A&E DESIGN - UPGRADE ENERGY MANAGEMENT CONTROL SYSTEMS

DEPARTMENT OF VETERANS AFFAIRS
ALEXANDRIA VA HEALTH CARE SYSTEM

SUBMITTED BY:

HERNANDEZ CONSULTING LLC

AND

ALLEN & HOSHALL

3/20/16

DEPARTMENT OF VETERANS AFFAIRS
VHA MASTER SPECIFICATIONS

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Addendum 1

This Addendum is issued for the purpose of modifying and /or clarifying the specifications and is to be construed as being as much a part of the original Contract Documents as though originally contained therein.

1. Brand names can be ignored in section 23 09 23, with the exception of the Siemens brand name when it is being used to describe the existing DDC system that is in place. An example of the wording that can be ignored would be: “Sensor shall be Drexel Brook or equal.”

2. Sheet M101 Note 1 of the METERING TO BE ADDED TABLE shall be replaced in its entirety with the following: ELECTRIC METERS TO BE AS SPECIFIED. INSTALL PER MFR’S RECOMMENDATIONS. ELECTRICAL EQUIPMENTS SHALL BE INSTALLED, OPERATED, SERVICED, AND MAINTAINED ONLY BY QUALIFIED PERSONNEL.

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SECTION 01 00 00
GENERAL REQUIREMENTS

1.1 SAFETY REQUIREMENTS

Refer to section 01 35 26, SAFETY REQUIREMENTS for safety and infection control requirements.

1.2 GENERAL INTENTION

A. Contractor shall completely prepare site for building operations, including demolition and removal of existing structures, and furnish labor and materials and perform work for Upgrade Energy Management Control Systems as required by drawings and specifications.

B. N/A

C. Offices of Hernandez Consulting, LLC, as Architect-Engineers, will render certain technical services during construction. Such services shall be considered as advisory to the Government and shall not be construed as expressing or implying a contractual act of the Government without affirmations by Contracting Officer or his duly authorized representative.

D. Before placement and installation of work subject to tests by testing laboratory retained by Department of Veterans Affairs, the Contractor shall notify the COR in sufficient time to enable testing laboratory personnel to be present at the site in time for proper taking and testing of specimens and field inspection. Such prior notice shall be not less than three work days unless otherwise designated by the COR.

E. All employees of general contractor and subcontractors shall comply with VA security management program and obtain permission of the VA police, be identified by project and employer, and restricted from unauthorized access.

1.3 STATEMENT OF BID ITEM(S)

A. ITEM I, CONTROLS UPGRADE: Work includes mechanical, electrical, data, controls, metering, fire protection, general site work.

1.4 SPECIFICATIONS AND DRAWINGS FOR CONTRACTOR

A. Drawings and contract documents may be obtained from the website where the solicitation is posted. Additional copies will be at Contractor's expense,.

1.5 CONSTRUCTION SECURITY REQUIREMENTS

A. Security Plan:

1. The security plan defines both physical and administrative security procedures that will remain effective for the entire duration of the project.

2. The General Contractor is responsible for assuring that all sub-contractors working on the project and their employees also comply with these regulations.

B. Security Procedures:

1. General Contractor’s employees shall not enter the project site without appropriate badge. They may also be subject to inspection of their personal effects when entering or leaving the project site.

2. Before starting work the General Contractor shall give one week’s notice to the Contracting Officer so that security arrangements can be provided for the employees. This notice is separate from any notices required for utility shutdown described later in this section.

3. No photography of VA premises is allowed without written permission of the Contracting Officer.

4. VA reserves the right to close down or shut down the project site and order General Contractor’s employees off the premises in the event of a national emergency. The General Contractor may return to the site only with the written approval of the Contracting Officer.

C. Guards:

GUARDS NOT REQUIRED

D. Key Control:

1. The General Contractor shall provide duplicate keys and lock combinations to the Contracting officers representative (COR) for the purpose of security inspections of every area of project including tool boxes and parked machines and take any emergency action.

2. N/A.

E. Document Control:

1. Before starting any work, the General Contractor/Sub Contractors shall submit an electronic security memorandum describing the approach to following goals and maintaining confidentiality of “sensitive information”.

2. The General Contractor is responsible for safekeeping of all drawings, project manual and other project information. This information shall be shared only with those with a specific need to accomplish the project.

3. Certain documents, sketches, videos or photographs and drawings may be marked “Law Enforcement Sensitive” or “Sensitive Unclassified”. Secure such information in separate containers and limit the access to only those who will need it for the project. Return the information to the Contracting Officer upon request.

4. These security documents shall not be removed or transmitted from the project site without the written approval of Contracting Officer.

5. All paper waste or electronic media such as CD’s and diskettes shall be shredded and destroyed in a manner acceptable to the VA.

6. Notify Contracting Officer and Site Security Officer immediately when there is a loss or compromise of “sensitive information”.

7. All electronic information shall be stored in specified location following VA standards and procedures using an Engineering Document Management Software (EDMS).

    a. Security, access and maintenance of all project drawings, both scanned and electronic shall be performed and tracked through the EDMS system.

    b. “Sensitive information” including drawings and other documents may be attached to e-mail provided all VA encryption procedures are followed.

F. Motor Vehicle Restrictions

1. Vehicle authorization request shall be required for any vehicle entering the site and such request shall be submitted 24 hours before the date and time of access. Access shall be restricted to picking up and dropping off materials and supplies.

2. A limited number of (2 to 5) permits shall be issued for General Contractor and its employees for parking in designated areas only.

1.6 OPERATIONS AND STORAGE AREAS

A. The Contractor shall confine all operations (including storage of materials) on Government premises to areas authorized or approved by the Contracting Officer. The Contractor shall hold and save the Government, its officers and agents, free and harmless from liability of any nature occasioned by the Contractor's performance.

B. Temporary buildings (e.g., storage sheds, shops, offices) and utilities may be erected by the Contractor only with the approval of the Contracting Officer and shall be built with labor and materials furnished by the Contractor without expense to the Government. The temporary buildings and utilities shall remain the property of the Contractor and shall be removed by the Contractor at its expense upon completion of the work. With the written consent of the Contracting

Officer, the buildings and utilities may be abandoned and need not be removed.

C. The Contractor shall, under regulations prescribed by the Contracting Officer, use only established roadways, or use temporary roadways constructed by the Contractor when and as authorized by the Contracting Officer. When materials are transported in prosecuting the work, vehicles shall not be loaded beyond the loading capacity recommended by the manufacturer of the vehicle or prescribed by any Federal, State, or local law or regulation. When it is necessary to cross curbs or sidewalks, the Contractor shall protect them from damage. The Contractor shall repair or pay for the repair of any damaged curbs, sidewalks, or roads.

D. Working space and space available for storing materials shall be as determined by the COR.

E. Workmen are subject to rules of the Medical Center applicable to their conduct.

F. Execute work so as to interfere as little as possible with normal functioning of the Medical Center as a whole, including operations of utility services, fire protection systems and any existing equipment, and with work being done by others. Use of equipment and tools that transmit vibrations and noises through the building structure, are not permitted in buildings that are occupied, during construction, jointly by patients or medical personnel, and Contractor's personnel, except as permitted by COR where required by limited working space.

   1. Do not store materials and equipment in other than assigned areas.

   2. Schedule delivery of materials and equipment to immediate construction working areas within buildings in use by Department of Veterans Affairs in quantities sufficient for not more than two work days. Provide unobstructed access to Medical Center areas required to remain in operation.

3. Where access by Medical Center personnel to vacated portions of buildings is not required, storage of Contractor's materials and equipment will be permitted subject to fire and safety requirements.

G. Phasing:

The Medical Center must maintain its operation 24 hours a day 7 days a week. Therefore, any interruption in service must be scheduled and coordinated with the COR to ensure that no lapses in operation occur. It is the CONTRACTOR'S responsibility to develop a work plan and schedule detailing, at a minimum, the procedures to be employed, the equipment and materials to be used, the interim life safety measure to be used during the work, and a schedule defining the duration of the work with milestone subtasks. The work to be outlined shall include, but not be limited to:

To insure such executions, Contractor shall furnish the COR with a schedule of approximate dates on which the Contractor intends to accomplish work in each specific area of site, building or portion thereof. In addition, Contractor shall notify the COR two weeks in advance of the proposed date of starting work in each specific area of site, building or portion thereof. Arrange such dates to insure accomplishment of this work in successive phases mutually agreeable to Medical Center Director, COR and Contractor, as follows:

H. The following buildings will be occupied during performance of work:

1 Admin*	8 Canteen
2 Admin	147 Chiller Plant
3 Admin*	7 Main Hospital
9 Psychiatric Hospital	41 Emergency Generator*
49 Mental Health Rehab	14 Boiler Plant*
4 Dietary	16 Laundry
5 Admin*	45 Nursing Home

6 Admin	46 Chapel

*Indicates fiber optic installation only

Contractor shall take all measures and provide all material necessary for protecting existing equipment and property in affected areas of construction against dust and debris, so that equipment and affected areas to be used in the Medical Centers operations will not be hindered. Contractor shall permit access to Department of Veterans Affairs personnel and patients through other construction areas which serve as routes of access to such affected areas and equipment. These routes whether access or egress shall be isolated from the construction area by temporary partitions and have walking surfaces, lighting etc to facilitate patient and staff access.
Coordinate alteration work in areas occupied by Department of Veterans Affairs so that Medical Center operations will continue during the construction period.

J. When a building and/or construction site is turned over to Contractor, Contractor shall accept entire responsibility including upkeep and maintenance therefore:

1. Contractor shall maintain a minimum temperature of 4 degrees C (40 degrees F) at all times, except as otherwise specified.

2. Contractor shall maintain in operating condition existing fire protection and alarm equipment. In connection with fire alarm equipment, Contractor shall make arrangements for pre-inspection of site with Fire Department or Company (Department of Veterans Affairs or municipal) whichever will be required to respond to an alarm from Contractor's employee or watchman.

K. Utilities Services: Maintain existing utility services for Medical Center at all times. Provide temporary facilities, labor, materials, equipment, connections, and utilities to assure uninterrupted services. Where necessary to cut existing water, steam, gases, sewer or air pipes, or conduits, wires, cables, etc. of utility services or of fire protection systems and communications systems (including telephone), they shall be cut and capped at suitable places where shown; or, in absence of such indication, where directed COR.

1. No utility service such as water, gas, steam, sewers or electricity, or fire protection systems and communications systems may be interrupted without prior approval of COR. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished, work on any energized circuits or equipment shall not commence without a detailed work plan, the Medical Center Director’s prior knowledge and written approval. Refer to specification Sections 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS for additional requirements.

2. Contractor shall submit a request to interrupt any such services to COR, in writing, 7 days in advance of proposed interruption. Request shall state reason, date, exact time of, and approximate duration of such interruption.

3. Contractor will be advised (in writing) of approval of request, or of which other date and/or time such interruption will cause least inconvenience to operations of Medical Center. Interruption time approved by Medical Center may occur at other than Contractor's normal working hours.

4. Major interruptions of any system must be requested, in writing, at least 15 calendar days prior to the desired time and shall be performed as directed by the COR.

5. In case of a contract construction emergency, service will be interrupted on approval COR. Such approval will be confirmed in writing as soon as practical.

6. Whenever it is required that a connection fee be paid to a public utility provider for new permanent service to the construction project, for such items as water, sewer, electricity, gas or steam, payment of such fee shall be the responsibility of the Government and not the Contractor.

L. Abandoned Lines: All service lines such as wires, cables, conduits, ducts, pipes and the like, and their hangers or supports, which are to be abandoned but are not required to be entirely removed, shall be sealed, capped or plugged at the main, branch or panel they originate from. The lines shall not be capped in finished areas, but shall be removed and sealed, capped or plugged in ceilings, within furred spaces, in unfinished areas, or within walls or partitions; so that they are completely behind the finished surfaces.

M. To minimize interference of construction activities with flow of Medical Center traffic, comply with the following:

1. Keep roads, walks and entrances to grounds, to parking and to occupied areas of buildings clear of construction materials, debris and standing construction equipment and vehicles. Wherever excavation for new utility lines cross existing roads, at least one lane must be open to traffic at all times with approval.

2. Method and scheduling of required cutting, altering and removal of existing roads, walks and entrances must be approved by the COR.

N. Coordinate the work for this contract with other construction operations as directed by COR. This includes the scheduling of traffic and the use of roadways, as specified in Article, USE OF ROADWAYS.

1.7 ALTERATIONS

A. Survey: Before any work is started, the Contractor shall make a thorough survey with the COR in which alterations occur and areas which are anticipated routes of access, and furnish a report, signed by both, to the Contracting Officer. This report shall list by rooms and spaces:

1. Existing condition and types of resilient flooring, doors, windows, walls and other surfaces not required to be altered throughout affected areas of buildings.

2. Existence and conditions of items such as plumbing fixtures and accessories, electrical fixtures, equipment, venetian blinds, shades, etc., required by drawings to be either reused or relocated, or both.

3. Shall note any discrepancies between drawings and existing conditions at site.

4. Shall designate areas for working space, materials storage and routes of access to areas within buildings where alterations occur and which have been agreed upon by Contractor and COR.

B. Any items required by drawings to be either reused or relocated or both, found during this survey to be nonexistent, or in opinion of COR to be in such condition that their use is impossible or impractical, shall be furnished and/or replaced by Contractor with new items in accordance with specifications which will be furnished by Government. Provided the contract work is changed by reason of this subparagraph B, the contract will be modified accordingly, under provisions of clause entitled "DIFFERING SITE CONDITIONS" (FAR 52.236-2) and "CHANGES" (FAR 52.243-4 and VAAR 852.236-88).

C. Re-Survey: Thirty days before expected partial or final inspection date, the Contractor and COR together shall make a thorough re-survey of the areas of buildings involved. They shall furnish a report on conditions then existing, of resilient flooring, doors, windows, walls and other surfaces as compared with conditions of same as noted in first condition survey report:

   1. Re-survey report shall also list any damage caused by Contractor to such flooring and other surfaces, despite protection measures; and, will form basis for determining extent of repair work required of Contractor to restore damage caused by Contractor's workmen in executing work of this contract.

D. Protection: Provide the following protective measures:

   1. Wherever existing roof surfaces are disturbed they shall be protected against water infiltration. In case of leaks, they shall be repaired immediately upon discovery.

   2. Temporary protection against damage for portions of existing structures and grounds where work is to be done, materials handled and equipment moved and/or relocated.

   3. Protection of interior of existing structures at all times, from damage, dust and weather inclemency. Wherever work is performed, floor surfaces that are to remain in place shall be adequately protected prior to starting work, and this protection shall be maintained intact until all work in the area is completed.

1.8 DISPOSAL AND RETENTION

A. Materials and equipment accruing from work removed and from demolition of buildings or structures, or parts thereof, shall be disposed of as follows:

   1. Reserved items which are to remain property of the Government are to

be stored. Items that remain property of the Government shall be removed or dislodged from present locations in such a manner as to prevent damage which would be detrimental to re-installation and reuse. Store such items where directed by COR. Reserved items include, removed controls (thermostats and control boxes) and control equipment (valves, VAV boxes, ect.).

2. Items not reserved shall become property of the Contractor and be removed by Contractor from Medical Center.

3. Items of portable equipment and furnishings located in rooms and spaces in which work is to be done under this contract shall remain the property of the Government. When rooms and spaces are vacated by the Department of Veterans Affairs during the alteration period, such items which are NOT required by drawings and specifications to be either relocated or reused will be removed by the Government in advance of work to avoid interfering with Contractor's operation.

1.9 PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES, AND IMPROVEMENTS

A. The Contractor shall preserve and protect all structures, equipment, and vegetation (such as trees, shrubs, and grass) on or adjacent to the work site, which are not to be removed and which do not unreasonably interfere with the work required under this contract. The Contractor shall only remove trees when specifically authorized to do so, and shall avoid damaging vegetation that will remain in place. If any limbs or branches of trees are broken during contract performance, or by the careless operation of equipment, or by workmen, the Contractor shall trim those limbs or branches with a clean cut and paint the cut with a tree-pruning compound as directed by the Contracting Officer.

B. The Contractor shall protect from damage all existing improvements and utilities at or near the work site and on adjacent property of a third party, the locations of which are made known to or should be known by the Contractor. The Contractor shall repair any damage to those facilities, including those that are the property of a third party, resulting from failure to comply with the requirements of this contract or failure to exercise reasonable care in performing the work. If the Contractor fails or refuses to repair the damage promptly, the Contracting Officer may have the necessary work performed and charge the cost to the Contractor.

(FAR 52.236-9)

C. Refer to Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS, for additional requirements on protecting vegetation, soils and the environment. Refer to Articles, "Alterations", "Restoration", and "Operations and Storage Areas" for additional instructions concerning repair of damage to structures and site improvements.

1.10 RESTORATION

A. Remove, cut, alter, replace, patch and repair existing work as necessary to install new work. Except as otherwise shown or specified, do not cut, alter or remove any structural work, and do not disturb any ducts, plumbing, steam, gas, or electric work without approval of the COR. Existing work to be altered or extended and that is found to be defective in any way, shall be reported to the Resident Engineer COR before it is disturbed. Materials and workmanship used in restoring work, shall conform in type and quality to that of original existing construction, except as otherwise shown or specified.

B. Upon completion of contract, deliver work complete and undamaged. Existing work (walls, ceilings, partitions, floors, mechanical and electrical work, lawns, paving, roads, walks, etc.) disturbed or removed as a result of performing required new work, shall be patched, repaired, reinstalled, or replaced with new work, and refinished and left in as good condition as existed before commencing work.

C. At Contractor's own expense, Contractor shall immediately restore to service and repair any damage caused by Contractor's workmen to existing piping and conduits, wires, cables, etc., of utility services or of fire protection systems and communications systems (including telephone) which are not scheduled for discontinuance or abandonment.

D. Expense of repairs to such utilities and systems not shown on drawings or locations of which are unknown will be covered by adjustment to contract time and price in accordance with clause entitled "CHANGES" (FAR 52.243-4 and VAAR 852.236-88) and "DIFFERING SITE CONDITIONS" (FAR 52.236-2).

1.11 NOT USED

1.12 PROFESSIONAL SURVEYING SERVICES

A registered professional land surveyor or registered civil engineer whose services are retained and paid for by the Contractor shall perform services specified herein and in other specification sections. The Contractor shall certify that the land surveyor or civil engineer is not one who is a regular employee of the Contractor, and that the land surveyor or civil engineer has no financial interest in this contract.

1.13 LAYOUT OF WORK

A. The Contractor shall lay out the work from Government established base lines and bench marks, indicated on the drawings, and shall be responsible for all measurements in connection with the layout. The Contractor shall furnish, at Contractor's own expense, all stakes, templates, platforms, equipment, tools, materials, and labor required to lay out any part of the work. The Contractor shall be responsible for executing the work to the lines and grades that may be established or indicated by the Contracting Officer. The Contractor shall also be responsible for maintaining and preserving all stakes and other marks established by the Contracting Officer until authorized to remove them. If such marks are destroyed by the Contractor or through Contractor's negligence before their removal is authorized, the Contracting Officer may replace them and deduct the expense of the replacement from any amounts due or to become due to the Contractor.

(FAR 52.236-17)

B. Not Used

C. Not Used

D. Not Used

E. Whenever changes from contract drawings are made in line or grading requiring certificates, record such changes on a reproducible drawing bearing the registered land surveyor or registered civil engineer seal, and forward these drawings upon completion of work to COR.

F. The Contractor shall perform the surveying and layout work of this and other articles and specifications in accordance with the provisions of Article "Professional Surveying Services".

1.14 AS-BUILT DRAWINGS

A. The contractor shall maintain two full size sets of as-built drawings which will be kept current during construction of the project, to include all contract changes, modifications and clarifications.

B. All variations shall be shown in the same general detail as used in the contract drawings. To insure compliance, as-built drawings shall be made available for the COR’s review, as often as requested.

C. Contractor shall deliver two approved completed sets of as-built drawings to the COR within 15 calendar days after each completed phase and after the acceptance of the project by the COR.

D. Paragraphs A, B, & C shall also apply to all shop drawings.

1.15 USE OF ROADWAYS

A. For hauling, use only established public roads and roads on Medical Center property and, when authorized by the COR, such temporary roads which are necessary in the performance of contract work. Temporary roads shall be constructed and restoration performed by the Contractor at Contractor's expense. When necessary to cross curbing, sidewalks, or similar construction, they must be protected by well-constructed bridges.

B. When new permanent roads are to be a part of this contract, Contractor may construct them immediately for use to facilitate building operations. These roads may be used by all who have business thereon within zone of building operations.

C. When certain buildings (or parts of certain buildings) are required to be completed in advance of general date of completion, all roads leading thereto must be completed and available for use at time set for completion of such buildings or parts thereof.

1.16 NOT USED

1.17 TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT

A. Use of new installed mechanical and electrical equipment to provide heat, ventilation, plumbing, light and power will be permitted subject to written approval and compliance with the following provisions:

1. Permission to use each unit or system must be given by COR in writing. If the equipment is not installed and maintained in accordance with the written agreement and following provisions, the COR will withdraw permission for use of the equipment.

2. Electrical installations used by the equipment shall be completed in accordance with the drawings and specifications to prevent damage to the equipment and the electrical systems, i.e. transformers, relays, circuit breakers, fuses, conductors, motor controllers and their overload elements shall be properly sized, coordinated and adjusted. Installation of temporary electrical equipment or devices shall be in accordance with NFPA 70, National Electrical Code, (2014 Edition), Article 590, *Temporary Installations.* Voltage supplied to each item of equipment shall be verified to be correct and it shall be determined that motors are not overloaded. The electrical equipment shall be thoroughly cleaned before using it and again immediately before final inspection including vacuum cleaning and wiping clean interior and exterior surfaces.

3. Units shall be properly lubricated, balanced, and aligned. Vibrations must be eliminated.

4. Automatic temperature control systems for preheat coils shall function properly and all safety controls shall function to prevent coil freeze-up damage.

5. The air filtering system utilized shall be that which is designed for the system when complete, and all filter elements shall be replaced at completion of construction and prior to testing and balancing of system.

6. All components of heat production and distribution system, metering equipment, condensate returns, and other auxiliary facilities used in temporary service shall be cleaned prior to use; maintained to prevent corrosion internally and externally during use; and cleaned, maintained and inspected prior to acceptance by the Government. Boilers, pumps, feedwater heaters and auxiliary equipment must be operated as a complete system and be fully maintained by operating personnel. Boiler water must be given complete and continuous chemical treatment.

B. Prior to final inspection, the equipment or parts used which show wear and tear beyond normal, shall be replaced with identical replacements, at no additional cost to the Government.

C. This paragraph shall not reduce the requirements of the mechanical and electrical specifications sections.

D. Any damage to the equipment or excessive wear due to prolonged use will be repaired replaced by the contractor at the contractor’s expense.

1.18 TEMPORARY USE OF EXISTING ELEVATORS

A. Use of existing elevators for handling building materials and Contractor's personnel will be permitted subject to following provisions:

1. Contractor makes all arrangements with the COR for use of elevators. The COR will ascertain that elevators are in proper condition.

2. Contractor covers and provides maximum protection of following elevator components:

a. Entrance jambs, heads soffits and threshold plates.

b. Entrance columns, canopy, return panels and inside surfaces of car enclosure walls.

c. Finish flooring.

1.19 NOT USED

1.20 TEMPORARY TOILETS

A. Provide where directed, (for use of all Contractor's workmen) ample temporary sanitary toilet accommodations with suitable sewer and water connections; or, when approved by COR, provide suitable dry closets where directed. Keep such places clean and free from flies, and all connections and appliances connected therewith are to be removed prior to completion of contract, and premises left perfectly clean.

1.21 AVAILABILITY AND USE OF UTILITY SERVICES

A. The Government shall make all reasonably required amounts of utilities available to the Contractor from existing outlets and supplies, as specified in the contract. The Contractor shall carefully conserve any utilities furnished without charge.

B. The VA will supply electrical limited to 120.

C. Not Used

D. Not Used

E. Electricity (for Construction and Testing): Furnish all temporary electric services.

1. Obtain electricity by connecting to the Medical Center electrical distribution system. The Contractor shall meter and pay for electricity required for electric cranes and hoisting devices, electrical welding devices and any electrical heating devices providing temporary heat. Electricity for all other uses is available at no cost to the Contractor.

F. Water (for Construction and Testing): Furnish temporary water service.

1. Obtain water by connecting to the Medical Center water distribution system. Provide reduced pressure backflow preventer at each connection as per code. Water is available at no cost to the Contractor.

2. Maintain connections, pipe, fittings and fixtures and conserve water-use so none is wasted. Failure to stop leakage or other wastes will be cause for revocation (at COR discretion) of use of water from Medical Center's system.

G. Fuel: Natural and LP gas and burner fuel oil required for boiler cleaning, normal initial boiler-burner setup and adjusting, and for performing the specified boiler tests will be furnished by the Government. Fuel required for prolonged boiler-burner setup, adjustments, or modifications due to improper design or operation of boiler, burner, or control devices shall be furnished and paid by the Contractor at Contractor's expense.

1.22 NOT USED

1.23 TESTS

A. As per specification section 23 05 93 the contractor shall provide a written testing and commissioning plan complete with component level, equipment level, sub-system level and system level breakdowns. The plan will provide a schedule and a written sequence of what will be tested, how and what the expected outcome will be. This document will be submitted for approval prior to commencing work. The contractor shall document the results of the approved plan and submit for approval with the as built documentation.

B. Pre-test mechanical and electrical equipment and systems and make corrections required for proper operation of such systems before requesting final tests. Final test will not be conducted unless pre-tested.

C. Conduct final tests required in various sections of specifications in presence of an authorized representative of the Contracting Officer. Contractor shall furnish all labor, materials, equipment, instruments, and forms, to conduct and record such tests.

D. Mechanical and electrical systems shall be balanced, controlled and coordinated. A system is defined as the entire system which must be coordinated to work together during normal operation to produce results for which the system is designed. For example, air conditioning supply air is only one part of entire system which provides comfort conditions for a building. Other related components are return air, exhaust air, steam, chilled water, refrigerant, hot water, controls and electricity, etc. Another example of a system which involves several components of different disciplines is a boiler installation. Efficient and acceptable boiler operation depends upon the coordination and proper operation of fuel, combustion air, controls, steam, feedwater, condensate and other related components.

E. All related components as defined above shall be functioning when any system component is tested. Tests shall be completed within a reasonably period of time during which operating and environmental conditions remain reasonably constant and are typical of the design conditions.

F. Individual test result of any component, where required, will only be accepted when submitted with the test results of related components and of the entire system.

1.24 INSTRUCTIONS

A. Contractor shall furnish Maintenance and Operating manuals (hard copies and electronic) and verbal instructions when required by the various sections of the specifications and as hereinafter specified.

B. Manuals: Maintenance and operating manuals and one compact disc (four hard copies and one electronic copy each) for each separate piece of equipment shall be delivered to the COR coincidental with the delivery of the equipment to the job site. Manuals shall be complete, detailed guides for the maintenance and operation of equipment. They shall include complete information necessary for starting, adjusting, maintaining in continuous operation for long periods of time and dismantling and reassembling of the complete units and sub-assembly components. Manuals shall include an index covering all component parts clearly cross-referenced to diagrams and illustrations. Illustrations shall include "exploded" views showing and identifying each separate item. Emphasis shall be placed on the use of special tools and instruments. The function of each piece of equipment, component, accessory and control shall be clearly and thoroughly explained. All necessary precautions for the operation of the equipment and the reason for each precaution shall be clearly set forth. Manuals must reference the exact model, style and size of the piece of equipment and system being furnished. Manuals referencing equipment similar to but of a different model, style, and size than that furnished will not be accepted.

C. Instructions: Contractor shall provide qualified, factory-trained manufacturers' representatives to give detailed training to assigned Department of Veterans Affairs personnel in the operation and complete maintenance for each piece of equipment. All such training will be at the job site. These requirements are more specifically detailed in the various technical sections. Instructions for different items of equipment that are component parts of a complete system, shall be given in an integrated, progressive manner. All instructors for every piece of component equipment in a system shall be available until instructions for all items included in the system have been completed. This is to assure proper instruction in the operation of inter-related systems. All instruction periods shall be at such times as scheduled by the COR and shall be considered concluded only when the COR is satisfied in regard to complete and thorough coverage. The contractor shall submit a course outline with associated material to the COR for review and approval prior to scheduling training to ensure the subject matter covers the expectations of the VA and the contractual requirements. The Department of Veterans Affairs reserves the right to request the removal of, and substitution for, any instructor who, in the opinion of the COR, does not demonstrate sufficient qualifications in accordance with requirements for instructors above.

1.25 NOT USED

1.26 RELOCATED EQUIPMENT & ITEMS

A. Contractor shall disconnect, dismantle as necessary, remove and reinstall in new location, all existing equipment and items indicated by symbol "R" or otherwise shown to be relocated by the Contractor.

B. Perform relocation of such equipment or items at such times and in such a manner as directed by the COR.

C. Suitably cap existing service lines, such as steam, condensate return, water, drain, gas, air, vacuum and/or electrical, at the main whenever such lines are disconnected from equipment to be relocated. Remove abandoned lines in finished areas and cap as specified herein before under paragraph "Abandoned Lines".

D. Provide all mechanical and electrical service connections, fittings, fastenings and any other materials necessary for assembly and installation of relocated equipment; and leave such equipment in proper operating condition.

E. Contractor shall employ services of an installation engineer, who is an authorized representative of the manufacturer of this equipment to supervise assembly and installation of existing equipment, required to be relocated.

F. All service lines such as noted above for relocated equipment shall be in place at point of relocation ready for use before any existing equipment is disconnected. Make relocated existing equipment ready for operation or use immediately after reinstallation.

1.27 NOT USED

1.28 CONSTRUCTION SIGN

A. Provide a Construction Sign where directed by the COR. All wood members shall be of framing lumber. Cover sign frame with 0.7 mm (24 gage) galvanized sheet steel nailed securely around edges and on all bearings. Provide three 100 by 100 mm (4 inch by 4 inch) posts (or equivalent round posts) set 1200 mm (four feet) into ground. Set bottom of sign level at 900 mm (three feet) above ground and secure to posts with through bolts. Make posts full height of sign. Brace posts with 50 x 100 mm (two by four inch) material as directed.

B. Paint all surfaces of sign and posts two coats of white gloss paint. Border and letters shall be of black gloss paint, except project title which shall be blue gloss paint.

C. Maintain sign and remove it when directed by the COR.

D. Detail Drawing of construction sign showing required legend and other characteristics of sign is attached hereto and made a part of this specification.

1.29 SAFETY SIGN

A. Provide a Safety Sign where directed by COR. Face of sign shall be 19 mm (3/4 inch) thick exterior grade plywood. Provide two 100 mm by 100 mm (four by four inch) posts extending full height of sign and 900 mm (three feet) into ground. Set bottom of sign level at 1200 mm (four feet) above ground.

B. Paint all surfaces of Safety Sign and posts with one prime coat and two coats of white gloss paint. Letters and design shall be painted with gloss paint of colors noted.

C. Maintain sign and remove it when directed by COR.

D. Standard Detail Drawing Number SD10000-02(Found on VA TIL) of safety sign showing required legend and other characteristics of sign is attached hereto and is made a part of this specification.

E. Post the number of accident free days on a daily basis.

1.30 NOT USED

1.31 NOT USED

1.32 HISTORIC PRESERVATION

Where the Contractor or any of the Contractor's employees, prior to, or during the construction work, are advised of or discover any possible archeological, historical and/or cultural resources, the Contractor shall immediately notify the COR verbally, and then with a written follow up.

- - - E N D - - -

SECTION 01 32 16.13
NETWORK ANALYSIS SCHEDULES - MAJOR PROJECTS

PART 1- GENERAL

1.1 DESCRIPTION:

A. The Contractor shall develop a Network Analysis System (NAS) plan and schedule demonstrating fulfillment of the contract requirements, shall keep the network up-to-date in accordance with the requirements of this section and shall utilize the plan for scheduling, coordinating and monitoring work under this contract (including all activities of subcontractors, equipment vendors and suppliers). Conventional Critical Path Method (CPM) Precedence Diagramming Method (PDM) technique will be utilized to satisfy both time and cost applications. All schedule data and reports required under this specification section shall be based upon regular total float, not relative total float schedules. The NAS submitted by the contractor, approved by the VA becomes the official project schedule of record governing schedule management, oversight and actions on the corresponding contract.

