPMS Advisory Services from the system supplier to be executed outside of this Contract.

- C. EPMS Advisory Services shall provide ongoing technical support services to advise on, optimize and tune the performance of the EPMS. The EPMS Advisory Service shall utilize the EPMS system through an internet connection for ready only data access for functionality. No EPMS data shall be modified and no devices shall be capable of being controlled. EPMS Advisory Service shall analyze data on the electrical power distribution equipment, identify problems through expert analysis and provide recommended actions for system improvement. Included services shall provide expert analysis through the review of data and reports by qualified electrical power distribution and power quality professionals. The EPMS Advisory Services shall include but not be limited to the following:
1. Periodic monitoring of EPMS server(s) and software to proactively alert for system problems. This shall include EPMS system diagnostic analytics and analysis of the electrical distribution network. Periodic power analysis diagnostic reports shall include results of remote diagnostics to assess EPMS system health including but not limited to configuration, data accuracy, communications infrastructure, software diagnostics, disc usage, server health, etc.
 2. Software verification including the provision and installation of service packs and license upgrades for the installed EPMS software. Software upgrades shall include system recommissioning to verify operational functionality.
 3. A minimum of [1] yearly visit for onsite maintenance to include system repairs, database maintenance, firmware upgrades, and software installations. Training on system operation shall be provided during onsite maintenance visit by an application engineer.
 4. Basic support via telephone and email during regular business hours to provide technical guidance, incident diagnosis, basic troubleshooting, and "how-to" instructions to operate installed software and hardware.
 5. Emergency after-hours support with guaranteed response within [4] hours.
 6. Reserved (specifically named) support engineer as a "single point of contact" for customer support. Direct access to advanced level support with priority case escalation to expert level support as needed. System maintenance is proactive and periodic, on a quarterly basis.
 7. Periodic reports with system optimization recommendations and actionable work orders.
 8. A system benchmark of the site with 'system score' showing percentage of the load potentially impacted or affected shall be provided. The Engineer and/or Owner shall be included in the setup of metering hierarchy in the EPMS Advisory Services to ensure the benchmark is relevant since the relationship between the metering devices in the system is highly relevant.
 9. Identified electrical network issues shall be prioritized on severity and provided within an executive report and detailed report on a periodic basis to promote power reliability.
 10. Periodic recommendations for system optimization to improve data quality and system performance on a 3 month basis.
 11. On-demand self-paced training with energy management, metering infrastructure, and power quality content modules.

2.18 ASSET MANAGEMENT ADVISORY SERVICES

- A. An asset monitoring service shall provide the current operating condition of monitored equipment, assign a health index for each asset, identify corrective actions needed, provide reports, etc. to optimize the management of electrical distribution system assets. The Condition Monitoring Services shall utilize the EPMS system through an internet connection for ready only data access. No EPMS data shall be modified and no devices shall be capable of being controlled. Refer to the Condition Monitoring Service specification for a full description of functionality and additional requirements.

2.19 COMMUNICATIONS AND INTERFACES

- A. The EPMS system shall communicate to equipment, devices, servers, etc. through an EPMS network. The EPMS network shall primarily use Ethernet except where specifically specified or shown. The EPMS network shall include but not be limited to the following:
 - 1. Connections to and use of the Owner's existing Ethernet network. A dedicated VPN shall be provided by the Owner as a communications channel for the EPMS network where physical media is shared with other networks.
 - 2. Ethernet network as shown and specified elsewhere. A dedicated VPN shall be provided for the EPMS network where physical media is shared with other networks.
 - 3. Serial communication connections where specified or shown to gateway devices for Ethernet EPMS network interface.
 - 4. Connection to the Building Management System network
 - 5. Connection to the Process Control and Instrumentation System or SCADA system network
- B. Cyber Security
 - 1. The EPMS shall follow best practices for cyber security and provide technical features to reduce risk to people, assets and processes.
 - a. Implement secure network architecture
 - b. 2 Factor Authentication
 - c. User privilege / authentication policy
 - d. Align with ISA/IEC-62443 series of standards and practices
 - e. Align with Owner cybers security program and practices
- C. Interface with Equipment: Unless specified or shown otherwise, the EPMS shall communicate to equipment using Modbus TCP Ethernet protocol. Modbus serial protocol shall only be used where specifically specified or shown.
- D. Equipment Interfaces: The Contractor shall coordinate between suppliers to ensure compatibility between software, computer systems, network, communications gateways, connected equipment, etc. for the specified functionality of the EPMS. The supplier of equipment to be connected to the EPMS shall provide the necessary compatible interface to the EPMS system's network and software. Any required gateways, transceivers, converters, etc. for this interface shall be integral to the supplied equipment.

PART 3 - EXECUTION

3.1 GENERAL

- A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of Specification Section 26 01 00 and Drawings.
- B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

- C. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- D. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.
- E. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.
- F. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer's representative field service engineer. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Report to the Engineer any discrepancies or issues with the installation.
- G. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

3.2 SYSTEM COMMISSIONING

- A. Factory-trained personnel shall perform on-site commissioning using automated commissioning tools to improve consistency and quality of commissioning.
- B. Central engineering resources in conjunction with onsite factory trained personnel shall be involved in preparing a client's system for startup.
- C. A trained and certified project manager shall be provided during project installation and commissioning.
- D. Commissioning shall include a detailed scope of work checklist document with delivered functionality listed and checked.
- E. The EPMS solution shall be fully tested in a test-bed environment with hardware devices representative of a large scale functional power distribution system (including both physical and simulated devices) such as advanced power quality meters, low voltage main meters, low voltage feeder meters, circuit breaker trip units, transformer monitoring units, protective relays, branch circuit power meters, etc. Documented test results including system response times, network performance, and recommended network architectures shall be published and provided upon request.
- F. Commissioning shall include a full working demonstration of the system under normal operating conditions and simulated scenarios.
- G. For control applications such as automatic transfer, commissioning shall include a thorough verification of the approved sequence of operation in both manual and automatic modes. Testing of source outage and breaker exercising shall be included in test procedures.
- H. For control applications, such as automatic transfer, source interruptions are necessary. The owner must schedule appropriate times for such commissioning and must plan for time (typically a day) for system pre-testing and a day for acceptance testing. Weekends are preferred due to minimized impact on operations.

3.3 TRAINING

- A. The EPMS system supplier shall provide training on the operation, maintenance, and optimization of the EPMS system. Training shall be delivered by experienced Instructors proficient in teaching the topics for the various courses and who has direct experience with the installed equipment.
- B. Majority of the training shall be hands-on (up to 80 %) with the equipment. Each student shall have access to their own mini power monitoring system by way of an electrical metering demo case, direct Ethernet communication, and laptop running applicable metering software, or by way of a virtual server if doing the class remotely
- C. Training manuals shall be provided for each student and include an agenda, defined objectives for each lesson, a detailed description of the subject matter for each lesson, and descriptive labs to complete the hands-on exercises.
- D. Training content shall cover the following as a minimum:
 - a. The function and operation of the EPMS system and software.
 - b. The definition and use of various system data (such as energy, demand, power factor, load profile, time of use, KYZ, etc.)
 - c. The system architecture and communication methods of the EPMS system
 - d. The function and operation of electric meters
- E. Training sessions shall be provided as follows:
 - 1. Self-paced on demand training on energy management, metering infrastructure, and power quality.
 - 2. At project site, hands-on training using power monitoring equipment involving hardware and relevant software to train the Owner to implement operate and maintain the power monitoring system.
 - a. Video recording services to coincide with custom client onsite training with professional post production services providing the customer with a polished training DVD custom to training on the client system.
 - 3. Instructor led remote web based training wherein the user has real time interaction with trainer and gets hands on training using virtual servers to performs labs and exercises.
 - 4. At EPMS system supplier's facility, hands on training on how to design, implement, and operate power monitoring system.

END OF SECTION

SECTION 26 12 30 WIRE & CABLE

PART 1 GENERAL

1.01 SUMMARY:

- A. Section includes copper wire, cable, associated connectors, and termination hardware used on systems operating at 600 volts or less.

1.02 REFERENCES:

- A. American Society for Testing and Materials (ASTM)
 - 1. B8 Concentric-Lay-Stranded Copper Conductor, Hard, Medium Hard, Or Soft.
- B. National Electrical Contractor Association (NECA)
 - 1. Standard of Installation
- C. National Fire Protection Association (NFPA)
 - 1. 70 National Electrical Code
- D. Underwriters Laboratories Inc. (UL)
 - 1. 44 Rubber-Insulated Wires and Cables
 - 2. 83 Thermoplastic-Insulated Wires and Cables
 - 3. 486A Wire Connectors and Soldering Lugs for Use With Copper Conductors
 - 4. 486C Splicing Wire Connectors
 - 5. 510 Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
 - 6. 1569 Metal-Clad Cables

1.03 SUBMITTALS – FOR APPROVAL:

- A. Procedures: Submit in accordance with Section 013000 and 260100.
- B. Product Data: Submit for each type of wire and cable, terminal lugs, connectors, and cable fittings.

1.04 SUBMITTALS – RECORD DATA:

- A. Procedure: Submit in accordance with Section 013000.
- B. Product Data: Approved, as furnished data as listed above.

1.05 QUALITY ASSURANCE:

- A. Furnish wire, cable, associated connectors, and termination hardware bearing UL label.

PART 2 PRODUCTS

2.01 BUILDING WIRE:

- A. Single conductor, soft drawn, annealed copper conductor, Class B stranded except that sizes No. 10 AWG and smaller used for lighting and power branch circuits may be solid. Insulation shall be 600 volt, type THHN/THWN per UL 83 or type XHHW per UL 44.

2.02 TYPE MC CABLE: Metal Clad Cable type MC multi-conductor cabling as manufactured by AFC Cable Systems or equivalent having the following construction features:

- A. Conductor: Bare, soft annealed copper, Class B stranded per ASTM B-8.
- B. Insulation: Polypropylene tape assembly with 600 volt, 90°C (dry) type THHN insulation with printed number and color identification.
- C. Neutral conductor: White – 120v circuits; Gray – 480Y277v circuits
- D. Grounding conductor: Green insulated copper ground conductor.
- E. Assembly: Three insulated conductors with grounding conductor, non-hygroscopic fillers and overall binder tape per UL 1569.
- F. Sheath: High strength, lightweight galvanized interlocking steel strip and color coded on the out side for easy identification.
- G. U.L rated 1569

2.03 CONNECTORS AND TERMINALS:

- A. Insulated Crimp Type Connectors and Terminals: Nylon insulated, Burndy INSULINK and INSULUG, or Thomas & Betts Sta-Kon.
- B. Split Bolts: High-conductivity copper alloy, Burndy SERVIT or Thomas & Betts Split-Bolt.
- C. Two Bolt Connectors: High-conductivity copper alloy, Burndy OKLIP, Type KVS or Blackburn 2BU.
- D. Compression Terminals: Copper, long barrel, Burndy HYLUG or Thomas & Betts Color-Keyed.
- E. Bolted Terminals: Cast copper alloy, Burndy QIKLUG or Thomas & Betts Locktite.
- F. Spring Wire Connectors: Insulated, twist-on type, Ideal Wire Nut or 3M Scotchlok. Push-in type connectors are prohibited.

2.04 CABLE TERMINATIONS:

- A. Type MC Cable: Steel set screw connectors

2.05 MISCELLANEOUS COMPONENTS:

- A. Tape: UL 510
 - 1. Vinyl Plastic: 3M Scotch 33+ or Scotch 88.
 - 2. Varnished Cambric (VC): 3M Irvington 2920.
 - 3. Friction: Black friction tape.
- B. Pulling Lubricants: Ideal Yellow 77 or Polywater Type J.
- C. Wire Markers:
 - 1. Individual Wires: Heat shrink, machine printed, Raychem.
 - 2. Multi-Conductor Cables or Groups of Wires as a Cable: Nylon tie on marker, Thomas & Betts Nylon I.D. Ties, Ty-Raps.
- D. Wire and Cable Ties: Thomas & Betts Ty-Raps.

PART 3 EXECUTION

3.01 APPLICATION:

A. Wire and Cable:

1. THWN-THHN for power wiring through No. 250 AWG and control wiring in conduit. XHHW for sizes above No. 250 AWG in conduit.
2. TW or THW for equipment grounding conductor.
3. Type MC cable for fixture wires no longer than 6' and in accordance with NEC Article 334.
4. No. 12 AWG minimum for power circuits and No. 14 AWG minimum for control circuits unless noted otherwise on drawings.

B. Splices and Taps:

1. Use insulated spring wire connectors for lighting and receptacle branch circuits No. 10 AWG and smaller. Push-in type connectors are prohibited.
2. Use solderless pressure connectors for branch circuit conductors No. 8 AWG and larger.
3. Do not make splices or taps in feeder circuits or control circuits.

C. Terminals:

1. Use copper compression terminals, NEMA 1 hole for sizes No. 4 AWG and smaller, NEMA 2 hole for sizes No. 2 AWG and larger.
2. Use insulated, ring tongue terminals for signal and control conductors.

3.02 INSTALLATION:

A. Install wire and cable in accordance with the NECA Standard of Installation.

B. Installation in Conduit:

1. Swab conduits completely and thoroughly before pulling in conductors.
2. Pull all conductors into conduit at same time.
3. Use suitable wire pulling lubricant for building wire No. 4 AWG and larger.
4. Do not pull in conductors until conduit system is completed. Do not pull through boxes, fittings or enclosures where a change of conduit alignment or direction occurs.
5. Limit pulling tension to maximum values as recommended by manufacturer.
6. Do not combine circuits into a common conduit other than as indicated on the drawings.

C. Direct Burial Cable:

1. Trench and backfill for direct burial cables. Minimum depth of installation shall be 24 inches.
2. Terminate and ground metallic cable sheath with suitable fittings.

D. Compression Connectors and Terminals:

1. Install on wire and cable with approved tool and die to recommended compression pressure. Do not cut strands from conductors to fit lugs or terminals.

E. Bolted Connectors and Terminals:

1. Torque to manufacturer's recommended foot-pounds for size and class of connector.
2. Where manufacturer's published torquing requirements are not indicated, tighten connectors and terminals to comply with UL 486A torque values.
3. Use galvanized steel bolts, nuts, split-lock washers and flat washers on terminal connections.

F. Wiring in Enclosures:

1. Form and tie conductors in panelboards, cabinets, control panels, motor controllers, wireways, and wiring troughs in a neat and orderly manner.
2. Use Thomas & Betts wire and cable ties of appropriate size and type.
3. Limit spacing between ties to not more than 6 inches.

G. Taping:

1. Above Ground and Dry Locations: Fill voids and irregularities with half-lapped layers of VC (two minimum) or electrical insulation putty. Insulate with three half-lapped layers of vinyl plastic and one half-layer of friction tape.
2. In damp or wet locations, wrap insulated spring wire connectors with 2 layers of vinyl plastic tape.

3.03 COLOR CODING:

A. Power Wiring: Provide color coding for single and multi-conductor power circuits as follows:

<u>Voltage</u>	<u>ΦA</u>	<u>ΦB</u>	<u>ΦC</u>	<u>Neutral</u>
240 volts and below	Black	Red	Blue	White
250 – 600 volts	Brown	Purple	Yellow	Gray

1. For specified insulation and jackets not manufactured with integral colors, use conductors with black insulation or jacket and color-coding tape.
 2. Color code conductors entering boxes, troughs, cabinets, and other enclosures.
 3. Color code conductors in wireways, trenches, and other locations where conductors are continuously accessible at intervals not exceeding 5 feet.
- B. Insulated Equipment Ground: Green.
- C. Isolated Ground conductor: Green with Yellow tracer.

3.04 WIRING IDENTIFICATION

- A. Control Circuits: Install a permanent wire label at each termination. Identifying numbers shall match approved schematic and wiring diagrams.
- B. Feeder and Branch Circuits: Install a permanent wire label at each termination. Identifying numbers shall include source panel designation and circuit number.

3.05 FIELD TESTS:

- A. Test conductors after installation is complete and prior to connection to equipment.
- B. Perform insulation resistance test on each conductor phase-to-ground with adjacent conductors grounded and test conductor disconnected from equipment. Applied potential shall be 1000 volts dc for one minute. Minimum acceptable test values shall be 50 megohms. Investigate deviations in test values between adjacent phases.
- C. Verify tightness of bolted connections with a calibrated torque wrench. Torque values shall be terminal lug manufacturer's recommendations.

END OF SECTION 26 12 30

SECTION 26 13 60 RACEWAYS

PART 1 GENERAL

1.01 SUMMARY:

A. Section Includes:

1. Rigid Galvanized Steel Conduit (RGS)
2. PVC-Coated Rigid Steel Conduit (CRGS)
3. Rigid Aluminum Conduit (RAC)
4. Electrical Metallic Tubing (EMT)
5. PVC Conduit (PVC)
6. Flexible Conduit
7. Associated Fittings
8. Wireways
9. Pull and Junction Boxes

1.02 REFERENCES:

A. American National Standards Institute (ANSI):

1. C80.1 Rigid Steel Conduit – Zinc Coated
2. C80.3 Electrical Metallic Tubing – Zinc Coated
3. C80.5 Rigid Aluminum Conduit

B. National Electrical Manufacturers Association (NEMA):

1. TC 2 Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
2. TC 3 PVC Fitting for Use with Rigid PVC Conduit and Tubing
3. TC 13 Electrical Nonmetallic Tubing (ENT)
4. TC 14 Filament-Wound Reinforced Thermosetting Resin Conduit and Fittings.