1.2 CONTRACTOR'S REPRESENTATIVE:

A. The Contractor shall designate an authorized representative in the firm who will be responsible for the preparation of the network diagram, review and report progress of the project with and to the Contracting Officer's representative.

B. The Contractor's representative shall have direct project control and complete authority to act on behalf of the Contractor in fulfilling the requirements of this specification section and such authority shall not be interrupted throughout the duration of the project.

1.3 CONTRACTOR'S CONSULTANT:

A. To prepare the network diagram, and electronic compact disk(s), which reflects the Contractor's project plan, the Contractor shall engage an independent CPM consultant who is skilled in the time and cost application of scheduling using (PDM) network techniques for construction projects, the cost of which is included in the Contractor's bid. This consultant shall not have any financial or business ties to the Contractor, and shall not be an affiliate or subsidiary company of the Contractor, and shall not be employed by an affiliate or subsidiary company of the Contractor. The consultant is expected to provide unbiased professional service to the contractor and to the VA representatives in developing and maintaining the project schedule.

B. (i) Prior to engaging a consultant, and within 10 calendar days after award of the contract, the Contractor shall submit to the Contracting Officer:

1. The name and address of the proposed consultant.
2. Sufficient information to show that the proposed consultant has the qualifications to meet the requirements specified in the preceding paragraph.
3. A list of prior construction projects, along with selected PDM network diagram samples on current projects which the proposed consultant has performed complete project scheduling services. These network diagram samples must show complete project planning for a project of similar size and scope as covered under this contract.

C. The Contracting Officer has the right to approve or disapprove employment of the proposed consultant, and will notify the Contractor of the VA decision within seven calendar days from receipt of information. In case of disapproval, the Contractor shall resubmit another consultant within 10 calendar days for renewed consideration. The Contractor must have their CPM Consultant approved prior to (i) submitting any diagram.

1.4 COMPUTER PRODUCED SCHEDULES

A. The contractor shall provide to the VA, Senior Resident Engineer and CPM Schedule Analyst, monthly computer processing of all computer-produced time/cost schedules and reports generated from monthly project updates. This monthly computer service will include: electronic file copies of up to five different reports (inclusive of all pages) available within the user defined reports of Primavera (P6) to the contracting officer’s representative; a hard copy listing of all project schedule changes, and associated data, made at the update and an electronic file of this data in Primavera (P6) batch format; and the resulting monthly updated schedule in a compressed electronic file in Primavera (P6),(PDM) format. These reports must be submitted within 10 calendar days of monthly update meeting and substantively support the contractor’s monthly payment request and the signed Look ahead report(with progress). The resident engineer shall identify the five different report formats that the contractor shall provide based upon the monthly schedule updates.

B. The contractor is responsible for the correctness and timeliness of the computer-produced reports. The Contractor is also responsible for the accurate and timely submittal (within 10 calendar days as noted above) of the updated project schedule and all CPM data necessary to produce the computer reports and payment request that is specified.

C. The VA may report errors in computer-produced reports to the Contractor’s representative within ten calendar days from receipt of reports, indicating approval or disapproval. In case of disapproval, the Contractor will reprocess the computer-produced reports and associated compact disk(s), when requested by the Contracting Officer’s representative, to correct errors which affect the payment and schedule for the project. In certain large and complex project, as determined by the Contracting Officer, this monthly reporting shall be formal submittal and approval process; meaning that the next month’s update shall not proceed without timely submittal and approval.

1.5 THE COMPLETE PROJECT NETWORK DIAGRAM SUBMITTAL

A. Within 30 calendar days (45 calendar days on projects over $50,000,000) after receipt of Notice to Proceed, the Contractor shall submit for the Contracting Officer's review; three blue line copies of the complete network diagram on sheets of paper 765 x 1070 mm (30 x 42 inches) and an electronic file in a compressed Primavera (P6), (PDM) format. The submittal shall also include three copies of a computer-produced activity/event ID schedule showing project duration; phase completion dates; and other data, including event cost. Each activity/event on the computer-produced schedule shall contain as a minimum, but not limited to, activity/event ID, description, duration, predecessor and successor relationships, trade code, area code, budget amount, manpower, early start date, early finish date, late start date, late finish date and total float. Work activity/event relationships shall be restricted to finish-to-start and start-to-start without lead or lag constraints. The lead or lag for the SS relationships may only be allowed in limited basis if justified in writing and must be approved by the Contracting Officer. Activity/event date constraints, not required by the contract, will not be accepted unless submitted to and approved by the

Contracting Officer. The contractor shall make a separate written detailed request to the Contracting Officer identifying these date constraints and secure the Contracting Officer’s written approval before incorporating them into the network diagram. The Contracting Officer’s separate approval of the network diagram shall not excuse the contractor of this requirement. Logic events (non-work) will be permitted where necessary to reflect proper logic among work events, but must have zero duration. The complete working network diagram shall reflect the Contractor's approach to scheduling the entire project. The intermediate Phasing milestones shall be clearly shown in the schedule as per the contract requirements. **The final network diagram in its original form shall reflect original contract scope of work and contain no contract changes or delays which may have been incurred during the final network diagram development period and shall reflect the entire contract duration as defined in the bid documents.** These changes/delays shall be entered at the first update after the final network diagram has been approved. The Contractor should provide their requests for time and supporting time extension analysis for contract time as a result of contract changes/delays, after this update, and in accordance with Article, ADJUSTMENT OF CONTRACT COMPLETION.

B. Within 30 calendar days after receipt of the complete project network diagram, the Contracting Officer or his representative will do one or both of the following:
   1. Notify the Contractor concerning his actions, opinions, and objections.
   2. A meeting with the Contractor at or near the job site for joint review, correction or adjustment of the proposed plan will be scheduled if required. Within 14 calendar days after the joint review, the Contractor shall revise and shall submit three hard copies of the revised network diagram, three copies of the revised computer-produced activity/event ID schedule and a revised electronic file as specified by the Contracting Officer. The revised submission will be reviewed by the Contracting Officer and, if found to be as previously agreed upon, will be approved.

C. The approved network diagram (Day 1) and the corresponding computer-produced schedule(s) shall constitute the **approved baseline schedule** until subsequently revised in accordance with the requirements of this section.

D. The Complete Project Network Diagram shall contain sufficient level of detailed work activities/events (following all requirements of item 1.7 below), to represent realistic work plan / sequence of construction and the critical path(s) to maintain the project schedule and monthly updates.

1.6 WORK ACTIVITY/EVENT COST AND TRADE RESOURCE DATA

A. The Contractor shall cost load all work activities/events except procurement activities. The cost loading shall reflect the appropriate level of effort of the work activities/events. The cumulative amount of all cost loaded work activities/events (including alternates) shall equal the total contract price. Prorate overhead, profit and general conditions on all work activities/events for the entire project length. The contractor shall generate from this information cash flow curves indicating graphically the total percentage of work activity/event dollar value scheduled to be in place on early finish, late finish. These cash flow curves will be used by the Contracting Officer to assist him in determining approval or disapproval of the cost loading. In the event of disapproval, the Contractor shall revise and resubmit in accordance with Article, THE COMPLETE PROJECT NETWORK DIAGRAM SUBMITTAL. Negative work activity/event cost data will not be acceptable, except on VA issued contract changes.

B. The Contractor shall cost load work activities/events for guarantee period services, test, balance and adjust various systems in accordance with the provisions in the FAR 52.232 – 5 (PAYMENTS UNDER FIXED-PRICE CONSTRUCTION), Article, and VAAR 852.236 - 83(PAYMENTS UNDER FIXED-PRICE CONSTRUCTION).

C. In accordance with Article PERFORMANCE OF WORK BY THE CONTRACTOR in FAR 52.236 – 1 and VAAR 852.236 - 72, the Contractor shall submit, simultaneously with the cost per work activity/event of the construction schedule required by this Section, a responsibility code for all activities/events of the project for which the Contractor's forces will perform the work. This shall be the basis for the “Resource loading” of the schedule and the contractor shall provide **“Manpower loading” reports by trades and the overall Trade manpower requirements**, when requested by the contracting officer or his/her representatives.

D. NOT USED

E. The Contractor shall cost load work activities/events for all BID ITEMS. The sum of the cost loading for each bid item work activities/events shall equal the value of the item in the Contractors' bid.

F. Work activities/events for Contractor bond shall have a trade code and area code of BOND.

1.7 NETWORK DIAGRAM REQUIREMENTS

A. Show on the network diagram the sequence and interdependence of work activities/events required for complete performance of all items of work. In preparing the network diagram, the Contractor shall:

1. **Exercise sufficient care to produce a clear, legible and accurate network diagram, refer to the construction document(CD)drawing, CPM-1(Sample CPM Network). Computer plotted network diagrams shall legibly display and plot all information required by the VA CPM activity/event legend, otherwise the computer plotted network diagram will not be accepted. If the computer plotted network diagram is not found acceptable by the contracting officer's representative, then the network diagram will need to be hand drafted and meet legibility requirements. The contracting officer also require that the Day 1 network logic diagram (in its pure logic format and not the P6 drawn network schedule or PERT) shall be electronically transmitted to the VA. Group activities related to specific physical areas of the project, on the network diagram for ease of understanding and simplification. Provide a key plan on each network diagram sheet showing the project area associated with the work activities/events shown on that sheet.**
2. Show the following on each work activity/event:
   a. Activity/Event ID number.
   b. Concise description of the work represented by the activity/event. (35 characters or less including spaces preferred).
   c. Performance responsibility or trade code (five alpha characters or less): GEN, MECH, ELEC, CARP, PLAST, or other acceptable abbreviations.
   d. Duration (in work days.)
   e. Cost (in accordance with Article, ACTIVITY/EVENT COST DATA of this section and less than $9,999,999 per activity).

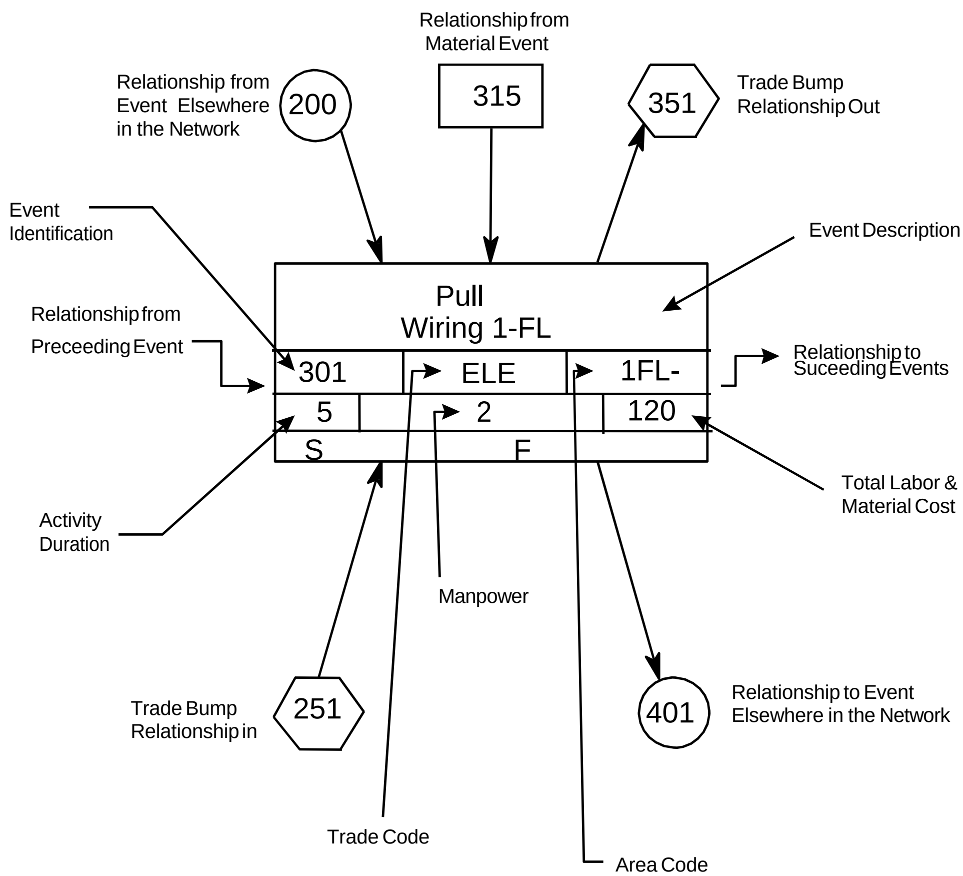
f. Work location or area code (five characters or less), descriptive of the area involved.

g. **Manpower required** (average number of men per day). Load manpower for each and every activity with proper trade codes in the “resource” field of P6 for ease of generating individual Trade and overall manpower profile required to plan and complete the project.

h. The SYMBOL LEGEND format shown below and on the drawing, CPM-1 (Sample CPM Network) is mandatory and shall be followed in preparing final network diagrams.

SYMBOL LEGEND

Show Network Diagram page number location(s) for all incoming/outgoing node connector(s).



3. Show activities/events as:

a. Contractor's time required for submittal of shop drawings, templates, fabrication, delivery and similar pre-construction work.

b. Contracting Officer's and Architect-Engineer's review and approval of shop drawings, equipment schedules, samples, template, or similar items.
c. Interruption of VA Medical Center utilities and rough-in drawings, project phasing and any other specification requirements.
d. All significant VC (VA furnished and Contractor installed) and VV (VA furnished and VA installed) equipment shall be clearly shown in the NAS Day 1 diagram. Any smaller VC and VV Equipment shall also be logically grouped together and shown in the NAS diagram and the schedule.
e. Test, balance and adjust various systems and pieces of equipment, maintenance and operation manuals, instructions and preventive maintenance tasks.
f. **Commissioning Activities** – Based upon the project specific Commissioning plan and the specification section 01 91 00, the contractor shall include in the **Day 1 CPM Diagram all the systems commissioning activities (see systems covered in Division 7, 8, 21, 22, 23, 26, 28, 31 and others as specified)** such as start up, Pre-functional check list, Pre –test, individual component and system level Functional test, Operator’s training, O.& M. Manuals etc.(including any deficiency correction and re-testing). **The majority of commissioning activities should be completed as part of the normal construction schedule and finalized prior to the construction contract completion date.** To this end, it is imperative that the Commissioning Agent and the Contractor collaborate to integrate commissioning activities into the Contractor’s overall construction schedule. All commissioning activities shall be cost loaded as required in the earlier paragraphs.

   The Commissioning Plan will identify critical commissioning activities and associated construction/start up tasks that must precede these activities to allow for successful execution of the commissioning activities. In order to coordinate these activities with the construction schedule, a **Commissioning Duration Schedule s**hould be provided by the Commissioning Agent to the VA RE and the Contractor to provide a rational basis for integration of commissioning into the Day 1 diagram and the construction schedule. The Commissioning Duration Schedule should include the following information:

1. Description of Commissioning Activity
2. Prerequisite Construction Tasks Required to Execute the Cx Activity
3. Elapsed Time Duration of Each Activity
4. Documentation Associated with Each Task/Document Responsibility

Once the duration schedule is delivered to the Contractor, the Commissioning Agent will collaborate with the Contractor to integrate all commissioning activities into the fixed duration construction schedule in accordance with VA NAS requirements for scheduling the project.

h. NOT USED

i. NOT USED

4. Show not only the activities/events for actual construction work for each trade category of the project, but also trade relationships to indicate the movement of trades from one area, floor, or building, to another area, floor, or building, for at least five trades who are performing major work under this contract.
5. Break up the work into activities/events of duration no longer than **20 work days** each, except as to non-construction activities/events (i.e., procurement of materials, delivery of equipment, concrete and asphalt curing) and any other activities/events for which the Contracting Officer may approve the showing of a longer duration. The duration for VA approval of any required submittal, shop drawing, or other submittals shall not be less than 20 work days. Refer to drawing CPM-1 for VA approval activities/events which will require minimum duration longer than 20 workdays. The construction time as determined by the CPM schedule from early start to late

finish for any sub-phase, phase or the entire project shall not exceed the contract time(s) specified or shown.

6. Describe work activities/events clearly, so the work is readily identifiable with clear scope for assessment of completion. Activities/events labeled "start," "continue," or "completion," are not specific and will not be allowed. Lead and lag time activities will not be acceptable, except when justified and must be approved in writing by the Contracting Officer.
7. Uniquely number each activity/event with numbers ranging from 1 to 99998 only. The network diagram should be generally numbered in such a way to reflect either discipline, phase or location of the work.

B. Submit the following supporting data in addition to the network diagram, activity/event ID schedule and electronic file (s). Failure of the Contractor to include this data will delay the review of the submittal until the Contracting Officer is in receipt of the missing data:
   1. The proposed number of working days per week.
   2. The holidays to be observed during the life of the contract (by day, month, and year).
   3. The planned number of shifts per day.
   4. The number of hours per shift.
   5. List the major construction equipment to be used on the site, describing how each piece relates to and will be used in support of the submitted network diagram work activities/events.
   6. Provide a typed, doubled spaced description, at least one page in length, of the plan and your approach to constructing the project.

C. To the extent that the network diagram or any revised network diagram shows anything not jointly agreed upon, it shall not be deemed to have been approved by the Contracting Officer. Failure to include any element of work required for the performance of this contract shall not excuse the Contractor from completing all work required within any applicable completion date of each phase regardless of the Contracting Officer's approval of the network diagram.

D. Compact Disk Requirements and CPM Activity/Event Record Specifications: Submit to the VA (Senior Resident Engineer and CPM Schedule Analyst) an electronic file(s) containing one file of the data required to produce a Primavera (P3 or P6), (PDM) produced schedule, reflecting all the activities/events of the complete project network diagram being submitted.

1.8 PAYMENT TO THE CONTRACTOR:

A. Monthly, the contractor shall submit the AIA application and certificate for payment documents G702 & G703 reflecting updated schedule activities and cost data in accordance with the provisions of the following Article, PAYMENT AND PROGRESS REPORTING, as the basis upon which progress payments will be made pursuant to Article FAR 52.232 – 5 (PAYMENTS UNDER FIXED-PRICE CONSTRUCTION), and VAAR 852.236 - 83(PAYMENTS UNDER FIXED-PRICE CONSTRUCTION). The Contractor is entitled to a monthly progress payment upon approval of estimates as determined from the currently approved updated computer-produced calendar-dated schedule unless, in special situations, the Contracting Officer permits an exception to this requirement. All manual payments prior to the approval of the Day 1 diagram and the baseline schedule shall use the activities from the schedule under development or any other schedule of values as approved by the contracting officer or his/her representative. Monthly payment requests shall include: one hard and electronic copies of up to five different reports (inclusive of all pages) available within the user defined reports of Primavera (P6), (PDM) to the contracting officer’s representatives; a listing of **all project schedule changes and associated data,** made at the update; and an electronic file(s) of the resulting monthly updated schedule in a compressed Primavera (P6), (PDM) format. These must be submitted with and substantively support the contractor’s monthly application and certificate for payment request documents.

B. When the Contractor fails or refuses to furnish to the Contracting Officer the information and the associated updated Primavera (P6), (PDM) schedule in electronic format, which, in the sole judgment of the Contracting Officer, is necessary for processing the monthly progress payment, the Contractor shall not be deemed to have provided an estimate and supporting schedule data upon which progress payment may be made.

1.9 PAYMENT AND PROGRESS REPORTING

A. **Schedule update meeting** - Monthly job site schedule update meeting shall be held on dates mutually agreed to by the Contracting Officer (or Contracting Officer's representative) and the Contractor. Contractor and his CPM consultant will be required to attend all monthly update meetings. Presence of Subcontractors during update meeting is optional unless required by the Contracting Officer (or Contracting Officer's representative). The Contractor shall update the project schedule and all other data required by this section shall be accurately filled in and completed (Pencil copy) prior to the monthly update meeting. The Contractor shall provide this information to the Contracting Officer or the VA representative in completed form **three work days** in advance of the update meeting. The contractor shall use only **approved previous month's schedule** to report progress (% complete) in "pencil copy" and shall not change this in shape or form. Logic or duration changes for future incomplete activities should be entered later and shown in the resulting reports. Job progress will be reviewed to verify:

1. Actual start and/or finish dates for updated/completed activities/events.
2. Remaining duration, required to complete each activity/event started, or scheduled to start, but not completed.
3. Logic, time and cost data for change orders (CO), and supplemental agreements (SA) that are to be incorporated into the network diagram and computer-produced schedule. **Submit "Fragnets" for each CO and SA for VA approval prior to monthly parallel run.** Changes in activity/event sequence and duration should be made pursuant to the provisions of following Article, ADJUSTMENT OF CONTRACT COMPLETION.
4. Percentage for completed and partially completed activities/events.
5. Logic and duration revisions required by this section of the specifications, particularly if the Day 1 logic / sequence have changed significantly, which could potentially alter or impact the critical path of the schedule. **Highlight and request VA approval prior to making any logic, durations, manpower and cost loading changes.**
6. Activity/event duration and percent complete **shall be updated independently, meaning that the Remaining Durations (RD) shall be reviewed for all "in-progress" activities and entered manually based on remaining work content, and shall not be left to "auto-calculate" by the software.**

B. **Schedule Narrative** - The Contractor, in addition to the 5 schedule reports noted earlier, shall submit a narrative report as a part of his monthly update reporting prepared after the update meeting, in a form agreed upon by the Contractor and the Contracting Officer. The narrative report shall include, at a minimum, a description of major problem areas; current and anticipated delaying factors and their estimated impact on performance of other activities/events and completion dates; and an explanation of corrective action being taken or proposed. This monthly schedule narrative should also briefly discuss the potential schedule risks / mitigation effort, as required by the item 1.13 below. This report is in addition to the daily reports pursuant to the provisions of Article, DAILY REPORT OF WORKERS AND MATERIALS in the GENERAL CONDITIONS.

C. After completion of the joint review and the Contracting Officer's approval of all entries, the contractor will generate an updated computer-produced calendar-dated schedule and submit to the contracting Officer’s representative with reports in accordance with the Article, COMPUTER PRODUCED SCHEDULES, specified. **These reports shall be submitted within 10 calendar days after the monthly update meeting to the SRE and the VA CPM analyst simultaneously via electronic media, as noted earlier.**

D. **Parallel Runs / Time Impact Analysis -** After completing the monthly schedule update, the contractor’s CPM consultant shall rerun all current period contract change(s) as a batch against the prior approved monthly project schedule with the approved “Fragnet” (Fragments of network or sub-network) logic and durations. The analysis shall only include original workday durations and schedule logic agreed upon by the contractor and the SRE for the contract change(s), and preferably shall be submitted as a part of the C.O. proposal and before any physical C.O. work is performed. **Fragnet logic shall include only relevant procurement and physical C.O. work activities, and shall not include any RFI (Request For Information) or non-work activities time.** Note: If timely resolution of the RFI is potentially impacting the contract schedule, in contractor’s opinion, the contractor must provide tangible proof and immediately submit in writing to the Contracting Officer’s review. When there is a disagreement on logic and/or durations, the **consultant shall use the schedule logic and/or durations provided and approved by the SRE.** The contractor must also allocate cost and average manpower loading to each CO or SA fragnet activities as required by the section 1.7 – Network Diagram Requirements. Note: Insertion of any CO or SA activities into the CPM database with faulty logic ties like NTP (predecessor) and Project complete (successor) and zero (0)duration will not be accepted. The proper “Fragnet” logic and durations must be used as approved by the SRE, tied to the related physical work area of the schedule. After each rerun update, the resulting electronic project schedule data file shall be appropriately identified and submitted to the VA **SRE and the CPM Analyst** in accordance to the requirements listed in articles 1.4 and 1.7. This electronic submission is separate from the regular monthly project schedule reports requirements and shall be submitted to the SRE within fourteen (14) calendar days of completing the regular schedule update meeting. **Before inserting the contract changes durations, care must be taken to ensure that only the original durations of the change will be used for the analysis, not the reported durations (as-built) after the progress. In addition, once the final network diagram is approved, the contractor must recreate all manual progress payment updates on this approved network diagram and associated reruns for contract changes in each of these update periods as outlined above for regular update periods. This will require detailed record keeping for each of the manual progress payment updates.**

E. After VA acceptance and approval of the final network diagram and the schedule, and after each monthly update, the contractor shall submit to the Contracting Officer electronic copies of a revised complete network diagram showing all completed and partially completed activities/events, **contract changes and logic changes** made on the intervening updates or at the first update on the final diagram. The Contracting Officer may elect to have the contractor do this on a less frequent basis, but it shall be done **when requested by the Contracting Officer.**

F. **Schedule Coordination/ Progress review meeting** - Following approval of the CPM schedule updates, the VA, the General Contractor, its approved CPM Consultant, RE office representatives, and all subcontractors needed, as determined by the SRE, shall meet to discuss the monthly updated schedule. The main emphasis shall be to address work activities to avoid slippages of project schedule and to identify any necessary corrective actions required to maintain project schedule during the reporting period. The

Government representatives and the Contractor should conclude the meeting with a **clear understanding of those work and administrative actions necessary to maintain project schedule** status during the reporting period. This schedule coordination meeting shall be chaired by the VA SRE and will occur after each monthly project schedule update meeting utilizing the resulting schedule reports from the previous schedule update. If the project is behind schedule, discussions should concentrate on ways to prevent further slippage as well as ways to improve the project schedule status, as appropriate. Furthermore, the critical Change Orders that impact the contract schedule, the contractor **must include a reasonable “work-around” plan or re-planning effort** (submit narrative) including revised logic sequence for the downstream base contract work, durations adjustments and crew re-allocation from less critical to the new critical path areas, without adversely impacting the change order cost to the government **to minimize the impact of the time delay**. This should not be implied as a direction to accelerate the schedule, rather reasonable mitigation effort within the current work plan.

1.10 RESPONSIBILITY FOR COMPLETION

A. Whenever it becomes apparent from the current monthly progress review meeting or the monthly computer-produced calendar-dated schedule that phasing or contract completion dates will not be met, the Contractor shall execute some or all of the following remedial actions:
   1. Increase construction manpower in such quantities and crafts as necessary to eliminate the backlog of work.
   2. Increase the number of working hours per shift, shifts per working day, working days per week, the amount of construction equipment, or any combination of the foregoing to eliminate the backlog of work.
   3. Reschedule the work in conformance with the specification requirements.

B. Prior to proceeding with any of the above actions, the Contractor shall notify and obtain approval from the Contracting Officer for the proposed schedule changes. If such actions are approved, the CPM revisions shall be incorporated by the Contractor into the network diagram before the next update, at no additional cost to the Government.

1.11 CHANGES TO NETWORK DIAGRAM AND SCHEDULE

A. Within 30 calendar days after VA acceptance and approval of any updated computer-produced schedule, the Contractor will submit a revised network diagram, the associated compact disk(s), and a list of any activity/event changes including predecessors and successors for any of the following reasons:

1. Delay in completion of any activity/event or group of activities/events; indicate an extension of the project completion by 20 working days or 10 percent of the remaining project duration, whichever is less. Such delays which may be involved with contract changes, strikes, unusual weather, and other delays will not relieve the Contractor from the requirements specified unless the conditions are shown on the CPM as the direct cause for delaying the project beyond the acceptable limits.
2. Delays in submittals, or deliveries, or work stoppage are encountered which make rescheduling of the work necessary.
3. The schedule does not represent the actual prosecution and progress of the project.
4. When there is, or has been, a substantial revision to the activity/event costs of the network diagram regardless of the cause for these revisions.

B. CPM revisions made under this paragraph which affect the previously approved computer-produced schedules for vacating of areas by the VA Medical Center, contract phase(s) and sub phase(s), utilities furnished by the Government to the Contractor, or any other previously contracted item, must be furnished in writing to the Contracting Officer for approval.

C. Contracting Officer's approval for the revised network diagram and all relevant data is contingent upon compliance with all other paragraphs of this section and any other previous agreements by the Contracting Officer or the VA representative.

D. The cost of revisions to the network diagram resulting from contract changes will be included in the proposal for changes in work as specified in Article, FAR 52.243 -4 (CHANGES), VAAR 852.236 – 88 (CHANGES – SUPPLEMENTS), and will be based on the complexity of the revision or contract change, man hours expended in analyzing the change, and the total cost of the change.

E. The cost of revisions to the network diagram not resulting from contract changes is the responsibility of the Contractor.

1.12 ADJUSTMENT OF CONTRACT COMPLETION

A. The contract completion time will be adjusted only for causes specified in this contract. Request for an extension of the contract completion date by the Contractor shall be submitted within reasonable time frame (within 1 month of the issuance of the Change order or Supplemental Agreement) and must be supported with a justification, CPM data and supporting evidence as the Contracting Officer may deem necessary for determination as to whether or not the Contractor is entitled to an extension of time under the provisions of the contract. Submission of proof based on revised activity/event logic, durations (in work days) and costs is obligatory to any approvals. The schedule must clearly display that the Contractor has used, in full, all the float time available for the work involved in this request. The Contracting Officer's determination as to the total number of days of contract extension will be based upon the current computer-produced calendar-dated schedule for the time period in question and all other relevant information.

B. Actual delays in activities/events which, according to the computer-produced calendar-dated schedule, do not affect the original or extended contract completion dates shown by the critical path in the network, will not be the basis for a change to the contract completion date. The Contracting Officer will within a reasonable time after receipt of such justification and supporting evidence, review the facts and advise the Contractor in writing of the Contracting Officer's decision. The burden of proof to request the time extension is the sole responsibility of the contractor, and the contractor is required to revise the Time analysis or provide further documentation when requested by the Contracting Officer.

C. The Contractor shall submit each request for a change in the contract completion date to the Contracting Officer in accordance with the provisions specified under Article, FAR 52.243 -4 (CHANGES), VAAR 852.236 – 88 (CHANGES – SUPPLEMENTS). The Contractor shall include, as a part of each change order proposal, a sequence of activities showing all CPM logic revisions (Fragnets), duration (in work days) changes, and cost changes, manpower loading for work in question and its relationship to other activities on the approved network diagram.

D. All delays due to non-work activities/events such as RFI’s, WEATHER, STRIKES, and similar non-work activities/events shall be analyzed on a month by month basis. Any weather related delays claimed by the contractor must be “above and beyond” the “normal weather” pattern (10 year average) and shall be supported by the data shown in the National Oceanic and Atmospheric Administration (NOAA) for the region of the country where the project site is located. The weather delay analysis shall be submitted to the VA within 30 calendar days after the weather event has passed.

1.13 Construction Schedule Risk Analysis / Mitigation Plan

A. **Schedule Risk Analysis** – The contractor shall conduct the statistical schedule risk analysis based on the above detailed construction activities in the Day 1 approved diagram, identifying major schedule risk areas and recommended risk mitigation plans as outlined below.

B. The risk analysis shall be conducted by a person or firm skilled in the statistical method of schedule risk analysis based on the (PDM) network techniques for major construction projects, preferably in the major health care related projects. The cost of this service shall be included in the Contractor's proposal.

C. The Contracting Officer has the right to approve or disapprove the Person or firm designated to perform the risk analysis.

1.14 Risk Analysis Format / Requirements / Submittals

A. **Risk Analysis Software / Format** - Within 45 calendar days (60 calendar days on projects over $50,000,000) after receipt of Notice to Proceed, the Contractor shall submit for the Contracting Officer's review; a qualification of a consultant or a representative to perform Risk Analysis, a software to be utilized, the method of performing the analysis, the format of presenting the data and the reports for VA approval.

B. **Conduct Risk Analysis / Submittals - Based on the approved software / format, the consultant shall** perform statistical risk analysis on the detailed approved Day 1 diagram and the baseline schedule. The contractor shall review and utilize any previous Risk analysis performed by the A/E of record based on the “semi-detailed” (yet at an overall level) construction logic and schedule to ensure the continuity of previous schedule risk analysis. The contractor’s project manager and Superintendent shall identify the major schedule risk areas and possible risk mitigation strategy/plan and record it in a narrative format, with **electronic file submission** to the VA. **The risk analysis exercise shall be performed or updated at least on a quarterly basis or as directed by the VA Contracting officer.**

C. The submittal shall include three copies of a computer-produced risk analysis results, predicting the various meaningful probability curves of achieving the contract schedules. It shall also include a detailed narrative list of all major and minor potential and specific schedule and cost risk areas and impact of them on the overall project, and a contractor’s recommendations of mitigating the identified risks which must be addressed by the VA Project and Resident engineer teams to maintain the contract schedule.