C. National Fire Protection Association (NFPA):

1. 70 National Electrical Code

D. Underwriters Laboratories Inc. (UL):

1. 1 Flexible Metal Conduit
2. 5 Surface Metal Raceways and Fittings
3. 5A Nonmetallic Surface Raceways and Fittings
4. 6 Rigid Metal Conduit

5.	360	Liquid-Tight Flexible Steel Conduit
6.	514B	Fittings for Conduit and Outlet Boxes
7.	797	Electrical Metallic Tubing
8.	870	Wireways, Auxiliary Gutters, and Associated Fittings
9.	886	Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
10.	1660	Liquid-Tight Flexible Nonmetallic Conduit

1.03 SUBMITTALS – FOR APPROVAL:

- A. Procedure: Submit in accordance with Section 013000 and 260100.
- B. Product Data: Submit for each type of conduit, fitting, connector, pull and junction box, and wireway used on the project.

1.04 SUBMITTALS – RECORD DATA:

- A. Procedure: Submit in accordance with Section 013000.
- B. Product Data: Approved, as furnished data as listed above.

PART 2 PRODUCTS

2.01 RIGID GALVANIZED STEEL (RGS):

- A. Conduit: Conduit including elbows, couplings, and nipples shall be standard weight zinc-coated steel, rigid threaded conduit; shall meet the requirements of ANSI C80.1; and shall be hot-dipped galvanized inside, outside and over threads and lacquered inside.
- B. Fittings: Conduit fittings and accessories for use with RGS conduit shall be cast malleable iron or ferrous alloy, hot-dipped galvanized or zinc-electro-plated and lacquered. Fittings shall have threaded hubs and gasketed covers. Fittings shall be the product of Crouse-Hinds, Appleton or Gedney or an equal.
- C. Boxes: Device and outlet boxes for use with RGS conduit shall be cast malleable iron, hot-dipped galvanized or zinc-electro-plated and lacquered. Boxes shall have threaded hubs and gasketed covers. Boxes shall be the product of Crouse-Hinds, Appleton, Gedney or equal.
- D. Fasteners and Supports: All clamps, straps, framing and supporting materials shall be hot-dipped galvanized steel or malleable iron. Bolts, nuts, screws, washers, etc. shall be stainless steel. Cadmium-plated or zinc-plated fasteners and hardware will not be acceptable.

2.02 POLYVINYL CHLORIDE (PVC - SCHEDULE 40):

- A. Conduit: Conduit, elbows and couplings shall be Schedule 40 rigid polyvinyl chloride (PVC) conduit per NEMA TC 2 with a 90° UL rating, and shall be the standard product of Krayloy or Carlon or approved equal.
- B. Fittings: Fittings and accessories for use with Schedule 40 PVC conduit shall conform to NEMA TC 3 and shall be of the same material and manufacturer as the conduit.

2.03 PVC COATED STEEL CONDUIT (CRGS):

- A. Conduit: Prior to coating, all conduits, elbows, couplings, nipples etc. shall be standard weight rigid, threaded steel and shall be hot dipped galvanized inside and out and over the ends. The conduit shall meet the requirements of ANSI C80.1, UL 6, and NEMA RN-1, 1980.
- B. Fittings: Prior to coating, fittings shall be cast malleable iron, hot dipped galvanized, Appleton Form 35 or Crouse-Hinds or equivalent with cast cover and neoprene gasket.
- C. Boxes: Device and outlet boxes for use with PVC coated conduit shall be cast malleable iron, hot dipped galvanized with threaded hubs and gasketed cast covers or device plates. Boxes shall be the product of Appleton or Crouse-Hinds.
- D. PVC Coating: Conduit, fittings, boxes and accessories shall be Plasti-Bond 2 coated, as produced by Robroy Industries Inc. or an approved equal. Before coating, the galvanized surfaces shall be coated with an epoxy-acrylic primer. Exterior surfaces shall have a 40 mil PVC coating applied by dip method. Interior surfaces of conduits, fittings, boxes, etc. shall have a fusion bonded phenolic coating with a thickness of 4-6 mils.
- E. Fasteners and Supports: U-bolts, conduit clamps, straps, modular framing channels shall be 1-5/8" x 1-5/8" minimum section dimensions, Type 304 stainless steel, and shall be the product of Unistrut. Fasteners and attachment hardware shall be Type 304 stainless steel.

2.04 RIGID ALUMINUM CONDUIT:

- A. Conduit: Conduit, including elbows, couplings and nipples shall be standard weight, threaded, rigid aluminum 6063 alloy, with a copper content not to exceed 0.20%. The conduit shall have a silicon or lacquer coating inside.
- B. Fittings: Fittings, accessories and device boxes for aluminum conduit systems shall be the standard threaded type as manufactured by Crouse-Hinds, Appleton, or equal. Both fittings and covers shall be aluminum containing less than 0.4 of 1% copper. All screws shall be stainless steel. Covers shall be gasketed.
- C. Fasteners: All straps and clamps used to support aluminum conduit shall be hot-dipped galvanized steel or malleable iron, with a 40 mil fused PVC coating, Plastibond,

Ocal or equivalent. Strut type framing channels shall be either PVC coated galvanized steel or fiberglass.

- D. Hardware: Nuts, bolts, screws, washers, etc. shall be stainless steel. Galvanized or cadmium-plated hardware will not be acceptable for use with aluminum conduit.

2.05 ELECTRICAL METALLIC TUBING (EMT):

- A. Conduit: Conduit, including elbows, couplings, and nipples shall be hot dipped galvanized steel inside and out with an organic corrosion resistant coating applied to the inside.
- B. Fittings and Boxes: Conduit fittings, boxes, and accessories for use with EMT conduit shall be cast malleable iron or ferrous alloy, hot-dipped galvanized or zinc-electro-plated and lacquered. Fittings shall be compression type. Setscrew fittings are not acceptable. Fittings shall be the product of Crouse-Hinds, Appleton, OZ Gedney or an equal.
- C. Fasteners and Supports: All clamps, straps, framing and supporting materials shall be hot-dipped galvanized steel or malleable iron.

2.06 LIQUID-TIGHT FLEXIBLE METAL CONDUIT:

- A. Flexible Conduit: Flexible conduit shall have a spiraled, flexible, galvanized steel inner core and an outer jacket of neoprene. Sizes 3/8" through 4" shall have a continuous, internal copper ground. Liquid-tight connectors shall be galvanized steel or malleable iron with neoprene sealing gaskets, external ground lugs and insulated throats. Connectors shall be Appleton type STB or Gedney or equal.

2.07 WIREWAYS:

- A. Sheet Metal:
 - 1. Indoor, dry locations: NEMA 1, sheet steel per UL 870 with hinged cover per NEMA ICS 6. Finish being manufacturer's standard gray enamel.
 - 2. Outdoor and damp locations: NEMA 3R, galvanized sheet steel per UL 870 with hinged cover per NEMA ICS 6.
- B. Non-Metallic:
 - 1. NEMA 4X, Robroy Industries fiberglass trough with gasketed cover attached with non-metallic fasteners.
- C. Fittings and Accessories: Include couplings, hubs, elbows, adapters, end caps and other fittings to match and mate with type of wireway furnished as required for a complete system.

PART 3 EXECUTION

3.01 APPLICATION:

A. General:

1. All field wiring shall be installed in conduit except as otherwise indicated.
2. Minimum conduit size shall be 1/2-inch nominal diameter.

B. Exposed:

1. Conduit installed outdoors exposed shall be rigid galvanized steel.
2. Conduit installed indoors exposed and below 7 feet shall be rigid galvanized steel. Exposed conduit above 7 feet installed indoors may be EMT.

C. Underground:

1. Conduit installed underground shall be Schedule 40 PVC. See section 3.02-E for additional requirements.
2. Elbows used for underground conduit stub-ups from below grade shall be PVC coated rigid galvanized steel, non-metallic Schedule 80 PVC, or Rigid Galvanized Steel completely taped with non-corrosive protective tape.

D. Concealed:

1. Conduit installed concealed above lay-in ceilings and in dry wall construction shall be EMT.

E. Flexible Connections:

1. Indoor-dry areas: Flexible metal conduit.
2. Indoor-wet, damp areas: Liquid-tight, flexible metal conduit.
3. Outdoors: Liquid-tight, flexible metal conduit.

3.02 INSTALLATION:

A. General:

1. Installation Methods: Conduit shall be installed concealed in walls or above ceiling or underground as indicated on the drawings.
2. Cleaning: All conduit systems shall be completed and shall be swabbed clean before conductors are pulled in.
3. Field cuts: Do not cut conduit with pipe cutters.

4. Bends: Field made bends and offsets shall be made with a hickey or conduit bending machine. Crushed or deformed raceways shall not be installed. The maximum number of 90° bends, or equivalent between pulling points in any conduit run shall be three. Pull and junction fittings and/or boxes shall be provided as necessary to satisfy this requirement.
5. Protection: The ends of all conduit runs shall be closed immediately after installation to prevent the accumulation of water, dirt and other foreign material.
6. Locknuts: Conduits shall be fastened to all sheet metal boxes and cabinets with two locknuts. Locknuts shall have sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be the insulating type.
7. Conduit couplings shall be threaded type for RGS or RA conduit and compression type for EMT conduit. Set-screw couplings are not acceptable.
8. Spare conduits: Spare conduits shall have a pull cord installed. The pull cord shall be plastic with a minimum tensile strength of 200 pounds. Not less than 12 inches of slack shall be left at each end of the pull cord.
9. Supports: Supports shall be provided a minimum of every 10' and within 3' of all enclosures. In addition, conduits shall be rigidly supported between couplings, on either side of bends and at terminations and fittings.
10. Boxes: Boxes shall be provided in the raceway system as indicated on the drawings and also wherever required for pulling of wires or making connections. Unless otherwise shown on the drawings, boxes installed in normally wet locations or on the outside of exterior surfaces shall be NEMA 3R, stainless steel sheet construction. Boxes shall be furnished with hinged and gasketed doors and stainless steel back panels. Each box shall have the volume required by the NEC for the number of conductors enclosed in the box. All boxes shall be securely anchored in place.
11. Flexible Connections: Flexible connections of short length shall be provided for equipment subject to vibration, noise transmission or movement. A separate ground conductor shall be provided across all flexible connections. Flexible conduit connections shall be rigidly and securely supported in an approved manner at intervals not exceeding 24 inches in length and within 12 inches of each conduit termination. Lengths of not more than 36 inches may be installed without such supports where flexibility is required.
12. Identification: Identify conduits in accordance with Section 260750.
13. PVC: PVC conduit joints shall be solvent cement welded and shall be watertight. All PVC conduits shall have a separate grounding conductor

installed. Where transition is made to the metallic conduit or enclosures, the grounding conductor shall be bonded to the metal conduit or enclosure.

14. Penetrations through walls, floors, and roof: All penetrations shall be sealed with a UL listed fire sealant equal to Dow Corning #3-6548.

B. Exposed Conduit:

1. Routing: Exposed conduit shall be run straight and true to structure lines. Changes in direction of runs shall be made with fittings or symmetrical bends. Conduit in damp locations or outdoors shall be exposed to the air on all sides and shall not be installed tight against walls, ceilings and structural members, etc. Clamp backs and/or offsets shall be used as necessary to maintain uniform clearances.
2. Supports: Acceptable supporting and clamping materials for exposed conduit include one-hole straps and clamp back, "U" bolts, parallel or right angle conduit clamps, hot-dipped galvanized structural steel frames or modular stainless steel channel as manufactured by Unistrut or equal. Perforated steel tape, stamped steel one- and two-hole straps shall not be used. Conduits shall be supported in accordance with NEC 346-12.
3. Obstructions: Conduit shall be routed so as not to create any tripping or head banging hazard and so as not to create any obstruction to Owner's operation and maintenance activities.
4. Hubs: Watertight conduit hubs shall be installed where conduits enter the tops or sides of sheet metal or non-metallic enclosures.
5. Drains: Drain fittings shall be installed at low points throughout the conduit system where condensation is likely to occur.

C. PVC Coated Conduit:

1. PVC coated conduit requires special care to minimize damage to the PVC coating during cutting, threading, bending and installation. Contractor shall install conduit in accordance with manufacturer's recommended installation procedures.
2. Contractor shall be responsible for providing strap wrenches, cutting dies, vises, and other special tools required to install PVC coated conduit. Standard pipe wrenches, chain wrenches or channel locks shall not be used. Conduit bending equipment shall have the proper diameter shoes or dies to allow for the thickness of the PVC coating.

3. PVC coated conduit shall be supported with Type 304 stainless steel clamps, straps, hangers and supports. Attachment hardware shall be Type 316 stainless steel.
4. All PVC coated conduit and fittings that have teeth marks, cuts, nicks or are otherwise damaged shall be repaired by coating damaged area with a liquid PVC touch-up compound. Spray-type compound is not acceptable.
5. Unistrut channel supports and related accessories for use with PVC coated conduit shall be Type 304 stainless steel.

D. Aluminum:

1. Aluminum conduit shall not be installed in direct contact with earth, concrete, steel, copper, brass or bronze. Where aluminum conduit comes into contact with dissimilar metals or passes through concrete walls or floors, it shall be wrapped with 2 layers, half-lapped, of corrosion preventative pipe tape, Scotch 50 or equal.
2. Aluminum conduit threads shall have a Penetrox, No-Ox-Id or equal, applied when installed.

E. Underground Conduit:

1. Under Landscaping (i.e. sod or grass):
 - a. Underground conduits 2" and larger shall be laid in sand and covered with a 4" red concrete cap. The conduit shall be surrounded by a minimum of 3-inches of virgin sand (top, bottom, and sides).
 - b. The top of concrete cap shall be a minimum of 24 inches below grade.
 - c. Communication conduits shall be buried a minimum of 36" to top of conduit.
 - d. Provide red caution tape 12" below finish grade over all conduits.
 - e. Unless otherwise indicated, electrical conduits must go below conflicts, such as yard piping, if the minimum depth cannot be met. Backfill for all trenches shall be compacted to original density.
2. Under Paved Areas (i.e. Parking Lot, Driveways, and Roads):
 - a. Underground communication conduit runs shall be buried a minimum 36" below grade to top of conduit. Provide red caution tape 12" below finish grade over all conduits.

- b. Underground power conduit runs shall be buried the minimum depth per the National Electric Code. Provide red caution tape 12" below finish grade over all conduits.
 - c. Unless otherwise indicated, electrical conduits must go below conflicts, such as yard piping, if the minimum depth cannot be met. Backfill for all trenches shall be compacted to original density.
- 3. Separation: Minimum separation between the outside edges of adjacent conduits shall be 3 inches.
- 4. Elbows: All elbows shall be long radius type.
- 5. Spacers: Conduit spacers shall be installed at 5 feet on centers.
- 6. Expansion Fittings: Provide expansion fittings in aboveground, vertical portion of each underground conduit stub-up.

END OF SECTION 26 13 60

SECTION 26 14 00 WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY:

A. Section Includes:

1. Receptacles
2. Ground Fault Circuit Interrupter Receptacles
3. Snap Switches
4. Wall Plates

1.02 REFERENCES:

A. National Electrical Manufacturers Association (NEMA):

1. WD1-83 General Requirements for Wiring Devices
2. WD-5 Specific Purpose Wiring Devices

B. National Fire Protection Association (NFPA):

1. 70 National Electrical Code

C. Underwriters Laboratories Inc. (UL):

1. 20-86 Standard for Safety General Use Snap Switches
2. 94-91 Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
3. 498091 Standard for Safety Attachment Plugs and Receptacles

1.03 SUBMITTALS:

A. Procedures: Submit for approval and record purposes in accordance with Section 013000 and 260100.

B. Product Data: Submit for each type of device used on project.

1.04 QUALITY ASSURANCE:

A. Items provided under this section shall be listed and labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.

2. Terms "listed" and "labeled" shall be defined as they are in National Electrical Code, Article 100.
- B. Regulatory Requirements:
1. National Electrical Code: Components and installation shall comply with NFPA 70.

PART 2 PRODUCTS

2.01 WIRING DEVICES:

- A. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA Standards.
- B: Receptacles, General Use Duplex Receptacles: 125 volt, 15 or 20 amp, heavy duty, grounding type, **TAMPER RESISTANT**, by Hubbell, Leviton, or P&S. Device color shall be selected by the Architect.
- C: Ground-Fault Circuit Interrupter (GFCI) Receptacles: 125 volt, 15 or 20 amp, heavy duty, grounding type "non feed-through" conforming to UL 498 and UL 943 by Hubbell, Leviton, or P&S. Device color shall be selected by the Architect.
- D: Snap Switches: 120/277 volt, 20 ampere, quiet rated, heavy duty, complying with UL 20 and NEMA WD1 by Hubbell, Leviton, or P&S. Device color shall be selected by the Architect.

2.02 WIRING DEVICE ACCESSORIES:

- A. Wall Plates:
1. Single and combination, of types, sizes, and with ganging and cutouts as required by devices.
 2. Provide plates which mate and match with wiring devices to which attached.
 3. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates.
 4. Provide plates possessing following additional construction features.
 - a. Device plates: Nylon. Color to match device
 - b. Device plates for surface mounted, 4 inch sq boxes: 1/2 inch stainless steel covers.
 - c. Weatherproof covers for exterior devices or devices in damp locations: Raintight while in use, UL listed, molded UV stabilized poly-carbonate

with stainless steel screws and mounting gaskets. Tay Mac Corporation safety outlet enclosure, or equal.

PART 3 EXECUTION

3.01 INSTALLATION:

- A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.
- C. Install wiring devices only in electrical boxes that are clean; free from building materials, dirt and debris.
- D. Mounting Heights: Unless otherwise indicated or directed, boxes for wiring devices shall be mounted so that the centerline of the device is at the following height above finished floor (AFF) or above finished grade (AFG).

DEVICE	FINISHED AREAS	UNFINISHED AREAS
Snap switches	48"	48"
Convenience Receptacles	18"	18"

- E. Install wiring devices after wiring work is completed.
- F. Install wall plates after painting work is completed.
- G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A. Use properly scaled torque indicating hand tool.
- H. Do not use terminals on wiring devices (hot or neutral) for feed-through connections, looped or otherwise. Make circuit connections via wire connectors and pigtails.
- I. Ground receptacles with insulated green ground wire from device ground screw to bolted outlet box connection.