D. The contractor shall, as a part of Risk monitoring, shall prepare a detailed Project Risk Register (PRR), identifying each risk items, risk assessment and its response plan. This PRR, at the discretion of the SRE and the CO, shall be discussed in a monthly risk management meeting for mitigation.

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SECTION 01 33 23
SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

1-1. Refer to Articles titled SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION (FAR 52.236-21) and, SPECIAL NOTES (VAAR 852.236-91), in GENERAL CONDITIONS.

1-2. For the purposes of this contract, samples, test reports, certificates, and manufacturers' literature and data shall also be subject to the previously referenced requirements. The following text refers to all items collectively as SUBMITTALS.

1-3. Submit for approval, all of the items specifically mentioned under the separate sections of the specification, with information sufficient to evidence full compliance with contract requirements. Materials, fabricated articles and the like to be installed in permanent work shall equal those of approved submittals. After an item has been approved, no change in brand or make will be permitted unless:

A. Satisfactory written evidence is presented to, and approved by Contracting Officer, that manufacturer cannot make scheduled delivery of approved item or;

B. Item delivered has been rejected and substitution of a suitable item is an urgent necessity or;

C. Other conditions become apparent which indicates approval of such substitute item to be in best interest of the Government.

1-4. Forward submittals in sufficient time to permit proper consideration and approval action by Government. Time submission to assure adequate lead time for procurement of contract - required items. Delays attributable to untimely and rejected submittals will not serve as a basis for extending contract time for completion.

1-5. Submittals will be reviewed for compliance with contract requirements by Architect-Engineer, and action thereon will be taken by Resident Engineer on behalf of the Contracting Officer.

1-6. Upon receipt of submittals, Architect-Engineer will assign a file number thereto. Contractor, in any subsequent correspondence, shall refer to this file and identification number to expedite replies relative to previously approved or disapproved submittals.

1-7. The Government reserves the right to require additional submittals, whether or not particularly mentioned in this contract. If additional submittals beyond those required by the contract are furnished pursuant to request therefor by Contracting Officer, adjustment in contract price and time will be made in accordance with Articles titled CHANGES (FAR 52.243-4) and CHANGES - SUPPLEMENT (VAAR 852.236-88) of the GENERAL CONDITIONS.

1-8. Schedules called for in specifications and shown on shop drawings shall be submitted for use and information of Department of Veterans Affairs and Architect-Engineer. However, the Contractor shall assume responsibility for coordinating and verifying schedules. The Contracting Officer and Architect- Engineer assumes no responsibility for checking schedules or layout drawings for exact sizes, exact numbers and detailed positioning of items.

1-9. Submittals must be submitted by Contractor only and shipped prepaid. Contracting Officer assumes no responsibility for checking quantities or exact numbers included in such submittals.

A. Submit shop drawings, schedules, manufacturers' literature and data, and certificates as two hard copy duplicates, except where a greater number is specified. Include two compact disk (CD) duplicates of shop drawings, schedules, manufacturer’s literature and data, and certificates. Include an emailed electronic PDF of shop drawings, schedules, manufacturer’s literature and data, and certificates with transmittal letter as indicated in 1.9B.

B. Submittals will receive consideration only when covered by a transmittal letter signed by Contractor. Letter shall be sent via first class mail, electronic PDF, and shall contain the list of items, name of Medical Center, name of Contractor, contract number, applicable specification paragraph numbers, applicable drawing numbers (and other information required for exact identification of location for each item), manufacturer and brand, ASTM or Federal Specification Number (if any) and such additional information as may be required by specifications for particular item being furnished. In addition, catalogs shall be marked to indicate specific items submitted for approval.

1. A copy of letter must be enclosed with items, and any items received without identification letter will be considered "unclaimed goods" and held for a limited time only.
2. Each certificate, manufacturers' literature and data shall be labeled to indicate the name and location of the Medical Center, name of Contractor, manufacturer, brand, contract number and ASTM or Federal Specification Number as applicable and location(s) on project.
3. Required certificates shall be signed by an authorized representative of manufacturer or supplier of material, and by Contractor.

C. NOT USED

D. Not Used

E. Not used

F. Submittal drawings (shop, erection or setting drawings) and schedules, required for work of various trades, shall be checked before submission by technically qualified employees of Contractor for accuracy, completeness and compliance with contract requirements. These drawings and schedules shall be stamped and signed by Contractor certifying to such check.

1. For each drawing required, submit two legible paper reproducibles. Include one electronic PDF copy emailed to A/E.
2. Reproducible shall be full size.
3. Each drawing shall have marked thereon, proper descriptive title, including Medical Center location, project number, manufacturer's number, reference to contract drawing number, detail Section Number, and Specification Section Number.
4. A space 120 mm by 125 mm (4-3/4 by 5 inches) shall be reserved on each drawing to accommodate approval or disapproval stamp.
5. Submit drawings, ROLLED WITHIN A MAILING TUBE, fully protected for shipment.
6. One reproducible print of approved or disapproved shop drawings will be forwarded to Contractor.
7. When work is directly related and involves more than one trade, shop drawings shall be submitted to the Resident Engineer under one cover.

1-10. Shop drawings, test reports, certificates and manufacturers' literature and data, shall be submitted for approval to the Resident Engineer. The Resident Engineer will submit to the Architect-Engineer for approval.

1-12. NOT USED

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SECTION 01 35 26
SAFETY REQUIREMENTS

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SECTION 01 35 26
SAFETY REQUIREMENTS

1.1 APPLICABLE PUBLICATIONS:

A. Latest publications listed below form part of this Article to extent referenced. Publications are referenced in text by basic designations only.

B. American Society of Safety Engineers (ASSE):

A10.1-2011...........Pre-Project & Pre-Task Safety and Health Planning

A10.34-2012..........Protection of the Public on or Adjacent to Construction Sites

A10.38-2013..........Basic Elements of an Employer's Program to Provide a Safe and Healthful Work Environment American National Standard Construction and Demolition Operations

C. American Society for Testing and Materials (ASTM):

E84-2013.............Surface Burning Characteristics of Building Materials

D. The Facilities Guidelines Institute (FGI):

FGI Guidelines-2010Guidelines for Design and Construction of Healthcare Facilities

E. National Fire Protection Association (NFPA):

10-2013..............Standard for Portable Fire Extinguishers

30-2012..............Flammable and Combustible Liquids Code

51B-2014.............Standard for Fire Prevention During Welding, Cutting and Other Hot Work

70-2014..............National Electrical Code

70B-2013.............Recommended Practice for Electrical Equipment Maintenance

70E-2012 ....Standard for Electrical Safety in the Workplace

99-2012..............Health Care Facilities Code

241-2013.............Standard for Safeguarding Construction, Alteration, and Demolition Operations

F. The Joint Commission (TJC)

TJC Manual ....Comprehensive Accreditation and Certification Manual

G. U.S. Nuclear Regulatory Commission

10 CFR 20 ....Standards for Protection Against Radiation

H. U.S. Occupational Safety and Health Administration (OSHA):

29 CFR 1904 ....Reporting and Recording Injuries & Illnesses

29 CFR 1910 ....Safety and Health Regulations for General Industry

29 CFR 1926 ....Safety and Health Regulations for Construction Industry

CPL 2-0.124..........Multi-Employer Citation Policy

I. VHA Directive 2005-007

1.2 DEFINITIONS:

A. OSHA “Competent Person” (CP). One who is capable of identifying existing and predictable hazards in the surroundings and working conditions which are unsanitary, hazardous or dangerous to employees, and who has the authorization to take prompt corrective measures to eliminate them (see 29 CFR 1926.32(f)).

B. "Qualified Person" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

C. High Visibility Accident is any mishap which may generate publicity or high visibility.

D. Medical Treatment. Treatment administered by a physician or by registered professional personnel under the standing orders of a physician. Medical treatment does not include first aid treatment even through provided by a physician or registered personnel.

E. Recordable Injuries or Illnesses. Any work-related injury or illness that results in:

1. Death, regardless of the time between the injury and death, or the length of the illness;
2. Days away from work (any time lost after day of injury/illness onset);
3. Restricted work;
4. Transfer to another job;
5. Medical treatment beyond first aid;
6. Loss of consciousness; or
7. A significant injury or illness diagnosed by a physician or other licensed health care professional, even if it did not result in (1) through (6) above.

1.3 REGULATORY REQUIREMENTS:

A. In addition to the detailed requirements included in the provisions of this contract, comply with 29 CFR 1926, comply with 29 CFR 1910 as incorporated by reference within 29 CFR 1926, comply with ASSE A10.34, and all applicable [federal, state, and local] laws, ordinances, criteria, rules and regulations. Submit matters of interpretation of standards for resolution before starting work. Where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements govern except with specific approval and acceptance by the Resident Engineer/Project Manager and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority.

1.4 ACCIDENT PREVENTION PLAN (APP):

A. The APP (aka Construction Safety & Health Plan) shall interface with the Contractor's overall safety and health program. Include any portions of the Contractor's overall safety and health program referenced in the APP in the applicable APP element and ensure it is site-specific. The Government considers the Prime Contractor to be the "controlling authority" for all worksite safety and health of each subcontractor(s). Contractors are responsible for informing their subcontractors of the safety provisions under the terms of the contract and the penalties for noncompliance, coordinating the work to prevent one craft from interfering with or creating hazardous working conditions for other crafts, and inspecting subcontractor operations to ensure that accident prevention responsibilities are being carried out.

B. The APP shall be prepared as follows:

1. Written in English by a qualified person who is employed by the Prime Contractor articulating the specific work and hazards pertaining to the contract (model language can be found in ASSE A10.33). Specifically articulating the safety requirements found within these VA contract safety specifications.

2. Address both the Prime Contractors and the subcontractors work operations.

3. State measures to be taken to control hazards associated with materials, services, or equipment provided by suppliers.

4. Address all the elements/sub-elements and in order as follows:

a. **SIGNATURE SHEET.** Title, signature, and phone number of the following:

1) Plan preparer (Qualified Person such as corporate safety staff person or contracted Certified Safety Professional with construction safety experience);

2) Plan approver (company/corporate officers authorized to obligate the company);

3) Plan concurrence (e.g., Chief of Operations, Corporate Chief of Safety, Corporate Industrial Hygienist, project manager or superintendent, project safety professional). Provide concurrence of other applicable corporate and project personnel (Contractor).

b. **BACKGROUND INFORMATION**. List the following:

1) Contractor;

2) Contract number;

3) Project name;

4) Brief project description, description of work to be performed, and location; phases of work anticipated (these will require an AHA).

c. **STATEMENT OF SAFETY AND HEALTH POLICY.** Provide a copy of current corporate/company Safety and Health Policy Statement, detailing commitment to providing a safe and healthful workplace for all employees. The Contractor’s written safety program goals, objectives, and accident experience goals for this contract should be provided.

d. **RESPONSIBILITIES AND LINES OF AUTHORITIES.** Provide the following:

1) A statement of the employer’s ultimate responsibility for the implementation of his SOH program;

2) Identification and accountability of personnel responsible for safety at both corporate and project level. Contracts specifically requiring safety or industrial hygiene personnel shall include a copy of their resumes.

3) The names of Competent and/or Qualified Person(s) and proof of competency/qualification to meet specific OSHA Competent/Qualified Person(s) requirements must be attached.;

4) Requirements that no work shall be performed unless a designated competent person is present on the job site;

5) Requirements for pre-task Activity Hazard Analysis (AHAs);

6) Lines of authority;

7) Policies and procedures regarding noncompliance with safety requirements (to include disciplinary actions for violation of safety requirements) should be identified;

e. **SUBCONTRACTORS AND SUPPLIERS.** If applicable, provide procedures for coordinating SOH activities with other employers on the job site:

1) Identification of subcontractors and suppliers (if known);

2) Safety responsibilities of subcontractors and suppliers.

f. **TRAINING.**

1) Site-specific SOH orientation training at the time of initial hire or assignment to the project for every employee before working on the project site is required.

2) Mandatory training and certifications that are applicable to this project (e.g., explosive actuated tools, crane operator, rigger, crane signal person, fall protection, electrical lockout/NFPA 70E, machine/equipment lockout, confined space, etc…) and any requirements for periodic retraining/recertification are required.

3) Procedures for ongoing safety and health training for supervisors and employees shall be established to address changes in site hazards/conditions.

4) OSHA 10-hour training is required for all workers on site and the OSHA 30-hour training is required for Trade Competent Persons (CPs)

g. SAFETY AND HEALTH INSPECTIONS.

1) Specific assignment of responsibilities for a minimum daily job site safety and health inspection during periods of work activity: Who will conduct (e.g., “Site Safety and Health CP”), proof of inspector’s training/qualifications, when inspections will be conducted, procedures for documentation, deficiency tracking system, and follow-up procedures.

2) Any external inspections/certifications that may be required (e.g., contracted CSP or CSHT)

h. ACCIDENT INVESTIGATION & REPORTING. The Contractor shall conduct mishap investigations of all OSHA Recordable Incidents. The APP shall include accident/incident investigation procedure & identify person(s) responsible to provide the following to the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority:

1) Exposure data (man-hours worked);

2) Accident investigations, reports, and logs.

i. PLANS (PROGRAMS, PROCEDURES) REQUIRED. Based on a risk assessment of contracted activities and on mandatory OSHA compliance programs, the Contractor shall address all applicable occupational risks in site-specific compliance and accident prevention plans. These Plans shall include but are not be limited to procedures for addressing the risks associates with the following:

1) Emergency response;

2) Contingency for severe weather;

3) Fire Prevention;

4) Medical Support;

5) Posting of emergency telephone numbers;

6) Prevention of alcohol and drug abuse;

7) Site sanitation (housekeeping, drinking water, toilets);

8) Night operations and lighting;

9) Hazard communication program;

10) Welding/Cutting “Hot” work;

11) Electrical Safe Work Practices (Electrical LOTO/NFPA 70E);

12) General Electrical Safety

13) Hazardous energy control (Machine LOTO);

14) Site-Specific Fall Protection & Prevention;

15) Excavation/trenching;

16) Asbestos abatement;

17) Lead abatement;

18) Crane Critical lift;

19) Respiratory protection;

20) Health hazard control program;

21) Radiation Safety Program;

22) Abrasive blasting;

23) Heat/Cold Stress Monitoring;

24) Crystalline Silica Monitoring (Assessment);

25) Demolition plan (to include engineering survey);

26) Formwork and shoring erection and removal;

27) PreCast Concrete.

C. Submit the APP to the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES 15 calendar days prior to the date of the preconstruction conference for acceptance. Work cannot proceed without an accepted APP.

D. Once accepted by the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority, the APP and attachments will be enforced as part of the contract. Disregarding the provisions of this contract or the accepted APP will be cause for stopping of work, at the discretion of the Contracting Officer, until the matter has been rectified.

E. Once work begins, changes to the accepted APP shall be made with the knowledge and concurrence of the Resident Engineer project superintendent, project overall designated OSHA Competent Person, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority. Should any severe hazard exposure, i.e. imminent danger, become evident, stop work in the area, secure the area, and develop a plan to remove the exposure and control the hazard. Notify the Contracting Officer within 24 hours of discovery. Eliminate/remove the hazard. In the interim, take all necessary action to restore and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public (as defined by ASSE/SAFE A10.34) and the environment.

1.5 ACTIVITY HAZARD ANALYSES (AHAS):

A. AHAs are also known as Job Hazard Analyses, Job Safety Analyses, and Activity Safety Analyses. Before beginning each work activity involving a type of work presenting hazards not experienced in previous project operations or where a new work crew or sub-contractor is to perform the work, the Contractor(s) performing that work activity shall prepare an AHA (Example electronic AHA forms can be found on the US Army Corps of Engineers web site)

B. AHAs shall define the activities being performed and identify the work sequences, the specific anticipated hazards, site conditions, equipment, materials, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level of risk.

C. Work shall not begin until the AHA for the work activity has been accepted by the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authorityand discussed with all engaged in the activity, including the Contractor, subcontractor(s), and Government on-site representatives at preparatory and initial control phase meetings.

1. The names of the Competent/Qualified Person(s) required for a particular activity (for example, excavations, scaffolding, fall protection, other activities as specified by OSHA and/or other State and Local agencies) shall be identified and included in the AHA. Certification of their competency/qualification shall be submitted to the Government Designated Authority (GDA) for acceptance prior to the start of that work activity.

2. The AHA shall be reviewed and modified as necessary to address changing site conditions, operations, or change of competent/qualified person(s).

   a. If more than one Competent/Qualified Person is used on the AHA activity, a list of names shall be submitted as an attachment to the AHA. Those listed must be Competent/Qualified for the type of work involved in the AHA and familiar with current site safety issues.

   b. If a new Competent/Qualified Person (not on the original list) is added, the list shall be updated (an administrative action not requiring an updated AHA). The new person shall acknowledge in writing that he or she has reviewed the AHA and is familiar with current site safety issues.

3. Submit AHAs to the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES for review at least 15 calendar days prior to the start of each phase. Subsequent

AHAs as shall be formatted as amendments to the APP. The analysis should be used during daily inspections to ensure the implementation and effectiveness of the activity's safety and health controls.

4. The AHA list will be reviewed periodically (at least monthly) at the Contractor supervisory safety meeting and updated as necessary when procedures, scheduling, or hazards change.

5. Develop the activity hazard analyses using the project schedule as the basis for the activities performed. All activities listed on the project schedule will require an AHA. The AHAs will be developed by the contractor, supplier, or subcontractor and provided to the prime contractor for review and approval and then submitted to the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority.

1.6 PRECONSTRUCTION CONFERENCE:

A. Contractor representatives who have a responsibility or significant role in implementation of the accident prevention program, as required by 29 CFR 1926.20(b)(1), on the project shall attend the preconstruction conference to gain a mutual understanding of its implementation. This includes the project superintendent, subcontractor superintendents, and any other assigned safety and health professionals.

B. Discuss the details of the submitted APP to include incorporated plans, programs, procedures and a listing of anticipated AHAs that will be developed and implemented during the performance of the contract. This list of proposed AHAs will be reviewed at the conference and an agreement will be reached between the Contractor and the Contracting Officer's representative as to which phases will require an analysis. In addition, establish a schedule for the preparation, submittal, review, and acceptance of AHAs to preclude project delays.

C. Deficiencies in the submitted APP will be brought to the attention of the Contractor within 14 days of submittal, and the Contractor shall revise the plan to correct deficiencies and re-submit it for acceptance. Do not begin work until there is an accepted APP.

1.7 “SITE SAFETY AND HEALTH OFFICER” (SSHO) AND “COMPETENT PERSON” (CP):

A. The Prime Contractor shall designate a minimum of one SSHO at each project site that will be identified as the SSHO to administer the

Contractor's safety program and government-accepted Accident Prevention Plan. Each subcontractor shall designate a minimum of one CP in compliance with 29 CFR 1926.20 (b) (2) that will be identified as a CP to administer their individual safety programs.

B. Further, all specialized Competent Persons for the work crews will be supplied by the respective contractor as required by 29 CFR 1926 (i.e. Asbestos, Electrical, Cranes, & Derricks, Demolition, Fall Protection, Fire Safety/Life Safety, Ladder, Rigging, Scaffolds, and Trenches/Excavations).

C. These Competent Persons can have collateral duties as the subcontractor's superintendent and/or work crew lead persons as well as fill more than one specialized CP role (i.e. Asbestos, Electrical, Cranes, & Derricks, Demolition, Fall Protection, Fire Safety/Life Safety, Ladder, Rigging, Scaffolds, and Trenches/Excavations).

D. The SSHO or an equally-qualified Designated Representative/alternate will maintain a presence on the site during construction operations in accordance with FAR Clause 52.236-6: *Superintendence by the Contractor*. CPs will maintain presence during their construction activities in accordance with above mentioned clause. A listing of the designated SSHO and all known CPs shall be submitted prior to the start of work as part of the APP with the training documentation and/or AHA as listed in Section 1.8 below.

E. The repeated presence of uncontrolled hazards during a contractor's work operations will result in the designated CP as being deemed incompetent and result in the required removal of the employee in accordance with FAR Clause 52.236-5: Material and Workmanship, Paragraph (c).

1.8 TRAINING:

A. The designated Prime Contractor SSHO must meet the requirements of all applicable OSHA standards and be capable (through training, experience, and qualifications) of ensuring that the requirements of 29 CFR 1926.16 and other appropriate Federal, State and local requirements are met for the project. As a minimum the SSHO must have completed the OSHA 30-hour Construction Safety class and have five (5) years of construction industry safety experience or three (3) years if he/she possesses a Certified Safety Professional (CSP) or certified Construction Safety and Health Technician (CSHT) certification or have a safety and health degree from an accredited university or college.

B. All designated CPs shall have completed the OSHA 30-hour Construction Safety course within the past 5 years.

C. In addition to the OSHA 30 Hour Construction Safety Course, all CPs with high hazard work operations such as operations involving asbestos, electrical, cranes, demolition, work at heights/fall protection, fire safety/life safety, ladder, rigging, scaffolds, and trenches/excavations shall have a specialized formal course in the hazard recognition & control associated with those high hazard work operations. Documented “repeat” deficiencies in the execution of safety requirements will require retaking the requisite formal course.

D. All other construction workers shall have the OSHA 10-hour Construction Safety Outreach course and any necessary safety training to be able to identify hazards within their work environment.

E. Submit training records associated with the above training requirements to the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES 15 calendar days prior to the date of the preconstruction conference for acceptance.

F. Prior to any worker for the contractor or subcontractors beginning work, they shall undergo a safety briefing provided by the SSHO or his/her designated representative. As a minimum, this briefing shall include information on the site-specific hazards, construction limits, VAMC safety guidelines, means of egress, break areas, work hours, locations of restrooms, use of VAMC equipment, emergency procedures, accident reporting etc... Documentation shall be provided to the Resident Engineer that individuals have undergone contractor’s safety briefing.

G. Ongoing safety training will be accomplished in the form of weekly documented safety meeting.

1.9 INSPECTIONS:

A. The SSHO shall conduct frequent and regular safety inspections (daily) of the site and each of the subcontractors CPs shall conduct frequent and regular safety inspections (daily) of the their work operations as required by 29 CFR 1926.20(b)(2). Each week, the SSHO shall conduct a formal documented inspection of the entire construction areas with the subcontractors' "Trade Safety and Health CPs" present in their work areas. Coordinate with, and report findings and corrective actions weekly to Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority

B. A Certified Safety Professional (CSP) with specialized knowledge in construction safety or a certified Construction Safety and Health Technician (CSHT) shall randomly conduct a monthly site safety inspection. The CSP or CSHT can be a corporate safety professional or independently contracted. The CSP or CSHT will provide their certificate number on the required report for verification as necessary.

1. Results of the inspection will be documented with tracking of the identified hazards to abatement.

2. The Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority will be notified immediately prior to start of the inspection and invited to accompany the inspection.

3. Identified hazard and controls will be discussed to come to a mutual understanding to ensure abatement and prevent future reoccurrence.

4. A report of the inspection findings with status of abatement will be provided to the Resident Engineer and Facility Safety Officer and Contracting Officer Representative or Government Designated Authority within one week of the onsite inspection.

1.10 ACCIDENTS, OSHA 300 LOGS, AND MAN-HOURS:

A. Notify the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority as soon as practical, but no more than four hours after any accident meeting the definition of OSHA Recordable Injuries or Illnesses or High Visibility

Accidents, property damage equal to or greater than $5,000, or any weight handling equipment accident. Within notification include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (to include type of construction equipment used, PPE used, etc.). Preserve the conditions and evidence on the accident site until the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority determine whether a government investigation will be conducted.

B. Conduct an accident investigation for recordable injuries and illnesses, for Medical Treatment defined in paragraph DEFINITIONS, and property damage accidents resulting in at least $20,000 in damages, to establish the root cause(s) of the accident. Complete the VA Form 2162, and provide the report to the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority within 5 calendar days of the accident. The Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority will provide copies of any required or special forms.

C. A summation of all man-hours worked by the contractor and associated sub-contractors for each month will be reported to the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority monthly.

D. A summation of all OSHA recordable accidents experienced on site by the contractor and associated sub-contractors for each month will be provided to the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority monthly. The contractor and associated sub-contractors’ OSHA 300 logs will be made available to the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority as requested.

1.11 PERSONAL PROTECTIVE EQUIPMENT (PPE):

A. PPE is governed in all areas by the nature of the work the employee is performing. For example, specific PPE required for performing work on electrical equipment is identified in NFPA 70E, Standard for Electrical Safety in the Workplace.

B. Mandatory PPE includes:

1. Hard Hats – unless written authorization is given by the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority in circumstances of work operations that have limited potential for falling object hazards such as during finishing work or minor remodeling. With authorization to relax the requirement of hard hats, if a worker becomes exposed to an overhead falling object hazard, then hard hats would be required in accordance with the OSHA regulations.

2. Safety glasses - unless written authorization is given by the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority appropriate safety glasses meeting the ANSI Z.87.1 standard must be worn by each person on site.

3. Appropriate Safety Shoes – based on the hazards present, safety shoes meeting the requirements of ASTM F2413-11 shall be worn by each person on site unless written authorization is given by the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority.

4. Hearing protection - Use personal hearing protection at all times in designated noise hazardous areas or when performing noise hazardous tasks.

1.12 INFECTION CONTROL

A. Infection Control is critical in all medical center facilities. Interior construction activities causing disturbance of existing dust, or creating new dust, must be conducted within ventilation-controlled areas that minimize the flow of airborne particles into patient areas. Exterior construction activities causing disturbance of soil or creates dust in some other manner must be controlled.

B. An AHA associated with infection control will be performed by VA personnel in accordance with FGI Guidelines (i.e. Infection Control Risk Assessment (ICRA)). The ICRA procedure found on the American Society for Healthcare Engineering (ASHE) website will be utilized. Risk classifications of Class II or lower will require approval by the Resident Engineer, Facility Safety Officer and Contracting Officer Representative or Government Designated Authority before beginning any construction work. Risk classifications of Class III or higher will require a permit before beginning any construction work. Infection Control permits will be issued by the Resident Engineer or Contracting Officer Representative. The Infection Control Permits will be posted outside the appropriate construction area. More than one permit may be issued for a construction project if the work is located in separate areas requiring separate classes. The primary project scope area for this project is: Class [II}, however, work outside the primary project scope area may vary. The required infection control precautions with each class are as follows:

1. Class I requirements:

   a. During Construction Work:

      1) Notify the Resident Engineer and Facility Safety Officer or Contracting Officer Representative

      2) Execute work by methods to minimize raising dust from construction operations.

      3) Ceiling tiles: Immediately replace a ceiling tiles displaced for visual inspection.

   b. Upon Completion:

      1) Clean work area upon completion of task

      2) Notify the Resident Engineer and Facility Safety Officer or Contracting Officer Representative

2. Class II requirements:

   a. During Construction Work:

1) Notify the Resident Engineer and Facility Safety Officer or Contracting Officer Representative

2) Provide active means to prevent airborne dust from dispersing into atmosphere such as wet methods or tool mounted dust collectors where possible.

3) Water mist work surfaces to control dust while cutting.

4) Seal unused doors with duct tape.

5) Block off and seal air vents.

6) Remove or isolate HVAC system in areas where work is being performed.

b. Upon Completion:

1) Wipe work surfaces with cleaner/disinfectant.

2) Contain construction waste before transport in tightly covered containers.

3) Wet mop and/or vacuum with HEPA filtered vacuum before leaving work area.

4) Upon completion, restore HVAC system where work was performed

5) Notify the Resident Engineer and Facility Safety Officer or Contracting Officer Representative

3. Class III requirements:

a. During Construction Work:

1) Obtain permit from the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority

2) Remove or Isolate HVAC system in area where work is being done to prevent contamination of duct system.

3) Complete all critical barriers i.e. sheetrock, plywood, plastic, to seal area from non-work area or implement control cube method (cart with plastic covering and sealed connection

to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. Install construction barriers and ceiling protection carefully, outside of normal work hours.

4) Maintain negative air pressure, 0.01 inches of water gauge, within work site utilizing HEPA equipped air filtration units and continuously monitored with a digital display, recording and alarm instrument, which must be calibrated on installation, maintained with periodic calibration and monitored by the contractor.

5) Contain construction waste before transport in tightly covered containers.

6) Cover transport receptacles or carts; tape covering unless solid lid.

b. Upon Completion:

1) Do not remove barriers from work area until completed project is inspected by the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority and thoroughly cleaned by the VA Environmental Services Department.

2) Remove construction barriers and ceiling protection carefully to minimize spreading of dirt and debris associated with construction, outside of normal work hours.

3) Vacuum work area with HEPA filtered vacuums.

4) Wet mop area with cleaner/disinfectant.

5) Upon completion, restore HVAC system where work was performed.

6) Return permit to the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority

4. Class IV requirements:

a. During Construction Work:

1) Obtain permit from the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority

2) Isolate HVAC system in area where work is being done to prevent contamination of duct system.

3) Complete all critical barriers i.e. sheetrock, plywood, plastic, to seal area from non-work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. Install construction barriers and ceiling protection carefully, outside of normal work hours.

4) Maintain negative air pressure within work site utilizing HEPA equipped air filtration units.

5) Seal holes, pipes, conduits, and punctures.

6) Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave work site.

7) All personnel entering work site are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area.

b. Upon Completion:

1) Do not remove barriers from work area until completed project is inspected by the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority with thorough cleaning by the VA Environmental Services Dept.

2) Remove construction barriers and ceiling protection carefully to minimize spreading of dirt and debris associated with construction, outside of normal work hours.

3) Contain construction waste before transport in tightly covered containers.

4) Cover transport receptacles or carts; tape covering unless solid lid.

5) Vacuum work area with HEPA filtered vacuums.

6) Wet mop area with cleaner/disinfectant.

7) Upon completion, restore HVAC system where work was performed.

8) Return permit to the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority

C. Barriers shall be erected as required based upon classification (Class III & IV requires barriers) and shall be constructed as follows:

1. Class III and IV - closed door with masking tape applied over the frame and door is acceptable for projects that can be contained in a single room.

2. Construction, demolition or reconstruction not capable of containment within a single room must have the following barriers erected and made presentable on hospital occupied side:

a. Class III & IV (where dust control is the only hazard, and an agreement is reached with the Resident Engineer and Medical Center) - Airtight plastic barrier that extends from the floor to ceiling. Seams must be sealed with duct tape to prevent dust and debris from escaping

b. Class III & IV - Drywall barrier erected with joints covered or sealed to prevent dust and debris from escaping.

c. Class III & IV - Seal all penetrations in existing barrier airtight

d. Class III & IV - Barriers at penetration of ceiling envelopes, chases and ceiling spaces to stop movement air and debris

e. Class IV only - Anteroom or double entrance openings that allow workers to remove protective clothing or vacuum off existing clothing

f. Class III & IV - At elevators shafts or stairways within the field of construction, overlapping flap minimum of two feet wide of polyethylene enclosures for personnel access.

D. Products and Materials:

1. Sheet Plastic: Fire retardant polystyrene, 6-mil thickness meeting local fire codes
2. Barrier Doors: Self Closing Two-hour solid core wood in steel frame, painted
3. Dust proof two-hour drywall
4. High Efficiency Particulate Air-Equipped filtration machine rated at 95% capture of 0.3 microns including pollen, mold spores and dust particles. HEPA filters should have ASHRAE 85 or other prefilter to extend the useful life of the HEPA. Provide both primary and secondary filtrations units. Maintenance of equipment and replacement of the HEPA filters and other filters will be in accordance with manufacturer’s instructions.
5. Exhaust Hoses: Heavy duty, flexible steel reinforced; Ventilation Blower Hose
6. Adhesive Walk-off Mats: Provide minimum size mats of 24 inches x 36 inches
7. Disinfectant: Hospital-approved disinfectant or equivalent product
8. Portable Ceiling Access Module

E. Before any construction on site begins, all contractor personnel involved in the construction or renovation activity shall be educated and trained in infection prevention measures established by the medical center.

F. A dust control program will be establish and maintained as part of the contractor’s infection preventive measures in accordance with the FGI Guidelines for Design and Construction of Healthcare Facilities. Prior to start of work, prepare a plan detailing project-specific dust protection measures with associated product data, including periodic status reports, and submit to Resident Engineer and Facility CSC for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.

G. Medical center Infection Control personnel will monitor for airborne disease (e.g. aspergillosis) during construction. A baseline of conditions will be established by the medical center prior to the start of work and periodically during the construction stage to determine impact of construction activities on indoor air quality with safe thresholds established.

H. In general, the following preventive measures shall be adopted during construction to keep down dust and prevent mold.

1. Contractor shall verify that construction exhaust to exterior is not reintroduced to the medical center through intake vents, or building openings. HEPA filtration is required where the exhaust dust may reenter the medical center.

2. Exhaust hoses shall be exhausted so that dust is not reintroduced to the medical center.

3. Adhesive Walk-off/Carpet Walk-off Mats shall be used at all interior transitions from the construction area to occupied medical center area. These mats shall be changed as often as required to maintain clean work areas directly outside construction area at all times.

4. Vacuum and wet mop all transition areas from construction to the occupied medical center at the end of each workday. Vacuum shall utilize HEPA filtration. Maintain surrounding area frequently. Remove debris as it is created. Transport these outside the construction area in containers with tightly fitting lids.

5. The contractor shall not haul debris through patient-care areas without prior approval of the Resident Engineer and the Medical Center. When, approved, debris shall be hauled in enclosed dust proof containers or wrapped in plastic and sealed with duct tape. No sharp objects should be allowed to cut through the plastic. Wipe down the exterior of the containers with a damp rag to remove dust. All equipment, tools, material, etc. transported through occupied

areas shall be made free from dust and moisture by vacuuming and wipe down.

6. There shall be no standing water during construction. This includes water in equipment drip pans and open containers within the construction areas. All accidental spills must be cleaned up and dried within 12 hours. Remove and dispose of porous materials that remain damp for more than 72 hours.

7. At completion, remove construction barriers and ceiling protection carefully, outside of normal work hours. Vacuum and clean all surfaces free of dust after the removal.

I. Final Cleanup:

1. Upon completion of project, or as work progresses, remove all construction debris from above ceiling, vertical shafts and utility chases that have been part of the construction.

2. Perform HEPA vacuum cleaning of all surfaces in the construction area. This includes walls, ceilings, cabinets, furniture (built-in or free standing), partitions, flooring, etc.

3. All new air ducts shall be cleaned prior to final inspection.

J. Exterior Construction

1. Contractor shall verify that dust will not be introduced into the medical center through intake vents, or building openings. HEPA filtration on intake vents is required where dust may be introduced.

2. Dust created from disturbance of soil such as from vehicle movement will be wetted with use of a water truck as necessary

3. All cutting, drilling, grinding, sanding, or disturbance of materials shall be accomplished with tools equipped with either local exhaust ventilation (i.e. vacuum systems) or wet suppression controls.

1.13 TUBERCULOSIS SCREENING

A. Contractor shall provide written certification that all contract employees assigned to the work site have had a pre-placement tuberculin screening within 90 days prior to assignment to the worksite and been found have negative TB screening reactions. Contractors shall be required to show documentation of negative TB screening reactions for any additional workers who are added after the 90-day requirement before they will be allowed to work on the work site. NOTE: This can be the Center for Disease Control (CDC) and Prevention and two-step skin testing or a Food and Drug Administration (FDA)-approved blood test.

1. Contract employees manifesting positive screening reactions to the tuberculin shall be examined according to current CDC guidelines prior to working on VHA property.

2. Subsequently, if the employee is found without evidence of active (infectious) pulmonary TB, a statement documenting examination by a physician shall be on file with the employer (construction contractor), noting that the employee with a positive tuberculin screening test is without evidence of active (infectious) pulmonary TB.

3. If the employee is found with evidence of active (infectious) pulmonary TB, the employee shall require treatment with a subsequent statement to the fact on file with the employer before being allowed to return to work on VHA property.

1.14 FIRE SAFETY

A. Fire Safety Plan: Establish and maintain a site-specific fire protection program in accordance with 29 CFR 1926. Prior to start of work, prepare a plan detailing project-specific fire safety measures, including periodic status reports, and submit to Resident Engineer Facility Safety Officer, Facility Fire Department and Contracting Officer Representative or Government Designated Authority for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES. This plan may be an element of the Accident Prevention Plan.

B. Site and Building Access: Maintain free and unobstructed access to facility emergency services and for fire, police and other emergency response forces in accordance with NFPA 241.

C. Separate temporary facilities, such as trailers, storage sheds, and dumpsters, from existing buildings and new construction by distances in accordance with NFPA 241. For small facilities with less than 6 m (20 feet) exposing overall length, separate by 3m (10 feet).

D. Temporary Construction Partitions: NOT USED

E. Temporary Heating and Electrical: Install, use and maintain installations in accordance with 29 CFR 1926, NFPA 241 and NFPA 70.

F. Means of Egress: Do not block exiting for occupied buildings, including paths from exits to roads. Minimize disruptions and coordinate with Resident Engineer, Facility Fire Department, and Contracting Officer Representative or Government Designated Authority.

G. Egress Routes for Construction Workers: Maintain free and unobstructed egress. Inspect daily. Report findings and corrective actions weekly to Resident Engineer, Facility Fire Department, and Contracting Officer Representative or Government Designated Authority.

H. Fire Extinguishers: Provide and maintain extinguishers in construction areas and temporary storage areas in accordance with 29 CFR 1926, NFPA 241 and NFPA 10.(must have tags from license extinguisher company) Must maintain records and complete monthly inspection of all extinguishers.

I. Flammable and Combustible Liquids: Store, dispense and use liquids in accordance with 29 CFR 1926, NFPA 241 and NFPA 30.

J. NOT USED

K. NOT USED

L. Existing Fire Protection: Do not impair automatic sprinklers, smoke and heat detection, and fire alarm systems, except for portions immediately under construction, and temporarily for connections. Provide fire watch for impairments more than 4 hours in a 24-hour period. Request interruptions in accordance with Article, OPERATIONS AND STORAGE AREAS, and coordinate with Resident Engineer, Facility Fire Department, and Contracting Officer Representative or Government Designated Authority. All existing or temporary fire protection systems (fire alarms, sprinklers) located in construction areas shall be tested as coordinated with the medical center. Parameters for the testing and results of any tests performed shall be recorded by the medical center and copies provided to the Resident Engineer.

INSTALLATION OF ANY AND ALL FIRE ALARM DETECTION DEVICES SHALL BE INSTALLED AND PROGRAMMED BY A CONTRACTOR WHICH MAINTAINS A CURRENT EDWARDS SYSTEMS TECHNOLOGIES EST-3 DEALER AUTHORIZATION, CURRENT EDWARDS SYSTEMS TECHNOLOGIES FIREWORKS NETWORK CERTIFICATION, AS WELL AS A CURRENT UL LABORATORIES® ISO 9001 CERTIFICATION. DEVICE PROGRAMMING SHALL INCORPORATE ESTABLISHED VISUAL DISPLAY AND AUDIO VERBAGE LABELLING AND MESSAGING WHICH INCLUDE BUILDING NUMBER, FLOOR NUMBER, AND ZONE IDENTIFIER. CONTRACTOR SHALL PROVIDE INFORMATION WHICH VERIFIES THE PAST PERFORMANCE IN THE INSTALLATION AND MAINTENANCE OF NO LESS THAN THREE (3) PREVIOUS EST-3/ EST-3 NETWORKS INSTALLATIONS.

M. Smoke Detectors: Prevent accidental operation. Remove temporary covers at end of work operations each day. Coordinate with Resident Engineer, Facility Fire Department, and Contracting Officer Representative or Government Designated Authority.

N. Hot Work: Perform and safeguard hot work operations in accordance with NFPA 241 and NFPA 51B. Coordinate with Resident Engineer and Facility Fire Department. Obtain permits from Facility Fire Department at least __1__ hour in advance. Designate contractor's responsible project-site fire prevention program manager to permit hot work. Hot work permits must be turned in at the end of each day.

O. Fire Hazard Prevention and Safety Inspections: Inspect entire construction areas weekly. Coordinate with, and report findings and corrective actions weekly to Resident Engineer, Facility Fire Department, and Contracting Officer Representative or Government Designated Authority.

P. Smoking: Smoking is prohibited in and adjacent to construction areas inside existing buildings and additions under construction. In separate and detached buildings under construction, smoking is prohibited except in designated smoking rest areas.

Q. Dispose of waste and debris in accordance with NFPA 241. Remove from buildings daily. All dumpsters must be fenced off to keep people away from the area.

R. If required, submit documentation to the Resident Engineer, Facility Fire Department, and Contracting Officer Representative or Government Designated Authority that personnel have been trained in the fire safety aspects of working in areas with impaired structural or compartmentalization features.

S. All doors leading to or from the construction area must be locked at the end of each work day to prevent unauthorized

1.15 ELECTRICAL

A. All electrical work shall comply with NFPA 70 (NEC), NFPA 70B, NFPA 70E, 29 CFR Part 1910 Subpart J – General Environmental Controls, 29 CFR Part 1910 Subpart S – Electrical, and 29 CFR 1926 Subpart K in addition to other references required by contract.

B. All qualified persons performing electrical work under this contract shall be licensed journeyman or master electricians. All apprentice electricians performing under this contract shall be deemed unqualified persons unless they are working under the immediate supervision of a licensed electrician or master electrician.

C. All electrical work will be accomplished de-energized and in the Electrically Safe Work Condition (refer to NFPA 70E for Work Involving Electrical Hazards, including Exemptions to Work Permit). Any Contractor, subcontractor or temporary worker who fails to fully comply with this requirement is subject to immediate termination in accordance with FAR clause 52.236-5(c). Only in rare circumstance where achieving an electrically safe work condition prior to beginning work would increase or cause additional hazards, or is infeasible due to equipment design or operational limitations is energized work permitted. The Chief Engineer, Chief of Facilities Management, Resident Engineer, Project Manager and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority with approval of the Medical Center Director will make the determination if the circumstances would meet the exception outlined above. An AHA specific to energized work activities will be developed, reviewed, and accepted prior to the start of that work.

1. Development of a Hazardous Electrical Energy Control Procedure is required prior to de-energization. A single Simple Lockout/Tagout Procedure for multiple work operations can only be used for work involving qualified person(s) de-energizing one set of conductors or circuit part source. Task specific Complex Lockout/Tagout Procedures are required at all other times.

2. Verification of the absence of voltage after de-energization and lockout/tagout is considered “energized electrical work” (live work) under NFPA 70E, and shall only be performed by qualified persons wearing appropriate shock protective (voltage rated) gloves and arc rate personal protective clothing and equipment, using Underwriters Laboratories (UL) tested and appropriately rated contact electrical testing instruments or equipment appropriate for the environment in which they will be used.

3. Personal Protective Equipment (PPE) and electrical testing instruments will be readily available for inspection by the Chief Engineer, Chief of Facilities Management, Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority.

D. Before beginning any electrical work, an Activity Hazard Analysis (AHA) will be conducted to include Shock Hazard and Arc Flash Hazard analyses (NFPA Tables can be used only as a last alterative and it is strongly suggested a full Arc Flash Hazard Analyses be conducted). Work shall not begin until the AHA for the work activity has been accepted by the Resident Engineer and Facility Safety Officer or Contracting Officer Representative or Government Designated Authority and discussed with all engaged in the activity, including the Contractor, subcontractor(s), and Government on-site representatives at preparatory and initial control phase meetings.

E. Ground-fault circuit interrupters. All 120-volt, single-phase 15- and 20-ampere receptacle outlets on construction sites shall have approved ground-fault circuit interrupters for personnel protection. “Assured Equipment Grounding Conductor Program” only is not allowed.

1.16 FALL PROTECTION

A. The fall protection (FP) threshold height requirement is 6 ft (1.8 m) for ALL WORK, unless specified differently or the OSHA 29 CFR 1926 requirements are more stringent, to include steel erection activities, systems-engineered activities (prefabricated) metal buildings, residential (wood) construction and scaffolding work.

1. The use of a Safety Monitoring System (SMS) as a fall protection method is prohibited.

2. The use of Controlled Access Zone (CAZ) as a fall protection method is prohibited.

3. A Warning Line System (WLS) may ONLY be used on floors or flat or low-sloped roofs (between 0 - 18.4 degrees or 4:12 slope) and shall be erected around all sides of the work area (See 29 CFR 1926.502(f) for construction of WLS requirements). Working within the WLS does not require FP. No worker shall be allowed in the area between the roof or floor edge and the WLS without FP. FP is required when working outside the WLS.

4. Fall protection while using a ladder will be governed by the OSHA requirements.

1.17 SCAFFOLDS AND OTHER WORK PLATFORMS

A. All scaffolds and other work platforms construction activities shall comply with 29 CFR 1926 Subpart L.

B. The fall protection (FP) threshold height requirement is 6 ft (1.8 m) as stated in Section 1.16.

C. The following hierarchy and prohibitions shall be followed in selecting appropriate work platforms.

1. Scaffolds, platforms, or temporary floors shall be provided for all work except that can be performed safely from the ground or similar footing.

2. Ladders less than 20 feet may be used as work platforms only when use of small hand tools or handling of light material is involved.

3. Ladder jacks, lean-to, and prop-scaffolds are prohibited.

4. Emergency descent devices shall not be used as working platforms.

D. Contractors shall use a scaffold tagging system in which all scaffolds are tagged by the Competent Person. Tags shall be color-coded: green indicates the scaffold has been inspected and is safe to use; red indicates the scaffold is unsafe to use. Tags shall be readily visible, made of materials that will withstand the environment in which they are used, be legible and shall include:

1. The Competent Person’s name and signature;

2. Dates of initial and last inspections.

E. Mast Climbing work platforms: When access ladders, including masts designed as ladders, exceed 20 ft (6 m) in height, positive fall protection shall be used.

1.18 EXCAVATION AND TRENCHES

A. All excavation and trenching work shall comply with 29 CFR 1926 Subpart P.

B. All excavations and trenches 5 feet in depth or greater shall require a written trenching and excavation permit (NOTE – some States and other local jurisdictions require separate state/jurisdiction-issued excavation permits). The permit shall be completed and provided to the Resident Engineer/Project Manager and/or Facility Safety Officer and/or other Government Designated Authority and Facility Fire Department prior to commencing work for the day. At the end of the day, the permit shall be closed out and provided to the Facility Fire Department and/or Facility Safety Officer. The permit shall be maintained onsite and include the following:

1. Determination of soil classification

2. Indication that utilities have been located and identified. If utilities could not be located after all reasonable attempt, then excavating operations will proceed cautiously.

3. Indication of selected excavation protective system.

4. Indication that the spoil pile will be stored at least 2 feet from the edge of the excavation and safe access provided within 25 feet of the workers.

5. Indication of assessment for a potential toxic, explosive, or oxygen deficient atmosphere.

C. If not using an engineered protective system such as a trench box, shielding, shoring, or other Professional Engineer designed system and using a sloping or benching system, soil classification cannot be Solid Rock or Type A. All soil will be classified as Type B or Type C and sloped or benched in accordance with Appendix B of 29 CFR 1926.

1.19 CRANES

A. All crane work shall comply with 29 CFR 1926 Subpart CC.

B. Prior to operating a crane, the operator must be licensed, qualified or certified to operate the crane. Thus, all the provisions contained with Subpart CC are effective and there is no “Phase In” date of November 10, 2014.

C. A detailed lift permit shall be submitted 14 days prior to the scheduled lift complete with route for truck carrying load, crane load analysis, siting of crane and path of swing. The lift will not be allowed without approval of this document.

D. Crane operators shall not carry loads

1. over the general public or VAMC personnel

2. over any occupied building unless

a. the top two floors are vacated

b. or overhead protection with a design live load of 300 psf is provided

1.20 CONTROL OF HAZARDOUS ENERGY (LOCKOUT/TAGOUT)

A. All installation, maintenance, and servicing of equipment or machinery shall comply with 29 CFR 1910.147 except for specifically referenced operations in 29 CFR 1926 such as concrete & masonry equipment [1926.702(j)], heavy machinery & equipment [1926.600(a)(3)(i)], and process safety management of highly hazardous chemicals (1926.64). Control of hazardous electrical energy during the installation, maintenance, or servicing of electrical equipment shall comply with Section 1.15 to include NFPA 70E and other VA specific requirements discussed in the section.

1.21 CONFINED SPACE ENTRY

A. All confined space entry shall comply with 29 CFR 1910.146 except for specifically referenced operations in 29 CFR 1926 such as excavations/trenches [1926.651(g)].

B. A site-specific Confined Space Entry Plan (including permitting process) shall be developed and submitted to the Resident Engineer/Project Manager and/or Facility Safety Officer and Facility Fire Department.

1.22 WELDING AND CUTTING

As specified in section 1.14, Hot Work: Perform and safeguard hot work operations in accordance with NFPA 241 and NFPA 51B. Coordinate with Resident Engineer and/or Facility Safety Officer and Facility Fire Department. Obtain permits from Facility Fire Department at least _1_ hours in advance. Designate contractor's responsible project-site fire prevention program manager to permit hot work.

1.23 LADDERS

A. All Ladder use shall comply with 29 CFR 1926 Subpart X.

B. All portable ladders shall be of sufficient length and shall be placed so that workers will not stretch or assume a hazardous position.

C. Manufacturer safety labels shall be in place on ladders

D. Step Ladders shall not be used in the closed position

E. Top steps or cap of step ladders shall not be used as a step

F. Portable ladders, used as temporary access, shall extend at least 3 ft (0.9 m) above the upper landing surface.

1. When a 3 ft (0.9-m) extension is not possible, a grasping device (such as a grab rail) shall be provided to assist workers in mounting and dismounting the ladder.

2. In no case shall the length of the ladder be such that ladder deflection under a load would, by itself, cause the ladder to slip from its support.

G. Ladders shall be inspected for visible defects on a daily basis and after any occurrence that could affect their safe use. Broken or damaged ladders shall be immediately tagged "DO NOT USE," or with similar wording, and withdrawn from service until restored to a condition meeting their original design.

1.24 FLOOR & WALL OPENINGS

A. All floor and wall openings shall comply with 29 CFR 1926 Subpart M.

B. Floor and roof holes/openings are any that measure over 2 in (51 mm) in any direction of a walking/working surface which persons may trip or fall into or where objects may fall to the level below. See 21.F for covering and labeling requirements. Skylights located in floors or roofs are considered floor or roof hole/openings.

C. All floor, roof openings or hole into which a person can accidentally walk or fall through shall be guarded either by a railing system with toe boards along all exposed sides or a load-bearing cover. When the cover is not in place, the opening or hole shall be protected by a removable guardrail system or shall be attended when the guarding system has been removed or other fall protection system.

1. Covers shall be capable of supporting, without failure, at least twice the weight of the worker, equipment and material combined.

2. Covers shall be secured when installed, clearly marked with the word “HOLE”, “COVER” or “Danger, Roof Opening-Do Not Remove” or color-coded or equivalent methods (e.g., red or orange “X”). Workers must be made aware of the meaning for color coding and equivalent methods.

3. Roofing material, such as roofing membrane, insulation or felts, covering or partly covering openings or holes, shall be immediately cut out. No hole or opening shall be left unattended unless covered.

4. Non-load-bearing skylights shall be guarded by a load-bearing skylight screen, cover, or railing system along all exposed sides.

5. Workers are prohibited from standing/walking on skylights.

- - - E N D - - -

SECTION 01 57 19
TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the control of environmental pollution and damage that the Contractor must consider for air, water, and land resources. It includes management of visual aesthetics, noise, solid waste, radiant energy, and radioactive materials, as well as other pollutants and resources encountered or generated by the Contractor. The Contractor is obligated to consider specified control measures with the costs included within the various contract items of work.

B. Environmental pollution and damage is defined as the presence of chemical, physical, or biological elements or agents which:
   1. Adversely effect human health or welfare,
   2. Unfavorably alter ecological balances of importance to human life,
   3. Effect other species of importance to humankind, or;
   4. Degrade the utility of the environment for aesthetic, cultural, and historical purposes.

C. Definitions of Pollutants:
   1. Chemical Waste: Petroleum products, bituminous materials, salts, acids, alkalis, herbicides, pesticides, organic chemicals, and inorganic wastes.
   2. Debris: Combustible and noncombustible wastes, such as leaves, tree trimmings, ashes, and waste materials resulting from construction or maintenance and repair work.
   3. Sediment: Soil and other debris that has been eroded and transported by runoff water.
   4. Solid Waste: Rubbish, debris, garbage, and other discarded solid materials resulting from industrial, commercial, and agricultural operations and from community activities.
   5. Surface Discharge: The term "Surface Discharge" implies that the water is discharged with possible sheeting action and subsequent soil erosion may occur. Waters that are surface discharged may terminate in drainage ditches, storm sewers, creeks, and/or "water of the United States" and would require a permit to discharge water from the governing agency.
   6. Rubbish: Combustible and noncombustible wastes such as paper, boxes, glass and crockery, metal and lumber scrap, tin cans, and bones.

7. Sanitary Wastes:
   a. Sewage: Domestic sanitary sewage and human and animal waste.
   b. Garbage: Refuse and scraps resulting from preparation, cooking, dispensing, and consumption of food.

1.2 QUALITY CONTROL

A. Establish and maintain quality control for the environmental protection of all items set forth herein.
B. Record on daily reports any problems in complying with laws, regulations, and ordinances. Note any corrective action taken.

1.3 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.
B. U.S. National Archives and Records Administration (NARA):
   33 CFR 328..............Definitions

1.4 SUBMITTALS

A. In accordance with Section, 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:
   1. Environmental Protection Plan: After the contract is awarded and prior to the commencement of the work, the Contractor shall meet with the Resident Engineer to discuss the proposed Environmental Protection Plan and to develop mutual understanding relative to details of environmental protection. Not more than 20 days after the meeting, the Contractor shall prepare and submit to the Resident Engineer for approval, a written and/or graphic Environmental Protection Plan including, but not limited to, the following:
      a. Name(s) of person(s) within the Contractor's organization who is (are) responsible for ensuring adherence to the Environmental Protection Plan.
      b. Name(s) and qualifications of person(s) responsible for manifesting hazardous waste to be removed from the site.
      c. Name(s) and qualifications of person(s) responsible for training the Contractor's environmental protection personnel.
      d. Description of the Contractor's environmental protection personnel training program.
      e. A list of Federal, State, and local laws, regulations, and permits concerning environmental protection, pollution control, noise control and abatement that are applicable to the Contractor's proposed operations and the requirements imposed by those laws, regulations, and permits.

f. Methods for protection of features to be preserved within authorized work areas including trees, shrubs, vines, grasses, ground cover, landscape features, air and water quality, fish and wildlife, soil, historical, and archeological and cultural resources.
g. Procedures to provide the environmental protection that comply with the applicable laws and regulations. Describe the procedures to correct pollution of the environment due to accident, natural causes, or failure to follow the procedures as described in the Environmental Protection Plan.
h. Permits, licenses, and the location of the solid waste disposal area.
i. Drawings showing locations of any proposed temporary excavations or embankments for haul roads, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials. Include as part of an Erosion Control Plan approved by the District Office of the U.S. Soil Conservation Service and the Department of Veterans Affairs.
j. Environmental Monitoring Plans for the job site including land, water, air, and noise.
k. Work Area Plan showing the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas. This plan may be incorporated within the Erosion Control Plan.

B. Approval of the Contractor's Environmental Protection Plan will not relieve the Contractor of responsibility for adequate and continued control of pollutants and other environmental protection measures.

1.5 PROTECTION OF ENVIRONMENTAL RESOURCES

A. Protect environmental resources within the project boundaries and those affected outside the limits of permanent work during the entire period of this contract. Confine activities to areas defined by the specifications and drawings.

B. Protection of Land Resources: Prior to construction, identify all land resources to be preserved within the work area. Do not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, top soil, and land forms without permission from the Resident Engineer. Do not fasten or attach ropes, cables, or guys to trees for anchorage unless specifically authorized, or where special emergency use is permitted.

1. Work Area Limits: Prior to any construction, mark the areas that require work to be performed under this contract. Mark or fence

isolated areas within the general work area that are to be saved and protected. Protect monuments, works of art, and markers before construction operations begin. Convey to all personnel the purpose of marking and protecting all necessary objects.

2. Protection of Landscape: Protect trees, shrubs, vines, grasses, land forms, and other landscape features shown on the drawings to be preserved by marking, fencing, or using any other approved techniques.
   a. Box and protect from damage existing trees and shrubs to remain on the construction site.
   b. Immediately repair all damage to existing trees and shrubs by trimming, cleaning, and painting with antiseptic tree paint.
   c. Do not store building materials or perform construction activities closer to existing trees or shrubs than the farthest extension of their limbs.
3. Reduction of Exposure of Unprotected Erodible Soils: Plan and conduct earthwork to minimize the duration of exposure of unprotected soils. Clear areas in reasonably sized increments only as needed to use. Form earthwork to final grade as shown. Immediately protect side slopes and back slopes upon completion of rough grading.
4. Temporary Protection of Disturbed Areas: Construct diversion ditches, benches, and berms to retard and divert runoff from the construction site to protected drainage areas approved under paragraph 208 of the Clean Water Act.

   a. NOT USED
   b. Reuse or conserve the collected topsoil sediment as directed by the Resident Engineer.
   c. Institute effluent quality monitoring programs as required by Federal, State, and local environmental agencies.
5. Erosion and Sedimentation Control Devices: The erosion and sediment controls selected and maintained by the Contractor shall be such that water quality standards are not violated as a result of the Contractor's activities. Construct or install all temporary and permanent erosion and sedimentation control features on the Environmental Protection Plan. Maintain temporary erosion and sediment control measures such as berms, dikes, drains, sedimentation basins, grassing, and mulching, until permanent drainage and erosion control facilities are completed and operative.

6. Manage borrow areas on and off Government property to minimize erosion and to prevent sediment from entering nearby water courses or lakes.
7. Manage and control spoil areas on and off Government property to limit spoil to areas on the Environmental Protection Plan and prevent erosion of soil or sediment from entering nearby water courses or lakes.
8. Protect adjacent areas from despoilment by temporary excavations and embankments.
9. Handle and dispose of solid wastes in such a manner that will prevent contamination of the environment. Place solid wastes (excluding clearing debris) in containers that are emptied on a regular schedule. Transport all solid waste off Government property and dispose of waste in compliance with Federal, State, and local requirements.
10. Store chemical waste away from the work areas in corrosion resistant containers and dispose of waste in accordance with Federal, State, and local regulations.
11. Handle discarded materials other than those included in the solid waste category as directed by the Resident Engineer.

C. Protection of Water Resources: Keep construction activities under surveillance, management, and control to avoid pollution of surface and ground waters and sewer systems. Implement management techniques to control water pollution by the listed construction activities that are included in this contract.

1. Washing and Curing Water: Do not allow wastewater directly derived from construction activities to enter water areas. Collect and place wastewater in retention ponds allowing the suspended material to settle, the pollutants to separate, or the water to evaporate.
2.

3. Monitor water areas affected by construction.

D. Protection of Fish and Wildlife Resources: Keep construction activities under surveillance, management, and control to minimize interference with, disturbance of, or damage to fish and wildlife. Prior to beginning construction operations, list species that require specific attention along with measures for their protection.

E. Protection of Air Resources: Keep construction activities under surveillance, management, and control to minimize pollution of air resources. Burning is not permitted on the job site. Keep activities, equipment, processes, and work operated or performed, in strict accordance with State and Federal emission and performance laws and standards. Maintain ambient air quality standards set by the Environmental Protection Agency, for those construction operations and activities specified.

1. Particulates: Control dust particles, aerosols, and gaseous by-products from all construction activities, processing, and preparation of materials (such as from asphaltic batch plants) at all times, including weekends, holidays, and hours when work is not in progress.
2. Particulates Control: Maintain all excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and all other work areas within or outside the project boundaries free from particulates which would cause a hazard or a nuisance. Sprinklering, chemical treatment of an approved type, light bituminous treatment, baghouse, scrubbers, electrostatic precipitators, or other methods are permitted to control particulates in the work area.
3. Hydrocarbons and Carbon Monoxide: Control monoxide emissions from equipment to Federal and State allowable limits.
4. Odors: Control odors of construction activities and prevent obnoxious odors from occurring.

F. Reduction of Noise: Minimize noise using every action possible. Perform noise-producing work in less sensitive hours of the day or week as directed by the Resident Engineer. Maintain noise-produced work at or below the decibel levels and within the time periods specified.

1. Perform construction activities involving repetitive, high-level impact noise only between 8:00 a.m. and 6:00p.m unless otherwise permitted by local ordinance or the Resident Engineer. Repetitive impact noise on the property shall not exceed the following dB limitations:

Time Duration of Impact Noise	Sound Level in dB
More than 12 minutes in any hour	70
Less than 30 seconds of any hour	85
Less than three minutes of any hour	80
Less than 12 minutes of any hour	75

2. Provide sound-deadening devices on equipment and take noise abatement measures that are necessary to comply with the requirements of this contract, consisting of, but not limited to, the following:

a. Maintain maximum permissible construction equipment noise levels at 15 m (50 feet) (dBA):

EARTHMOVING		MATERIALS HANDLING	
FRONT LOADERS	75	CONCRETE MIXERS	75
BACKHOES	75	CONCRETE PUMPS	75
DOZERS	75	CRANES	75
TRACTORS	75	DERRICKS IMPACT	75
SCAPERS	80	PILE DRIVERS	95
GRADERS	75	JACK HAMMERS	75
TRUCKS	75	ROCK DRILLS	80
PAVERS, STATIONARY	80	PNEUMATIC TOOLS	80
PUMPS	75	BLASTING	//--//
GENERATORS	75	SAWS	75
COMPRESSORS	75	VIBRATORS	75

b. Use shields or other physical barriers to restrict noise transmission.

c. Provide soundproof housings or enclosures for noise-producing machinery.

d. Use efficient silencers on equipment air intakes.

e. Use efficient intake and exhaust mufflers on internal combustion engines that are maintained so equipment performs below noise levels specified.

f. Line hoppers and storage bins with sound deadening material.

g. Conduct truck loading, unloading, and hauling operations so that noise is kept to a minimum.

3. Measure sound level for noise exposure due to the construction at least once every five successive working days while work is being performed above 80 dB(A) noise level. Measure noise exposure at the property line or 15 m (50 feet) from the noise source, whichever is greater. Measure the sound levels on the A weighing network of a General Purpose sound level meter at slow response. To minimize the effect of reflective sound waves at buildings, take measurements at 900 to 1800 mm (three to six feet) in front of any building face. Submit the recorded information to the Resident Engineer noting any problems and the alternatives for mitigating actions.

G. Restoration of Damaged Property: If any direct or indirect damage is done to public or private property resulting from any act, omission, neglect, or misconduct, the Contractor shall restore the damaged property to a condition equal to that existing before the damage at no additional cost to the Government. Repair, rebuild, or restore property as directed or make good such damage in an acceptable manner.

H. Final Clean-up: On completion of project and after removal of all debris, rubbish, and temporary construction, Contractor shall leave the construction area in a clean condition satisfactory to the Resident Engineer. Cleaning shall include off the station disposal of all items and materials not required to be salvaged, as well as all debris and rubbish resulting from demolition and new work operations.

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SECTION 01 74 19
CONSTRUCTION WASTE MANAGEMENT

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies the requirements for the management of non-hazardous building construction and demolition waste.

B. Waste disposal in landfills shall be minimized to the greatest extent possible. Of the inevitable waste that is generated, as much of the waste material as economically feasible shall be salvaged, recycled or reused.

C. Contractor shall use all reasonable means to divert construction and demolition waste from landfills and incinerators, and facilitate their salvage and recycle not limited to the following:

1. Waste Management Plan development and implementation.
2. Techniques to minimize waste generation.
3. Sorting and separating of waste materials.
4. Salvage of existing materials and items for reuse or resale.
5. Recycling of materials that cannot be reused or sold.