3.02 PROTECTION:

- A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.03 FIELD QUALITY CONTROL:

- A. Testing: Prior to energizing circuits, test wiring for electrical continuity and for short circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six (6) times.
- B. Test receptacles with Hubbell 5200, Woodhead 1750 or equal for correct polarity, proper ground connection and wiring faults.
- C. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer's recommendations.

END OF SECTION 26 14 00

SECTION 26 24 13.11 SWITCHBOARDS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Low-voltage switchboards.
- B. Overcurrent protective devices.

1.02 RELATED REQUIREMENTS

- A. 260913 - Electrical Power Management System - Schneider Electric Square D EcoStruxure PME.
- B. Section 262713 - Power and Energy Meters - Schneider Electric PowerLogic.
- C. Section 26 43 13 - Surge Protective Devices for Power Circuits.

1.03 ABBREVIATIONS AND ACRONYMS

- A. EMI: Electromagnetic interference.
- B. EPMS: Electrical power management system.
- C. ERMS: Energy reduction maintenance setting.
- D. RFI: Radio-frequency interference.
- E. SPD: Surge protective device.

1.04 DEFINITIONS

- A. Switchboards may also be identified as SWBD.

1.05 REFERENCE STANDARDS

- A. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels; 2011 (Reaffirmed 2017).
- B. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures; Most Recent Edition Cited by Referring Code or Reference Standard.
- C. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; 2013e, with Amendment (2017).
- D. ICC (IBC) - International Building Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components; 2010, with Editorial Revision (2015).
- F. IEC 62443-4-1 - Security for Industrial Automation and Control Systems – Part 4-1: Secure Product Development Lifecycle Requirements; 2018.
- G. IEEE 802.11 - IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; 2020 (Corrigendum 2022).
- H. IEEE 802.15.4 - IEEE Standard for Low-Rate Wireless Networks; 2020, with Amendment (2021).
- I. ISO 9001 - Quality Management Systems — Requirements; 2015.
- J. ISO 14001 - Environmental Management Systems — Requirements with Guidance for Use; 2015.
- K. MIL-STD-220 - Method of Insertion Loss Measurement; 2009c (Validated 2019).

- L. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- M. NECA 400 - Standard for Installing and Maintaining Switchboards; 2007.
- N. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.
- O. NEMA PB 2 - Deadfront Distribution Switchboards; 2011.
- P. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less; 2013.
- Q. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.
- R. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- S. NFPA 70B - Recommended Practice for Electrical Equipment Maintenance; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- T. NFPA 70E - Standard for Electrical Safety in the Workplace; 2021.
- U. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.
- V. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.
- W. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.
- X. UL 891 - Switchboards; Current Edition, Including All Revisions.
- Y. UL 977 - Fused Power-Circuit Devices; Current Edition, Including All Revisions.
- Z. UL 1008 - Transfer Switch Equipment; Current Edition, Including All Revisions.
- AA. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.
- BB. UL 1066 - Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures; Current Edition, Including All Revisions.
- CC. UL 1283 - Standard for Electromagnetic Interference Filters; Current Edition, Including All Revisions.
- DD. UL 1449 - Standard for Surge Protective Devices; Current Edition, Including All Revisions.
- EE. UL RP 2986 - Recommended Practice for Measuring Incident Energy Exposure; 2015.

1.06 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Review material selections and installation procedures with **Owner Engineer, manufacturer's representative, and affected installers**.
- B. Scheduling: Do not schedule functional demonstration testing until operational readiness testing is complete and associated report and certification have been submitted.

1.07 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Provide sufficient information to determine compliance with Contract Documents. Identify submittal data with specific equipment tags and/or service descriptions to which they pertain. Identify specific model numbers, options, and features of equipment proposed.
- C. Indicate deviations from Contract Documents with reference to corresponding drawing or specification number and written justification for deviation.
- D. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, components, and accessories.

- E. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, instruments, features, and accessories.
 - 1. Include dimensioned plan and elevation views of switchboards; indicate dimensions, weights, shipping splits, and required clearances.
 - 2. Include single-line diagram.
 - 3. Include proposed mimic bus arrangement.
- F. Seismic Qualification Certification:
 - 1. Certificate of compliance.
 - 2. Dimensioned equipment outline drawings identifying center of gravity and mounting/anchoring provisions.
 - 3. Details and installation requirements of equipment anchorage devices on which certification is based.
- G. Operational Readiness Report:
 - 1. Document test results, including assumptions, conditions, allowances, and corrections made.
 - 2. Provide listing of field modifications and adjustments made including settings/parameters not identified as factory defaults within equipment's operations and maintenance manual documentation.
 - 3. Include certification, signed by **Contractor and manufacturer's representative**, that equipment and associated system have been installed, configured, and tested in accordance with manufacturer's recommendations, conforms to requirements of Contract Documents, and is ready for operation.
- H. Functional Demonstration Testing Report: Document test results, including assumptions, conditions, allowances, and corrections made.
- I. Manufacturer's qualification statement.
- J. Installer's qualification statement.
- K. Operation and Maintenance Data:
 - 1. Provide detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 - a. Include manufacturer, supplier, support, and repair center contact information.
 - b. Include manufacturer's standard operation and maintenance data assembled for each size and type of equipment furnished.
 - c. Include contact information for parts stocking location closest to Owner.
 - d. Identify critical spare parts associated with long lead times and/or those critical to unit operation.
 - e. Identify maintenance spare parts required to regularly perform scheduled equipment maintenance including, but not limited to, consumable parts required to be exchanged during scheduled maintenance periods.
 - 2. Digital Record Keeping:
 - a. Provide maintenance logbook application/website available on PC/mobile device to assist in compliance with NFPA 70B.
 - b. Include access to manufacturer's standard documentation, equipment serial number, as-built drawings, assembly and testing results, device settings, and spare parts list.
 - c. Provide password-protected access to Owner.
 - d. Provide access via scannable QR code on front face of equipment.
- L. Specimen Warranty: Statement of standard warranty.
- M. Executed warranty.
- N. Project Record Documents:

1. Construction, installation, schematic, and wiring diagrams updated to as-installed and commissioned state.
 2. Configured settings/parameters for adjustable components updated to as-installed and commissioned state, noted if different from factory default.
- O. Maintenance Materials: Furnish the following for Owner's use in maintenance of project:
1. See Section 26 01 00 - Product Requirements for additional provisions.
 2. Spare Parts: For each type and size of unit installed.
 - a. Provide minimum spare parts recommended by manufacturer.
 - b. Fuses: **One set** of each type of power and control fuse installed within equipment.
 - c. Spare Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet.
 - d. Touch-up paint for finishes.
 - e. Package and mark spare parts for long-term storage. Provide separate anti-static containers for printed circuit boards.
 3. Tools: Manufacturer-specific special tools required to install, remove, test, and maintain switchboard components.
 - a. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 - b. Portable Test Set: For testing functions of solid state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
 - c. Drawout Circuit Breakers:
 - 1) Remote Racking Device: **One**.
 - 2) Portable Lifting Device: **One** floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in/out of compartments for present and future circuit breakers.
 - 3) Lifting Yokes: **One** of each different yoke required.
 - d. Equipment Configuration Software: PC-based or mobile device application; provide **one** of each different communication interface cable required to connect computer/device configuration and programming.
 - e. Equipment Configuration Files: For future upload into replaced/repaired components, in media format acceptable by Owner.

1.08 QUALITY ASSURANCE

- A. Comply with the following:
1. NFPA 70.
 2. Requirements of local authorities having jurisdiction.
 3. Applicable local codes.
- B. Manufacturer Qualifications:
1. Firm engaged in manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for minimum of 20 years.
 2. Certified in accordance with ISO 9001 with applicable quality assurance system regularly reviewed and audited by third-party registrar. Develop and control manufacturing, inspection, and testing procedures under guidelines of quality assurance system.
 3. Service, repair, and technical support services available 24 hours per day, 7 days per week from manufacturer or their representative.
 4. Certified in accordance with ISO 14001, with product environmental profiles (PEPs) for specified products.
- C. Installer Qualifications: Firm with minimum 10 years of experience with equipment of similar type and scope.
- D. Product Listing Organization Qualifications: Organization recognized by OSHA as Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. See Section 017419 - Construction Waste Management and Disposal for packaging waste requirements.
- B. Prior to delivery to project site, verify suitable storage space is available to store materials in well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres.
- C. Protect materials during delivery and storage and maintain within manufacturer's written storage requirements. At minimum, store indoors in clean, dry space with uniform temperature to prevent condensation and protect electronics from potential damage from electrical and magnetic energy.
- D. Deliver materials to project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified in Contract Documents.
- E. Inspect products and report concealed damage or violation of delivery, storage, and handling requirements to **Engineer** and owner's representative.

1.10 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.11 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer Warranty: Provide manufacturer warranty for defects in material and workmanship for 12 months from date of commissioning or 18 months from date of shipment, whichever comes first. Complete forms in Owner's name and register with manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Schneider Electric; Square D FlexSeT or QED-2 per project requirements; www.se.com/#sle.
- B. Siemens
- C. Substitutions: **See Section 26 01 00 - Product Requirements**
- D. Source Limitations: Furnish products produced by single manufacturer.

2.02 LOW-VOLTAGE SWITCHBOARDS

- A. Basis of Design: Schneider Electric; Square D FlexSeT or QED-2 per project requirements; www.se.com/#sle.
- B. Switchboard Ratings/Configurations: As indicated on drawings.
- C. Switchboard Rating/Configuration:
 - 1. Source: As indicated on drawings.
 - 2. Main Breaker: **Fixed**.
 - 3. Nominal System Voltage: As indicated on drawings.
 - 4. System Ampacity: As indicated on drawings.
 - 5. Short Circuit Current Rating: As indicated on drawings.
 - 6. Available Access: For front, rear, and side.
 - 7. Service Entrance Rating: As indicated on drawings.
 - 8. Incoming Connection Type: As indicated on drawings.
 - 9. Incoming Mains Location: Through bottom.
 - 10. Incoming Side: As indicated on drawings.
 - 11. Incoming Auxiliary Section: As indicated on drawings.
 - 12. Utility Metering Compartment: Comply with Utility Company requirements.

- D. Switchboard Assemblies:
 - 1. Comply with NEMA PB 2; list and label as complying with UL 891.
 - 2. Provide front and rear alignment of adjacent sections.
 - 3. Provide barriers between sections.
- E. Short Circuit Current Rating: Where not specified, provide switchgear with listed short circuit current rating as determined by short-circuit study.
- F. Ground Fault Protection: List and label as complying with UL 1053.
- G. Cable Terminations for Incoming Conductors:
 - 1. Provide lugs in quantity and size required for conductors indicated on drawings.
 - 2. Lug Type: **Aluminum mechanical lugs, suitable for terminating aluminum or copper conductors** unless otherwise indicated; rate for 167 degrees F (75 degrees C).
- H. Bussing:
 - 1. Bus Density Rating: **Standard, in accordance with UL 891 temperature rise requirements.**
 - 2. Bus Material: **Tin-plated, high-strength, electrical-grade aluminum alloy** unless otherwise indicated.
 - 3. Plating: Apply to bus surfaces except cut edges. Plating on contact surfaces only is not permitted.
 - 4. Phase and Neutral Horizontal Bus: Ampacity equal to or greater than switchboard system rating. Tapered bus is not permitted.
 - 5. Group-Mounted Feeder Vertical Bus Stack:
 - a. Provide capability to mount feeder breakers with different frame sizes/poles across from one another on bus stack.
 - b. Design to remove nonconducting surface films during circuit breaker installation by wiping action of circuit breaker jaws.
 - c. Design in conjunction with circuit breaker jaws to create blow-on forces under fault conditions.
 - d. Bolted connections for group-mounted feeder breakers are not permitted.
 - 6. Ground Bus:
 - a. Size in accordance with NFPA 70 and UL 891.
 - b. Bus Material: Hard-drawn copper of 98 percent conductivity.
 - c. Equip with pressure connectors for feeder and branch circuit equipment grounding conductors.
 - d. Busway Feeders: Extend insulated equipment grounding cable to busway ground connection. Support cables at intervals in vertical run.
- I. Enclosures:
 - 1. Construction: Steel.
 - 2. UL 50E Rating, Unless Otherwise Indicated:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Indoor Locations with Fire Sprinkler Protection: Type 1 with drip hood.
 - c. Outdoor Locations: Type 3R.
 - 3. Front Covers: Removable with single tool.
 - 4. Doors: Hinged with removable hinge pins.
 - 5. Finish: Manufacturer's standard paint color over rust-inhibiting primer on treated metal surface.
 - 6. Enclosure Heaters:
 - a. Provide electric strip heaters in each switchboard vertical section installed **outdoors or in unconditioned indoor spaces.**
 - b. Size to maintain enclosure temperature above expected dew point.
 - c. Heater Control: Humidistat.
 - d. Heater Power Source: Provide connection **internally from switchboard.**

- J. Future Provisions:
 - 1. Future Switchboard Sections: Equip horizontal bus with splicing hardware for additional switchboard sections.
 - 2. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit breaker compartment.
- K. Markings and Labeling:
 - 1. Provide identification and warning labels/nameplates exterior to equipment resistant to weather, UV, and intended installation environment.
 - 2. Provide engraved nameplate identifying project-specific equipment tag and service description.
 - 3. Provide warning labels/nameplates complying with ANSI Z535.4 at access locations to advise personnel of possible hazards in accordance with listing, NFPA 70, NFPA 70E, and other applicable standards.
 - 4. Provide scannable QR code on front face of equipment for access to maintenance logbook application/website available on PC/mobile device.
- L. Control Power:
 - 1. Control Circuits: **120 VAC control power transformer or** 24 VDC power supply.
 - 2. Control Circuits: 24 VDC; supply through Schneider Electric Smart Cell device with primary fused disconnect for current limiting and overload protection of control circuits.
 - 3. Control Wiring: Factory install with bundling, lacing, and protection. Provide flexible conductors for size 8 AWG and smaller, across hinges, and for interconnections between shipping units.
 - 4. Electrically Interlocked Main and Tie Circuit Breakers: Connect two control power transformers with interlocking relays to primary side of each control power transformer at line side of associated main circuit breaker. Provide 120 V secondaries connected through automatic transfer relays to enable automatic transfer scheme.
- M. Switchboards with Drawout Circuit Breakers: Provide overhead circuit breaker lifting device mounted at top front of switchboard.
- N. Top-Mounted Pull Box:
 - 1. Ventilation: Maintain temperature within same limits as switchboard.
 - 2. Covers: Removable from top, front, and sides.
 - 3. Bottom: Insulating, fire-resistive material with separate cable drop holes.
 - 4. Mounting: Set back from front to provide clearance for circuit breaker lifting device.
- O. Line-Side Isolation:
 - 1. Provide circuit breaker section with energy-reducing, line-side isolation to reduce line-side incident energy exposure to less than 4.4 Btu/sq ft (1.2 cal/sq cm) at 18 inches (460 mm), as verified by UL RP 2986.
 - 2. Independent of design, current duration, and trip level of upstream protective device.
 - 3. Rated for full voltage and interrupting rating marked on equipment.
 - 4. Provide passive system that continuously protects from effects of arc flash incidents without requiring arc flash relay system, power (e.g., control power), special commissioning, testing, or operator intervention.
 - 5. Reusable for multiple arc flash events.
 - 6. Do not use means for reducing arc energy that cause additional system level stresses, including bolted fault short circuit.
 - 7. Remote Continuous Thermal Monitoring: Provide thermal monitoring of each line-side conductor of energy-reducing, line-side isolation section to eliminate need for exposure to energized line-side conductors for thermal scans.
 - 8. Provide indication of arc flash incident on line-side conductors.
 - 9. Products:
 - a. Schneider Electric; ArcBlok.

- P. Maintenance Mode Switches:
1. Description: Local, lockable switch with blue status indicator light that permits selection of maintenance mode with alternate electronic trip unit settings for reduced fault clearing time in accordance with NFPA 70.
 2. Provide for circuit breakers 1,200 A and larger **and where indicated on drawings**, unless providing other means of reducing clearing time in accordance with NFPA 70.
 3. Switch Type: Provide **energy reduction maintenance settings (ERMS) switches or maintenance mode settings (MMS) switches as indicated**.
 - a. ERMS Switches: Clearing time of less than 50 milliseconds when activated.
 - b. MMS Switches: Clearing time of less than 80 milliseconds when activated.
 4. Insulated Case Circuit Breakers (ICCBs) and Power Circuit Breakers (PCBs) with ERMS: Provide Android/iOS mobile application that enables remote maintenance mode activation, at distance typically greater than 33 feet (10.1 m) line-of-sight.
- Q. Modified Differential Ground Fault Protection:
1. Application: Provide for 3-phase, 4-wire switchboards with multiple sources where required by applicable electrical codes.
 2. Performance Requirements:
 - a. System alarms with occurrence of ground fault at any switchboard location.
 - b. System **trips** with combination of normal current flow and ground fault current flowing together.
 - c. System does not trip without ground fault and with normal current flow.
 - d. System does not trip due to large single-phase currents.
 - e. System does not trip with circulating currents through neutral due to multiple grounds and sources external to immediate low-voltage power sources.
 3. Provide additional wiring and components, including but not limited to current transformers, ground fault relays, and interlocks as required.
 4. Provide system wiring diagram and test procedure using high current injection equipment.
- R. Surge Protective Device (SPD):
1. See Section 26 43 13 for additional information.
- S. Power Metering:
1. Factory installed, integrated within switchboard.
 2. Applications:
 - a. Low-Voltage Mains: **Power and energy meter**.
 - b. Low-Voltage Feeders: Power and energy meter.
 3. Power and Energy Meters:
 - a. See Section 26 27 13 for additional information.
- T. Communications:
1. Provide internal wired communications network for connection to Owner's network for power monitoring and equipment status/alarm information via:
 - a. Connection to building management system, electrical power management system (EPMS), or other software.
 - b. Access to each breaker's embedded web pages through standard web browser for maintenance review, troubleshooting, and monitoring.
 2. Communications Protocol: Ethernet Modbus TCP/IP network connected via daisy-chain architecture from each circuit breaker and separate meters (where specified) upstream to switchboard Ethernet port.
 3. Communications Protocol: Modbus RS485 serial link network via daisy-chain architecture to each circuit breaker. Modbus RS485 to Modbus TCP/IP gateway or separate meters (where specified) connect upstream to switchboard Ethernet port.
 4. Embedded Web Pages for Power Circuit Breakers: Provide access to drawout breaker/cradle status (where specified), energy monitoring, historical trending, maintenance indicators/logging, email alerts, and communications diagnostics.