D. At a minimum the following waste categories shall be diverted from landfills:

1. Soil.
2. Inerts (eg, concrete, masonry and asphalt).
3. Clean dimensional wood and palette wood.
4. Green waste (biodegradable landscaping materials).
5. Engineered wood products (plywood, particle board and I-joists, etc).
6. Metal products (eg, steel, wire, beverage containers, copper, etc).
7. Cardboard, paper and packaging.
8. Bitumen roofing materials.
9. Plastics (eg, ABS, PVC).
10. Carpet and/or pad.
11. Gypsum board.
12. Insulation.
13. Paint.
14. Fluorescent lamps.

1.2 RELATED WORK

B. Section 01 00 00, GENERAL REQUIREMENTS.

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1.3 QUALITY ASSURANCE

A. Contractor shall practice efficient waste management when sizing, cutting and installing building products. Processes shall be employed to ensure the generation of as little waste as possible. Construction /Demolition waste includes products of the following:

1. Excess or unusable construction materials.
2. Packaging used for construction products.
3. Poor planning and/or layout.
4. Construction error.
5. Over ordering.
6. Weather damage.
7. Contamination.
8. Mishandling.
9. Breakage.

B. Establish and maintain the management of non-hazardous building construction and demolition waste set forth herein. Conduct a site assessment to estimate the types of materials that will be generated by demolition and construction.

C. Contractor shall develop and implement procedures to recycle construction and demolition waste to a minimum of 50 percent.

D. Contractor shall be responsible for implementation of any special programs involving rebates or similar incentives related to recycling. Any revenues or savings obtained from salvage or recycling shall accrue to the contractor.

E. Contractor shall provide all demolition, removal and legal disposal of materials. Contractor shall ensure that facilities used for recycling, reuse and disposal shall be permitted for the intended use to the extent required by local, state, federal regulations. The Whole Building Design Guide website http://www.wbdg.org/tools/cwm.php provides a Construction Waste Management Database that contains information on companies that haul, collect, and process recyclable debris from construction projects.

F. Contractor shall assign a specific area to facilitate separation of materials for reuse, salvage, recycling, and return. Such areas are to be kept neat and clean and clearly marked in order to avoid contamination or mixing of materials.

G. Contractor shall provide on-site instructions and supervision of separation, handling, salvaging, recycling, reuse and return methods to be used by all parties during waste generating stages.
H. Record on daily reports any problems in complying with laws, regulations and ordinances with corrective action taken.

1.4 TERMINOLOGY

A. Class III Landfill: A landfill that accepts non-hazardous resources such as household, commercial and industrial waste resulting from construction, remodeling, repair and demolition operations.
B. Clean: Untreated and unpainted; uncontaminated with adhesives, oils, solvents, mastics and like products.
C. Construction and Demolition Waste: Includes all non-hazardous resources resulting from construction, remodeling, alterations, repair and demolition operations.
D. Dismantle: The process of parting out a building in such a way as to preserve the usefulness of its materials and components.
E. Disposal: Acceptance of solid wastes at a legally operating facility for the purpose of land filling (includes Class III landfills and inert fills).
F. Inert Backfill Site: A location, other than inert fill or other disposal facility, to which inert materials are taken for the purpose of filling an excavation, shoring or other soil engineering operation.
G. Inert Fill: A facility that can legally accept inert waste, such as asphalt and concrete exclusively for the purpose of disposal.
H. Inert Solids/Inert Waste: Non-liquid solid resources including, but not limited to, soil and concrete that does not contain hazardous waste or soluble pollutants at concentrations in excess of water-quality objectives established by a regional water board, and does not contain significant quantities of decomposable solid resources.
I. Mixed Debris: Loads that include commingled recyclable and non-recyclable materials generated at the construction site.
J. Mixed Debris Recycling Facility: A solid resource processing facility that accepts loads of mixed construction and demolition debris for the purpose of recovering re-usable and recyclable materials and disposing non-recyclable materials.
K. Permitted Waste Hauler: A company that holds a valid permit to collect and transport solid wastes from individuals or businesses for the purpose of recycling or disposal.

L. Recycling: The process of sorting, cleansing, treating, and reconstituting materials for the purpose of using the altered form in the manufacture of a new product. Recycling does not include burning, incinerating or thermally destroying solid waste.
   1. On-site Recycling – Materials that are sorted and processed on site for use in an altered state in the work, i.e. concrete crushed for use as a sub-base in paving.
   2. Off-site Recycling – Materials hauled to a location and used in an altered form in the manufacture of new products.

M. Recycling Facility: An operation that can legally accept materials for the purpose of processing the materials into an altered form for the manufacture of new products. Depending on the types of materials accepted and operating procedures, a recycling facility may or may not be required to have a solid waste facilities permit or be regulated by the local enforcement agency.

N. Reuse: Materials that are recovered for use in the same form, on-site or off-site.

O. Return: To give back reusable items or unused products to vendors for credit.

P. Salvage: To remove waste materials from the site for resale or re-use by a third party.

Q. Source-Separated Materials: Materials that are sorted by type at the site for the purpose of reuse and recycling.

R. Solid Waste: Materials that have been designated as non-recyclable and are discarded for the purposes of disposal.

S. Transfer Station: A facility that can legally accept solid waste for the purpose of temporarily storing the materials for re-loading onto other trucks and transporting them to a landfill for disposal, or recovering some materials for re-use or recycling.

1.5 SUBMITTALS

A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES, furnish the following:

B. Prepare and submit to the Resident Engineer a written demolition debris management plan. The plan shall include, but not be limited to, the following information:
   1. Procedures to be used for debris management.
   2. Techniques to be used to minimize waste generation.
   3. Analysis of the estimated job site waste to be generated:

a. List of each material and quantity to be salvaged, reused, recycled.

b. List of each material and quantity proposed to be taken to a landfill.

4. Detailed description of the Means/Methods to be used for material handling.

a. On site: Material separation, storage, protection where applicable.

b. Off site: Transportation means and destination. Include list of materials.

1) Description of materials to be site-separated and self-hauled to designated facilities.

2) Description of mixed materials to be collected by designated waste haulers and removed from the site.

c. The names and locations of mixed debris reuse and recycling facilities or sites.

d. The names and locations of trash disposal landfill facilities or sites.

e. Documentation that the facilities or sites are approved to receive the materials.

C. Designated Manager responsible for instructing personnel, supervising, documenting and administer over meetings relevant to the Waste Management Plan.

D. Monthly summary of construction and demolition debris diversion and disposal, quantifying all materials generated at the work site and disposed of or diverted from disposal through recycling.

1.6 APPLICABLE PUBLICATIONS

A Publications listed below form a part of this specification to the extent referenced. Publications are referenced by the basic designation only. In the event that criteria requirements conflict, the most stringent requirements shall be met.

B. U.S. Green Building Council (USGBC):
LEED Green Building Rating System for New Construction

1.7 RECORDS

Maintain records to document the quantity of waste generated; the quantity of waste diverted through sale, reuse, or recycling; and the quantity of waste disposed by landfill or incineration. Records shall be kept in accordance with the LEED Reference Guide and LEED Template.

PART 2 - PRODUCTS

2.1 MATERIALS

A. List of each material and quantity to be salvaged, recycled, reused.

B. List of each material and quantity proposed to be taken to a landfill.

C. Material tracking data: Receiving parties, dates removed, transportation costs, weight tickets, tipping fees, manifests, invoices, net total costs or savings.

PART 3 - EXECUTION

3.1 COLLECTION

A. Provide all necessary containers, bins and storage areas to facilitate effective waste management.

B. Clearly identify containers, bins and storage areas so that recyclable materials are separated from trash and can be transported to respective recycling facility for processing.

C. Hazardous wastes shall be separated, stored, disposed of according to local, state, federal regulations.

3.2 DISPOSAL

A. Contractor shall be responsible for transporting and disposing of materials that cannot be delivered to a source-separated or mixed materials recycling facility to a transfer station or disposal facility that can accept the materials in accordance with state and federal regulations.

B. Construction or demolition materials with no practical reuse or that cannot be salvaged or recycled shall be disposed of at a landfill or incinerator.

3.3 REPORT

A. With each application for progress payment, submit a summary of construction and demolition debris diversion and disposal including beginning and ending dates of period covered.

B. Quantify all materials diverted from landfill disposal through salvage or recycling during the period with the receiving parties, dates removed, transportation costs, weight tickets, manifests, invoices. Include the net total costs or savings for each salvaged or recycled material.

C. Quantify all materials disposed of during the period with the receiving parties, dates removed, transportation costs, weight tickets, tipping fees, manifests, invoices. Include the net total costs for each disposal.

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SECTION 01 81 11

SUSTAINABLE DESIGN REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

This Section describes general requirements and procedures to comply with the Guiding Principles for Leadership in High Performance and Sustainable Buildings Memorandum of Understanding incorporated in the Executive Orders 13423 and 13514; Energy Policy Act of 2005 (EPA 2005) and the Energy Independence and Security Act of 2007 (EISA 2007).

1.2 OBJECTIVES

A. To maximize resource efficiency and reduce the environmental impacts of construction and operation, the Contractor during the construction phase of this project shall implement the following procedures:

1. Select products that minimize consumption of energy, water and non-renewable resources, while minimizing the amounts of pollution resulting from the production and employment of building technologies. It is the intent of this project to conform with EPA’s Five Guiding Principles on environmentally preferable purchasing. The five principles are:
    a. Include environmental considerations as part of the normal purchasing process.
    b. Emphasize pollution prevention early in the purchasing process.
    c. Examine multiple environmental attributes throughout a product’s or service’s life cycle.
    d. Compare relevant environmental impacts when selecting products and services.
    e. Collect and base purchasing decisions on accurate and meaningful information about environmental performance.
2. Control sources for potential Indoor Air Quality (IAQ) pollutants by controlled selection of materials and processes used in project construction in order to attain superior IAQ.
3. Products and processes that achieve the above objectives to the extent currently possible and practical have been selected and included in these Construction Documents. The Contractor is responsible to maintain and support these objectives in developing means and methods for performing the work of this Contract and in

proposing product substitutions and/or changes to specified processes.

4. Use building practices that insure construction debris and particulates do not contaminate or enter duct work prior to system startup and turn over.

1.3 RELATED DOCUMENTS

A. Section 01 74 19 CONSTRUCTION WASTE MANANGEMENT

C. Section 01 91 00 GENERAL COMMISSIONG REQUIREMENTS

1.4 DEFINITIONS

A. NOT USED

B. NOT USED

C. NOT USED

D. NOT USED

E. NOT USED

F. Construction and Demolition Wast.e: Includes solid wastes, such as building materials, packaging, rubbish, debris, and rubble resulting from construction, remodeling, repair and demolition operations. A construction waste management plan is to be provided by the Contractor as defined in Section 01 74 19.

G. Third Party Certification: Certification of levels of environmental achievement by nationally recognized sustainability rating system.

H. Not Used

I. Recycled Content Materials: Products that contain pre-consumer or post-consumer materials as all or part of their feedstock

J. Post-Consumer Recycled Content: The percentage by weight of constituent materials that have been recovered or otherwise diverted from the solid-waste stream after consumer use

K. Pre-Consumer Recycled Content: Materials that have been recovered or otherwise diverted from the solid-waste stream during the manufacturing process. Pre-consumer content must be material that would not have otherwise entered the waste stream as per Section 5 of the FTC Act, Part 260 “Guidelines for the Use of Environmental Marketing Claims”: www.ftc.gov/bcp/grnrule/guides980427

L. Regional Materials: Materials that are extracted, harvested, recovered, and manufactured within a radius of 250 miles (400 km) from the Project site

M. Salvaged or Reused Materials: Materials extracted from existing buildings in order to be reused in other buildings without being manufactured
N. Sealant: Any material that fills and seals gaps between other materials
O. Type 1 Finishes: Materials and finishes which have a potential for short-term levels of off gassing from chemicals inherent in their manufacturing process, or which are applied in a form requiring vehicles or carriers for spreading which release a high level of particulate matter in the process of installation and/or curing.
P. Type 2 Finishes: “Fuzzy" materials and finishes which are woven, fibrous, or porous in nature and tend to adsorb chemicals offgas
Q. Volatile Organic Compounds (VOCs): Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions. Compounds that have negligible photochemical reactivity, listed in EPA 40 CFR 51.100(s), are also excluded from this regulatory definition.

1.5 SUBMITTALS

A. Sustainable Design Submittals:
   1. NOT USED
   2. NOT USED
   3. NOT USED
   4. NOT USED
   5. NOT USED
   6. NOT USED
   7. Elimination of CFCs AND HCFCs: Provide manufacturer’s cut sheets for all cooling equipment with manufacturer’s product data, highlighting refrigerants; provide manufacturer’s cut sheets for all fire-suppression equipment, highlighting fire-suppression agents; provide manufacturer’s cut-sheets for all polystyrene insulation (XPS) and closed-cell spray foam polyurethane insulation, highlighting the blowing agent(s).
   8. Appliances and Equipment: Provide copies of manufacturer’s product data for all Energy Star eligible equipment and appliances, including office equipment, computers and printers, electronics, and commercial food service equipment (excluding HVAC and lighting components), verifying compliance with EPA’s Energy Star program.

9. On-Site Renewable Energy Systems: Provide cut sheets and manufacturer’s product data for all on-site renewable energy generating components and equipment, including documentation of output capacity.
10. Measurement and Verification Systems: Provide cut sheets and manufacturer’s product data for all controls systems, highlighting electrical metering and trending capability components.
11. Salvaged or Reused Materials: Provide documentation that lists each salvaged or reused material, the source or vendor of the material, the purchase price, and the replacement cost if greater than the purchase price.
12. Recycled Content: Submittals for all materials with recycled content (excluding MEP systems equipment and components) must include the following documentation: Manufacturer’s product data, product literature, or a letter from the manufacturer verifying the percentage of post-consumer and pre-consumer recycled content (by weight) of each material or product
    a. An electronic spreadsheet that tabulates the Project’s total materials cost and combined recycled content value (defined as the sum of the post-consumer recycled content value plus one-half of the pre-consumer recycled content value) expressed as a percentage of total materials cost. This spreadsheet shall be submitted every third month with the Contractor’s Certificate and Application for Payment. It should indicate, on an ongoing basis, line items for each material, including cost, pre-consumer recycled content, post-consumer recycled content, and combined recycled content value.
13. Not Used

14. Outdoor Air Delivery Monitoring: Provide manufacturer’s cut sheets highlighting the installed carbon dioxide monitoring system components and sequence of controls shop drawing documentation, including CO_2 differential set-points and alarm capabilities.
15. Interior Adhesives and Sealants: Submittals for all field-applied adhesives and sealants, which have a potential impact on indoor air, must include manufacturer’s MSDSs or other Product Data highlighting VOC content.

a. Provide manufacturers' documentation verifying all adhesives used to apply laminates, whether shop-applied or field-applied, contain no urea-formaldehyde.

16. NOT USED
17. NOT USED
18. NOT USED
19. NOT USED
20. NOT USED
21. NOT USED
22. NOT USED
23. NOT USED
24. NOT USED
25. Thermal Comfort Controls: Provide manufacturer's cut sheets and shop drawing documentation highlighting all thermal comfort-control systems components.
26. NOT USED
27. NOT USED
28. NOT USED
29. Duct Acoustical Insulation: Provide manufacturer's cut sheets or product data verifying that mechanical sound insulation materials in air distribution ducts consists of an impervious, non-porous coatings that prevent dust from accumulating in the insulating materials.
30. Green Housekeeping: Provide documentation that all cleaning products and janitorial paper products meet the VOC limits and content requirements of this specification section.

B. Project Materials Cost Data: Provide a spreadsheet in an electronic file indicating the total cost for the Project and the total cost of building materials used for the Project, as follows:

1. Not more than 60 days after the Preconstruction Meeting, the General Contractor shall provide to the Owner and Architect a preliminary schedule of materials costs for all materials used for the Project organized by specification section. Exclude labor costs and all mechanical, electrical, and plumbing (MEP) systems materials and labor costs. Include the following:

   a. Identify each reused or salvaged material, its cost, and its replacement value.

b. Identify each recycled-content material, its post-consumer and pre-consumer recycled content as a percentage the product's weight, its cost, its combined recycled content value (defined as the sum of the post-consumer recycled content value plus one-half of the pre-consumer recycled content value), and the total combined recycled content value for all materials as a percentage of total materials costs.

c. Identify each regional material, its cost, its manufacturing location, the distance of this location from the Project site, the source location for each raw material component of the material, the distance of these extraction locations from the Project site, and the total value of regional materials as a percentage of total materials costs.

d. Identify each biobased material, its source, its cost, and the total value of biobased materials as a percentage of total materials costs. Also provide the total value of rapidly renewable materials (materials made from plants that are harvested in less than a 10-year cycle) as a percentage of total materials costs.

e. Identify each wood-based material, its cost, the total wood-based materials cost, each FSC Certified wood material, its cost, and the total value of Certified wood as a percentage of total wood-based materials costs.

2. Provide final versions of the above spreadsheets to the Owner and Architect not more than 14 days after Substantial Completion.

C. Construction Waste Management: See Section 01 74 19 “Construction Waste Management” for submittal requirements.

D. Construction Indoor Air Quality (IAQ) Management: Submittals must include the following:

1. Not more than 30 days after the Preconstruction Meeting, prepare and submit for the Architect and Owner's approval, an electronic copy of the draft Construction IAQ Management Plan in an electronic file including, but not limited to, descriptions of the following:

2. Instruction procedures for meeting or exceeding the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings Under Construction, 1995, Chapter 3, including procedures

for HVAC Protection, Source Control, Pathway Interruption, Housekeeping, and Scheduling

a. Instruction procedures for protecting absorptive materials stored on-site or installed from moisture damage
b. Schedule of submission to Architect of photographs of on-site construction IAQ management measures such as protection of ducts and on-site stored oil installed absorptive materials
c. Instruction procedures if air handlers must be used during construction, including a description of filtration media to be used at each return air grille
d. Instruction procedure for replacing all air-filtration media immediately prior to occupancy after completion of construction, including a description of filtration media to be used at each air handling or air supply unit

3. Not more than 30 days following receipt of the approved draft CIAQMP, submit an electronic copy of the approved CIAQMP in an electronic file, along with the following:
   a. Manufacturer’s cut sheets and product data highlighting the Minimum Efficiency Reporting Value (MERV) for all filtration media to be installed at return air grilles during construction if permanently installed AHUs are used during construction.
   b. Manufacturer’s cut sheets and product data highlighting the Minimum Efficiency Reporting Value (MERV) for filtration media in all air handling units (AHUs).
4. Not more than 14 days after Substantial Completion provide the following:
   a. Documentation verifying required replacement of air filtration media in all air handling units (AHUs) after the completion of construction and prior to occupancy and, if applicable, required installation of filtration during construction.
   b. Minimum of 18 Construction photographs: Six photographs taken on three different occasions during construction of the SMACNA approaches employed, along with a brief description of each approach, documenting implementation of the IAQ management measures, such as protection of ducts and on-site stored or installed absorptive materials.
   c. A copy of the report from testing and inspecting agency documenting the results of IAQ testing, demonstrating conformance

with IAQ testing standards

E. Commissioning: See Section 01 91 00 “General Commissioning Requirements” for submittal requirements.

F. Sustainable Design Progress Reports: Concurrent with each Application for Payment, submit reports for the following:

1. Construction Waste Management: Waste reduction progress reports and logs complying with the requirements of Section 01 74 19 ”Construction Waste Management.”
2. Construction IAQ Management: See details below under Section 3.2 Construction Indoor Air Quality Management for Construction IAQ management progress report requirements.

1.6 QUALITY ASSURANCE

A. Preconstruction Meeting: After award of Contract and prior to the commencement of the Work, schedule and conduct meeting with Owner, Architect, and all Subcontractors to discuss the Construction Waste Management Plan, the required Construction Indoor Air Quality (IAQ) Management Plan, and all other Sustainable Design Requirements. The purpose of this meeting is to develop a mutual understanding of the Project’s Sustainable Design Requirements and coordination of the Contractor’s management of these requirements with the Contracting Officer and the Construction Quality Manager.

B. Construction Job Conferences: The status of compliance with the Sustainable Design Requirements of these specifications will be an agenda item at all regular job meetings conducted during the course of work at the site.

PART 2 - PRODUCTS

2.1 PRODUCT ENVIRONMENTAL REQUIREMENTS

A. Site Clearing: Topsoil shall be provided by the Contractor from on-site material which has been stockpiled for reuse. Off-site borrow should only be used when on-site sources are exhausted. Chip and/or compost on site all vegetated material identified for removal.

B. Do not burn rubbish, organic matter, etc. or any material on the site. Dispose of legally in accordance with Specifications Sections 01 74 19.

C. NOT USED

D. NOT USED

E. NOT USED

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F. Landscape Irrigation: Use water-efficient landscape and irrigation strategies, including water reuse and recycling, to reduce outdoor potable water consumption by a minimum of 50 percent over that consumed by conventional means (plant species and plant densities).

G. Not Used

H. Process Water Use: Employ strategies that in aggregate result in 20% less water use than the process water use baseline for the building after meeting the commercial equipment and HVAC performance requirements as listed in the Table below. For equipment not addressed by EPACT 2005 or the list below, additional equipment performance requirements may be proposed provided documentation supporting the proposed benchmark or industry standard is submitted.

   1. Clothes Washer: 7.5 gallons/cubic foot/cycle
   2. Dishwasher with Racks: 1.0 gallons/rack
   3. Ice Machine: 20 gallons/100 pounds ice for machines making over 175 pounds of ice per day; 30 gallons/100 pounds ice for machines making less than 175 ice per day. Avoid water-cooled machines.
   4. Food Steamer: 2 gallons/hour. Use only boilerless steamers.
   5. Pre-Rinse Spray Valves: 1.4 gallons/minute
   6. Kitchen Pot-Washing Sinks: 2.2 gallons/minute
   7. Cooling Towers: 2.3 gallons/ton-hr. water loss

I. Elimination of CFCs AND HCFCs:

   1. Ozone Protection and Greenhouse Gas Reduction: Base building cooling equipment shall contain no refrigerants other than the following: HCFC-123, HFC-134a, HFC-245fa, HFC-407c, or HFC 410a.
   2. Fire suppression systems may not contain ozone-depleting substances such as halon 1301 and 1211.
   3. Extruded polystyrene insulation (XPS) and closed-cell spray foam polyurethane insulation shall not be manufactured with hydrochlorofluorocarbon (HCFC) blowing agents.

J. Appliances and Equipment: All materials and equipment being installed that falls under the Energy Star or FEMP programs must be Energy Star or FEMP-rated. Eligible equipment includes refrigerators, motors, laundry equipment, office equipment and more. Refer to each program’s website for a complete list.

K. Not Used

L. Measurement and Verification: Install controls and monitoring devices as required by MEP divisions order to comply with International

Performance Measurement & Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction, April 2003, Option D.

1. The IPMVP provides guidance on situation-appropriate application of measurement and verification strategies.

M. Salvaged or Reused materials: There shall be no substitutions for specified salvaged and reused materials and products.

1. Salvaged materials: Use of salvaged materials reduces impacts of disposal and manufacturing of replacements.

N. Recycled Content of Materials:

1. Provide building materials with recycled content such that post-consumer recycled content value plus half the pre-consumer recycled content value constitutes a minimum of 30% of the cost of materials used for the Project, exclusive of all MEP equipment, labor, and delivery costs. The Contractor shall make all attempts to maximize the procurement of materials with recycled content.
   a. e post-consumer recycled content value of a material shall be determined by dividing the weight of post-consumer recycled content by the total weight of the material and multiplying by the cost of the material.
   b. Do not include mechanical and electrical components in the calculations.
   c. Do not include labor and delivery costs in the calculations.
   d. Recycled content of materials shall be defined according to the Federal Trade Commission's "Guide for the Use of Environmental Marketing Claims," 16 CFR 260.7 (e).
   e. Utilize all on-site existing paving materials that are scheduled for demolition as granulated fill, and include the cost of this material had it been purchased in the calculations for recycled content value.
   f. The materials in the following list must contain the minimum recycled content indicated:

Category	**Minimum Recycled Content**
Compost/mulch	100% post-consumer
Asphaltic Concrete Paving	25% post-consumer
Cast-in-Place Concrete	6% pre-consumer

CMU: Gray Block	20% pre-consumer
Steel Reinforcing Bars	90% combined
Structural Steel Shapes	90% combined
Steel Joists	75% combined
Steel Deck	75% combined
Steel Fabrications	60% combined
Steel Studs	30% combined
Steel Roofing	30% post-consumer
Aluminum Fabrications	35% combined
Rigid Insulation	20% pre-consumer
Batt insulation	30% combined

O. Biobased Content:

1. For products designated by the USDA’s BioPreferred program, provide products that meet or exceed USDA recommendations for biobased content, so long as products meet all other performance requirements in VA master specifications. For more information regarding the product categories covered by the BioPreferred program, visit http://www.biopreferred.gov

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SECTION 01 91 00

GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 COMMISSIONING DESCRIPTION

A. This Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS shall form the basis of the construction phase commissioning process and procedures. The Commissioning Agent shall add, modify, and refine the commissioning procedures, as approved by the Department of Veterans Affairs (VA), to suit field conditions and actual manufacturer's equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks.

B. Various sections of the project specifications require equipment startup, testing, and adjusting services. Requirements for startup, testing, and adjusting services specified in the Division 7, Division 23, Division 25, and Division 26 series sections of these specifications are intended to be provided in coordination with the commissioning services and are not intended to duplicate services. The Contractor shall coordinate the work required by individual specification sections with the commissioning services requirements specified herein.

C. Where individual testing, adjusting, or related services are required in the project specifications and not specifically required by this commissioning requirements specification, the specified services shall be provided and copies of documentation, as required by those specifications shall be submitted to the VA and the Commissioning Agent to be indexed for future reference.

D. Where training or educational services for VA are required and specified in other sections of the specifications, including but not limited to Division 7, , Division 23, Division 25, and Division 26series sections of the specification, these services are intended to be provided in addition to the training and educational services specified herein.

E. Commissioning is a systematic process of verifying that the building systems perform interactively according to the construction documents and the VA’s operational needs. The commissioning process shall encompass and coordinate the system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. Commissioning during the construction, and post-occupancy phases is intended to achieve the following specific objectives according to the contract documents:

1. Verify that the applicable equipment and systems are installed in accordance with the contact documents and according to the manufacturer's recommendations.
2. Verify and document proper integrated performance of equipment and systems.
3. Verify that Operations & Maintenance documentation is complete.
4. Verify that all components requiring servicing can be accessed, serviced and removed without disturbing nearby components including ducts, piping, cabling or wiring.
5. Verify that the VA’s operating personnel are adequately trained to enable them to operate, monitor, adjust, maintain, and repair building systems in an effective and energy-efficient manner.
6. Document the successful achievement of the commissioning objectives listed above.

F. The commissioning process does not take away from or reduce the responsibility of the Contractor to provide a finished and fully functioning product.

G. The Commissioning Agent, both the firm and individual designated as the Commissioning Agent, shall be certified as a commissioning provider/authority by at least one of the following entities: the National Environmental Balancing Bureau (NEBB), the Associated Air Balance Council Commissioning Group (AABC), the Building Commissioning Association (BCA, Association of Energy Engineers (AEE), ASHRAE, and University of Wisconsin-Madison. Certification(s) shall be valid and active. Proof of certification(s) shall be submitted to the Contracting Officer and the Resident Engineer three (3) calendar days after the Notice to Proceed.

1.2 CONTRACTUAL RELATIONSHIPS

A. For this construction project, the Department of Veterans Affairs contracts with a Contractor to provide construction services. The contracts are administered by the VA Contracting Officer and the Resident Engineer as the designated representative of the Contracting Officer. On this project, the authority to modify the contract in any way is strictly limited to the authority of the Contracting Officer.

B. In this project, only two contract parties are recognized and communications on contractual issues are strictly limited to VA Resident Engineer and the Contractor. It is the practice of the VA to require that communications between other parties to the contracts (Subcontractors and Vendors) be conducted through the Resident Engineer and Contractor. It is also the practice of the VA that communications between other parties of the project (Commissioning Agent and Architect/Engineer) be conducted through the Resident Engineer.

C. Whole Building Commissioning is a process that relies upon frequent and direct communications, as well as collaboration between all parties to the construction process. By its nature, a high level of communication and cooperation between the Commissioning Agent and all other parties (Architects, Engineers, Subcontractors, Vendors, third party testing agencies, etc.) is essential to the success of the Commissioning effort.

D. With these fundamental practices in mind, the commissioning process described herein has been developed to recognize that, in the execution of the Commissioning Process, the Commissioning Agent must develop effective methods to communicate with every member of the construction team involved in delivering commissioned systems while simultaneously respecting the exclusive contract authority of the Contracting Officer and Resident Engineer. Thus, the procedures outlined in this specification must be executed within the following limitations:

  1. No communications (verbal or written) from the Commissioning Agent shall be deemed to constitute direction that modifies the terms of any contract between the Department of Veterans Affairs and the Contractor.
  2. Commissioning Issues identified by the Commissioning Agent will be delivered to the Resident Engineer and copied to the designated Commissioning Representatives for the Contractor and subcontractors on the Commissioning Team for information only in order to expedite the communication process. These issues must be understood as the professional opinion of the Commissioning Agent and as suggestions for resolution.
  3. In the event that any Commissioning Issues and suggested resolutions are deemed by the Resident Engineer to require either an official interpretation of the construction documents or require a

modification of the contract documents, the Contracting Officer or Resident Engineer will issue an official directive to this effect.

4. All parties to the Commissioning Process shall be individually responsible for alerting the Resident Engineer of any issues that they deem to constitute a potential contract change prior to acting on these issues.
5. Authority for resolution or modification of design and construction issues rests solely with the Contracting Officer or Resident Engineer, with appropriate technical guidance from the Architect/Engineer and/or Commissioning Agent.

1.3 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.
B. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.
D. Section 25 10 10 ADVANCED UTILITY METERING SYSTEMS.
E. Section 26 08 00 COMMISSIONING OF ELECTRICAL SYSTEMS.

1.4 SUMMARY

A. This Section includes general requirements that apply to implementation of commissioning without regard to systems, subsystems, and equipment being commissioned.
B. The commissioning activities have been developed to support the VA requirements to meet guidelines for Federal Leadership in Environmental, Energy, and Economic Performance.

1.5 ACRONYMS

List of Acronyms	
Acronym	Meaning
A/E	Architect / Engineer Design Team
AHJ	Authority Having Jurisdiction
ASHRAE	Association Society for Heating Air Condition and Refrigeration Engineers
BOD	Basis of Design
BSC	Building Systems Commissioning
CCTV	Closed Circuit Television
CD	Construction Documents
CMMS	Computerized Maintenance Management System
CO	Contracting Officer (VA)
COR	Contracting Officer’s Representative (see also VA-RE)

List of Acronyms	
Acronym	Meaning
COBie	Construction Operations Building Information Exchange
CPC	Construction Phase Commissioning
Cx	Commissioning
CxA	Commissioning Agent
CxM	Commissioning Manager
CxR	Commissioning Representative
DPC	Design Phase Commissioning
FPT	Functional Performance Test
GBI-GG	Green Building Initiative - Green Globes
HVAC	Heating, Ventilation, and Air Conditioning
LEED	Leadership in Energy and Environmental Design
NC	Department of Veterans Affairs National Cemetery
NCA	Department of Veterans Affairs National Cemetery Administration
NEBB	National Environmental Balancing Bureau
O&M	Operations & Maintenance
OPR	Owner’s Project Requirements
PFC	Pre-Functional Checklist
PFT	Pre-Functional Test
SD	Schematic Design
SO	Site Observation
TAB	Test Adjust and Balance
VA	Department of Veterans Affairs
VAMC	VA Medical Center
VA CFM	VA Office of Construction and Facilities Management
VACO	VA Central Office
VA PM	VA Project Manager
VA-RE	VA Resident Engineer
USGBC	United States Green Building Council

1.6 DEFINITIONS

Acceptance Phase Commissioning: Commissioning tasks executed after most construction has been completed, most Site Observations and Static Tests have been completed and Pre-Functional Testing has been completed and accepted. The main commissioning activities performed during this phase are verification that the installed systems are functional by conducting Systems Functional Performance tests and Owner Training.

Accuracy: The capability of an instrument to indicate the true value of a measured quantity.

Back Check: A back check is a verification that an agreed upon solution to a design comment has been adequately addressed in a subsequent design review

Basis of Design (BOD): The Engineer's Basis of Design is comprised of two components: the Design Criteria and the Design Narrative, these documents record the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements (OPR) and to satisfy applicable regulatory requirements, standards, and guidelines.

Benchmarks: Benchmarks are the comparison of a building's energy usage to other similar buildings and to the building itself.. For example, ENERGY STAR Portfolio Manager is a frequently used and nationally recognized building energy benchmarking tool.

Building Information Modeling (BIM): Building Information Modeling is a parametric database which allows a building to be designed and constructed virtually in 3D, and provides reports both in 2D views and as schedules. This electronic information can be extracted and reused for pre-populating facility management CMMS systems. Building Systems Commissioning (BSC): NEBB acronym used to designate its commissioning program.

Calibrate: The act of comparing an instrument of unknown accuracy with a standard of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the tested instrument.

CCTV: Closed circuit Television. Normally used for security surveillance and alarm detections as part of a special electrical security system.

COBie: Construction Operations Building Information Exchange (COBie) is an electronic industry data format used to transfer information developed during design, construction, and commissioning into the Computer Maintenance Management Systems (CMMS) used to operate facilities. See the Whole Building Design Guide website for further information (http://www.wbdg.org/resources/cobie.php)

Commissionability: Defines a design component or construction process that has the necessary elements that will allow a system or component to be effectively measured, tested, operated and commissioned

Commissioning Agent (CxA): The qualified Commissioning Professional who administers the Cx process by managing the Cx team and overseeing the Commissioning Process. Where CxA is used in this specification it means the Commissioning Agent, members of his staff or appointed members of the commissioning team. Note that LEED uses the term Commissioning Authority in lieu of Commissioning Agent.

Commissioning Checklists: Lists of data or inspections to be verified to ensure proper system or component installation, operation, and function. Verification checklists are developed and used during all phases of the commissioning process to verify that the Owner’s Project Requirements (OPR) is being achieved.

Commissioning Design Review: The commissioning design review is a collaborative review of the design professionals design documents for items pertaining to the following: owner’s project requirements; basis of design; operability and maintainability (O&M) including documentation; functionality; training; energy efficiency, control systems’ sequence of operations including building automation system features; commissioning specifications and the ability to functionally test the systems.

Commissioning Issue: A condition identified by the Commissioning Agent or other member of the Commissioning Team that adversely affects the commissionability, operability, maintainability, or functionality of a system, equipment, or component. A condition that is in conflict with the Contract Documents and/or performance requirements of the installed systems and components. (See also – Commissioning Observation).

Commissioning Manager (CxM): A qualified individual appointed by the Contractor to manage the commissioning process on behalf of the Contractor.

Commissioning Observation: An issue identified by the Commissioning Agent or other member of the Commissioning Team that does not conform to the project OPR, contract documents or standard industry best practices. (See also Commissioning Issue)

Commissioning Plan: A document that outlines the commissioning process, commissioning scope and defines responsibilities, processes, schedules, and the documentation requirements of the Commissioning Process.

Commissioning Process: A quality focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems, components, and assemblies are planned, designed, installed, tested, can be operated, and maintained to meet the Owner's Project Requirements.

Commissioning Report: The final commissioning document which presents the commissioning process results for the project. Cx reports include an executive summary, the commissioning plan, issue log, correspondence, and all appropriate check sheets and test forms.

Commissioning Representative (CxR): An individual appointed by a sub-contractor to manage the commissioning process on behalf of the sub-contractor.

Commissioning Specifications: The contract documents that detail the objective, scope and implementation of the commissioning process as developed in the Commissioning Plan.

Commissioning Team: Individual team members whose coordinated actions are responsible for implementing the Commissioning Process.

Construction Phase Commissioning: All commissioning efforts executed during the construction process after the design phase and prior to the Acceptance Phase Commissioning.

Contract Documents (CD): Contract documents include design and construction contracts, price agreements and procedure agreements. Contract Documents also include all final and complete drawings, specifications and all applicable contract modifications or supplements.

Construction Phase Commissioning (CPC): All commissioning efforts executed during the construction process after the design phase and prior to the Acceptance Phase Commissioning.

Coordination Drawings: Drawings showing the work of all trades that are used to illustrate that equipment can be installed in the space allocated without compromising equipment function or access for maintenance and replacement. These drawings graphically illustrate and dimension manufacturers’ recommended maintenance clearances. On mechanical projects, coordination drawings include structural steel, ductwork, major piping and electrical conduit and show the elevations and locations of the above components.

Data Logging: The monitoring and recording of temperature, flow, current, status, pressure, etc. of equipment using stand-alone data recorders.

Deferred System Test: Tests that cannot be completed at the end of the acceptance phase due to ambient conditions, schedule issues or other conditions preventing testing during the normal acceptance testing period.

Deficiency: See "Commissioning Issue".

Design Criteria: A listing of the VA Design Criteria outlining the project design requirements, including its source. These are used during the design process to show the design elements meet the OPR.

Design Intent: The overall term that includes the OPR and the BOD. It is a detailed explanation of the ideas, concepts, and criteria that are defined by the owner to be important. The design intent documents are utilized to provide a written record of these ideas, concepts and criteria.

Design Narrative: A written description of the proposed design solutions that satisfy the requirements of the OPR.

Design Phase Commissioning (DPC): All commissioning tasks executed during the design phase of the project.

Environmental Systems: Systems that use a combination of mechanical equipment, airflow, water flow and electrical energy to provide heating, ventilating, air conditioning, humidification, and dehumidification for the purpose of human comfort or process control of temperature and humidity.

Executive Summary: A section of the Commissioning report that reviews the general outcome of the project. It also includes any unresolved issues, recommendations for the resolution of unresolved issues and all deferred testing requirements.

Functionality: This defines a design component or construction process which will allow a system or component to operate or be constructed in a manner that will produce the required outcome of the OPR.

Functional Test Procedure (FTP): A written protocol that defines methods, steps, personnel, and acceptance criteria for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

Industry Accepted Best Practice: A design component or construction process that has achieved industry consensus for quality performance and functionality. Refer to the current edition of the NEBB Design Phase Commissioning Handbook for examples.

Installation Verification: Observations or inspections that confirm the system or component has been installed in accordance with the contract documents and to industry accepted best practices.

Integrated System Testing: Integrated Systems Testing procedures entail testing of multiple integrated systems performance to verify proper functional interface between systems. Typical Integrated Systems Testing includes verifying that building systems respond properly to loss of utility, transfer to emergency power sources, re-transfer from emergency power source to normal utility source; interface between HVAC controls and Fire Alarm systems for equipment shutdown, interface between Fire Alarm system and elevator control systems for elevator recall and shutdown; interface between Fire Alarm System and Security Access Control Systems to control access to spaces during fire alarm conditions; and other similar tests as determined for each specific project.

Issues Log: A formal and ongoing record of problems or concerns – and their resolution – that have been raised by members of the Commissioning Team during the course of the Commissioning Process.

Lessons Learned Workshop: A workshop conducted to discuss and document project successes and identify opportunities for improvements for future projects.

Maintainability: A design component or construction process that will allow a system or component to be effectively maintained. This includes adequate room for access to adjust and repair the equipment. Maintainability also includes components that have readily obtainable repair parts or service.

Manual Test: Testing using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the ‘observation’).

Owner’s Project Requirements (OPR): A written document that details the project requirements and the expectations of how the building and its systems will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

Peer Review: A formal in-depth review separate from the commissioning review processes. The level of effort and intensity is much greater than a typical commissioning facilitation or extended commissioning review. The VA usually hires an independent third-party (called the IDIQ A/E) to conduct peer reviews.

Precision: The ability of an instrument to produce repeatable readings of the same quantity under the same conditions. The precision of an instrument refers to its ability to produce a tightly grouped set of values around the mean value of the measured quantity.

Pre-Design Phase Commissioning: Commissioning tasks performed prior to the commencement of design activities that includes project programming and the development of the commissioning process for the project

Pre-Functional Checklist (PFC): A form used by the contractor to verify that appropriate components are onsite, correctly installed, set up, calibrated, functional and ready for functional testing.

Pre-Functional Test (PFT): An inspection or test that is done before functional testing. PFT's include installation verification and system and component start up tests.

Procedure or Protocol: A defined approach that outlines the execution of a sequence of work or operations. Procedures are used to produce repeatable and defined results.

Range: The upper and lower limits of an instrument's ability to measure the value of a quantity for which the instrument is calibrated.

Resolution: This word has two meanings in the Cx Process. The first refers to the smallest change in a measured variable that an instrument can detect. The second refers to the implementation of actions that correct a tested or observed deficiency.

Site Observation Visit: On-site inspections and observations made by the Commissioning Agent for the purpose of verifying component, equipment, and system installation, to observe contractor testing, equipment start-up procedures, or other purposes.

Site Observation Reports (SO): Reports of site inspections and observations made by the Commissioning Agent. Observation reports are intended to provide early indication of an installation issue which will need correction or analysis.

Special System Inspections: Inspections required by a local code authority prior to occupancy and are not normally a part of the commissioning process.

Static Tests: Tests or inspections that validate a specified static condition such as pressure testing. Static tests may be specification or code initiated.

Start Up Tests: Tests that validate the component or system is ready for automatic operation in accordance with the manufactures requirements.

Systems Manual: A system-focused composite document that includes all information required for the owners operators to operate the systems.

Test Procedure: A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

Testing: The use of specialized and calibrated instruments to measure parameters such as: temperature, pressure, vapor flow, air flow, fluid flow, rotational speed, electrical characteristics, velocity, and other data in order to determine performance, operation, or function.

Testing, Adjusting, and Balancing (TAB): A systematic process or service applied to heating, ventilating and air-conditioning (HVAC) systems and other environmental systems to achieve and document air and hydronic flow rates. The standards and procedures for providing these services are referred to as “Testing, Adjusting, and Balancing” and are described in the Procedural Standards for the Testing, Adjusting and Balancing of Environmental Systems, published by NEBB or AABC.

Thermal Scans: Thermographic pictures taken with an Infrared Thermographic Camera. Thermographic pictures show the relative temperatures of objects and surfaces and are used to identify leaks, thermal bridging, thermal intrusion, electrical overload conditions, moisture containment, and insulation failure.

Training Plan: A written document that details, in outline form the expectations of the operator training. Training agendas should include instruction on how to obtain service, operate, startup, shutdown and maintain all systems and components of the project.

Trending: Monitoring over a period of time with the building automation system.

Unresolved Commissioning Issue: Any Commissioning Issue that, at the time that the Final Report or the Amended Final Report is issued that has not been either resolved by the construction team or accepted by the VA. Validation: The process by which work is verified as complete and operating correctly:

1. First party validation occurs when a firm or individual verifying the task is the same firm or individual performing the task.
2. Second party validation occurs when the firm or individual verifying the task is under the control of the firm performing the task or has other possibilities of financial conflicts of interest in the

resolution (Architects, Designers, General Contractors and Third Tier Subcontractors or Vendors).

3. Third party validation occurs when the firm verifying the task is not associated with or under control of the firm performing or designing the task.

Verification: The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the Owner's Project Requirements.

Warranty Phase Commissioning: Commissioning efforts executed after a project has been completed and accepted by the Owner. Warranty Phase Commissioning includes follow-up on verification of system performance, measurement and verification tasks and assistance in identifying warranty issues and enforcing warranty provisions of the construction contract.

Warranty Visit: A commissioning meeting and site review where all outstanding warranty issues and deferred testing is reviewed and discussed.

Whole Building Commissioning: Commissioning of building systems such as Building Envelope, HVAC, Electrical, Special Electrical (Fire Alarm, Security & Communications), Plumbing and Fire Protection as described in this specification.

1.7 SYSTEMS TO BE COMMISSIONED

A. Commissioning of a system or systems specified for this project is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel, is required in cooperation with the VA and the Commissioning Agent.

B. The following systems will be commissioned as part of this project:

Systems To Be Commissioned	
System	**Description**
HVAC	

Systems To Be Commissioned	
System	**Description**
Direct Digital Control System**	Operator Interface Computer, Operator Work Station (including graphics, point mapping, trends, alarms), Network Communications Modules and Wiring (including Fiber Optic system), Control System communication network, and Integration Panels. [DDC Control panels will be commissioned with the systems controlled by the panel]
Utility Metering	Steam, Natural Gas, Demestic Water, Chilled Water, Heating Water (*including graphis, point mapping, trends,), Network Communications Modules, and Wiring.
Chilled Water System**	Chillers (centrifugal, rotary screw, air-cooled), pumps (primary, secondary, variable primary), VFDs associated with chilled water system components, DDC Control Panels (including integration with Building Control System)(Does not include Bldg 147)
Condenser Water System**	Cooling Towers, Fluid Coolers, heat exchangers/economizers, pumps, VFDs associated with condenser water system components, DDC control panels.
Steam/Heating Hot Water System**	Boilers, boiler feed water system, economizers/heat recovery equipment, condensate recovery, water treatment, boiler fuel system, controls, interface with facility DDC system.
HVAC Air Handling Systems**	Air handling Units, packaged rooftop AHU, Outdoor Air conditioning units, humidifiers, DDC control panels
HVAC Ventilation/Exhaust Systems	General exhaust, toilet exhaust, laboratory exhaust, isolation exhaust, room pressurization control systems
HVAC Energy Recovery Systems**	Heat Wheels, Heat Recovery Loops, AHU Integrated Heat Recovery

Systems To Be Commissioned	
System	**Description**
HVAC Terminal Unit Systems**	VAV Terminal Units, CAV terminal units, fan coil units, fin-tube radiation, unit heaters
Humidity Control Systems	Humidifiers, de-humidifiers, controls, interface with facility DDC
Hydronic Distribution Systems	Pumps, DDC control panels, heat exchangers,
Electrical	
Electric Power Monitoring Systems	Metering, sub-metering, power monitoring systems, PLC control systems
Low-Voltage Distribution System	Normal power distribution system, Life-safety power distribution system, critical power distribution system, equipment power distribution system, switchboards, distribution panels, panelboards, verify breaker testing results (injection current, etc)
Communications	
Electronic Safety and Security	
Fire Detection and Alarm System	100% device acceptance testing, verify system monitoring, verify interface with other systems.
Renewable Energy Sources	
Site Utilities	
Transportation	
Integrated Systems Tests	
Fire Alarm Response	Integrated System Response to Fire Alarm Condition and Return to Normal
Table Notes	
** Denotes systems that LEED requires to be commissioned to comply with the LEED Fundamental Commissioning pre-requisite.	

COMMISSIONING TEAM

A. The commissioning team shall consist of, but not be limited to, representatives of Contractor, including Project Superintendent and subcontractors, installers, schedulers, suppliers, and specialists deemed appropriate by the Department of Veterans Affairs (VA) and Commissioning Agent.

B. Members Appointed by Contractor:
   1. Contractor’ Commissioning Manager: The designated person, company, or entity that plans, schedules and coordinates the commissioning activities for the construction team.
   2. Contractor’s Commissioning Representative(s): Individual(s), each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions.

C. Members Appointed by VA:
   1. Commissioning Agent: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. The VA will engage the CxA under a separate contract.
   2. User: Representatives of the facility user and operation and maintenance personnel.
   3. A/E: Representative of the Architect and engineering design professionals.

1.9 VA'S COMMISSIONING RESPONSIBILITIES

A. Appoint an individual, company or firm to act as the Commissioning Agent.

B. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities including, but not limited to, the following:
   1. Coordination meetings.
   2. Training in operation and maintenance of systems, subsystems, and equipment.
   3. Testing meetings.
   4. Witness and assist in Systems Functional Performance Testing.
   5. Demonstration of operation of systems, subsystems, and equipment.

C. Provide the Construction Documents, prepared by Architect and approved by VA, to the Commissioning Agent and for use in managing the commissioning process, developing the commissioning plan, systems manuals, and reviewing the operation and maintenance training plan.

1.10 CONTRACTOR'S COMMISSIONING RESPONSIBILITIES

A. The Contractor shall assign a Commissioning Manager to manage commissioning activities of the Contractor, and subcontractors.

B. The Contractor shall ensure that the commissioning responsibilities outlined in these specifications are included in all subcontracts and that subcontractors comply with the requirements of these specifications.

C. The Contractor shall ensure that each installing subcontractor shall assign representatives with expertise and authority to act on behalf of the subcontractor and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:

1. Participate in commissioning coordination meetings.
2. Conduct operation and maintenance training sessions in accordance with approved training plans.
3. Verify that Work is complete and systems are operational according to the Contract Documents, including calibration of instrumentation and controls.
4. Evaluate commissioning issues and commissioning observations identified in the Commissioning Issues Log, field reports, test reports or other commissioning documents. In collaboration with entity responsible for system and equipment installation, recommend corrective action.
5. Review and comment on commissioning documentation.
6. Participate in meetings to coordinate Systems Functional Performance Testing.
7. Provide schedule for operation and maintenance data submittals, equipment startup, and testing to Commissioning Agent for incorporation into the commissioning plan.
8. Provide information to the Commissioning Agent for developing commissioning plan.
9. Participate in training sessions for VA's operation and maintenance personnel.
10. Provide technicians who are familiar with the construction and operation of installed systems and who shall develop specific test procedures to conduct Systems Functional Performance Testing of installed systems.

1.11 COMMISSIONING AGENT'S RESPONSIBILITIES

A. Organize and lead the commissioning team.

B. Prepare the commissioning plan. See Paragraph 1.11-A of this specification Section for further information.

C. Review and comment on selected submittals from the Contractor for general conformance with the Construction Documents. Review and comment on the ability to test and operate the system and/or equipment, including providing gages, controls and other components required to operate, maintain, and test the system. Review and comment on performance expectations of systems and equipment and interfaces between systems relating to the Construction Documents.

D. At the beginning of the construction phase, conduct an initial construction phase coordination meeting for the purpose of reviewing the commissioning activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; TAB Work; Pre-Functional Checklists, Systems Functional Performance Testing; and project completion.

E. Convene commissioning team meetings for the purpose of coordination, communication, and conflict resolution; discuss status of the commissioning processes. Responsibilities include arranging for facilities, preparing agenda and attendance lists, and notifying participants. The Commissioning Agent shall prepare and distribute minutes to commissioning team members and attendees within five workdays of the commissioning meeting.

F. Observe construction and report progress, observations and issues. Observe systems and equipment installation for adequate accessibility for maintenance and component replacement or repair, and for general conformance with the Construction Documents.

G. Prepare Project specific Pre-Functional Checklists and Systems Functional Performance Test procedures.

H. Coordinate Systems Functional Performance Testing schedule with the Contractor.

I. Witness selected systems startups.

J. Verify selected Pre-Functional Checklists completed and submitted by the Contractor.

K. Witness and document Systems Functional Performance Testing.

L. Compile test data, inspection reports, and certificates and include them in the systems manual and commissioning report.

M. Review and comment on operation and maintenance (O&M) documentation and systems manual outline for compliance with the Contract Documents. Operation and maintenance documentation requirements are specified in Paragraph 1.25, Section 01 00 00 GENERAL REQUIREMENTS.

N. Review operation and maintenance training program developed by the Contractor. Verify training plans provide qualified instructors to conduct operation and maintenance training.

O. Prepare commissioning Field Observation Reports.

P. Prepare the Final Commissioning Report.

Q. Return to the site at 10 months into the 12 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal Systems Functional Performance Testing. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

R. Assemble the final commissioning documentation, including the Final Commissioning Report and Addendum to the Final Commissioning Report.

1.12 COMMISSIONING DOCUMENTATION

A. Commissioning Plan: A document, prepared by Commissioning Agent, that outlines the schedule, allocation of resources, and documentation requirements of the commissioning process, and shall include, but is not limited, to the following:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports. Identification of the relationship of these documents to other functions and a detailed description of submittals that are required to support the commissioning processes. Submittal dates shall include the latest date approved submittals must be received without adversely affecting commissioning plan.
2. Description of the organization, layout, and content of commissioning documentation (including systems manual) and a detailed description of documents to be provided along with identification of responsible parties.
3. Identification of systems and equipment to be commissioned.
4. Schedule of Commissioning Coordination meetings.

5. Identification of items that must be completed before the next operation can proceed.
6. Description of responsibilities of commissioning team members.
7. Description of observations to be made.
8. Description of requirements for operation and maintenance training.
9. Schedule for commissioning activities with dates coordinated with overall construction schedule.
10. Process and schedule for documenting changes on a continuous basis to appear in Project Record Documents.
11. Process and schedule for completing prestart and startup checklists for systems, subsystems, and equipment to be verified and tested.
12. Preliminary Systems Functional Performance Test procedures.

B. Systems Functional Performance Test Procedures: The Commissioning Agent will develop Systems Functional Performance Test Procedures for each system to be commissioned, including subsystems, or equipment and interfaces or interlocks with other systems. Systems Functional Performance Test Procedures will include a separate entry, with space for comments, for each item to be tested. Preliminary Systems Functional Performance Test Procedures will be provided to the VA, Architect/Engineer, and Contractor for review and comment. The Systems Performance Test Procedure will include test procedures for each mode of operation and provide space to indicate whether the mode under test responded as required. Each System Functional Performance Test procedure, regardless of system, subsystem, or equipment being tested, shall include, but not be limited to, the following:
1. Name and identification code of tested system.
2. Test number.
3. Time and date of test.
4. Indication of whether the record is for a first test or retest following correction of a problem or issue.
5. Dated signatures of the person performing test and of the witness, if applicable.
6. Individuals present for test.
7. Observations and Issues.
8. Issue number, if any, generated as the result of test.

C. Pre-Functional Checklists: The Commissioning Agent will prepare Pre-Functional Checklists. Pre-Functional Checklists shall be completed and signed by the Contractor, verifying that systems, subsystems, equipment, and associated controls are ready for testing. The Commissioning Agent will spot check Pre-Functional Checklists to verify accuracy and readiness for testing. Inaccurate or incomplete Pre-Functional Checklists shall be returned to the Contractor for correction and resubmission.

D. Test and Inspection Reports: The Commissioning Agent will record test data, observations, and measurements on Systems Functional Performance Test Procedure. The report will also include recommendation for system acceptance or non-acceptance. Photographs, forms, and other means appropriate for the application shall be included with data. Commissioning Agent Will compile test and inspection reports and test and inspection certificates and include them in systems manual and commissioning report.

E. Corrective Action Documents: The Commissioning Agent will document corrective action taken for systems and equipment that fail tests. The documentation will include any required modifications to systems and equipment and/or revisions to test procedures, if any. The Commissioning Agent will witness and document any retesting of systems and/or equipment requiring corrective action and document retest results.

F. Commissioning Issues Log: The Commissioning Agent will prepare and maintain Commissioning Issues Log that describes Commissioning Issues and Commissioning Observations that are identified during the Commissioning process. These observations and issues include, but are not limited to, those that are at variance with the Contract Documents. The Commissioning Issues Log will identify and track issues as they are encountered, the party responsible for resolution, progress toward resolution, and document how the issue was resolved. The Master Commissioning Issues Log will also track the status of unresolved issues.

   1. Creating an Commissioning Issues Log Entry:
      a. Identify the issue with unique numeric or alphanumeric identifier by which the issue may be tracked.
      b. Assign a descriptive title for the issue.
      c. Identify date and time of the issue.
      d. Identify test number of test being performed at the time of the observation, if applicable, for cross reference.

e. Identify system, subsystem, and equipment to which the issue applies.
f. Identify location of system, subsystem, and equipment.
g. Include information that may be helpful in diagnosing or evaluating the issue.
h. Note recommended corrective action.
i. Identify commissioning team member responsible for corrective action.
j. Identify expected date of correction.
k. Identify person that identified the issue.

2. Documenting Issue Resolution:
   a. Log date correction is completed or the issue is resolved.
   b. Describe corrective action or resolution taken. Include description of diagnostic steps taken to determine root cause of the issue, if any.
   c. Identify changes to the Contract Documents that may require action.
   d. State that correction was completed and system, subsystem, and equipment are ready for retest, if applicable.
   e. Identify person(s) who corrected or resolved the issue.
   f. Identify person(s) verifying the issue resolution.

G. Final Commissioning Report: The Commissioning Agent will document results of the commissioning process, including unresolved issues, and performance of systems, subsystems, and equipment. The Commissioning Report will indicate whether systems, subsystems, and equipment have been properly installed and are performing according to the Contract Documents. This report will be used by the Department of Veterans Affairs when determining that systems will be accepted. This report will be used to evaluate systems, subsystems, and equipment and will serve as a future reference document during VA occupancy and operation. It shall describe components and performance that exceed requirements of the Contract Documents and those that do not meet requirements of the Contract Documents. The commissioning report will include, but is not limited to, the following:

1. Lists and explanations of substitutions; compromises; variances with the Contract Documents; record of conditions; and, if appropriate, recommendations for resolution. Design Narrative documentation maintained by the Commissioning Agent.

2. Commissioning plan.
3. Pre-Functional Checklists completed by the Contractor, with annotation of the Commissioning Agent review and spot check.
4. Systems Functional Performance Test Procedures, with annotation of test results and test completion.
5, Commissioning Issues Log.
6. Listing of deferred and off season test(s) not performed, including the schedule for their completion.

H. Addendum to Final Commissioning Report: The Commissioning Agent will prepare an Addendum to the Final Commissioning Report near the end of the Warranty Period. The Addendum will indicate whether systems, subsystems, and equipment are complete and continue to perform according to the Contract Documents. The Addendum to the Final Commissioning Report shall include, but is not limited to, the following:
1. Documentation of deferred and off season test(s) results.
2. Completed Systems Functional Performance Test Procedures for off season test(s).
3. Documentation that unresolved system performance issues have been resolved.
4. Updated Commissioning Issues Log, including status of unresolved issues.
5. Identification of potential Warranty Claims to be corrected by the Contractor.

I. Systems Manual: The Commissioning Agent will gather required information and compile the Systems Manual. The Systems Manual will include, but is not limited to, the following:
1. Design Narrative, including system narratives, schematics, single-line diagrams, flow diagrams, equipment schedules, and changes made throughout the Project.
2. Reference to Final Commissioning Plan.
3. Reference to Final Commissioning Report.
4. Approved Operation and Maintenance Data as submitted by the Contractor.

1.13 SUBMITTALS

A. Preliminary Commissioning Plan Submittal: The Commissioning Agent will prepare a Preliminary Commissioning Plan based on the final Construction Documents. Commissioning Agent to forward the Preliminary

Commissioning Plan as a submittal to the architect and the VA. The Preliminary Commissioning Plan is provided for information only. It contains preliminary information about the following commissioning activities:

1. The Commissioning Team: A list of commissioning team members by organization.
2. Systems to be commissioned. A detailed list of systems to be commissioned for the project. This list also provides preliminary information on systems/equipment submittals to be reviewed by the Commissioning Agent; preliminary information on Pre-Functional Checklists that are to be completed; preliminary information on Systems Performance Testing, including information on testing sample size (where authorized by the VA).
3. Commissioning Team Roles and Responsibilities: Preliminary roles and responsibilities for each Commissioning Team member.
4. Commissioning Documents: A preliminary list of commissioning-related documents, include identification of the parties responsible for preparation, review, approval, and action on each document.
5. Commissioning Activities Schedule: Identification of Commissioning Activities, including Systems Functional Testing, the expected duration and predecessors for the activity.
6. Pre-Functional Checklists: Preliminary Pre-Functional Checklists for equipment, components, subsystems, and systems to be commissioned. These Preliminary Pre-Functional Checklists provide guidance on the level of detailed information the Contractor shall include on the final submission.
7. Systems Functional Performance Test Procedures: Preliminary step-by-step System Functional Performance Test Procedures to be used during Systems Functional Performance Testing. These Preliminary Systems Functional Performance procedures provide information on the level of testing rigor, and the level of Contractor support required during performance of system’s testing.

B. Final Commissioning Plan Submittal: Based on the Final Construction Documents and the Contractor’s project team, the Commissioning Agent will prepare the Final Commissioning Plan as described in this section. The Commissioning Agent will submit three hard copies and three sets of electronic files of Final Commissioning Plan. The Contractor shall review the Commissioning Plan and provide any comments to the VA. The

Commissioning Agent will incorporate review comments into the Final Commissioning Plan as directed by the VA.

C. Systems Functional Performance Test Procedure: The Commissioning Agent will submit preliminary Systems Functional Performance Test Procedures to the Contractor, and the VA for review and comment. The Contractor shall return review comments to the VA and the Commissioning Agent. The VA will also return review comments to the Commissioning Agent. The Commissioning Agent will incorporate review comments into the Final Systems Functional Test Procedures to be used in Systems Functional Performance Testing.

D. Pre-Functional Checklists: The Commissioning Agent will submit Pre-Functional Checklists to be completed by the Contractor.

E. Test and Inspection Reports: The Commissioning Agent will submit test and inspection reports to the VA with copies to the Contractor and the Architect/Engineer.

F. Corrective Action Documents: The Commissioning Agent will submit corrective action documents to the VA Resident Engineer with copies to the Contractor and Architect.

G. Preliminary Commissioning Report Submittal: The Commissioning Agent will submit three electronic copies of the preliminary commissioning report. One electronic copy, with review comments, will be returned to the Commissioning Agent for preparation of the final submittal.

H. Final Commissioning Report Submittal: The Commissioning Agent will submit four sets of electronically formatted information of the final commissioning report to the VA. The final submittal will incorporate comments as directed by the VA.

I. Data for Commissioning:

1. The Commissioning Agent will request in writing from the Contractor specific information needed about each piece of commissioned equipment or system to fulfill requirements of the Commissioning Plan.
2. The Commissioning Agent may request further documentation as is necessary for the commissioning process or to support other VA data collection requirements, including Construction Operations Building Information Exchange (COBIE), Building Information Modeling (BIM), etc.

1.14 COMMISSIONING PROCESS

A. The Commissioning Agent will be responsible for the overall management of the commissioning process as well as coordinating scheduling of commissioning tasks with the VA and the Contractor. As directed by the VA, the Contractor shall incorporate Commissioning tasks, including, but not limited to, Systems Functional Performance Testing (including predecessors) with the Master Construction Schedule.

B. Within 14 days of contract award, the Contractor shall designate a specific individual as the Commissioning Manager (CxM) to manage and lead the commissioning effort on behalf of the Contractor. The Commissioning Manager shall be the single point of contact and communications for all commissioning related services by the Contractor.

C. Within 14 days of contract award, the Contractor shall ensure that each subcontractor designates specific individuals as Commissioning Representatives (CXR) to be responsible for commissioning related tasks. The Contractor shall ensure the designated Commissioning Representatives participate in the commissioning process as team members providing commissioning testing services, equipment operation, adjustments, and corrections if necessary. The Contractor shall ensure that all Commissioning Representatives shall have sufficient authority to direct their respective staff to provide the services required, and to speak on behalf of their organizations in all commissioning related contractual matters.

1.15 QUALITY ASSURANCE

A. Instructor Qualifications: Factory authorized service representatives shall be experienced in training, operation, and maintenance procedures for installed systems, subsystems, and equipment.

B. Test Equipment Calibration: The Contractor shall comply with test equipment manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately whenever instruments have been repaired following damage or dropping. Affix calibration tags to test instruments. Instruments shall have been calibrated within six months prior to use.

1.16 COORDINATION

A. Management: The Commissioning Agent will coordinate the commissioning activities with the VA and Contractor. The Commissioning Agent will submit commissioning documents and information to the VA. All commissioning team members shall work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.

B. Scheduling: The Contractor shall work with the Commissioning Agent and the VA to incorporate the commissioning activities into the construction schedule. The Commissioning Agent will provide sufficient information (including, but not limited to, tasks, durations and predecessors) on commissioning activities to allow the Contractor and the VA to schedule commissioning activities. All parties shall address scheduling issues and make necessary notifications in a timely manner in order to expedite the project and the commissioning process. The Contractor shall update the Master Construction as directed by the VA.