5. Preconfigure and factory-test network communication system with user-configurable final addressing. Provide network drawings with device addresses.
 6. Provide software for adjusting circuit breaker trip/alarm points, displaying trip curves, and updating firmware.
 7. Internal Network Wiring: Shielded cables with pluggable connectors to facilitate connection across shipping splits.
 8. Panel Server:
 - a. See Section 26 27 13 for additional information.
 - b. Capable of acting as solution- and services-enabler for energy management system located on premises or cloud based, remote from building.
 - c. Support IEEE 802.11 a/b/g/n (Wi-Fi).
 - d. Provide two Ethernet ports, configurable either as bridged ports or separated ports with one IP address for each.
 - e. Capable of serving as wired gateway to access downstream serial- and Ethernet- connected Modbus-enabled electrical devices and values in real time.
 - f. Support IEEE 802.15.4 (Zigbee) as data concentrator for close distance, wireless devices.
 - g. Collects and stores WAGES (Water, Air, Gas, Electricity, Steam) consumption readings.
 - h. Provide integral web pages for accessing stored data including views of real-time data for each connected device and summary of connected devices; access to login page via HTTPS.
 - i. Designed through secured development lifecycle in accordance with IEC 62443-4-1.
 - j. Provide option to disable ports or protocols not used.
- U. Electrical Power Management System Capabilities:
1. See Section **26 09 13 (EcoStruxure Power Management software)** for additional requirements.
 2. Provide communications connectivity and functionality to support electrical power management system (EPMS), including but not limited to:
 - a. Communications connectivity via Ethernet network and protocols of EPMS and related equipment, either through communications gateway or integral interface.
 - b. Internal wired communications network for multiple sections/devices to provide single point of connection to EPMS network.
 - c. Compliance with recognized cybersecurity requirements.
 - d. Breaker aging modeling for electronic trip circuit breakers.
 - e. Remote EPMS capability for equipment configuration, operational control, electrical power monitoring, power quality monitoring, compliance, and correction; alarm monitoring with event log.
 3. Provide factory-tested native software compatibility, including the following:
 - a. Capability for pre-engineered, interactive graphical display screens to view and analyze real-time device data.
 - b. Pre-mapping of registers to standard measurement names without need for additional configuration or internal device registers.
 - c. Automatic collection and logging of device data by EPMS software without additional configuration.
- V. Condition Monitoring Service:
1. See Section 26 09 13 for additional information.
 2. Provide asset monitoring service to assess current operating condition of monitored equipment, assign health index for each asset, identify corrective actions needed, and provide reports to optimize management of electrical distribution system assets.

2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Circuit Breakers:

1. Interrupting Capacity: As required to provide short circuit current rating indicated.
2. Insulated Case Circuit Breakers (ICCBs):
 - a. See Section 26 2811.12 for additional information.
 - b. Description: Quick-make, quick-break circuit breakers with two-step stored energy closing mechanism; maximum five-cycle closing time.
 - c. Listed and labeled as complying with UL 489.
 - d. Construction:
 - 1) Provide fixed-mount circuit breakers **unless otherwise indicated** for circuit breaker frame sizes 1200 amperes or less.
 - 2) Provide drawout circuit breakers **where indicated** for circuit breaker frame sizes 1500 amperes and above.
 - e. Electronic Trip Units:
 - 1) Microprocessor based, with circuit breaker status display and LED trip indicators.
 - 2) Provide energy reduction maintenance settings (ERMS).
 - 3) Provide network monitoring capability for amperage, voltage, power, energy, and harmonics.
 - 4) Provide capability to upgrade by uploading digital modules without requiring replacement/modification of hardware.
 - 5) Where indicated on drawings, provide electronic trip units with field-adjustable **long-time**, short-time, **instantaneous**, ground-fault protection settings.
 - 6) Zone Selective Interlocking: Provide capability to communicate with other electronic trip units and ground fault systems for coordination purposes.
 - f. Provide the following where indicated or required:
 - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator, energized from separate circuit.
 - 2) Auxiliary Contacts: Two SPDT switches for indicating status of circuit breaker contacts.
 - 3) Undervoltage Release: For tripping circuit breaker between 35 and 75 percent of rated voltage **with time delay, field adjustable from 0.1 to 0.6 seconds**.
 - 4) Remote trip indication and control.
 - 5) Key Interlock: Externally mount to prohibit circuit breaker operation; key removable only when circuit breaker is in off position.
 - g. Control Voltage: **120 VAC** or 24 VDC.
 - h. Products:
 - 1) Schneider Electric; MasterPact MTZ series.
 - 2) Siemens
3. Power Circuit Breakers (PCBs):
 - a. Description: Quick-make, quick-break circuit breakers with two-step stored energy closing mechanism; maximum five-cycle closing time.
 - b. Listed and labeled as complying with UL 1066.
 - c. Construction:
 - 1) Provide fixed-mount circuit breakers **unless otherwise indicated** for circuit breaker frame sizes 1200 amperes or less.
 - 2) Provide drawout circuit breakers **where indicated** for circuit breaker frame sizes 1500 amperes and above.
 - d. Electronic Trip Units:
 - 1) Microprocessor based, with circuit breaker status display and LED trip indicators.
 - 2) Provide energy reduction maintenance settings (ERMS).
 - 3) Provide network monitoring capability for amperage, voltage, power, energy, and harmonics.
 - 4) Provide capability to upgrade by uploading digital modules without requiring replacement/modification of hardware.

- 5) Where indicated on drawings, provide electronic trip units with field-adjustable **long-time**, short-time, **instantaneous**, ground-fault protection settings.
- 6) Zone Selective Interlocking: Provide capability to communicate with other electronic trip units and ground fault systems for coordination purposes.
- e. Provide the following where indicated or required:
 - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator, energized from separate circuit.
 - 2) Auxiliary Contacts: Two SPDT switches for indicating status of circuit breaker contacts.
 - 3) Undervoltage Release: For tripping circuit breaker between 35 and 75 percent of rated voltage **with time delay, field adjustable from 0.1 to 0.6 seconds**.
 - 4) Remote trip indication and control.
 - 5) Key Interlock: Externally mount to prohibit circuit breaker operation; key removable only when circuit breaker is in off position.
- f. Control Voltage: **120 VAC** or 24 VDC.
- g. Products:
 - 1) Schneider Electric; MasterPact MTZ series.
 - 2) Siemens
4. Molded Case Circuit Breakers (MCCBs):
 - a. Comply with FS W-C-375; listed and labeled as complying with UL 489.
 - b. Lugs: **Mechanical** type, suitable for number, size, trip ratings, and conductor material.
 - c. Circuit Breaker Type:
 - 1) Provide thermal magnetic circuit breakers for circuit breaker frame sizes 400amperes or less.
 - 2) Provide electronic trip circuit breakers for circuit breaker frame sizes 600amperes and above.
 - d. Electronic Trip Units:
 - 1) Microprocessor based, with circuit breaker status display and LED trip indicators.
 - 2) Where indicated on drawings, provide electronic trip units with field-adjustable **long-time**, short-time, **instantaneous** protection settings.
 - 3) Provide network monitoring capability for **amperage, voltage, power**, energy, and harmonics where indicated.
 - 4) Zone Selective Interlocking: Provide capability to communicate with other electronic trip units and ground fault systems for coordination purposes.
 - e. Provide the following where indicated or required:
 - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator, energized from separate circuit.
 - 2) Auxiliary Contacts: Two SPDT switches for indicating status of circuit breaker contacts.
 - 3) Undervoltage Release: For tripping circuit breaker between 35 and 75 percent of rated voltage **with time delay, field adjustable from 0.1 to 0.6 seconds**.
 - 4) Ground Fault Protection: Integral to circuit breaker with adjustable pickup and time delay settings, push to test feature, and ground fault indicator.
 - 5) Key Interlock: Externally mount to prohibit circuit breaker operation; key removable only when circuit breaker is in off position.
 - f. Products:
 - 1) Schneider Electric; PowerPacT series.
 - 2) Siemens

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine equipment exterior and interior for damage, including but not limited to, structure, moisture, and mildew.
- B. Examine for conditions detrimental to completion of work, including:
 - 1. Verify concrete pads are level and free of irregularities.
 - 2. Verify installation space is enclosed and weatherproof.
 - 3. Verify wet work located in or in close proximity to switchboard installation location is completed and dry.
 - 4. Verify work above ceilings is complete.

3.02 INSTALLATION

- A. Install equipment in accordance with manufacturer's written instructions.
- B. Install switchboards in accordance with NECA 1, NECA 400, and NEMA PB 2.1.
- C. Unless otherwise indicated, install and anchor switchboards on raised concrete pad high;.
- D. Set field-adjustable circuit breaker tripping function settings **as determined by coordination study**.
- E. Identify switchboard operating instructions, including but not limited to control and key interlocking sequences and emergency procedures.
 - 1. Use **finished wood or metal frame with clear acrylic cover**. Mount on front of switchboard unless otherwise indicated.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements for additional requirements.
- B. Manufacturer Services: **Provide services of manufacturer's field representative to perform functional testing, commissioning, and first parameter adjusting.**
 - 1. Include necessary material, equipment, labor, and technical supervision.
 - 2. Replace damaged or malfunctioning equipment and report discrepancies or installation issues.
 - 3. Identify switchboards with label indicating inspection/testing agency and date of service.
- C. Operational Readiness Testing:
 - 1. Inspect and test equipment and associated systems for conformance to Contract Documents, including equipment manufacturer's recommendations, and readiness for operation.
 - a. Visually inspect for physical damage and proper installation.
 - b. Perform tests in accordance with manufacturer's instructions.
 - c. Perform tests to verify compliance with Contract Documents.
 - d. Perform tests to verify equipment is ready for operation.
 - e. Touch-up paint chips and scratches with manufacturer-supplied paint.
 - f. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - g. Measure, using high potential testing, insulation resistance of each bus structure phase-to-phase and phase-to-ground for one minute each, at minimum test voltage of 1,000 VDC.
 - 1) Comply with manufacturer's documented specific testing procedures.
 - 2) Minimum Insulation Resistance: 1 megohm.
 - h. Physically test key interlock systems for proper functionality prior to energizing.
 - i. Test continuity of each circuit.
 - j. Perform each electrical test and visual/mechanical inspection listed in NETA ATS as applicable. Certify compliance with test parameters.
 - 1) Switchboards: See Section 7.1.
 - 2) Fusible Switches: See Section 7.5.
 - 3) Circuit Breakers: See Section 7.6.

- 4) Relays: See Section 7.9.
- 5) Instrument Transformers: See Section 7.10.
- 6) Meters: See Section 7.11.
- 7) Ground Fault Protection Systems: See Section 7.14.

D. Correct deficiencies and replace damaged or defective switchboards or associated components.

3.04 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals for additional submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.
- C. Functional Demonstration Testing: Demonstrate proper operation of switchboards and associated systems to Owner's designated representative **and Engineer**, observing and documenting compliance with Contract Documents.
- D. Training:
 1. Train Owner's personnel on operation and maintenance of system.
 - a. Accommodate minimum of **four** attendees.
 - b. Provide not less than **one** session with **four hours** of classroom and hands-on training.
 - c. Training Reference: **Use submitted operations and maintenance manuals**. Provide a copy of manuals and documentation for each participant.
 - d. Instructor: Factory-trained manufacturer's representative.
 - e. Location: Project site.
 2. Provide sufficient time and detail in each session to cover the following at minimum:
 - a. Operation theory.
 - b. Major equipment components.
 - c. Equipment operation.
 - d. Equipment configurations.
 - e. Maintenance, troubleshooting, and repair.
 - f. Component-level parts replacement.

3.05 PROTECTION

- A. Protect installed switchboards from subsequent construction operations.

END OF SECTION

SECTION 26 24 16 PANELBOARDS

PART 1 GENERAL

1.01 SCOPE:

- A. Furnish and install panelboards as specified herein and as indicated on the drawings.
- B. Panelboard types included in this Section are:
 - 1. Power distribution panelboards
 - 2. Lighting and appliance panelboards

1.02 REFERENCES:

- A. National Electrical Contractors Association (NECA)
 - 1. Standard of Installation
- B. National Electrical Manufacturers Association (NEMA)
 - 1. AB 1 Molded Case Circuit Breakers
 - 2. PB 1 Panelboards
 - 3. PB1.1 General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- C. Underwriters Laboratories Inc. (UL)
 - 1. 50 Cabinets and Boxes
 - 2. 67 Panelboards

1.03 SUBMITTALS - FOR APPROVAL:

- A. Procedure: Submit in accordance with Section 013000, 260100, and as stated herein.
- B. Product Data:
 - 1. Descriptive bulletins
 - 2. Enclosure outline drawing with complete dimensions
 - 3. Breaker layout drawing
 - 4. Component list
 - 5. Conduit entry/exit locations

6. Assembly ratings including:
 - a. Short circuit current
 - b. Voltage
 - c. Continuous current
7. Cable terminal sizes.
8. Installation Instructions

1.04 SUBMITTALS – RECORD DATA:

- A. Procedure: Submit in accordance with Section 013000.
- B. The following information shall be submitted for record purposes:
 1. Final (as-built) drawings and information for items listed in Paragraph 1.03
 2. Installation, operation and maintenance instruction
 3. Spare parts list

1.05 QUALIFICATIONS:

- A. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.
- B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

1.06 DELIVERY, STORAGE, AND HANDLING:

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS:

- A. Square D
- B. Siemens

2.02 RATINGS:

- A. Panelboards rated 240 Vac or less shall have short circuit ratings as indicated on the drawings or as herein scheduled, but not less than 10,000 amperes RMS symmetrical.

- B. Panelboards rated 480 Vac shall have short circuit ratings as indicated on the drawings or as herein scheduled, but not less than 14,000 amperes RMS symmetrical.
- C. Panelboards shall be labeled with a UL short circuit rating. All panelboards shall be fully rated. Series ratings shall not be used.

2.03 CONSTRUCTION:

- A. Interiors shall be completely factory assembled 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.
- B. Trims for lighting and appliance panelboards shall be supplied with a hinged door covering all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semiflush, cylinder lock and catch assembly. Doors over 48 inches in height shall have auxiliary fasteners.
- C. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible.
- D. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 inch on all sides. Trims shall be secured to box with concealed clamps.
- E. A directory card with a clear plastic cover shall be supplied and mounted on the inside of each door in a metal frame.
- F. All locks shall be keyed alike.

2.04 BUS:

- A. Main bus bars shall be tin-plated copper, sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 65° C above an ambient of 40° C maximum.
- B. A bolted ground bus shall be included in all panels.
- C. Full-size (100%-rated) insulated neutral bars shall be included for panelboards indicated to have a neutral bus. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection. 200%-rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors.

2.05 DISTRIBUTION PANELBOARDS:

- A. Distribution panelboards including circuit breakers contained therein shall have fully rated interrupting ratings as indicated on the drawings. Panelboards shall have bolt-on, molded case circuit breakers as indicated below.
- B. Molded case circuit breakers shall provide circuit overcurrent protection with inverse time and instantaneous tripping characteristics. Ground fault protection shall be provided where indicated.
- C. Circuit breakers shall be 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.

- D. Where indicated, circuit breakers shall be current limiting.
- E. Circuit breakers below 600-ampere shall have thermal-magnetic trip units and inverse time-current characteristics.
- F. Circuit breakers 600-ampere through 1200-ampere shall be provided with microprocessor-based RMS sensing trip units.
 - 1. Each molded case circuit breaker microprocessor-based tripping system shall consist of three (3) current sensors, a trip unit, and a flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the 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.
 - 2. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be fixed or adjustable as indicated. 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.
 - 3. The microprocessor-based trip unit shall have thermal memory capabilities to prevent the breaker from being reset following an overload condition until after a preset time delay.

4. When the adjustable instantaneous setting is omitted, the trip unit shall be provided with an instantaneous override. Internal ground fault protection adjustable pick-up ratings shall not exceed 1200 amperes. Provide neutral ground fault current sensor for four-wire loads.
5. Breakers shall have built-in test points for testing the long-time delay, instantaneous, and ground fault functions of the breaker, by means of a 120-volt operated test set. Provide one test set capable of testing all breakers 600-ampere and above.
6. System coordination shall be provided by the following microprocessor-based, time-current curve shaping adjustments:

Adjustable long-time pick-up
Adjustable short-time pick-up and delay, with selective curve shaping
Adjustable instantaneous pick-up
Adjustable ground fault pick-up and delay, with selective curve shaping.

- G. Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere rating in their intended enclosure.
- H. Provide shunt trips, bell alarms, and auxiliary switches as indicated on the drawings.
- I. Circuit breakers supplying air conditioning branch circuits shall be UL listed as type HACR.

2.06 LIGHTING AND APPLIANCE PANELBOARDS:

- A. The minimum integrated short circuit rating for branch circuit panelboards shall be indicated on the drawings.
- B. Bolt-in 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.
- C. 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. Circuit breakers shall be UL listed as type SWD for lighting circuits and HACR for air conditioning branch circuits.
 1. 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.