C. Initial Schedule of Commissioning Events: The Commissioning Agent will provide the initial schedule of primary commissioning events in the Commissioning Plan and at the commissioning coordination meetings. The Commissioning Plan will provide a format for this schedule. As construction progresses, more detailed schedules will be developed by the Contractor with information from the Commissioning Agent.

D. Commissioning Coordinating Meetings: The Commissioning Agent will conduct periodic Commissioning Coordination Meetings of the commissioning team to review status of commissioning activities, to discuss scheduling conflicts, and to discuss upcoming commissioning process activities.

E. Pretesting Meetings: The Commissioning Agent will conduct pretest meetings of the commissioning team to review startup reports, Pre-Functional Checklist results, Systems Functional Performance Testing procedures, testing personnel and instrumentation requirements.

F. Systems Functional Performance Testing Coordination: The Contractor shall coordinate testing activities to accommodate required quality assurance and control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting. The Contractor shall coordinate the schedule times for tests, inspections, obtaining samples, and similar activities.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all standard and specialized testing equipment required to perform Systems Functional Performance Testing.

Test equipment required for Systems Functional Performance Testing will be identified in the detailed System Functional Performance Test Procedure prepared by the Commissioning Agent.

B. Data logging equipment and software required to test equipment shall be provided by the Contractor.

C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5 ^{o}C (1.0 ^{o}F) and a resolution of + or - 0.1 ^{o}C (0.2 ^{o}F). Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and following any repairs to the equipment. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCESS ROLES AND RESPONSIBILITIES

A. The following table outlines the roles and responsibilities for the Commissioning Team members during the Construction Phase:

Construction Phase		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Commissioning Roles & Responsibilities							
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
Meetings	Construction Commissioning Kick Off meeting	L	A	P	P	O	
	Commissioning Meetings	L	A	P	P	O	
	Project Progress Meetings	P	A	P	L	O	
	Controls Meeting	L	A	P	P	O	
Coordination	Coordinate with [OGC's, AHJ, Vendors, etc.] to ensure that Cx interacts properly with other systems as needed to support the OPR and BOD.	L	A	P	P	N/A	
Cx Plan & Spec	Final Commissioning Plan	L	A	R	R	O	
Schedules	Duration Schedule for Commissioning Activities	L	A	R	R	N/A	
OPR and BOD	Maintain OPR on behalf of Owner	L	A	R	R	O	

Construction Phase Commissioning Roles & Responsibilities		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
	Maintain BOD/DID on behalf of Owner	L	A	R	R	O	
Document Reviews	TAB Plan Review	L	A	R	R	O	
	Submittal and Shop Drawing Review	R	A	R	L	O	
	Review Contractor Equipment Startup Checklists	L	A	R	R	N/A	
	Review Change Orders, ASI, and RFI	L	A	R	R	N/A	
Site Observations	Witness Factory Testing	P	A	P	L	O	
	Construction Observation Site Visits	L	A	R	R	O	
Functional Test Protocols	Final Pre-Functional Checklists	L	A	R	R	O	
	Final Functional Performance Test Protocols	L	A	R	R	O	
Technical Activities	Issues Resolution Meetings	P	A	P	L	O	
Reports and Logs	Status Reports	L	A	R	R	O	
	Maintain Commissioning Issues Log	L	A	R	R	O	

Construction Phase		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Commissioning Roles & Responsibilities							
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes

B. The following table outlines the roles and responsibilities for the Commissioning Team members during the Acceptance Phase:

Acceptance Phase		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Commissioning Roles & Responsibilities							
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
Meetings	Commissioning Meetings	L	A	P	P	O	
	Project Progress Meetings	P	A	P	L	O	
	Pre-Test Coordination Meeting	L	A	P	P	O	
	Lessons Learned and Commissioning Report Review Meeting	L	A	P	P	O	
Coordination	Coordinate with [OGC's, AHJ, Vendors, etc.] to ensure that Cx interacts properly with other systems as needed to support OPR and BOD	L	P	P	P	O	
Cx Plan & Spec	Maintain/Update Commissioning Plan	L	A	R	R	O	
Schedules	Prepare Functional Test Schedule	L	A	R	R	O	

Acceptance Phase Commissioning Roles & Responsibilities		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov't Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
OPR and BOD	Maintain OPR on behalf of Owner	L	A	R	R	O	
	Maintain BOD/DID on behalf of Owner	L	A	R	R	O	
Document Reviews	Review Completed Pre-Functional Checklists	L	A	R	R	O	
	Pre-Functional Checklist Verification	L	A	R	R	O	
	Review Operations & Maintenance Manuals	L	A	R	R	R	
	Training Plan Review	L	A	R	R	R	
	Warranty Review	L	A	R	R	O	
	Review TAB Report	L	A	R	R	O	
Site Observations	Construction Observation Site Visits	L	A	R	R	O	
	Witness Selected Equipment Startup	L	A	R	R	O	
Functional Test Protocols	TAB Verification	L	A	R	R	O	
	Systems Functional Performance Testing	L	A	P	P	P	
	Retesting	L	A	P	P	P	
Technical Activities	Issues Resolution Meetings	P	A	P	L	O	
	Systems Training	L	S	R	P	P	
Reports and Logs	Status Reports	L	A	R	R	O	
	Maintain Commissioning Issues Log	L	A	R	R	O	
	Final Commissioning Report	L	A	R	R	R	

Acceptance Phase Commissioning Roles & Responsibilities		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov’t Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
	Prepare Systems Manuals	L	A	R	R	R	

C. The following table outlines the roles and responsibilities for the Commissioning Team members during the Warranty Phase:

Warranty Phase Commissioning Roles & Responsibilities		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov’t Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
Meetings	Post-Occupancy User Review Meeting	L	A	O	P	P	

Warranty Phase Commissioning Roles & Responsibilities		CxA = Commissioning Agent RE = Resident Engineer A/E = Design Arch/Engineer PC = Prime Contractor O&M = Gov’t Facility O&M					L = Lead P = Participate A = Approve R = Review O = Optional
Category	Task Description	CxA	RE	A/E	PC	O&M	Notes
Site Observations	Periodic Site Visits	L	A	O	O	P	
Functional Test Protocols	Deferred and/or seasonal Testing	L	A	O	P	P	
Technical Activities	Issues Resolution Meetings	L	S	O	O	P	
	Post-Occupancy Warranty Checkup and review of Significant Outstanding Issues	L	A		R	P	
Reports and Logs	Final Commissioning Report Amendment	L	A		R	R	
	Status Reports	L	A		R	R	

3.2 STARTUP, INITIAL CHECKOUT, AND PRE-FUNCTIONAL CHECKLISTS

A. The following procedures shall apply to all equipment and systems to be commissioned, according to Part 1, Systems to Be Commissioned.

1. Pre-Functional Checklists are important to ensure that the equipment and systems are hooked up and operational. These ensure that Systems Functional Performance Testing may proceed without unnecessary delays. Each system to be commissioned shall have a full Pre-Functional Checklist completed by the Contractor prior to Systems Functional Performance Testing. No sampling strategies are used.
   a. The Pre-Functional Checklist will identify the trades responsible for completing the checklist. The Contractor shall ensure the appropriate trades complete the checklists.
   b. The Commissioning Agent will review completed Pre-Functional Checklists and field-verify the accuracy of the completed checklist using sampling techniques.
2. Startup and Initial Checkout Plan: The Contractor shall develop detailed startup plans for all equipment. The primary role of the Contractor in this process is to ensure that there is written documentation that each of the manufacturer recommended procedures have been completed. Parties responsible for startup shall be identified in the Startup Plan and in the checklist forms.
   a. The Contractor shall develop the full startup plan by combining (or adding to) the checklists with the manufacturer's detailed startup and checkout procedures from the O&M manual data and the field checkout sheets normally used by the Contractor. The plan shall include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
   b. The full startup plan shall at a minimum consist of the following items:
      1) The Pre-Functional Checklists.
      2) The manufacturer's standard written startup procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
      3) The manufacturer's normally used field checkout sheets.
   c. The Commissioning Agent will submit the full startup plan to the VA and Contractor for review. Final approval will be by the VA.

d. The Contractor shall review and evaluate the procedures and the format for documenting them, noting any procedures that need to be revised or added.

3. Sensor and Actuator Calibration
   a. All field installed temperature, relative humidity, CO2 and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described in Division 23, Division 25, and Division 26, specifications.
   b. All procedures used shall be fully documented on the Pre-Functional Checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.
4. Execution of Equipment Startup
   a. Four weeks prior to equipment startup, the Contractor shall schedule startup and checkout with the VA and Commissioning Agent. The performance of the startup and checkout shall be directed and executed by the Contractor.
   b. The Commissioning Agent will observe the startup procedures for selected pieces of primary equipment.
   c. The Contractor shall execute startup and provide the VA and Commissioning Agent with a signed and dated copy of the completed startup checklists, and contractor tests.
   d. Only individuals that have direct knowledge and witnessed that a line item task on the Startup Checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

3.3 DEFICIENCIES, NONCONFORMANCE, AND APPROVAL IN CHECKLISTS AND STARTUP

A. The Contractor shall clearly list any outstanding items of the initial startup and Pre-Functional Checklist procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the VA and the Commissioning Agent within two days of completion.

B. The Commissioning Agent will review the report and submit comments to the VA. The Commissioning Agent will work with the Contractor to correct and verify deficiencies or uncompleted items. The Commissioning Agent will involve the VA and others as necessary. The Contractor shall correct all areas that are noncompliant or incomplete in the checklists in a timely manner, and shall notify the VA and Commissioning Agent as soon as outstanding items have been corrected. The Contractor shall submit an updated startup report and a Statement of Correction on the original noncompliance report. When satisfactorily completed, the Commissioning Agent will recommend approval of the checklists and startup of each system to the VA.

C. The Contractor shall be responsible for resolution of deficiencies as directed the VA.

3.4 PHASED COMMISSIONING

A. The project may require startup and initial checkout to be executed in phases. This phasing shall be planned and scheduled in a coordination meeting of the VA, Commissioning Agent, and the Contractor. Results will be added to the master construction schedule and the commissioning schedule.

3.5 DDC SYSTEM TRENDING FOR COMMISSIONING

A. Trending is a method of testing as a standalone method or to augment manual testing. The Contractor shall trend any and all points of the system or systems at intervals specified below.

B. Alarms are a means to notify the system operator that abnormal conditions are present in the system. Alarms shall be structured into three tiers – Critical, Priority, and Maintenance.

1. Critical alarms are intended to be alarms that require the immediate attention of and action by the Operator. These alarms shall be displayed on the Operator Workstation in a popup style window that is graphically linked to the associated unit's graphical display. The popup style window shall be displayed on top of any active window within the screen, including non DDC system software.
2. Priority level alarms are to be printed to a printer which is connected to the Operator’s Work Station located within the engineer’s office. Additionally Priority level alarms shall be able to be monitored and viewed through an active alarm application. Priority level alarms are alarms which shall require reaction from the operator or maintenance personnel within a normal work shift, and not immediate action.
3. Maintenance alarms are intended to be minor issues which would require examination by maintenance personnel within the following shift. These alarms shall be generated in a scheduled report

automatically by the DDC system at the start of each shift. The generated maintenance report will be printed to a printer located within the engineer's office.

C. The Contractor shall provide a wireless internet network in the building for use during controls programming, checkout, and commissioning. This network will allow project team members to more effectively program, view, manipulate and test control devices while being in the same room as the controlled device.

D. The Contractor shall provide graphical trending through the DDC control system of systems being commissioned. Trending requirements are indicated below and included with the Systems Functional Performance Test Procedures. Trending shall occur before, during and after Systems Functional Performance Testing. The Contractor shall be responsible for producing graphical representations of the trended DDC points that show each system operating properly during steady state conditions as well as during the System Functional Testing. These graphical reports shall be submitted to the Resident Engineer and Commissioning Agent for review and analysis before, during dynamic operation, and after Systems Functional Performance Testing. The Contractor shall provide, but not limited to, the following trend requirements and trend submissions:

1. Pre-testing, Testing, and Post-testing – Trend reports of trend logs and graphical trend plots are required as defined by the Commissioning Agent. The trend log points, sampling rate, graphical plot configuration, and duration will be dictated by the Commissioning Agent. At any time during the Commissioning Process the Commissioning Agent may recommend changes to aspects of trending as deemed necessary for proper system analysis. The Contractor shall implement any changes as directed by the Resident Engineer. Any pre-test trend analysis comments generated by the Commissioning Team should be addressed and resolved by the Contractor, as directed by the Resident Engineer, prior to the execution of Systems Functional Performance Testing.
2. Dynamic plotting – The Contractor shall also provide dynamic plotting during Systems Functional Performance testing at frequent intervals for points determined by the Systems Functional Performance Test Procedure. The graphical plots will be formatted and plotted at durations listed in the Systems Functional Performance Test Procedure.

3. Graphical plotting - The graphical plots shall be provided with a dual y-axis allowing 15 or more trend points (series) plotted simultaneously on the graph with each series in distinct color. The plots will further require title, axis naming, legend etc. all described by the Systems Functional Performance Test Procedure. If this cannot be sufficiently accomplished directly in the Direct Digital Control System then it is the responsibility of the Contractor to plot these trend logs in Microsoft Excel.
4. Points lists are contained on the control drawings. Controls specification calls for all points to be capable of trending on a user defined interval. The following tables indicate the initial trend interval values and alarmed by system for typical points. The Operational Trend Duration column indicates the trend duration for normal operations. The Testing Trend Duration column indicates the trend duration prior to Systems Functional Performance Testing and again after Systems Functional Performance Testing. The Type column indicates point type: AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, Calc = Calculated Point. In the Trend Interval Column, COV = Change of Value. The Alarm Type indicates the alarm priority; C = Critical, P = Priority, and M = Maintenance. The Alarm Range column indicates when the point is considered in the alarm state. The Alarm Delay column indicates the length of time the point must remain in an alarm state before the alarm is recorded in the DDC. The intent is to allow minor, short-duration events to be corrected by the DDC system prior to recording an alarm.

Dual-Path Air Handling Unit Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
OA Temperature	AI	15 Min	24 hours	3 days	N/A		
RA Temperature	AI	15 Min	24 hours	3 days	N/A		
RA Humidity	AI	15 Min	24 hours	3 days	P	>60% RH	10 min
Mixed Air Temp	AI	None	None	None	N/A		
SA Temp	AI	15 Min	24 hours	3 days	C	±5°F from SP	10 min

Dual-Path Air Handling Unit Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Supply Fan Speed	AI	15 Min	24 hours	3 days	N/A		
Return Fan Speed	AI	15 Min	24 hours	3 days	N/A		
RA Pre-Filter Status	COV	24 hours	3 days	COV	N/A		
OA Pre-Filter Status	COV	24 hours	3 days	COV	N/A		
After Filter Status	COV	24 hours	3 days	COV	N/A		
SA Flow	AI	15 Min	24 hours	3 days	C	±10% from SP	10 min
OA Supply Temp	AI	15 Min	24 hours	3 days	P	±5°F from SP	10 min
RA Supply Temp	AI	15 Min	24 hours	3 days	N/A		
RA CHW Valve Position	AI	15 Min	24 hours	3 days	N/A		
OA CHW Valve Position	AI	15 Min	24 hours	3 days	N/A		
OA HW Valve Position	AI	15 Min	24 hours	3 days	N/A		
OA Flow	AI	15 Min	24 hours	3 days	P	±10% from SP	5 min
RA Flow	AI	15 Min	24 hours	3 days	P	±10% from SP	5 min
Duct Pressure	AI	15 Min	24 hours	3 days	C	±25% from SP	6 min
CO2 Level	AI	15 Min	24 hours	3 days	P	±10% from SP	10 min
Supply Fan Status	DI	COV	24 hours	3 days	C	Status <> Command	10 min
Return Fan Status	DI	COV	24 hours	3 days	C	Status <> Command	10 Min
High Static Status	DI	COV	24 hours	3 days	P	True	1 min
Fire Alarm Status	DI	COV	24 hours	3 days	C	True	5 min
Freeze Stat Level 1	DI	COV	24 hours	3 days	C	True	10 min
Freeze Stat Level 2	DI	COV	24 hours	3 days	C	True	5 min
Freeze Stat Level 3	DI	COV	24 hours	3 days	P	True	1 min
Fire/Smoke Damper Status	DI	COV	24 hours	3 days	P	Closed	1 min

Dual-Path Air Handling Unit Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Emergency AHU Shutdown	DI	COV	24 hours	3 days	P	True	1 min
Exhaust Fan #1 Status	DI	COV	24 hours	3 days	C	Status <> Command	10 min
Exhaust Fan #2 Status	DI	COV	24 hours	3 days	C	Status <> Command	10 min
Exhaust Fan #3 Status	DI	COV	24 hours	3 days	C	Status <> Command	10 min
OA Alarm	DI	COV	24 hours	3 days	C	True	10 min
High Static Alarm	DI	COV	24 hours	3 days	C	True	10 min
UVC Emitter Alarm	DI	COV	24 hours	3 days	P	True	10 min
CO2 Alarm	DI	COV	24 hours	3 days	P	True	10 min
Power Failure	DI	COV	24 hours	3 days	P	True	1 min
Supply Fan Speed	AO	15 Min	24 hours	3 days	N/A		
Return Fan Speed	AO	15 Min	24 hours	3 days	N/A		
RA CHW Valve Position	AO	15 Min	24 hours	3 days	N/A		
OA CHW Valve Position	AO	15 Min	24 hours	3 days	N/A		
OA HW Valve Position	AO	15 Min	24 hours	3 days	N/A		
Supply Fan S/S	DO	COV	24 hours	3 days	N/A		
Return Fan S/S	DO	COV	24 hours	3 days	N/A		
Fire/Smoke Dampers	DO	COV	24 hours	3 days	N/A		
Exhaust Fan S/S	DO	COV	24 hours	3 days	N/A		
Exhaust Fan S/S	DO	COV	24 hours	3 days	N/A		
Exhaust Fan S/S	DO	COV	24 hours	3 days	N/A		
AHU Energy	Calc	1 Hour	30 day	N/A	N/A		

Terminal Unit (VAV, CAV, etc.) Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Space Temperature	AI	15 Min	12 hours	3 days	P	±5°F from SP	10 min
Air Flow	AI	15 Min	12 hours	3 days	P	±5°F from SP	10 min
SA Temperature	AI	15 Min	12 hours	3 days	P	±5°F from SP	10 min
Local Setpoint	AI	15 Min	12 hours	3 days	M	±10°F from SP	60 min
Space Humidity	AI	15 Min	12 hours	3 days	P	> 60% RH	5 min
Unoccupied Override	DI	COV	12 hours	3 days	M	N/A	12 Hours
Refrigerator Alarm	DI	COV	12 hours	3 days	C	N/A	10 min
Damper Position	AO	15 Minutes	12 hours	3 days	N/A		
Heating coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		

4-Pipe Fan Coil Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Space Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
SA Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
Pre-Filter Status	AI	None	None	None	M	> SP	1 hour
Water Sensor	DI	COV	12 hours	3 days	M	N/A	30 Min
Cooling Coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		
Heating coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		

4-Pipe Fan Coil Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Fan Coil ON/OFF	DO	COV	12 hours	3 days	M	Status <> Command	30 min

2-Pipe Fan Coil Unit Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Space Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
SA Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
Pre-Filter Status	AI	None	None	None	M	> SP	1 hour
Water Sensor	DI	COV	12 hours	3 days	M	N/A	30 Min
Cooling Coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		
Fan Coil ON/OFF	DO	COV	12 hours	3 days	M	Status <> Command	30 min

Unit Heater Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Space Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
Heating Valve Position	AO	15 Minutes	12 hours	3 days	N/A		

Unit Heater Trending a Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Unit Heater ON/OFF	DO	COV	12 hours	3 days	M	Status <> Command	30 min

Steam and Condensate Pumps Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Steam Flow (LB/HR)	AI	15 Minutes	12 hours	3 days	N/A		
Condensate Pump Run Hours	AI	15 Minutes	12 hours	3 days	N/A		
Water Meter (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
Electric Meter (KW/H)	AI	15 Minutes	12 hours	3 days	N/A		
Irrigation Meter (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
Chilled Water Flow (TONS)	AI	15 Minutes	12 hours	3 days	N/A		
Condensate Flow (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
High Water Level Alarm	DI	COV	12 hours	3 days	C	True	5 Min
Condensate Pump Start/Stop	DO	COV	12 hours	3 days	P	Status <> Command	10 min

Domestic Hot Water Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Domestic HW Setpoint WH-1	AI	15 Minute	12 Hours	3 days	N/A		
Domestic HW Setpoint WH-2	AI	15 Minute	12 Hours	3 days	N/A		
Domestic HW Temperature	AI	15 Minute	12 Hours	3 days	C	> 135 oF	10 Min

Domestic Hot Water Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Domestic HW Temperature	AI	15 Minute	12 Hours	3 days	P	±5°F from SP	10 Min
Dom. Circ. Pump #1 Status	DI	COV	12 Hours	3 days	M	Status <> Command	30 min
Dom. Circ. Pump #2 Status	DI	COV	12 Hours	3 days	M	Status <> Command	30 min
Dom. Circ. Pump #1 Start/Stop	DO	COV	12 Hours	3 days	N/A		
Dom. Circ. Pump #2 Start/Stop	DO	COV	12 Hours	3 days	N/A		
Domestic HW Start/Stop	DO	COV	12 Hours	3 days	N/A		

Hydronic Hot Water Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
System HWS Temperature	AI	15 min	12 hours	3 days	C	±5°F from SP	10 Min
System HWR Temperature	AI	15 min	12 hours	3 days	M	±15°F from SP	300 Min
HX-1 Entering Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
HX-2 Entering Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
HX-2 Leaving Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
System Flow (GPM)	AI	15 min	12 hours	3 days	N/A		
System Differential Pressure	AI	15 min	12 hours	3 days	P	±10% from SP	8 Min
				3 days			
HW Pump 1 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min

Hydronic Hot Water Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
HW Pump 2 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
HW Pump 1 VFD Speed	AO	15 Min	12 Hours	3 days	N/A		
HW Pump 2 VFD Speed	AO	15 Min	12 Hours	3 days	N/A		
Steam Station #1 1/3 Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Station #1 2/3 Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Station #2 1/3 Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Station #2 2/3 Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Station Bypass Valve Position	AO	15 Min	12 Hours	3 days	N/A		
HW Pump 1 Start/Stop	DO	COV	12 Hours	3 days	N/A		
HW Pump 2 Start/Stop	DO	COV	12 Hours	3 days	N/A		
HWR #1 Valve	DO	COV	12 Hours	3 days	N/A		
HWR #2 Valve	DO	COV	12 Hours	3 days	N/A		

Chilled Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Chiller 1 Entering Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Leaving Temperature	AI	15 Minutes	12 Hours	3 days	P	±5°F from SP	10 Min

Chilled Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Chiller 1 Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Percent Load	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 KW Consumption	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Tonnage	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Entering Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Leaving Temperature	AI	15 Minutes	12 Hours	3 days	P	±5°F from SP	10 Min
Chiller 2 Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Percent Load	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 KW Consumption	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Tonnage	AI	15 Minutes	12 Hours	3 days	N/A		
Primary Loop Decoupler Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Primary Loop Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Primary Loop Supply Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Secondary Loop Differential Pressure	AI	15 Minutes	12 Hours	3 days	P	±5% from SP	10 Min
Secondary Loop Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Secondary Loop Supply Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Secondary Loop Return Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Secondary Loop Tonnage	AI	15 Minutes	12 Hours	3 days	N/A		
Primary Loop Pump 1 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min

Chilled Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Primary Loop Pump 2 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
Secondary Loop Pump 1 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
Secondary Loop Pump 2 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
Chiller 1 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
Chiller 1 Evaporator Iso-Valve	DI	COV	12 Hours	3 days	N/A		
Chiller 1 Evaporator Flow Switch	DI	COV	12 Hours	3 days	N/A		
Chiller 1 Unit Alarm	DI	COV	12 Hours	3 days	C	True	10 Min
Chiller 2 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
Chiller 2 Evaporator Iso-Valve	DI	COV	12 Hours	3 days	N/A		
Chiller 2 Evaporator Flow Switch	DI	COV	12 Hours	3 days	N/A		
Chiller 2 Unit Alarm	DI	COV	12 Hours	3 days	C	True	10 Min
Refrigerant Detector	DI	COV	12 Hours	3 days	C	True	10 Min
Refrigerant Exhaust Fan Status	DI	COV	12 Hours	3 days	M	Status <> Command	30 min
Emergency Shutdown	DI	COV	12 Hours	3 days	P	True	1 Min
Primary Loop Pump 1 VFD Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Primary Loop Pump 2 VFD Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Secondary Loop Pump 1 VFD Speed	AO	15 Minutes	12 Hours	3 days	N/A		

Chilled Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Secondary Loop Pump 2 VFD Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Primary Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Primary Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Secondary Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Secondary Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Chiller 1 Enable	DO	COV	12 Hours	3 days	N/A		
Chiller 1 Iso-Valve Command	DO	COV	12 Hours	3 days	N/A		
Chiller 2 Enable	DO	COV	12 Hours	3 days	N/A		
Chiller 2 Iso-Valve Command	DO	COV	12 Hours	3 days	N/A		
Refrigerant Exhaust Fan Start / Stop	DO	COV	12 Hours	3 days	N/A		

Condenser Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Chiller 1 Condenser Entering Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Condenser Leaving Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Condenser Entering Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Condenser Leaving Temp	AI	15 Minutes	12 Hours	3 days	N/A		

Condenser Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Cooling Tower 1 Supply Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Return Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Basin Temp	AI	15 Minutes	12 Hours	3 days	P	< 45 oF	10 Min
Cooling Tower 2 Supply Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Return Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Basin Temp	AI	15 Minutes	12 Hours	3 days	P	< 45 oF	10 Min
Condenser Water Supply Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Condenser Water Return Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Outdoor Air Wet Bulb	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Fan Status	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Cooling Tower 1 Basin Heat	DI	COV	12 Hours	3 days	N/A		
Cooling Tower 1 Heat Trace	DI	COV	12 Hours	3 days	N/A		
Cooling Tower 2 Fan Status	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Cooling Tower 2 Basin Heat	DI	COV	12 Hours	3 days	N/A		
Cooling Tower 2 Heat Trace	DI	COV	12 Hours	3 days	N/A		
Chiller 1 Isolation Valve	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Chiller 2 Isolation Valve	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Condenser Water Pump 1 Status	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Condenser Water Pump 2 Status	DI	COV	12 Hours	3 days	P	Status <> Command	1 min

Condenser Water System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Chiller 1 Condenser Bypass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Condenser By-Pass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Bypass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Fan Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Bypass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Fan Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Fan Start / Stop	DO	COV	12 Hours	3 days	N/A		
Cooling Tower 2 Fan Start / Stop	DO	COV	12 Hours	3 days	N/A		
Condenser Water Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Condenser Water Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		

Steam Boiler System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Boiler 1 Steam Pressure	AI	15 Minutes	12 Hours	3 days	P	±5% from SP	10 Min
Boiler 1 Steam Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 1 Fire Signal	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 2 Steam Pressure	AI	15 Minutes	12 Hours	3 days	P	±5% from SP	10 Min

Steam Boiler System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Boiler 2 Steam Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 2 Fire Signal	AI	15 Minutes	12 Hours	3 days	N/A		
System Steam Pressure	AI	15 Minutes	12 Hours	3 days	P	±5% from SP	10 Min
Boiler 1 Enable	DI	COV	12 Hours	3 days	N/A		
Boiler 1 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Boiler 1 Alarm	DI	COV	12 Hours	3 days	C	True	1 Min
Boiler 1 on Fuel Oil	DI	COV	12 Hours	3 days	N/A		
Boiler 1 Low Water Alarm	DI	COV	12 Hours	3 days	C	True	5 Min
Boiler 1 High Water Alarm	DI	COV	12 Hours	3 days	C	True	5 Min
Boiler 1 Feed Pump	DI	COV	12 Hours	3 days	N/A		
Boiler 2 Enable	DI	COV	12 Hours	3 days	N/A		
Boiler 2 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Boiler 2 Alarm	DI	COV	12 Hours	3 days	C	True	1 Min
Boiler 2 on Fuel Oil	DI	COV	12 Hours	3 days	N/A		
Boiler 2 Low Water Alarm	DI	COV	12 Hours	3 days	C	True	5 Min
Boiler 2 High Water Alarm	DI	COV	12 Hours	3 days	C	True	5 Min
Boiler 2 Feed Pump	DI	COV	12 Hours	3 days	N/A		
Combustion Damper Status	DI	COV	12 Hours	3 days	P	Status <> Command	5 min
Condensate Recovery Pump Status	DI	COV	12 Hours	3 days	P	Status <> Command	5 min
Boiler 1 Feed Pump Start / Stop	DO	COV	12 Hours	3 days	N/A		

Steam Boiler System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Boiler 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Combustion Damper Command	DO	COV	12 Hours	3 days	N/A		
Condensate Recovery Pump Start / Stop	DO	COV	12 Hours	3 days	N/A		

Hot Water Boiler System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Outside Air Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 1 Fire Signal	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 1 Entering Water Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 1 Leaving Water Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 2 Fire Signal	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 2 Entering Water Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 2 Leaving Water Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Hot Water Supply Temperature	AI	15 Minutes	12 Hours	3 days	P	±5 oF from SP	10 Min
Hot Water Return Temperature	AI	15 Minutes	12 Hours	3 days	N/A		

Hot Water Boiler System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Secondary Loop Differential Pressure	AI	15 Minutes	12 Hours	3 days	C	±5% from SP	10 Min
Lead Boiler	AI	15 Minutes	12 Hours	3 days	N/A		
Boiler 1 Enable	DI	COV	12 Hours	3 days	N/A		
Boiler 1 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Boiler 1 Isolation Valve	DI	COV	12 Hours	3 days	N/A		
Boiler 1 on Fuel Oil	DI	COV	12 Hours	3 days	N/A		
Boiler 1 Alarm	DI	COV	12 Hours	3 days	C	True	1 Min
Boiler 2 Enable	DI	COV	12 Hours	3 days	N/A		
Boiler 2 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Boiler 2 Isolation Valve	DI	COV	12 Hours	3 days	N/A		
Boiler 2 on Fuel Oil	DI	COV	12 Hours	3 days	N/A		
Boiler 2 Alarm	DI	COV	12 Hours	3 days	C	True	1 Min
Combustion Dampers Open	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Primary Pump 1 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Primary Pump 2 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Secondary Pump 1 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Secondary Pump 2 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Primary Pump 1 VFD Speed	AO	COV	12 Hours	3 days	N/A		

Hot Water Boiler System Trending and Alarms							
Point	**Type**	**Trend Interval**	**Operational Trend Duration**	**Testing Trend Duration**	**Alarm Type**	**Alarm Range**	**Alarm Delay**
Primary Pump 2 VFD Speed	AO	COV	12 Hours	3 days	N/A		
Secondary Pump 1 VFD Speed	AO	COV	12 Hours	3 days	N/A		
Secondary Pump 2 VFD Speed	AO	COV	12 Hours	3 days	N/A		
Hot Water System Enable	DO	COV	12 Hours	3 days	N/A		
Combustion Dampers Command	DO	COV	12 Hours	3 days	N/A		
Primary Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Primary Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Secondary Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Secondary Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		

E. The Contractor shall provide the following information prior to Systems Functional Performance Testing. Any documentation that is modified after submission shall be recorded and resubmitted to the Resident Engineer and Commissioning Agent.

1. Point-to-Point checkout documentation;
2. Sensor field calibration documentation including system name, sensor/point name, measured value, DDC value, and Correction Factor.
3. A sensor calibration table listing the referencing the location of procedures to following in the O&M manuals, and the frequency at which calibration should be performed for all sensors, separated by system, subsystem, and type. The calibration requirements shall be submitted both in the O&M manuals and separately in a standalone document containing all sensors for inclusion in the commissioning

documentation. The following table is a sample that can be used as a template for submission.

SYSTEM		
Sensor	**Calibration Frequency**	**O&M Calibration Procedure Reference**
Discharge air temperature	Once a year	Volume I Section D.3.aa
Discharge static pressure	Every 6 months	Volume II Section A.1.c

4. Loop tuning documentation and constants for each loop of the building systems. The documentation shall be submitted in outline or table separated by system, control type (e.g. heating valve temperature control); proportional, integral and derivative constants, interval (and bias if used) for each loop. The following table is a sample that can be used as a template for submission.