2.07 ENCLOSURE:

- A. General: Enclosures shall be at least 20 inches wide and made from galvanized steel. Provide minimum gutter space in accordance with the National Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided. Enclosures shall be provided with blank ends.
- B. Rating: NEMA type 12 enclosure except where other enclosure requirements are indicated.

2.08 FINISH:

- A. Surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of the manufacturers standard paint color shall be applied.

2.09 MISCELLANEOUS DEVICES

- A. Provide TVSS system integral to distribution panelboards and appliance panelboards where indicated on drawings. Reference section 266710 for specifications on TVSS units.

PART 3 EXECUTION

3.01 EXAMINATION:

- A. Confirm installation space and clearance requirements for panelboards in accordance with NEC requirements.

3.02 INSTALLATION:

- A. General: Install panelboards as indicated on the drawings and in accordance with manufacturer's published instructions, NEMA PB 1.1, and NECA "Standard of Installation".
- B. Mounting Heights: Top of trim 6 feet 2 inches above finished floor, except as otherwise indicated.
- C. Mounting:
 - 1. Plumb and rigid without distortion of box.
 - 2. Mount flush panels uniformly flush with wall finish.
- D. Circuit Directory: Typed directory indicating final circuit connections. Obtain approval before installing.

- E. Install filler plates in unused breaker spaces.
- F. Provisions for Future Circuits at Flush Panelboards:
 - 1. Stub four 1-inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future.
 - 2. Stub four 1-inch empty conduits into raised floor space or below slab other than slabs on grade.
- G. Wiring in Panel Gutters: Train conductors neatly in groups, bundle, and wrap with wire ties after completion of load balancing.

3.03 IDENTIFICATION:

- A. Identify field-installed wiring and components and provide unit nameplate in accordance with Section 260750.
- B. Provided one (1) 8-1/2"x11" stainless steel nameplate engraved with one-line diagram and year installed. One-line diagram shall include panel voltages, amps, AIC ratings, and feeder sizes. Nameplate shall be mounted to the exterior door of the main distribution panel – LB.

3.04 GROUNDING:

- A. Connections: Make equipment grounding connections for panelboards as required in Section 260600.
- B. Provide ground continuity to main electrical ground bus.
- C. Provide isolated ground bars for panels serving sensitive electronic equipment and as indicated on panel schedules.

3.05 CONNECTIONS:

- A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.06 FIELD TESTING:

- A. Inspect for compliance with drawings and specifications.
- B. Inspect for defects, damaged or missing parts.

- C. Operate each breaker a minimum of three (3) times to insure proper operation.
- D. Perform insulation resistance test on complete assembly at 1000 Vdc. Disconnect any solid-state devices prior to testing. Minimum acceptable test results are 100 megohms.

3.07 CLEANING:

- A. Upon completion of installation, inspect interior and exterior of panelboards.
- B. Remove paint splatters and other spots, dirt, and debris.
- C. Touch up scratches and mars of finish to match original finish.
- D. Clean interior of panelboard.

3.08 FIELD ADJUSTMENTS:

- A. Balancing Loads: Prior to final acceptance, conduct load-balancing measurements and circuit changes as follows:
 - 1. Perform measurements during period of normal working load as advised by Owner.
 - 2. Advise Engineer of load imbalances exceeding 20% or of loads exceeding 80% of circuit ratings. Reconnect branch circuit loads as directed by Engineer.
 - 3. Perform load-balancing circuit changes outside the normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical circuits.
 - 4. Recheck loads after circuit changes during normal load period. Record load readings before and after changes and submit test records.

END OF SECTION 26 24 16

SECTION 26 27 13 POWER AND ENERGY METERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for power and energy meters as required for the complete performance of the work, as shown on the drawings, as specified herein, and as specified elsewhere for the assemblies or systems comprised of the components specified herein.
- B. Related Sections: Related sections include, but shall not be limited to, the following:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
 - 2. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.
 - 3. Refer to specification Section 26 09 13 Electrical Power Management System for additional requirements.
- C. This specification includes requirements for the following equipment that may be referenced elsewhere within the Contract Documents.
 - 1. Power Meters
 - 2. Energy Meters
 - 3. Multi-Circuit Meters
 - 4. Advanced Multi-Circuit Meters
 - 5. Integrated Panelboard Multi-Circuit Meters
 - 6. Energy Server
 - 7. High Density Metering Cabinets
 - 8. Multi-Metering Cabinets
 - 9. Electrical Power Management System

1.2 REFERENCES

- A. General, Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced PUBLICATIONS shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
 - 1. American National Standards Institute (ANSI)
 - a. ANSI C12.20, "Electricity Meters - 0.2 and 0.5 Accuracy Classes"
 - b. ANSI C12.18, "Protocol Specification for ANSI Type 2 Optical Port"
 - 2. Canadian Standards Association (CSA)

- a. CAN/CSA-C22.2 No. 61010-1 "Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements"
 - b. C22.1, "Canadian Electrical Code, Part I" (CEC)
- 3. International Electrotechnical Commission (IEC)
 - a. IEC 62053-22 Class 0.5, "Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 0.2 and 0.5) Edition 1.1 2016-11"
- 4. European Engineering Standards (CSN EN)
 - a. EN 61000-6-2, "Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments"
 - b. EN 61000-6-3 Class B, "Electromagnetic compatibility (EMC) - Part 6-3: Generic standards – "Emission standard for residential, commercial and light-industrial environments"
 - c. EN 61000-6-4 Class A, "Electromagnetic compatibility (EMC) - Part 6: Generic Standards - Emission standard for industrial environments"
 - d. EN 61010-1, "Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements"
 - e. EN 61326-1 Class A, Electrical equipment for measurement, control and laboratory use EMC requirements Part 1: General requirements
 - f. EN 61326-1 Class B, Electrical equipment for measurement, control and laboratory use EMC requirements Part 1: General requirements, (Residential and light industrial)
- 5. International Organization for Standardization (ISO)
 - a. ISO 9001, "Quality Management Systems - Requirements"
 - b. ISO 14001, "Environmental Management Systems - Requirements with Guidance for Use"
 - c. ISO 14062, "Environmental Management - Integrating Environmental Aspects into Product Design and Development"
 - d. ISO 50001:2011 "Energy management systems"
- 6. National Fire Protection Agency (NFPA)
 - a. NFPA 70, "National Electrical Code® (NEC)"
- 7. Underwriters Laboratories, Inc. (UL):
 - a. UL 61010, "Electrical Equipment for Measurement, Control, and Laboratory Use"
 - b. UL 61010-1, "Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements"
 - c. UL 508, "Standard for Industrial Control Equipment"
 - d. UL508A, "Standard for Industrial Control Panels"
- 8. USA Federal Communications Commission (FCC)
 - a. FCC 47 CFR Part 15 Class A, "Radio Frequency Devices"
 - b. FCC 47 CFR Part 15 Class B, "Radio Frequency Devices"

1.3 DEFINITIONS

- A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

1.4 SUBMITTALS

- A. General: Submittals shall be in accordance with the requirements of Section 01 33 00 Submittals and Section 26 01 00 Electrical Requirements, in addition to those specified herein.
 - 1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
 - 2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of ten years.
 - 1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
 - 2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.
- B. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.
- B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.7 WARRANTY

- A. General: Refer to Section 01 77 00 - Closeout Procedures.

- B. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.8 SPECIAL TOOLS AND SPARE PARTS

- A. The Contractor shall provide a recommended spare parts list with the following information provided as a minimum:
1. Contact information for the closest parts stocking location to the Owner.
 2. Critical spare parts shall be identified as those parts being associated with long lead times and/or those being critical to the unit's operation.
 3. Maintenance spares shall be identified as being those parts required to regularly perform scheduled maintenance on the furnished equipment. These spares shall include, but shall not be limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.
- B. Spare parts shall be provided for each type and size of unit furnished. At a minimum, the following shall be provided:
1. Provide the minimum spare parts recommended by the manufacturer.
 2. Provide one (1) set of each type of power and control fuse installed within equipment.
- C. Any manufacturer specific special tool, not normally found in an electrician's toolbox, required to remove and install recommended or furnished spare parts shall be furnished. At a minimum the following shall be provided:
1. If available from manufacture, provide PC-based configuration software tool and a minimum of one (1) communication interface cable for each type of cable required to connect a PC-based computer to the devices specified herein for configuration and programming.
 2. Electronic configuration files, in a media format acceptable by the Owner (e.g., CD, USB stick, etc.), updated to an as-installed and commissioned state.
- D. Spare parts shall be properly marked and packaged for long term storage. Printed circuit boards shall be provided in separate anti-static containers.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Products specified herein shall be the product of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements.
- B. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date:
1. Square D PowerLogic by Schneider Electric
 2. Siemens

2.2 POWER METERS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PowerLogic PM5000 series by Schneider Electric or Siemens.
- B. The metering device used to monitor circuits for purposes of network management, energy cost management, energy allocation, and operational efficiency shall provide the following minimum features:
 - 1. Connections and form factor - direct connect to circuits up to 600 VAC, eliminating the need for voltage (potential) transformers; 5 A nominal current inputs; control power voltage range option of 100-480VAC/125-250VDC. Meter shall have removable connectors required for voltage inputs, control power, communications, aux. inputs and outputs; easy mounting in enclosure panel/door without tools; form factor of ¼ DIN size with 92 X 92mm cut-out and 96 x 96mm panel mount integrated display.
 - 2. Supported monitoring parameters—full range of 3-phase voltage, measure each phase and neutral current using 4 current inputs, power and energy measurements, power factor, frequency, total harmonic distortion (THD), individual power harmonics (up to 63rd order).
 - 3. Accuracy standards - use four-quadrant metering and sample current/voltage simultaneously without gaps with 64 samples per cycle (zero blind); comply with ANSI C12.20 class 0.2 and IEC 61557-12 class 0.2 for revenue meters.
 - 4. Display - Backlit dot-matrix LCD display, anti-glare and scratch resistant with a minimum of 128 x128 pixels, capable of displaying four values in one screen simultaneously; a summary screen to allow the user to view a snapshot of the system; support either integrated or remote display.
 - 5. Support 4 digital inputs for Demand Synch Pulse, Time Synch Input, and Conditional Energy Control; have 2 digital outputs that operate either by user command sent over communication link, or in response to a user defined alarm or event.
 - 6. Communications - serial RS-485 Modbus, Ethernet Modbus TCP, Ethernet BACnet IP (BTL listed), DNP over Ethernet, and EtherNet IP; provide 2 Ethernet ports to allow wiring from meter to meter as a daisy-chain; be capable of serving data over the Ethernet network accessible through a standard web browser; the monitor shall contain default pages from the factory.
 - 7. Onboard data logging capabilities - to log data, alarms and events; logged information shall include data logs, minimum/maximum log files of selected parameter values, and alarm logs for each user defined alarm or event log; support the following on-board nonvolatile memory—14 parameters every 15 minutes for 90 days.
 - 8. Alarming capabilities - support 29 set-point driven alarms, 4 digital alarms, 4 unary alarms, 10 Boolean alarms and 5 custom alarms; user definable alarm events; set-point driven alarms shall be available for voltage/current parameters, input status, and end of interval status; shall send emails and/or text messages containing alarm condition indication via Simple Mail Transfer Protocol [SMTP]; Shall have the capability to manage and monitor devices on the IP network via Simple Network Management Protocol [SNMP]; Indication of an alarm condition shall be delivered by SNMP Traps.
 - 9. Firmware-upgradeable to enhance functionality through the Ethernet or serial communication connection and shall allow upgrades of individual meters or groups.
 - 10. Integrated gateway functionality, enabling the capability to connect via Ethernet to downstream, serially connected devices.

11. Designed accordingly to eco-design complying with ISO 14062, especially MCCB materials shall be halogen free type; designed for easy disassembly and recycling at end of life and comply with environmental directives ROHS and WEEE.
12. The meter shall provide 4 digital inputs configurable for input metering with on-board pulse weight calculation and conversion to standard units for external water, air, gas, electrical or steam (WAGES) meters.

2.3 ENERGY METERS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PowerLogic IEM3000 by Schneider Electric or Siemens.
- B. The metering device used to monitor circuits for purposes of energy cost management, energy allocation, and operational efficiency shall provide the following minimum features:
 1. The energy meter shall be UL and cUL listed per UL 61010-1. The meter shall be rated for an operating temperature range of -13 °F (-25 °C) to 158 °F (70 °C) minimum.
 2. The energy meter shall directly accept both single-phase or three-phase voltage input up to and including 480 volts line-to-line.
 3. The energy meter current inputs shall support both x/0.333V and x/1.0V low-voltage current transformers (LVCT) or Rogowski coil type sensors. The current range of the energy meter shall be configurable and capable of monitoring circuits up to 5000 A.
 4. The energy meter shall be equipped with anti-tamper security features to ensure the integrity of all measurements and provide an additional safety barrier. The energy meter shall have password-protection to prevent tampering from the front panel.
 5. The energy meter shall be self-enclosed to prevent exposure to live parts and protect sensitive electronics if the enclosure cabinet is open. Meters shall snap-on and be easily removable for serviceability.
 6. The Energy Meter shall be designed to meet 0.5% accuracy for real energy and real power defined by ANSI C12.20 and IEC 62053-22. No annual recalibration shall be required to maintain accuracy.
 7. The energy meter shall provide an on-board RS-485 data port using Modbus (RTU) or BacNet MS/TP protocol to allow multipoint communications. The energy meter shall have removable connectors for communication wiring.
 8. The energy meter shall support up to 4 tariffs for the accumulation of real energy controlled by internal clock, digital input, or communications.
 9. The energy meter shall provide 1 digital input configurable for tariff control or WAGES input. The energy meter shall provide 1 digital output configurable for kWh pulse or kW overload alarm.
 10. The energy meter shall provide the following measurements: Real energy (kWh) four-quadrant, Reactive energy (kVARh) four-quadrant, Active power (kW), Reactive power (kVAR), Current per phase (I), Voltage per phase (V), Power factor (PF), Frequency (F), Overload alarm, Hour counter. The values shall be read directly from the energy meter display without the need for multipliers.
 11. The energy meter shall provide the following capabilities for measurement of demand: – Fixed block or sliding block demand modes with selectable interval, providing measurement of total active, reactive, and apparent power demand (accessible through front panel or communications); Current demand per each phase, neutral, and average (available through

communications); Peak demand for all demand parameters, maintained in non-volatile memory with date and time of peak since last reset accessible through front panel or communications; Demand parameters resettable from front panel and communications.

2.4 MULTI CIRCUIT METERS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PowerLogic EM4900 by Schneider Electric or Siemens.
- B. The metering device used to monitor multiple circuits for purposes of energy cost management, energy allocation, and operational efficiency shall provide the following minimum features:
- C. The operating environment of the multi circuit meter shall meet or exceed the following environmental parameters: Operational Temperature: 0 to 60 °C (32 to 140 °F) (<95% RH non-condensing); Maximum Operational Altitude: 3000m (10,000 ft); Storage temperature: -40 to 70 °C (-40 to 158 °F)
- D. The multi circuit meter shall accommodate varied control power sources and system types:
 - 1. The multi circuit meter shall operate on a wide input power range of at least 100 to 277 Vac line-to-neutral, 50/60 Hz to allow for power fluctuation.
 - 2. The multi circuit meter shall support the following system wiring configurations: 120/240 V Delta High Leg; 3-Wire (Ungrounded) Delta; 4-Wire Wye; 3-Wire split-phase; and 2-wire single phase.
- E. The multi circuit meter shall provide a full set of measurements for a variety of applications:
 - 1. The multi circuit meter shall be configurable to accommodate varied measurement needs. It shall allow configuring individual measurement channels as 1ph, 2ph or 3ph circuits, or a mix thereof. The meter shall support on site configuration for re-assignment of the channels if circuits are modified during facility evolution.
 - 2. The multi circuit meter shall be available with different input densities to economically fit a variety of applications up to a maximum of 84 inputs or 28 three-phase meters. The multi-circuit meter shall have a minimal sample rate of 2560 Hz and a refresh rate per meter of no more than 1.8 seconds when configured for the maximum number of meters.
 - 3. The current inputs of the multi circuit meter shall accept low voltage current transformers (LVCTs) and shall support an ampacity range from at least 50A to 5,000A. Lead length of low voltage current transformers shall be up to 100 ft. (33 m). Current inputs shall utilize push pin terminals accepting wire leads of 26 to 16 AWG to simplify installation.
 - 4. The multi circuit meter shall provide the following real-time measurements: Current per phase, multi-phase average, and phase angle per branch; Real power (kW) per phase and multi-phase total; Apparent power (kVA) per phase and multi-phase total; Power factor per phase and multi-phase total.
 - 5. The multi circuit meter shall provide the following demand measurements: Current present demand per phase and multi-phase average; Real power (kW) present demand per phase and multi-phase average.
 - 6. The multi circuit meter shall provide the following historic maximums: Maximum instantaneous current per phase and multi-phase average; Maximum current demand per phase and multi-phase average; Maximum real power demand per phase and multi-phase average.

7. The multi circuit meter shall provide accumulated energy (kWh) per phase and multi-phase average and shall also provide energy snapshots (kWh) per phase and multi-phase average.
 8. The multi circuit meter shall provide total harmonic distortion (THD) measurements for every channel/meter, with measurements comprised of: THD % of line-to-line voltage, THD % of line-to-neutral voltage, and THD % of current.
- F. The multi circuit meter shall provide Modbus RTU/TCP, BACnet IP, SNMP V2 network communications protocols. Ethernet protocols shall be able to run concurrently to support multiple client systems.
- G. The multi circuit meter shall provide 4 levels of onboard alarming with configurable thresholds: Low level to inform of a value below the expected range, High level to inform of a value above the expected range, Low-Low level to inform of a value much below the expected range, and High-High level to inform of a value much higher than the expected range.

2.5 ADVANCED MULTI-CIRCUIT METERS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PowerLogic HDPM6000 by Schneider Electric or Siemens.
- B. The metering device used to monitor circuits for purposes of network management, energy cost management, energy allocation, and operational efficiency shall have the following minimum features:
1. Connections and form factor – direct connect to circuits up to 480VAC, eliminating the need for voltage (potential) transformers; 250mV current transformer inputs, supporting CTs up to 6000A amperes (A). Terminal block for voltage inputs, removable connectors for control power and communications, easily mountable, DIN rail form factor.
 2. Supported monitoring parameters – full range of 3-phase voltage, current, power and energy measurements, power factor, frequency, total harmonic distortion (THD), individual power harmonics (up to 63rd order).
 3. Accuracy standards – sample current/voltage simultaneously without gaps with at least 128 samples per cycle (zero-blind).
 4. Display – 4.3" (480x272 resolution) or 7" (800x480 resolution) TFT touch screen backlit display capable of displaying main or branch circuit values.
 5. Communications – serial RS-485 Modbus and Ethernet Modbus TCP; two Ethernet ports to allow wiring from meter to meter as a daisy-chain; capable of serving data over the Ethernet network accessible through a standard web browser and on the HMI (front display); the monitor shall contain default pages from the factory.
 6. Communications - The meter shall support IPv6 protocol.
 7. Ethernet ports—two Ethernet ports, which can be used either as a switch or separated ports (one (1) IP address for each). Ethernet ports shall be independently controllable to enable / disable or specify allowed protocols.
 8. Network Discovery – the meter supports auto discovery on an Ethernet network without the need for any user configuration or interaction
 9. Native BACnet/IP support with capability to communicate via Modbus TCP/IP and BACnet/IP simultaneously

10. Native SNMP support with capability to communicate via Modbus TCP/IP and SNMP simultaneously
11. Onboard data logging capabilities – Non-volatile event and 20 user configurable data logs. 8GB of storage for logged data and waveform captures.
12. Alarming capabilities – Provide user defined alarms for low and high voltage, high current, tripped breaker detected.
13. Voltage sag and swell detection shall be provided with waveform capture for both current and voltage channels at 133 samples per cycle.
14. Firmware-upgradeable to enhance functionality through the Ethernet connection
15. The power meter shall support a control power low voltage DC input of 24V DC or up to 480V AC / 250V DC through an external power supply.
16. Branch circuit and busway monitoring – optionally support up to 192 monitored circuits with current, power and energy measurements, power factor, frequency, total harmonic distortion (THD), and individual power harmonics (up to 63rd order).
17. Input/Output Module – Support two digital inputs and one digital output
18. Designed for easy disassembly and recycling at end of life and comply with environment directives ROHS and WEEE.

2.6 INTEGRATED PANELBOARD MULTI-CIRCUIT METERS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PowerLogic BCPM by Schneider Electric or Siemens.
- B. The metering device used to monitor branch circuits for network management, energy cost allocation and compliance reporting, shall have at minimum the following features:
 1. Form fit and function—the branch circuit sub-metering device will:
 2. Use 2 or 4 strips of solid-core, tombstone type CTs mounted to circuit board based strips that are:
 3. Calibrated to ensure system accuracy.
 4. Connected to the main circuit board of the meter via a standard 50 pin connector ribbon cable connection capable of a maximum of 20 feet or 6 meters.
 5. Spaced at 1" center intervals to align appropriately with the panel-board branch circuit breakers.
 6. Be configurable via free software for stacked (in-line) or parallel panel-boards circuits numbered in series or in even/odd configurations.
 7. Be designed to use manufacturer supplied mounting brackets to accommodate a variety of manufacturers' panelboards, power distribution units (PDUs), or remote power panels (RPPs).
 8. Voltage and current inputs, control power.
 - a. Direct reading metered or calculated values for 42 branch circuits with auxiliary inputs available for 1 or 2 three-phase main devices and 1 or 2 neutral.
 - b. 50/60 Hz with a measurement input voltage range of 90 to 277 VAC and 22 kAIC overload capability.

- c. Control Power ranging from 100 VAC to 277 VAC.
- 9. Supported measured and calculated metering parameters:
 - a. Main device level—full range of per phase current, power (kW, kVA) and energy measurements, per-phase demand values, power factor; phase angles, voltages (line-line and line-neutral), current phase angle, frequency.
 - b. Per Branch circuit level—full range of per-branch currents, demand, power (kW, kVA), energy, current phase angle, power factor.
- 10. Standards compliance—The device shall:
- 11. Be UL, cUL listed, and CE marked.
- 12. Meet ANSI standard C12.1-2008 energy revenue metering accuracy and IEC 62053-21 Class 1 accuracy (at the panelboard level), including branch CTs and measure current with 0.5% accuracy, including the branch CTs.
- 13. Comply with ANSI standard C12.1-2008 energy revenue metering accuracy.
- 14. Operate at temperature range 0° to 60°C (32° to 140°F) with <95% RH, non-condensing.
- 15. Communications Capability.
 - a. Serial.
 - 1) Native Modbus RTU and BACnet MS/TP protocol accessible via standard RS-485 cable with selectable baud rates of 9600, 19200, 38400, or 76800; configurable Modbus RTU parity NONE, ODD, EVEN.
 - 2) Communication termination such that a daisy-chained communication link still functions for other devices on the link if the connector is disconnected from the BCPME.
 - 3) BACnet MS/TP protocol implementation must support Subscribe_COV and BBMD functionality and allow user configuration of the Device_IDs used, the Max_Master property of the Main device and the Network number used internally by the Virtual Router.
 - b. Ethernet.
 - 1) Native TCP, BACnet IP and SNMP protocol accessible via standard 10/100 Mbit Ethernet cable connection
 - 2) BACnet MS/TP protocol implementation must support Subscribe_COV and BBMD functionality and allow user configuration of the Device_IDs used, the Max_Master property of the Main device and the Network number used internally by the Virtual Router
 - 3) SNMP implementation must support SNMP V2c functionality, including table views of data and event notifications
 - 4) A MIB (Management Information Base) file must be available for download for using the product via SNMP with standard MIB browsers
 - 5) Native support for connectivity to energy and power monitoring software
- 16. Alarming capabilities.
 - a. Device event alarming must include user configurable low, low-low, high, and high-high alarm thresholds.
 - b. Standard alarms must include Over/Under Voltage and Over/Under Current.

17. Programmability.

- a. The device must be firmware upgradeable and field programmable to support updating the following configuration parameters via any supported protocol (stored in non-volatile memory):
 - 1) CT configuration and channel numbering.
 - 2) Breaker size used for each channel, alarm thresholds and delay settings.
 - 3) Logical circuit assignments for multi-phase loads.
 - 4) Channel phase assignments.
 - 5) Settings to enable advanced features.

2.7 ENERGY SERVER

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: EcoStruxure Advanced Energy Server PAS800 Series by Schneider Electric or Siemens.
- B. Standards & Operating Environment
 1. The Energy Server shall comply with safety standards UL61010-1 and IEC 61010-1
 2. The Energy Server shall comply with the following radio/wireless communication standards:
 - a. FCC Class B
 - b. IEEE 802.11 a/b/g/n (Wi-Fi)
 - c. IEEE 802.15.4 (Zigbee)
 3. The Energy Server shall comply with data-logging standard IEC 62974-1
- C. Power Supply
 1. The Energy Server shall be able to operate using a wide range of power supplies:
 - a. 110 to 277 V AC/DC (PAS800 only)
 - b. 24 V DC (PAS800L only)
 - c. PoE-PD Class 0, IEEE802.3af/at (PAS800P only)
- D. Communications Interfaces
 1. Inputs - The Energy Server shall have two IEC62053-31 Class A-compatible digital inputs (PAS800L)
Ethernet Port - The Energy Server shall have two Ethernet ports which can be used to bridge or isolate networks. The ports shall support DHCP or static IP addressing.
 2. Modbus Port – The Energy Server shall support Modbus serial communications with a 4-pin screw connector
 3. Wi-Fi – The Energy Server shall support Wi-Fi as an access point without any infrastructure for setup or by connecting through a Wi-Fi network for monitoring
 4. Wireless IEEE 802.15.4
 - a. Wireless communication shall be encrypted on AES128 bit CCM using star topology

- b. Wireless communication with the Energy Server shall have a limited Isotropic Radiated power up to 0dBm (or 1mW) to prevent undesired radio emissions
 - c. The Energy Server shall be able to communicate with up to 100 wireless devices
- E. Hardware Installation
 - 1. The Energy Server shall be compatible with type 'O' DIN rail. Its size on the DIN rail shall not be greater than 72 mm.
 - 2. The Energy Server shall be easy to connect: the ports shall be equipped with removable screw connectors or plug-in connectors
 - 3. The Energy Server shall provide an automatic grounding connection point through the DIN rail
- F. Energy Server Configuration
 - 1. The Energy Server shall support backup-up and restore of settings and commissioning for multiple devices using configuration software
 - 2. The Energy Server settings shall be accessible through its onboard web pages
 - 3. The Energy Server shall be equipped with DPWS (Device Profile for Web Services) technology with both Discovery and Identification web services
 - 4. The Energy Server shall auto-discover wireless devices and support custom labeling and identification per each wireless monitoring device
- G. Security Features
 - 1. The Energy Server shall be designed through a secured development lifestyle in accordance to IEC 62443-4-1
 - 2. Users shall have the ability to set their own passwords following Cybersecurity best practices
 - 3. A password containing letters, numbers and special characters shall be mandatory for the gateway in operation phase. User passwords shall be stored encrypted.
 - 4. The Energy Server shall have a unique device genuineness certificate proving it is genuine hardware from the manufacturer. The certificate shall be stored in an EAL6+ certified security controller.
 - 5. Access to the login page shall use HTTPS protocol
 - 6. The Energy Server shall have the ability to install web server certificates
 - 7. The Energy Server shall only accept signed firmware from the manufacturer
 - 8. The Energy Server shall provide the option to disable wireless connections, ports or protocols not used
- H. Energy Server Features
 - 1. The Energy Server shall have the ability to serve as a Modbus serial to Modbus TCP/IP gateway for connected software
 - 2. The Energy Server shall be capable of acting as a solution and services enabler for either local or remote energy & asset management systems

3. The Energy Server shall have embedded web pages to view real-time and historical data for each connected device
 4. The Energy Server shall have 32GB memory for measurement logging up to 3 years and support historical trending through its embedded web pages
 5. The Energy Server shall allow customizable thresholds for alarms for electrical and environmental measurements
 6. The Energy Server shall be able to send alerts and alarms over email to users
 7. The Energy Server shall support multiple concurrent connections and up to 64 concurrent TCP sessions opened
- I. Troubleshooting
1. The Energy Server shall have a visible indicator on its front-face to show nominal operation, minor malfunction requiring service or major malfunction requiring replacement
 2. The Energy Server shall detect and report device communication loss, CPU overuse and memory overuse
 3. The Energy Server shall log internal diagnostics events for troubleshooting
 4. The Energy Server shall have embedded webpages for diagnostic and troubleshooting.

2.8 HIGH DENSITY METERING CABINETS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: PM5000 Value Series Enclosures for PM5000 series power meters by Schneider Electric or Siemens.
- B. Any metering enclosed cabinets supplied shall meet the following specifications:
1. Minimum NEMA Type 1, padlock-able steel enclosure with factory-supplied knockouts and cover plates for blank meter spaces.
 2. UL508A listed.
 3. Option of one-, four-, or eight- meter enclosures with configurable quantities and meter models.
 4. Set of incoming terminals per meter for connecting the voltage measurement leads with separate control power.
 5. External control power transformers not required for Wye or Delta power systems up to, and including, 600VAC.
 6. Option of Ethernet and/or serial communications. Common daisy chain wiring for communications wiring, with a single loop for all meters connected to the circuit and each end terminated in a common location. Communication wiring installed such that interference from the power wiring is minimized.
 7. Integrated Ethernet gateway functionality option on the first meter for connecting downstream devices with serial communications.
 8. Shorting terminal blocks for connecting the current transformer leads from the field to all factory installed meters. Factory installed wiring harness shall be provided to connect the CT circuit from the shorting block to the meter.

9. Capability to field-install meters without cutting or splicing the voltage or communication wiring.
10. Terminal blocks for incoming and outgoing communications circuit connections.

2.11 MULTI-METER UNIT CABINETS

- A. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date: Square D PowerLogic MMU Series Multi-Metering Unit Cabinet for iEM3000 series energy meters by Schneider Electric or Siemens.
- B. Multi-meter unit (MMU) enclosed cabinets supplied for entry energy submeters shall meet the following specifications:
 1. The MMU cabinet shall be a minimum NEMA Type 1 UL listed steel enclosure. The cabinet shall be lockable and shall provide for the application of a security seal.
 2. MMU cabinets shall be provided in configurations of up to 24 energy submeters. Energy submeters shall be readable external to the cabinet without opening a door.
 3. The MMU cabinet, energy submeters, and communications devices shall be provided as a UL listed factory assembled enclosure.
 4. The MMU cabinet shall have a set of incoming terminals with fuses for connecting the voltage metering leads. Control and voltage sensing power shall be distributed to each meter from this main set of incoming terminals.
 5. The MMU cabinet shall have finger-safe terminals. Color coded and labeled wiring shall connect all submeters to control and voltage sensing power.
 6. The MMU cabinet shall have terminal blocks for incoming and outgoing communication circuit connections in which energy submeters are connected with common, single-loop daisy-chain communication wiring. Communication wiring shall be arranged in such a manner as to minimize interference from the power wiring.
 7. The MMU cabinet shall be provided with Modbus TCP Ethernet with energy server factory installed and wired communications interface.

2.12 ELECTRICAL POWER MANAGEMENT SYSTEM

- A. The equipment specified herein shall provide the necessary communications connectivity and functionality required to support the functionality of an Electrical Power Management System (EPMS). This shall include, but not be limited, to the following:
 1. Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected equipment necessary to provide functionality. Equipment may be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the equipment.
 2. Compliance with Cyber security requirements.
 3. Remote EPMS application functionality for equipment configuration and operational control; electrical power monitoring; power quality monitoring, compliance and correction; and alarm monitoring with event log.
 4. Circuit breakers shall support breaker aging modeling by the EPMS software.

5. Continuous thermal monitoring capabilities including alarming, notification and visualization shall be compatible with EPMS software.
6. Refer to the Electrical Power Management System specification 26 09 13 for on-premise software requirements.

PART 3 - EXECUTION

3.1 GENERAL

- A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of Specification Section 26 01 00 and Drawings.
- B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.
- C. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- D. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.
- E. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.
- F. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer's representative field service engineer. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Report to the Engineer any discrepancies or issues with the installation.
- G. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

END OF SECTION

SECTION 26 32 00 NATURAL GAS ENGINE GENERATOR

1. General Description of System & Site

- 1.1.1. Provide a 450 kW standby generator to provide power at 120/208 Volts, 60 Hertz, 3 Phase. The generator shall consist of a liquid cooled, rich burn, natural gas engine, a synchronous AC alternator, and system controls with all necessary accessories for a complete operating system, including but not limited to the items as specified hereinafter.
- 1.1.2. The basis of design for the genset is Generac Power Systems. Equivalent manufactures include Kohler, Cummins, and Caterpillar.
- 1.1.3. The site is an NEC ordinary location with no specific harsh environment requirements.
- 1.1.4. The genset shall be applied at the listed ambient and elevation. Bidders to submit the generators rated power output at 100degrees ambient (°F) and 100' elevation (Ft).
- 1.1.5. The on-site gas pressure is 17 inches of water column.
- 1.1.6. Bidders are to submit the genset's sound level in dBA at 23 ft based on the configuration specified.

1.2. Requirements of Regulatory Agencies

- 1.2.1. An electric generating system, consisting of a prime mover, generator, governor, coupling and all controls, must have been tested, as a complete unit, on a representative engineering prototype model of the equipment to be sold.
- 1.2.2. The generator set must conform to applicable NFPA requirements.
- 1.2.3. The generator set must be available with the Underwriters Laboratories listing (UL2200) for a stationary engine generator assembly.
- 1.2.4. The generator set must be pre-certified to meet EPA federal emission requirements for stationary standby. The generator shall utilize a rich burn engine, air fuel ratio control, and a three-way catalytic converter. On-site emission testing & certification will not be acceptable for standby applications.

1.3. Manufacturer Qualifications

- 1.3.1. This system shall be supplied by an original equipment manufacturer (OEM) who has been regularly engaged in the production of engine-alternator sets, automatic transfer switches, and associated controls for a minimum of 25 years, thereby identifying one source of supply and responsibility. Approved suppliers are Generac Industrial Power or an approved equal.
- 1.3.2. The manufacturer shall produce the generator in facilities that meet the standards of ISO9001.
- 1.3.3. The manufacturer shall have printed literature and brochures describing the standard series specified, not a one of a kind fabrication. Custom designed paralleling solutions using site specific PLC programs and site-specific schematics are not acceptable.
- 1.3.4. Manufacturer's authorized service representative shall meet the following criteria:
 - 1.3.4.1. Certified, factory trained, industrial generator technicians
 - 1.3.4.2. Service support 24/7
 - 1.3.4.3. Service location within 200 miles

- 1.3.4.4. Response time of 4 hours
- 1.3.4.5. Service & repair parts in-stock at performance level of 95%

1.4. Submittals

- 1.4.1.Engine Generator specification sheet
- 1.4.2.Controls specification sheet(s)
- 1.4.3.Installation / Layout dimensional drawing
- 1.4.4.Wiring schematic
- 1.4.5.Sound data
- 1.4.6.Emission certification
- 1.4.7.Manufacturer quality statement
- 1.4.8.Warranty statement

2. Engine

2.1. Engine Rating and Performance

- 2.1.1.The prime mover shall be a liquid cooled, rich burn spark-ignited, 4-cycle engine. It will have adequate horsepower to achieve rated kW output
- 2.1.2.The engine shall support a 100% load step per NFPA110
- 2.1.3.The system shall be sized to allow emergency system loads as defined by NEC 700 to be transferred onto the generator(s) within 10 seconds.

2.2. Engine Oil System

- 2.2.1.Full pressure lubrication shall be supplied by a positive displacement lube oil pump. The engine shall have a replaceable oil filter(s) with internal bypass and replaceable element(s).
- 2.2.2.The engine shall operate on mineral based oil. Synthetic oils shall not be required.
- 2.2.3.The oil shall be cooled by an oil cooler which is integrated into the engine system.

2.3. Engine Cooling System

- 2.3.1.The engine is to be cooled with a unit mounted radiator, fan, water pump, and closed coolant recovery system. The coolant system shall include a coolant fill box, which will provide visual means to determine if the system has adequate coolant level. The radiator shall be designed for operation in 122 degrees F, (50 degrees C) ambient temperature
- 2.3.2.The engine shall have unit mounted, thermostatically controlled, circulating style water jacket heater to aid in quick starting. The wattage shall be as recommended by the manufacturer. .
- 2.3.3.Engine coolant and oil drain extensions, equipped with pipe plugs and shut-off valves, must be provided to the outside of the mounting base for cleaner and more convenient engine servicing.
- 2.3.4.A radiator fan guard must be installed for personnel safety that meets UL and OSHA safety requirements.

2.4. Engine Starting System

- 2.4.1. Starting shall be by a solenoid shift, DC starting system.
- 2.4.2. The engine's cranking batteries shall be lead acid. The batteries shall be sized per the manufacturer's recommendations. The batteries supplied shall meet NFPA 110 cranking requirements of 90 seconds of total crank time. Battery specifications (type, amp-hour rating, cold cranking amps) to be provided in the submittal.
- 2.4.3. The genset shall have an engine driven, battery-charging alternator with integrated voltage regulation.
- 2.4.4. The genset shall have an automatic dual rate, float equalize, 10-amp battery charger. The charger must be protected against a reverse polarity connection. The chargers charging current shall be monitored within the generator controller to support remote monitoring and diagnostics. The battery charger is to be factory installed on the generator set. Due to line voltage drop concerns, a battery charger mounted in the transfer switch will be unacceptable.

2.5. Engine Fuel System

- 2.5.1. The engine shall be configured to operate on pipeline grade natural gas.
- 2.5.2. The engine shall utilize a fuel system inclusive of carburetor, gas regulator, air fuel ratio control, low gas pressure switch, and fuel shut-off solenoids.
- 2.5.3. The engine's internal fuel connections shall be terminated to the generator frame via an NPT fitting for easy installation

2.6. Engine Controls

- 2.6.1. Engine speed shall be controlled with an integrated isochronous governor function with no change in alternator frequency from no load to full load. Steady state regulation is to be 0.25%.
- 2.6.2. To support EPA emission requirements, the engine will incorporate an active air-fuel-ratio controller. The air-fuel-ratio controller shall be integrated into the generator controller to ensure security of settings and to support monitoring and remote diagnostics. External air-fuel-ratio controllers are not acceptable.
- 2.6.3. Engine ignition shall be variable timing based upon load levels to provide maximum transient load performance.
- 2.6.4. All engine sensor connections shall be sealed to prevent corrosion and improve reliability.

2.7. Engine Exhaust & Intake

- 2.7.1. Engine Exhaust Emissions, Emergency use only: Comply with 40 CFR Part 60, Subpart JJJJ, Sections 60.4231 – 60.4232, Emission Standards for Manufacturers, and applicable state and local government requirements. A requirement to test and certify engine emissions in the field, as part of system commissioning, is not acceptable.
- 2.7.2. The engine shall incorporate a 3-way catalytic converter to meet EPA emission requirements.
- 2.7.3. The manufacturer shall supply its recommended stainless steel, flexible connector to couple the engine exhaust manifold to the exhaust system. A rain cap will terminate the exhaust pipe after the silencer. All components must be properly sized to assure operation without excessive back pressure when installed.

- 2.7.4. The manufacturer shall supply a critical grade exhaust silencer/catalyst as standard.
- 2.7.5. For gensets in a weather or sound attenuated enclosure, all exhaust piping from the turbo-charger discharge to the silencer/catalyst shall be thermally wrapped to minimize heat dissipation inside the enclosure.
- 2.7.6. The engine intake air is to be filtered with engine mounted, replaceable, dry element filters.

3. Alternator

- 3.5. The alternator shall be the voltage and phase configuration as specified in section 1.1.1.
- 3.6. The alternator shall be a 4-pole, revolving field, stationary armature, synchronous machine. The excitation system shall utilize a brushless exciter with a three-phase full wave rectifier assembly protected against abnormal transient conditions by a surge protector. Photo-sensitive components will not be permitted in the rotating exciter.
- 3.7. The alternator shall include a permanent magnet generator (PMG) for excitation support. The system shall supply a minimum short circuit support current of 300% of the rating (250% for 50Hz operation) for 10 seconds
- 3.8. The alternator shall support 1036 skVA with a maximum voltage dip of 15%.
- 3.9. The alternator shall be at least a 6 lead design to support option protective relaying. All leads must be extended into a NEMA 1 connection box for easy termination. A fully rated, isolated neutral connection must be included by the generator set manufacturer.
- 3.10. The alternator shall use a single, sealed bearing design. The rotor shall be connected to the engine flywheel using flexible drive disks. The stator shall be direct connected to the engine to ensure permanent alignment.
- 3.11. The alternator shall meet temperature rise standards of UL2200 (120 degrees C). The insulation system material shall be class "H" capable of withstanding 150 degrees C temperature rise.
- 3.12. The alternator shall be protected against overloads and short circuit conditions by advanced control panel protective functions. The control panel is to provide a time current algorithm that protects the alternator against short circuits. To ensure precision protection and repeatable trip characteristics, these functions must be implemented electronically in the generator control panel -- thermal magnetic breaker implementation are not acceptable.
- 3.12.1. The algorithm shall allow the alternator to be protected from thermal damage and the power system to produce 10 seconds of 300% fault current for breaker coordination.
- 3.13. An alternator strip heater shall be installed to prevent moisture condensation from forming on the alternator windings. A tropical coating shall also be applied to the alternator windings to provide additional protection against the entrance of moisture.

4. Controls & Operating Sequence

- 4.5. Genset Controller must be certified UL6200.
- 4.5.1. The generator control system shall be a fully integrated microprocessor-based control system for standby emergency engine generators, meeting all requirements of NFPA 110 level 1.

- 4.5.2. The generator control system shall be a fully integrated control system enabling remote diagnostics and easy building management integration of all generator functions. The generator controller shall provide integrated and digital control over all generator functions including: engine protection, alternator protection, speed governing, voltage regulation, synchronizing, load-sharing (real and reactive) and all related generator operations. The generator controller must also provide seamless digital integration with the engine's electronic engine control module (ECM) if so equipped.
- 4.5.3. Communications shall be supported with building automation via the Modbus or SNMP protocol. The controller shall provide native Ethernet, Wifi, and Bluetooth connectivity. All interfacing shall be done by via a web browser interface. Solutions that utilize dedicated software for connectivity are not acceptable. Connectivity may be set up to operate internally or externally to the user's network, based on network security preferences. All remote connectivity may be disabled at any time by the user.
- 4.5.4. Automated Notification: Controller shall be capable of sending multiple automated e-mail and/or text alerts without the need for a third-party intermediate service provider. Users shall be able to individually set up notifications to internal personnel for any selected operational or fault condition, including (but not limited to) automated notification to the generator service provider.
- 4.5.5. The control system shall provide an environmentally hardened design. The use of open circuit boards, edge cards, and pc ribbon cable connections are considered unacceptable.
- 4.5.6. Circuit boards shall utilize surface mount technology to provide vibration durability. Circuit boards that utilize large capacitors or heat sinks must utilize encapsulation methods to securely support these components.
- 4.5.7. All engine, voltage regulator, and accessory unit parameter settings shall be accessible through protected menus on the generator control panel. The following maintenance functionality shall be integral to the generator set controls:
- 4.5.7.1. Engine running hours (non-resettable).
 - 4.5.7.2. Service maintenance interval (running hours, calendar days).
 - 4.5.7.3. Engine crank attempt counter.
 - 4.5.7.4. Engine successful starts counter.
 - 4.5.7.5. 1,000 events are stored in control panel memory.
 - 4.5.7.6. Control panel shall time and date stamp all alarms and warnings. A snap shot of key parameters shall be saved in the control panel for use in troubleshooting alarms.
 - 4.5.7.7. A predictive maintenance algorithm will determine the optimal time for maintenance service based on the generator loading and operation.
- 4.5.8. Diagnostic capabilities should include time-stamped event and alarm logs, ability to capture operational parameters during events, simultaneous monitoring of all input or output parameters, email capabilities, support for multi-channel digital strip chart functionality, and pre and post alarm operational data for all measured inputs.
- 4.5.9. In addition to standard NFPA 110 alarms, the application loads should also be protected through instantaneous and steady state protective settings on system voltage, frequency, and power levels.
- 4.5.10. The control system shall provide pre-wired customer use I/O: 4 relay outputs (user definable functions), 4 contact inputs, 2 analog inputs, communications support via Ethernet, WiFi, and Bluetooth. RS485 communications shall be included for communicating to remote annunciator panels.
- 4.5.11. Generator shall provide the ability to monitor ground fault and trip main output circuit breaker and or annunciate through audible alarm as applicable.

- 4.5.12. Customer I/O shall be software configurable providing full access to all alarm, event, data logging, and shutdown functionality. In addition, custom ladder logic functionality inside the generator controller shall be supported to provide application support flexibility. The ladder logic function shall have access to all the controller inputs and customer assignable outputs.
- 4.5.13. The control panel shall include a touch screen to display all user pertinent unit parameters including: engine and alternator operating conditions; oil pressure and optional oil temperature; coolant temperature and level alarm; fuel level (where applicable); engine speed; DC battery voltage; run time hours; generator voltages, amps, frequency, kilowatts, and power factor; alarm status and current alarm(s) condition per NFPA 110 level 1.
- 4.5.14. User manuals for the generator controller and generator maintenance shall be available electronically in a library on the generator controller for download to authorized end-user devices.

4.6. Remote Annunciator Panel

- 4.6.1. The manufacturer shall provide two (2) remote annunciator panels for owners use.
- 4.6.2. The Remote Annunciator Panel must comply with NFPA 110.
- 4.6.3. Provide remote monitoring and annunciation for up to 21 generator system indications.
- 4.6.4. Remote Annunciator must include one function capable of starting system test.

5. Engine / Alternator Packaging

- 5.1. The engine/alternator shall be rigidly mounted to structural steel main frame. This frame shall be supported with spring isolators for vibration dampening.

5.2 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.
1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
 2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
 3. Refer to drawings for sizes and quantities of overcurrent protective devices.
- B. Generator Overcurrent Protective Device:
1. Molded-case circuit breaker, thermal-magnetic type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristic: Designed specifically for generator protection.
 - b. Trip Rating: Matched to generator output rating.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to or integrated with control and monitoring panel.
 2. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to or integrated with control and monitoring panel.
 3. Insulated-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:

- a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
- b. Trip Settings: Selected to coordinate with generator thermal damage curve.
- c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
- d. Mounting: Adjacent to, or integrated with control and monitoring panel.

4. Molded-case type disconnect switch, 100 percent rated:

- a. Trip Rating: Matched to generator output rating.
- b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

C. Generator Protector: Integrated controller base unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

- 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
- 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
- 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
- 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

- 1. Indicate ground fault with other engine generator alarm indications.
- 2. Trip generator protective device on ground fault.

E. Arc Energy Reduction: Comply with NFPA 70 for arc energy reduction for circuit breakers 1200A and greater.

- 1. Energy reducing maintenance switch with local status indicator.
- 2. Instantaneous override that is less than the available arcing current.

5.2.

- 5.3. The generator shall include a unit mounted auxiliary power load center. All ancillary AC devices (block heater, battery charger, alternator strip heater, etc) shall have a dedicated breaker within the load center.

6. Enclosure

6.1.1. The genset shall be packaged with a **standard weatherproof outdoor enclosure rated for 150mph wind load.**

6.1.2. The enclosure shall be made of with a minimum thickness of 14 gauge. The enclosure is to have hinged, removable doors to allow access to the engine, alternator and control panel. The hinges shall allow for door fit adjustment. Hinges and all exposed fasteners will be stainless steel or Sermagard coated. The use of pop-rivets weakens the paint system and not allowed on external painted surfaces. Each door will have lockable hardware with identical keys.

6.1.3. The enclosure shall utilize an upward discharging radiator hood.

6.1.4. The enclosure shall be coated with electrostatic applied powder paint, baked and finished to manufacturer's specifications. The color will be manufacturer's standard.

6.1.5. The genset silencer/catalyst shall be mounted on the top of the enclosure.

7. Loose Items

7.1. Supplier to itemize loose parts that require site mounting and installation. Preference will be shown for gensets that factory mount items like mufflers, battery chargers, etc.

7.2. Spare Parts:

7.2.1. Fuses: One spare set

7.2.2. Filters One spare set (air, fuel, oil)

8. Additional project requirements

8.1. Factory testing

8.1.1. Before shipment of the equipment, the engine-generator set shall be tested under rated load for performance and proper functioning of control and interfacing circuits. Tests shall include:

8.1.1.1. Verify voltage & frequency stability.

8.1.1.2. Verify transient voltage & frequency dip response.

8.1.1.3. Full Load test the generator for four (4) hours.

8.2. Manuals

8.2.1. Three (3) sets of owner's manuals specific to the product supplied must accompany delivery of the equipment. General operating instruction, preventive maintenance, wiring diagrams, schematics and parts exploded views specific to this model must be included.

8.3. Installation

8.3.1. Contractor shall install the complete electrical generating system including all external fuel connections in accordance with requirements of NEC, NFPA, and the manufacturer's recommendations as reviewed by the Engineer.

8.4. Service

8.4.1. Supplier of the genset and associated items shall have permanent service facilities in this trade area. These facilities shall comprise a permanent force of factory trained service personnel on 24 hour call, experienced in servicing this type of equipment, providing warranty and routine maintenance service to afford the owner maximum protection. Delegation of this service responsibility for any of the equipment listed herein will not be considered fulfillment of these specifications. Service contracts shall also be available.

8.5. Warranty

8.5.1. The standby electric generating system components, complete genset and instrumentation panel shall be warranted by the manufacturer against defective materials and factory workmanship for a period of ten (10) years. Such defective parts shall be repaired or replaced at the manufacturer's

option, free of charge for parts, labor and travel.

- 8.5.2. The warranty period shall commence when the standby power system is first placed into service. Multiple warranties for individual components (engine, alternator, controls, etc.) will not be acceptable. Satisfactory warranty documents must be provided. Also, in the judgment of the specifying authority, the manufacturer supplying the warranty for the complete system must have the necessary financial strength and technical expertise with all components supplied to provide adequate warranty support.

8.6. Startup and Commissioning

- 8.6.1. The supplier of the electric generating plant and associated items covered herein shall provide factory trained technicians to check out the completed installation and to perform an initial startup inspection to include:

- 8.6.1.1. Ensuring the engine starts (both hot and cold) within the specified time.
- 8.6.1.2. Verification of engine parameters within specification.
- 8.6.1.3. Verify no load frequency and voltage, adjusting if required.
- 8.6.1.4. Test all automatic shutdowns of the engine-generator.
- 8.6.1.5. Perform a load test of the electric plant, ensuring full load frequency and voltage are within specification by using a load bank supplied by the manufacturer or manufacturer's representative. The electric plant shall be tested to the full load capabilities of the unit. Full load test shall be ran for a minimum of 4-hours.

8.7. Training

- 8.7.1. Training is to be supplied by the start-up technician for the end-user during commissioning. The training should cover basic generator operation and common generator issues that can be managed by the end-user.
- 8.7.2. Training is to include manual operation of system.

END OF SECTION

SECTION 26 33 00
AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.01 System

- A. Furnish the automatic transfer switches to automatically transfer between the normal and emergency power source.
- B. Utilities & Energy Services (UES) manages close to 170 emergency generators (EG's) on campus with associated automatic transfer switches (ATS's) serving Texas A&M University (TAMU). UES is in the process of installing a comprehensive EG/ATS monitoring and control system from Blue Pillar using their Aurora program, which will allow real-time monitoring and control of these mission-critical assets. The provided dashboard allows our UES emergency power systems (EPS) team to remotely view and run weekly diagnostic reports on the entire emergency generator system. The program gives our team the ability to monitor temperatures, fuel levels, oil pressures, run time, and other important data points that are essential to the monitoring, testing, and preventive maintenance program. The Blue Pillar Aurora program also provides EPS technicians and managers the ability to receive notifications when pre-defined system alarm points are reached, allowing improved responsiveness to on-site issues. Blue Pillar's Aurora program is an effective tool that is assisting the UES team to enhance the efficiency of servicing our campus emergency power systems, while improving monitoring and documentation to ensure specific compliance requirements are achieved.

1.02 Applicable Standards

- A. The automatic transfer switches covered by these specifications shall be designed, tested, and assembled in strict accordance with NEC 70E and all applicable standards of ANSI, U.L., IEEE and NEMA.

1.03 Submittals

- A. Manufacturer shall submit shop drawings for review, which shall include the following, as a minimum:
 - 1. Descriptive literature
 - 2. Plan, elevation, side, and front view arrangement drawings, including overall dimension, weights and clearances, as well as mounting or anchoring requirements and conduit entrance locations.
 - 3. Schematic diagrams.
 - 4. Wiring diagrams.

5. Accessory list.

PART 2 - PRODUCTS

2.01 Acceptable Manufacturers

- A. ASCO
- B. ASCO approved equal construction.

EG/ATS supplier shall be responsible for purchasing, installing, integrating and commissioning Blue Pillar IT hardware and sensors required to provide real-time monitoring and control of EG/ATS.

A. General

1. The automatic transfer switch shall be furnished as shown on the drawings. Voltage and continuous current ratings and number of poles shall be as shown.
2. On 3 phase, 4 wire systems, utilizing ground fault protection, a true 4-pole switch shall be supplied with all four poles mounted on a common shaft. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.
3. The transfer switch shall be mounted in a NEMA 1 enclosure, unless otherwise indicated. Enclosures shall be fabricated from 12-gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008.
4. The transfer switch shall be equipped with an internal welded steel pocket, housing an operations and maintenance manual.
5. The transfer switch shall be top and bottom accessible.
6. The main contacts shall be capable of being replaced without removing the main power cables.
7. The main contacts shall be visible for inspection without any major disassembly of the transfer switch.
8. All bolted bus connections shall have Belleville compression type washers.
9. When a solid neutral is required, a fully rated bus bar with required AL-CU neutral lugs shall be provided.
10. Control components and wiring shall be front accessible. All control wires shall be multiconductor 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.
11. The switch shall be equipped with 90 degrees C rated copper/aluminum solderless mechanical type lugs.

12. The complete transfer switch assembly shall be factory tested to ensure proper operation and compliance with the specification requirements. A copy of the factory test report shall be delivered with shipping unit.

B. Automatic Transfer Switch

1. The transfer switch shall be double throw, actuated by two electric operators momentarily energized, and connected to the transfer mechanism by a simple over center type linkage. Minimum transfer time shall be 400 milliseconds.
2. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked, molded case circuit breakers or contactors are not acceptable.
3. The transfer switch shall be equipped with a safe external manual operator, designed to prevent injury to operating personnel. The manual operator shall provide the same contact to contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. The external manual operator shall be safely operated from outside of the transfer switch enclosure while the enclosure door is closed.

C. Automatic Transfer Switch Controls

1. The transfer switch shall be equipped with a microprocessor based control system, to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with NiCad battery back-up.
2. The CPU shall be equipped with self diagnostics which perform periodic checks of the memory I/O and communication circuits, with a watchdog/power fail circuit.
3. The controller shall use industry standard open architecture communication protocol for high-speed serial communications via multidrop connection to other controllers and to a master terminal with up to 4000 ft of cable, or further, with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.
4. The serial communication port shall allow interface to either the manufacturer's or the owner's furnished remote supervisory control.
5. The controller shall have password protection required to limit access to qualified and authorized personnel.
6. The controller shall include a 20 character, LCD display, with a keypad, which allows access to the system.

7. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection and phase differential monitoring on both normal and emergency sources.
8. The controller shall be capable of storing the following records in memory for access either locally or remotely:
 - i. Number of hours transfer switch is in the emergency position (total since record reset).
 - ii. Number of hours emergency power is available (total since record reset).
 - iii. Total transfer in either direction (total since record reset).
 - iv. Date, time, and description of the last four source failures.
 - v. Date of the last exercise period.
 - vi. Date of record reset.

D. Sequence of Operation

1. When the voltage on any phase of the normal source drops below 80% or increases to 120%, or frequency drops below 90%, or increase to 110%, or 20% voltage differential between phases occurs, after a programmable time delay period of 0-9999 seconds factory set at 3 seconds to allow for momentary dips, the engine starting contacts shall close to start the generating plant.
2. The transfer switch shall transfer to emergency when the generating plant has reached specified voltage and frequency on all phases.
3. After restoration of normal power on all phases to a preset value of at least 90% to 110% of rated voltage, and at least 95% to 105% of rated frequency, and voltage differential is below 20%, an adjustable time delay period of 0-9999 seconds (factory set at 300 seconds) shall delay retransfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically return to the normal source.
4. After retransfer to normal, the engine generator shall be allowed to operate at no load for a programmable period of 0-9999 seconds, factory set at 300 seconds.

E. Automatic Transfer Switch Accessories

1. Programmable three phase sensing of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential b

etween phases, set at 20%, and phase sequence monitoring.

2. Programmable three phase sensing of the emergency source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases set at 20%, and phase sequence monitoring.
3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds, if not otherwise specified.
4. Time delay to control contact transition time on transfer to either source. Programmable 0-9999 seconds, factory set at 3 seconds.
5. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds if not otherwise specified, with overrun to provide a programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.
6. Time delay on transfer to emergency, programmable 0-9999 seconds, factory set at 3 seconds.
7. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.
8. A remote type load test switch shall be included to simulate a normal power failure, remote switch initiated.
9. A time delay bypass on retransfer to normal shall be included. Keypad initiated.
10. Contact, rated 10 Amps 30 volts DC, to close on failure of normal source to initiate engine starting.
11. Contact, rated 10 Amps 30 volts DC, to open on failure of normal source for customer functions.
12. Light emitting diodes shall be mounted on the microprocessor panel to indicate: switch is in normal position, switch is in emergency position and controller is running.
13. A plant exerciser shall be provided with (10) 7-day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise generating plant programmable in one-minute increments. Also include selection of either "no load" (switch will not transfer) or "load" (switch will transfer) exercise period. Keypad initiated.
14. Provision to select either "no commit" or "commit" to transfer operation in the event of a normal power failure shall be included. In the "no commit position," the load will transfer to the emergency position unless normal p

ower returns before the emergency source has reach 90% of it's rated values (switch will remain in normal). In the "commit position" the load will transfer to the emergency position after any normal power failure. Keypad initiated.

15. Two auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 amps) 15 amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, one closed on normal, the other closed on emergency. Both contacts will be wired to a terminal strip for ease of customer connections.
16. A three phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase to phase voltages simultaneously, for both the normal and emergency source.
17. A digital LCD frequency readout with 1% accuracy shall display frequency for both normal and emergency source.
18. An LCD readout shall display normal source and emergency source availability.

F. Specifiers Notes:

The following accessories shall be available by simple activation, via the keypad, if required.

1. Include (2) time delay contacts that open simultaneously just (milliseconds) prior to transfer in either direction. These contacts close after a time delay upon transfer. Programmable 0-9999 seconds after transfer.
2. A block transfer function shall be included, energized from a 24VDC signal from the generator control switchgear, to allow transfer to emergency.
3. A load-shed function shall be included, energized from a 24VDC signal from the generator control switchgear, to disconnect the load from the emergency source when an overload condition occurs.
4. A peak shave function shall be included, energized from a 24VDC signal from the generator control switchgear. This function will start the emergency generator and transfer the ATS to the emergency source reducing the utility supply to the building. After the peak shave signal is removed, the transfer switch will retransfer to the normal supply, bypassing the retransfer time delay.

G. Approval

1. As a condition of approval, the manufacturer of the automatic transfer switches shall verify that their switches are listed by Underwriters Laboratories, Inc., Standard UL-1008 with 3 cycle short circuit closing and withstand as follows:

RMS Symmetrical Amperes 480 VAC

Current Limiting

<u>Amperes</u>	<u>Closing and Withstand</u>	<u>Fuse Rating</u>
100 – 400	42,000	200,000
600 – 800	65,000	200,000
1000 – 1200	85,000	200,000
1600 – 4000	100,000	200,000

2. During the 3 cycle closing and withstand tests, there shall be no contact welding or damage. The 3 cycle tests shall be performed without the use of current limiting fuses. The test shall verify that contacts separation has not occurred, and there is contact continuity across all phases. Test procedures shall be in accordance with UL-1008, and testing shall be certified by Underwriters' Laboratories, Inc.
3. When conducting temperature rise tests to UL-1008, the manufacture shall include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.
4. The microprocessor controller shall meet the following requirements:
 - a. Storage conditions - 25 degrees C to 85 degrees C.
 - b. Operation conditions - 20 degrees C to 70 degrees C ambient.
 - c. Humidity 0 to 99% relative humidity, noncondensing.
 - d. Capable of withstanding infinite power interruptions.
 - e. Surge withstand per ANSI/IEEE C-37.90A-1978.
5. Manufacturer shall provide copies of test reports upon request.

H. Manufacturer / Supplier ²

1. The supplier shall include a telephone number, for field service contact, affixed to each enclosure.

PART 3 - EXECUTION

3.01 Installation

- A. Automatic Transfer Switches shall be provided with adequate lifting means for ease of installation of wall or floor mounted enclosures.
- B. Provide access and working space as indicated or as required.

3.02 Adjustments

- A. Tighten assembled bolted connections with appropriate tools to manufacturer's torque recommendations prior to first energization.

END OF SECTION

SECTION 26 43 13 SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SCOPE

- A. This section describes the materials and installation requirements for surge protective devices (SPD) for the protection of all AC electrical circuits.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Other sections that may relate to the work in this section include, but are not limited to, the following:
 - 1. Section 26 24 13.11 – Switchboards
 - 2. Section 26 24 16 – Low-Voltage Panelboards

1.3 SUBMITTALS

- A. Submit shop drawings and product information for approval and final documentation in the quantities listed according to the Conditions of the Contract. All transmittals shall be identified by customer name, customer location, and customer order number.
- B. Submittals shall include UL 1449 4th Edition Listing documentation verifiable by visiting www.UL.com, clicking "Certifications" link, searching using UL Category Code: VZCA.
 - 1. Short Circuit Current Rating (SCCR)
 - 2. Voltage Protection Ratings (VPRs) for all modes
 - 3. Maximum Continuous Operating Voltage rating (MCOV)
 - 4. I-nominal rating (I-n)
 - 5. SPD shall be Type 1 UL listed and labeled
- C. Upon request, an unencapsulated but complete SPD formally known as TVSS shall be presented for visual inspection.
- D. Minimum of ten (10) year warranty

1.4 RELATED STANDARDS

- A. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits,
- B. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits,
- C. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
- D. National Electrical Code: Article 285
- E. UL 1283 - Electromagnetic Interference Filters
- F. UL 1449, Fourth Edition – Surge Protective Devices

1.5 LISTING REQUIREMENTS

- A. SPD shall bear the UL Mark and shall be Listed to most recent editions of UL 1449 and UL 1283. "Manufactured in accordance with" is not equivalent to UL listing and does not meet the intent of this specification.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Engage a firm with at least ten (10) years experience in manufacturing transient voltage surge suppressors.
- B. Manufacturer shall be ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (10) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Handle and store equipment in accordance with manufacturer's Installation and Maintenance Manuals. One (1) copy of this document to be provided with the equipment at time of shipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Provide an externally mounted transient voltage suppressors by Siemens or pre-approved equal. Approved manufacturers are as follows:
 - 1. SIEMENS
 - 2. Square D – Schneider Electric

2.2 SURGE PROTECTIVE DEVICE FEATURES

- A. SPD shall be UL 1449 listed and labeled with 200kA Short Circuit Current Rating (SCCR). Fuse ratings shall not be considered in lieu of demonstrated withstand testing of SPD, per NEC 285.6.
- B. SPD shall be UL 1449 labeled as Type 1 intended for use without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal over-temperature controls. SPDs relying upon external or supplementary installed safety disconnects do not meet the intent of this specification.
- C. SPD shall be UL 1449 labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.
- D. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.

- E. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
- F. If a dedicated breaker for the SPD is not provided in the switchboard, the service entrance SPD shall include an integral UL Recognized disconnect switch. A dedicated breaker shall serve as a means of disconnect for distribution SPD's.

G. SPD shall meet or exceed the following criteria:

1. Minimum surge current capability (single pulse rated) per phase shall be:
 - a. Service Entrance applications:
 - 1.) Siemens Model TPS3 12 with Maximum 7-Mode surge current capability shall be 250kA per phase.
 - b. Distribution applications:
 - 1.) Siemens Model TPS3 09 with Maximum surge current capability of 100kA per phase
2. UL 1449 Listed Voltage Protection Ratings (VPRs) shall not exceed the following:

VOLTAGE	L-N	L-G	N-G
208Y/120V	700V	700V	700V
480Y/277V	1500V	1500V	1500V

- I. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) for L-N, L-G, and N-G modes of protection (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	25%	150V
480Y/277V	20%	320V

- J. Service Entrance SPD shall be complimentary UL 1283 listed for EMI/RFI filtering with minimum attenuation of -50dB at 100kHz.
- K. SPD shall have a warranty for a period of ten (10) years, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period.
- L. Service Entrance SPDs shall be equipped with the following diagnostics:
 1. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 2. Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 3. Form C dry contacts
 4. Optional – Surge Counter
 5. No other test equipment shall be required for SPD monitoring or testing before or after installation.
- M. Distribution Panels SPDs shall be equipped with the following diagnostics:
 1. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 2. Audible Alarm & Dry Contacts

3. No other test equipment shall be required for SPD monitoring or testing before or after installation.

PART 3 - EXECUTION

3.2 INSTALLATION

- I. The installation shall meet the following criteria:
 1. Install per manufacturer's recommendations and contract documents.
 2. Install units plumb, level and rigid without distortion
 3. One primary suppressor shall be installed external to the service entrance in accordance with manufacturer instructions.
 4. Service Entrance SPD shall be installed on the line or load side of the main service disconnect.
 5. Service Entrance SPD ground shall be bonded to the service entrance ground.
 6. At Service Entrance or Transfer Switch, a UL approved disconnect switch shall be provided as a means of servicing disconnect if a 60A breaker is not available.
 7. One SPD shall be installed external to each designated distribution panelboard.
 8. At Distribution, MCC and Branch, SPD shall have an independent means of servicing disconnect such that the protected panel remains energized. A 30A breaker (or larger) may serve this function.
 9. SPD shall be installed per manufacturer's installation instructions with lead lengths as short (less than 24") and straight as possible. Gently twist conductors together.
 10. Installer may reasonably rearrange breaker locations to ensure short & straightest possible leads to SPDs.
 11. Before energizing, installer shall verify service and separately derived system Neutral to Ground bonding jumpers per NEC.

3.3 ADJUSTMENTS AND CLEANING

- A. Remove debris from SPD and wipe dust and dirt from all components.
- B. Repaint marred and scratched surface with touch up paint to match original finish.

3.4 TESTING

- A. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture's recommendations.
- B. Check all installed panels for proper grounding, fastening and alignment.

3.5 WARRANTY

- A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operations, but not more than eighteen months from date of shipment.

END OF SECTION 26 43 13

SECTION 26 44 10
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SCOPE

- A. The Contractor shall furnish and install the low-voltage fused and non-fused switches as specified herein and as shown on the contract drawings.

1.02 RELATED SECTIONS

1.03 REFERENCES

- A. The switches and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL.

1.04 SUBMITTALS -- FOR REVIEW/APPROVAL

- A. Procedure: Submit in accordance with Section 013000, 260100, and as stated herein.
- B. The following information shall be submitted to the Engineer:
 - 1. Master drawing index
 - 2. Dimensioned outline drawing
 - 3. Conduit entry/exit locations
 - 4. Switch ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current
 - 5. Fuse ratings and type
 - 6. Cable terminal sizes.

1.05 SUBMITTALS -- FOR INFORMATION

- A. When requested by the Engineer the following product information shall be submitted:
 - 1. Descriptive bulletins
 - 2. Product sheets.

1.06 SUBMITTALS--FOR CLOSEOUT

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in section 1.04

1.07 QUALIFICATIONS

A. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

1.08 NOT USED

1.09 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

A. FIELD MEASUREMENTS

A. Contractor shall field verify all dimensions prior to installation. Installation of all switches shall comply with the National Electric Codes clearance and mounting height requirements.

B. OPERATION AND MAINTENANCE MANUALS

A. Three (3) copies of these instruction manuals shall be submitted with the closeout documents listed in section 1.06.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Square D
- B. Siemens

2.02 DISCONNECT SWITCHES

A. Provide switches as shown on drawings, with the following ratings:

- 1. 30 to 1200 amperes
- 2. 250 volts AC, DC; 600 volts AC (30A to 200A 600 volts DC)
- 3. 2, 3, 4, and 6 poles
- 4. Non-Fusible and Fusible

5. Copper/aluminum standard mechanical lugs.

B. Construction

1. Switchblades and jaws shall be plated copper.
2. Switches shall have a handle that is easily pad lockable in the OFF position.
3. Switches shall have defeat-able door interlocks that prevent the door from opening when the handle is in the ON position.
4. Switch assembly and operating handle shall be an integral part of the enclosure base.
5. Fusible switches rated 100A to 1200A shall have reinforced fuse clips.
6. Switch blades shall be readily visible in the OFF position.
7. Switch operating mechanism shall be non-teasible, positive quick-make/quick-break type (except 30A plug fuse-type).
8. Fusible switches shall be suitable for service entrance equipment.
9. Switches shall have line terminal shields.
10. All exterior switches shall be heavy-duty type.
11. All interior switches shall be general-duty type unless otherwise noted.

C. Enclosures

- A. Exterior: All enclosures shall be NEMA 3R rainproof unless otherwise noted.
- B. Interior: All enclosures shall be NEMA 1 unless otherwise noted.

D. Fuses

1. Fuses shall be dual element, current limiting type such as Bussmann Low-Peak Yellow or equal.

2.04 NAMEPLATES

- A. Manufacturers nameplates shall be front cover mounted, contain a permanent record of switch type, ampere rating, and maximum voltage rating.

PART 3 EXECUTION

3.01 EXAMINATION

- A. All switches shall be cleaned free of debris after installation and prior to final acceptance by the owner. Remove all miscellaneous paint markings, grease and tar.

3.02 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

3.03 INSTALLATION

- A. The equipment shall be installed per the manufacturer's recommendations.

END OF SECTION 26 44 10