AIR HANDLING UNIT AHU-1				
Control Reference	Proportional Constant	Integral Constant	Derivative Constant	Interval
Heating Valve Output	1000	20	10	2 sec.

3.6 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. This paragraph applies to Systems Functional Performance Testing of systems for all referenced specification Divisions.

B. Objectives and Scope: The objective of Systems Functional Performance Testing is to demonstrate that each system is operating according to the Contract Documents. Systems Functional Performance Testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of noncompliant performance are identified and corrected, thereby improving the operation and functioning of the systems. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load, fire alarm and emergency power) where there is a specified system response. The Contractor shall verify each sequence in the sequences of operation. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.

C. Development of Systems Functional Performance Test Procedures: Before Systems Functional Performance Test procedures are written, the Contractor shall submit all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. Using the testing parameters and requirements found in the Contract Documents and approved submittals and shop drawings, the Commissioning Agent will develop specific Systems Functional Test Procedures to verify and document proper operation of each piece of equipment and system to be commissioned. The Contractor shall assist the Commissioning Agent in developing the Systems Functional Performance Test procedures as requested by the Commissioning Agent i.e. by answering questions about equipment, operation, sequences, etc. Prior to execution, the Commissioning Agent will provide a copy of the Systems Functional Performance Test procedures to the VA, the Architect/Engineer, and the Contractor, who shall review the tests for feasibility, safety, equipment and warranty protection.

D. Purpose of Test Procedures: The purpose of each specific Systems Functional Performance Test is to verify and document compliance with the stated criteria of acceptance given on the test form. Representative test formats and examples are found in the Commissioning Plan for this project. (The Commissioning Plan is issued as a separate document and is available for review.) The test procedure forms developed by the Commissioning Agent will include, but not be limited to, the following information:

1. System and equipment or component name(s)
2. Equipment location and ID number
3. Unique test ID number, and reference to unique Pre-Functional Checklists and startup documentation, and ID numbers for the piece of equipment
4. Date
5. Project name
6. Participating parties
7. A copy of the specification section describing the test requirements
8. A copy of the specific sequence of operations or other specified parameters being verified

9. Formulas used in any calculations
10. Required pretest field measurements
11. Instructions for setting up the test.
12. Special cautions, alarm limits, etc.
13. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
14. Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
15. A section for comments.
16. Signatures and date block for the Commissioning Agent. A place for the Contractor to initial to signify attendance at the test.

E. Test Methods: Systems Functional Performance Testing shall be achieved by manual testing (i.e. persons manipulate the equipment and observe performance) and/or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by standalone data loggers. The Contractor and Commissioning Agent shall determine which method is most appropriate for tests that do not have a method specified.
   1. Simulated Conditions: Simulating conditions (not by an overwritten value) shall be allowed, although timing the testing to experience actual conditions is encouraged wherever practical.
   2. Overwritten Values: Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.
   3. Simulated Signals: Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.

4. Altering Setpoints: Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the Air Conditioning compressor lockout initiate at an outside air temperature below 12 C (54 F), when the outside air temperature is above 12 C (54 F), temporarily change the lockout setpoint to be 2 C (4 F) above the current outside air temperature.
5. Indirect Indicators: Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification shall be completed during systems startup and initial checkout.

F. Setup: Each function and test shall be performed under conditions that simulate actual conditions as closely as is practically possible. The Contractor shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Contractor shall return all affected building equipment and systems, due to these temporary modifications, to their pretest condition.

G. Sampling: No sampling is allowed in completing Pre-Functional Checklists. Sampling is allowed for Systems Functional Performance Test Procedures execution. The Commissioning Agent will determine the sampling rate. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the Commissioning Agent may stop the testing and require the Contractor to perform and document a checkout of the remaining units, prior to continuing with Systems Functional Performance Testing of the remaining units.

H. Cost of Retesting: The cost associated with expanded sample System Functional Performance Tests shall be solely the responsibility of the Contractor. Any required retesting by the Contractor shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

I. Coordination and Scheduling: The Contractor shall provide a minimum of 7 days’ notice to the Commissioning Agent and the VA regarding the completion schedule for the Pre-Functional Checklists and startup of all equipment and systems. The Commissioning Agent will schedule Systems Functional Performance Tests with the Contractor and VA. The Commissioning Agent will witness and document the Systems Functional Performance Testing of systems. The Contractor shall execute the tests in accordance with the Systems Functional Performance Test Procedure.

J. Testing Prerequisites: In general, Systems Functional Performance Testing will be conducted only after Pre-Functional Checklists have been satisfactorily completed. The control system shall be sufficiently tested and approved by the Commissioning Agent and the VA before it is used to verify performance of other components or systems. The air balancing and water balancing shall be completed before Systems Functional Performance Testing of air-related or water-related equipment or systems are scheduled. Systems Functional Performance Testing will proceed from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems will be checked.

K. Problem Solving: The Commissioning Agent will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the Contractor.

3.7 DOCUMENTATION, NONCONFORMANCE AND APPROVAL OF TESTS

A. Documentation: The Commissioning Agent will witness, and document the results of all Systems Functional Performance Tests using the specific procedural forms developed by the Commissioning Agent for that purpose. Prior to testing, the Commissioning Agent will provide these forms to the VA and the Contractor for review and approval. The Contractor shall include the filled out forms with the O&M manual data.

B. Nonconformance: The Commissioning Agent will record the results of the Systems Functional Performance Tests on the procedure or test form. All items of nonconformance issues will be noted and reported to the VA on Commissioning Field Reports and/or the Commissioning Master Issues Log.

1. Corrections of minor items of noncompliance identified may be made during the tests. In such cases, the item of noncompliance and resolution shall be documented on the Systems Functional Test Procedure.
2. Every effort shall be made to expedite the systems functional Performance Testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the

Commissioning Agent shall not be pressured into overlooking noncompliant work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so by direction from the VA.

3. As the Systems Functional Performance Tests progresses and an item of noncompliance is identified, the Commissioning Agent shall discuss the issue with the Contractor and the VA.
4. When there is no dispute on an item of noncompliance, and the Contractor accepts responsibility to correct it:
   a. The Commissioning Agent will document the item of noncompliance and the Contractor's response and/or intentions. The Systems Functional Performance Test then continues or proceeds to another test or sequence. After the day's work is complete, the Commissioning Agent will submit a Commissioning Field Report to the VA. The Commissioning Agent will also note items of noncompliance and the Contractor’s response in the Master Commissioning Issues Log. The Contractor shall correct the item of noncompliance and report completion to the VA and the Commissioning Agent.
   b. The need for retesting will be determined by the Commissioning Agent. If retesting is required, the Commissioning Agent and the Contractor shall reschedule the test and the test shall be repeated.
5. If there is a dispute about item of noncompliance, regarding whether it is an item of noncompliance, or who is responsible:
   a. The item of noncompliance shall be documented on the test form with the Contractor's response. The item of noncompliance with the Contractor’s response shall also be reported on a Commissioning Field Report and on the Master Commissioning Issues Log.
   b. Resolutions shall be made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive and acceptance authority is with the Department of Veterans Affairs.
   c. The Commissioning Agent will document the resolution process.
   d. Once the interpretation and resolution have been decided, the Contractor shall correct the item of noncompliance, report it to the Commissioning Agent. The requirement for retesting will be

determined by the Commissioning Agent. If retesting is required, the Commissioning Agent and the Contractor shall reschedule the test. Retesting shall be repeated until satisfactory performance is achieved.

C. Cost of Retesting: The cost to retest a System Functional Performance Test shall be solely the responsibility of the Contractor. Any required retesting by the Contractor shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

D. Failure Due to Manufacturer Defect: If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform in compliance with the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance specifications, all identical units may be considered unacceptable by the VA. In such case, the Contractor shall provide the VA with the following:

1. Within one week of notification from the VA, the Contractor shall examine all other identical units making a record of the findings. The findings shall be provided to the VA within two weeks of the original notice.
2. Within two weeks of the original notification, the Contractor shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
3. The VA shall determine whether a replacement of all identical units or a repair is acceptable.
4. Two examples of the proposed solution shall be installed by the Contractor and the VA shall be allowed to test the installations for up to one week, upon which the VA will decide whether to accept the solution.
5. Upon acceptance, the Contractor shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

E. Approval: The Commissioning Agent will note each satisfactorily demonstrated function on the test form. Formal approval of the Systems Functional Performance Test shall be made later after review by the Commissioning Agent and by the VA. The Commissioning Agent will evaluate each test and report to the VA using a standard form. The VA will give final approval on each test using the same form, and provide signed copies to the Commissioning Agent and the Contractor.

3.8 DEFERRED TESTING

A. Unforeseen Deferred Systems Functional Performance Tests: If any Systems Functional Performance Test cannot be completed due to the building structure, required occupancy condition or other conditions, execution of the Systems Functional Performance Testing may be delayed upon approval of the VA. These Systems Functional Performance Tests shall be conducted in the same manner as the seasonal tests as soon as possible. Services of the Contractor to conduct these unforeseen Deferred Systems Functional Performance Tests shall be negotiated between the VA and the Contractor.

B. Deferred Seasonal Testing: Deferred Seasonal Systems Functional Performance Tests are those that must be deferred until weather conditions are closer to the systems design parameters. The Commissioning Agent will review systems parameters and recommend which Systems Functional Performance Tests should be deferred until weather conditions more closely match systems parameters. The Contractor shall review and comment on the proposed schedule for Deferred Seasonal Testing. The VA will review and approve the schedule for Deferred Seasonal Testing. Deferred Seasonal Systems Functional Performances Tests shall be witnessed and documented by the Commissioning Agent. Deferred Seasonal Systems Functional Performance Tests shall be executed by the Contractor in accordance with these specifications.

3.9 OPERATION AND MAINTENANCE TRAINING REQUIREMENTS

A. Training Preparation Conference: Before operation and maintenance training, the Commissioning Agent will convene a training preparation conference to include VA's Resident Engineer, VA’s Operations and Maintenance personnel, and the Contractor. The purpose of this conference will be to discuss and plan for Training and Demonstration of VA Operations and Maintenance personnel.

B. The Contractor shall provide training and demonstration as required by other Division 23, Division 25, and Division 26 sections. The Training and Demonstration shall include, but is not limited to, the following:
   1. Review the Contract Documents.
   2. Review installed systems, subsystems, and equipment.
   3. Review instructor qualifications.
   4. Review instructional methods and procedures.
   5. Review training module outlines and contents.
   6. Review course materials (including operation and maintenance manuals).
   7. Review and discuss locations and other facilities required for instruction.
   8. Review and finalize training schedule and verify availability of educational materials, instructors, audiovisual equipment, and facilities needed to avoid delays.
   9. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

C. Training Module Submittals: The Contractor shall submit the following information to the VA and the Commissioning Agent:
   1. Instruction Program: Submit two copies of outline of instructional program for demonstration and training, including a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module. At completion of training, submit two complete training manuals for VA's use.
   2. Qualification Data: Submit qualifications for facilitator and/or instructor.
   3. Attendance Record: For each training module, submit list of participants and length of instruction time.
   4. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.
   5. Demonstration and Training Recording:
      a. General: Engage a qualified commercial photographer to record demonstration and training. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.

At beginning of each training module, record each chart containing learning objective and lesson outline.

b. Video Format: Provide high quality color DVD color on standard size DVD disks.

c. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

d. Narration: Describe scenes on video recording by audio narration by microphone while demonstration and training is recorded. Include description of items being viewed. Describe vantage point, indicating location, direction (by compass point), and elevation or story of construction.

e. Submit two copies within seven days of end of each training module.

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

D. Quality Assurance:

1. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

2. Instructor Qualifications: A factory authorized service representative, complying with requirements in Division 01 Section "Quality Requirements," experienced in operation and maintenance procedures and training.

3. Photographer Qualifications: A professional photographer who is experienced photographing construction projects.

E. Training Coordination:

1. Coordinate instruction schedule with VA's operations. Adjust schedule as required to minimize disrupting VA's operations.

2. Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.

3. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit

instruction program until operation and maintenance data has been reviewed and approved by the VA.

F. Instruction Program:
   1. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:
      a. Fire protection systems, including fire alarm, fire pumps, and fire suppression systems.
      b. Intrusion detection systems.
      c. Conveying systems, including elevators, wheelchair lifts, escalators, and automated materials handling systems.
      d. Medical equipment, including medical gas equipment and piping.
      e. Laboratory equipment, including laboratory air and vacuum equipment and piping.
      f. Heat generation, including boilers, feedwater equipment, pumps, steam distribution piping, condensate return systems, heating hot water heat exchangers, and heating hot water distribution piping.
      g. Refrigeration systems, including chillers, cooling towers, condensers, pumps, and distribution piping.
      h. HVAC systems, including air handling equipment, air distribution systems, and terminal equipment and devices.
      i. HVAC instrumentation and controls.
      j. Electrical service and distribution, including switchgear, transformers, switchboards, panelboards, uninterruptible power supplies, and motor controls.
      k. Packaged engine generators, including synchronizing switchgear/switchboards, and transfer switches.
      l. Lighting equipment and controls.
      m. Communication systems, including intercommunication, surveillance, nurse call systems, public address, mass evacuation, voice and data, and entertainment television equipment.
      n. Site utilities including lift stations, condensate pumping and return systems, and storm water pumping systems.

G. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participants are expected to master. For each module, include instruction for the following:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:
   a. System, subsystem, and equipment descriptions.
   b. Performance and design criteria if Contractor is delegated design responsibility.
   c. Operating standards.
   d. Regulatory requirements.
   e. Equipment function.
   f. Operating characteristics.
   g. Limiting conditions.
   H, Performance curves.
2. Documentation: Review the following items in detail:
   a. Emergency manuals.
   b. Operations manuals.
   c. Maintenance manuals.
   d. Project Record Documents.
   e. Identification systems.
   f. Warranties and bonds.
   g. Maintenance service agreements and similar continuing commitments.
3. Emergencies: Include the following, as applicable:
   a. Instructions on meaning of warnings, trouble indications, and error messages.
   b. Instructions on stopping.
   c. Shutdown instructions for each type of emergency.
   d. Operating instructions for conditions outside of normal operating limits.
   e. Sequences for electric or electronic systems.
   f. Special operating instructions and procedures.
4. Operations: Include the following, as applicable:
   a. Startup procedures.
   b. Equipment or system break-in procedures.
   c. Routine and normal operating instructions.
   d. Regulation and control procedures.
   e. Control sequences.
   f. Safety procedures.

g. Instructions on stopping.
h. Normal shutdown instructions.
i. Operating procedures for emergencies.
j. Operating procedures for system, subsystem, or equipment failure.
k. Seasonal and weekend operating instructions.
l. Required sequences for electric or electronic systems.
m. Special operating instructions and procedures.

5. Adjustments: Include the following:
   a. Alignments.
   b. Checking adjustments.
   c. Noise and vibration adjustments.
   d. Economy and efficiency adjustments.
6. Troubleshooting: Include the following:
   a. Diagnostic instructions.
   b. Test and inspection procedures.
7. Maintenance: Include the following:
   a. Inspection procedures.
   b. Types of cleaning agents to be used and methods of cleaning.
   c. List of cleaning agents and methods of cleaning detrimental to product.
   d. Procedures for routine cleaning
   e. Procedures for preventive maintenance.
   f. Procedures for routine maintenance.
   g. Instruction on use of special tools.
8. Repairs: Include the following:
   a. Diagnosis instructions.
   b. Repair instructions.
   c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
   d. Instructions for identifying parts and components.
   e. Review of spare parts needed for operation and maintenance.

H. Training Execution:
   1. Preparation: Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a combined training manual. Set up instructional equipment at instruction location.
   2. Instruction:

a. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Department of Veterans Affairs for number of participants, instruction times, and location.

b. Instructor: Engage qualified instructors to instruct VA's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

1) The Commissioning Agent will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.

2) The VA will furnish an instructor to describe VA's operational philosophy.

3) The VA will furnish the Contractor with names and positions of participants.

3. Scheduling: Provide instruction at mutually agreed times. For equipment that requires seasonal operation, provide similar instruction at start of each season. Schedule training with the VA and the Commissioning Agent with at least seven days' advance notice.

4. Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of an oral, or a written, performance-based test.

5. Cleanup: Collect used and leftover educational materials and remove from Project site. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

I. Demonstration and Training Recording:

1. General: Engage a qualified commercial photographer to record demonstration and training. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice. At beginning of each training module, record each chart containing learning objective and lesson outline.

2. Video Format: Provide high quality color DVD color on standard size DVD disks.

3. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

4. Narration: Describe scenes on videotape by audio narration by microphone while demonstration and training is recorded. Include description of items being viewed. Describe vantage point, indicating location, direction (by compass point), and elevation or story of construction.

----- END -----

SECTION 07 84 00
FIRESTOPPING

PART 1 GENERAL

1.1 DESCRIPTION

A. Closures of openings in walls, floors, and roof decks against penetration of flame, heat, and smoke or gases in fire resistant rated construction.

B. Closure of openings in walls against penetration of gases or smoke in smoke partitions.

1.2 RELATED WORK

A. NOT USED

B. NOT USED

C. NOT USED

D. NOT USED

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturers literature, data, and installation instructions for types of firestopping and smoke stopping used.

C. List of FM, UL, or WH classification number of systems installed.

D. Certified laboratory test reports for ASTM E814 tests for systems not listed by FM, UL, or WH proposed for use.

1.4 DELIVERY AND STORAGE

A. Deliver materials in their original unopened containers with manufacturer’s name and product identification.

B. Store in a location providing protection from damage and exposure to the elements.

1.5 WARRANTY

Firestopping work subject to the terms of the Article “Warranty of Construction”, FAR clause 52.246-21, except extend the warranty period to five years.

1.6 QUALITY ASSURANCE

FM, UL, or WH or other approved laboratory tested products will be acceptable.

1.7 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM):

E84-10..................Surface Burning Characteristics of Building Materials

E814-11.................Fire Tests of Through-Penetration Fire Stops

C. Factory Mutual Engineering and Research Corporation (FM):

Annual Issue Approval Guide Building Materials

D. Underwriters Laboratories, Inc. (UL):

Annual Issue Building Materials Directory

Annual Issue Fire Resistance Directory

1479-10.................Fire Tests of Through-Penetration Firestops

E. Warnock Hersey (WH):

Annual Issue Certification Listings

PART 2 - PRODUCTS

2.1 FIRESTOP SYSTEMS

A. Use either factory built (Firestop Devices) or field erected (through-Penetration Firestop Systems) to form a specific building system maintaining required integrity of the fire barrier and stop the passage of gases or smoke.

B. Through-penetration firestop systems and firestop devices tested in accordance with ASTM E814 or UL 1479 using the "F" or "T" rating to maintain the same rating and integrity as the fire barrier being sealed. "T" ratings are not required for penetrations smaller than or equal to 100 mm (4 in) nominal pipe or 0.01 m^2 (16 sq. in.) in overall cross sectional area.

C. Products requiring heat activation to seal an opening by its intumescence shall exhibit a demonstrated ability to function as designed to maintain the fire barrier.

D. Firestop sealants used for firestopping or smoke sealing shall have following properties:

1. Contain no flammable or toxic solvents.
2. Have no dangerous or flammable out gassing during the drying or curing of products.
3. Water-resistant after drying or curing and unaffected by high humidity, condensation or transient water exposure.

4. When used in exposed areas, shall be capable of being sanded and finished with similar surface treatments as used on the surrounding wall or floor surface.

E. Firestopping system or devices used for penetrations by glass pipe, plastic pipe or conduits, unenclosed cables, or other non-metallic materials shall have following properties:
   1. Classified for use with the particular type of penetrating material used.
   2. Penetrations containing loose electrical cables, computer data cables, and communications cables protected using firestopping systems that allow unrestricted cable changes without damage to the seal.
   3. Intumescent products which would expand to seal the opening and act as fire, smoke, toxic fumes, and, water sealant.

F. Maximum flame spread of 25 and smoke development of 50 when tested in accordance with ASTM E84.

G. FM, UL, or WH rated or tested by an approved laboratory in accordance with ASTM E814.

H. Materials to be asbestos free.

2.2 SMOKE STOPPING IN SMOKE PARTITIONS

A. Use silicone sealant in smoke partitions as approved by COR/A&E

B. Use mineral fiber filler and bond breaker behind sealant.

C. Sealants shall have a maximum flame spread of 25 and smoke developed of 50 when tested in accordance with E84.

D. When used in exposed areas capable of being sanded and finished with similar surface treatments as used on the surrounding wall or floor surface.

PART 3 - EXECUTION

3.1 EXAMINATION

Submit product data and installation instructions, as required by article, submittals, after an on site examination of areas to receive firestopping. Any existing firestopping or smoke stopping that is disturbed under this contract must also be repaired under this contract.

3.2 PREPARATION

A. Remove dirt, grease, oil, loose materials, or other substances that prevent adherence and bonding or application of the firestopping or smoke stopping materials.

B. Remove insulation on insulated pipe for a distance of 150 mm (six inches) on either side of the fire rated assembly prior to applying the firestopping materials unless the firestopping materials are tested and approved for use on insulated pipes.

3.3 INSTALLATION

A. Do not begin work until the specified material data and installation instructions of the proposed firestopping systems have been submitted and approved.

B. Install firestopping systems with smoke stopping in accordance with FM, UL, WH, or other approved system details and installation instructions.

C. Install smoke stopping seals in smoke partitions.

3.4 CLEAN-UP AND ACCEPTANCE OF WORK

A. As work on each floor is completed, remove materials, litter, and debris.

B. Do not move materials and equipment to the next-scheduled work area until completed work is inspected and accepted by the Resident Engineer.

C. Clean up spills of liquid type materials.

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SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

B. Definitions:

1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
2. Option or optional: Contractor's choice of an alternate material or method.
3. RE: Resident Engineer
4. COR: Contracting Officer’s Representative.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 07 84 00, FIRESTOPPING

F. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC

G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training

I. Section 26 05 19 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

1.3 QUALITY ASSURANCE

A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC

B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

C. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work

station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.

2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
3. Conform to codes and standards as required by the specifications. Conform to local codes, if required by local authorities such as the natural gas supplier, if the local codes are more stringent then those specified. Refer any conflicts to the Resident Engineer.
4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
6. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
7. Asbestos products or equipment or materials containing asbestos shall not be used.

D. Equipment Service Organizations:

1. HVAC: Products and systems shall be supported by service organizations that maintain a complete inventory of repair parts and are located within 100 miles to the site.

E. HVAC Mechanical Systems Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:

1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.

F. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to the Resident Engineer

for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the Resident Engineer at least two weeks prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations is a cause for rejection of the material.

2. Provide complete layout drawings required by Paragraph, SUBMITTALS. Do not commence construction work on any system until the layout drawings have been approved.

G. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with telephone numbers and e-mail addresses.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections.

B. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

C. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

D. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

E. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient.

F. Layout Drawings:

1. Submit complete consolidated and coordinated layout drawings for all new systems, and for existing systems that are in the same areas.
2. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations

of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed layout drawings of all piping and duct systems.

3. Do not install equipment foundations, equipment or piping until layout drawings have been approved.
4. In addition, for HVAC systems, provide details of the following:
   a. Mechanical equipment rooms.
   c. Hangers, inserts, supports, and bracing.
   d. Pipe sleeves.
   e. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

G. Manufacturer's Literature and Data: Submit under the pertinent section rather than under this section.
   1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the Resident Engineer.
   2. Submit electric motor data and variable speed drive data with the driven equipment.
   3. Equipment and materials identification.
   4. Fire-stopping materials.
   5. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
   6. Wall, floor, and ceiling plates.

H. HVAC Maintenance Data and Operating Instructions:
   1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
   2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

I. Provide copies of approved HVAC equipment submittals to the Testing, Adjusting and Balancing Subcontractor.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
   430-2009................Central Station Air-Handling Units

C. American National Standard Institute (ANSI):

B31.1-2007..............Power Piping

D. Rubber Manufacturers Association (ANSI/RMA):

IP-20-2007..............Specifications for Drives Using Classical V-Belts and Sheaves

IP-21-2009..............Specifications for Drives Using Double-V (Hexagonal) Belts

IP-22-2007..............Specifications for Drives Using Narrow V-Belts and Sheaves

E. Air Movement and Control Association (AMCA):

410-96..................Recommended Safety Practices for Air Moving Devices

F. American Society of Mechanical Engineers (ASME):

Boiler and Pressure Vessel Code (BPVC):

Section I-2007..........Power Boilers

Section IX-2007.........Welding and Brazing Qualifications

Code for Pressure Piping:

B31.1-2007..............Power Piping

G. American Society for Testing and Materials (ASTM):

A36/A36M-08.............Standard Specification for Carbon Structural Steel

A575-96(2007)...........Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

E84-10..................Standard Test Method for Surface Burning Characteristics of Building Materials

E119-09c................Standard Test Methods for Fire Tests of Building Construction and Materials

H. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:

SP-58-2009..............Pipe Hangers and Supports-Materials, Design and Manufacture, Selection, Application, and Installation

SP 69-2003..............Pipe Hangers and Supports-Selection and Application

SP 127-2001.............Bracing for Piping Systems, Seismic – Wind – Dynamic, Design, Selection, Application

I. National Electrical Manufacturers Association (NEMA):

MG-1-2009...............Motors and Generators

J. National Fire Protection Association (NFPA):

31-06...................Standard for Installation of Oil-Burning Equipment

54-09...................National Fuel Gas Code

70-08...................National Electrical Code

85-07...................Boiler and Combustion Systems Hazards Code

90A-09..................Standard for the Installation of Air Conditioning and Ventilating Systems

101-09..................Life Safety Code

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the Resident Engineer. Such repair or replacement shall be at no additional cost to the Government.
3. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
4. Boilers shall be left clean following final internal inspection by Government insurance representative or inspector.
5. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.7 JOB CONDITIONS – WORK IN EXISTING BUILDING

A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.

B. Maintenance of Service: Schedule all work to permit continuous service as required by the medical center.

C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the Resident Engineer during periods when the demands are not critical to the operation of the medical center. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least one week advance notice to the Resident Engineer.

D. Phasing of Work: Comply with all requirements shown on drawings or specified.

E. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.

F. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

G. Temporary Facilities: Refer to Article, TEMPORARY PIPING AND EQUIPMENT in this section.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

A. Provide maximum standardization of components to reduce spare part requirements.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of same manufacturer.
2. Constituent parts that are alike shall be products of a single manufacturer.
3. Components shall be compatible with each other and with the total assembly for intended service.

4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions will be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

2.3 BELT DRIVES

A. Type: ANSI/RMA standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ANSI/RMA IP-20 and IP-21.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ANSI/RMA service factor (not less than 20 percent) in addition to the ANSI/RMA allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ANSI/RMA standard allowances for installation and take-up.

F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.

G. Multiple Belts: Matched to ANSI/RMA specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:
   1. Material: Pressed steel, or close grained cast iron.
   2. Bore: Fixed or bushing type for securing to shaft with keys.
   3. Balanced: Statically and dynamically.
   4. Groove spacing for driving and driven pulleys shall be the same.

I. Drive Types, Based on ARI 435:
   1. Provide adjustable-pitch or fixed-pitch drive as follows:
      a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.
      b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
   2. Provide fixed-pitch drives for drives larger than those listed above.

3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

2.4 DRIVE GUARDS

A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

B. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.

C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

D. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.5 LIFTING ATTACHMENTS

Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.6 ELECTRIC MOTORS

A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT; and Section 26 29 11, MOTOR CONTROLLERS;. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.7 VARIABLE SPEED MOTOR CONTROLLERS

A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, MOTOR CONTROLLERS for specifications.

B. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.

C. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.

D. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.

E. Controller shall be provided with the following operating features and accessories:

1. Suitable for variable torque load.

2.8 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals.

B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.

C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.

D. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.

E. Valve Tags and Lists:

1. HVAC and Boiler Plant: Provide for all valves.
2. Valve tags: Engraved black filled numbers and letters not less than 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm(1/4-inch) for service designation on 19 gage 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Typed or printed plastic coated card(s), sized 216 mm(8-1/2 inches) by 280 mm (11 inches) showing tag number, valve

function and area of control, for each service or system. Punch sheets for a 3-ring notebook.

4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color coded thumb tack in ceiling.

2.9 FIRESTOPPING

Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork.

2.10 GALVANIZED REPAIR COMPOUND

Mil. Spec. DOD-P-21035B, paint form.

2.11 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Attachment to Concrete Building Construction:
   1. Concrete insert: MSS SP-58, Type 18.
   2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
   3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.

B. Attachment to Steel Building Construction:
   1. Welded attachment: MSS SP-58, Type 22.
   2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23mm (7/8-inch) outside diameter.

C. Attachment to existing structure: Support from existing floor/roof frame.

D. Attachment to Wood Construction: Wood screws or lag bolts.

E. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

2.14 SPECIAL TOOLS AND LUBRICANTS

A. Furnish, and turn over to the Resident Engineer, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.

C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

D. Tool Containers: Hardwood or metal, permanently identified for in tended service and mounted, or located, where directed by the Resident Engineer.

E. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.15 WALL, FLOOR AND CEILING PLATES

A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.

B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.

C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.16 ASBESTOS

Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Prepare equipment layout drawings to coordinate proper location and personnel access of all facilities. Submit the drawings for review as required by Part 1. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the drawings.

C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

E. Cutting Holes:

   1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by Resident Engineer where working area space is limited.
   2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by Resident Engineer. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to Resident Engineer for approval.
   3. Do not penetrate membrane waterproofing.

F. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.

G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

H. Protection and Cleaning:

   1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Resident Engineer. Damaged or defective items in the opinion of the Resident Engineer, shall be replaced.
   2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

J. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

K. Install steam piping expansion joints as per manufacturer’s recommendations.

L. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.
3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Resident Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Resident Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Resident Engineer's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

M. Work in Animal Research Areas: Seal all pipe and duct penetrations with silicone sealant to prevent entrance of insects.

N. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment of to ceiling structure, whichever is lower (NFPA 70).

O. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 TEMPORARY PIPING AND EQUIPMENT

A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.

B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Paragraph 3.1 apply.

C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.3 RIGGING

A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.

B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Government under specified restrictions of phasing and maintenance of service as well as structural integrity of the building.

C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.

E. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.

F. Rigging plan and methods shall be referred to Resident Engineer for evaluation prior to actual work.

G. Restore building to original condition upon completion of rigging work.

3.4 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Resident Engineer.

B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.

C. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work.

D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-69. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.

E. HVAC Vertical Pipe Supports:

1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.

F. Overhead Supports:

1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
3. Tubing and capillary systems shall be supported in channel troughs.

G. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Anchor and dowel concrete bases and structural systems to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
2. Do not locate or install bases and supports until equipment mounted thereon has been approved. Size bases to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Boiler foundations shall have horizontal dimensions that exceed boiler base frame dimensions by at least 150 mm (6 inches) on all sides. Refer to structural drawings. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.

3.5 MECHANICAL DEMOLITION

A. Rigging access, other than indicated on the drawings, shall be provided by the Contractor after approval for structural integrity by the

Resident Engineer. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Do not permit debris to accumulate in the area to the detriment of plant operation. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VA Medical Center, and Contractor shall follow all directives of the RE or COR with regard to rigging, safety, fire safety, and maintenance of operations.

C. Completely remove all piping, wiring, conduit, and other devices associated with the equipment not to be re-used in the new work. This includes all pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. Seal all openings, after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.

D. All valves including gate, globe, ball, butterfly and check, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to Resident Engineer and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.6 CLEANING AND PAINTING

A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted.

B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
2. Material And Equipment Not To Be Painted Includes:
   a. Motors, controllers, control switches, and safety switches.
   b. Control and interlock devices.
   c. Regulators.
   d. Pressure reducing valves.
   e. Control valves and thermostatic elements.
   f. Lubrication devices and grease fittings.
   g. Copper, brass, aluminum, stainless steel and bronze surfaces.
   h. Valve stems and rotating shafts.
   i. Pressure gauges and thermometers.
   j. Glass.
   k. Name plates.
3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
6. Paint shall withstand the following temperatures without peeling or discoloration:
   a. Condensate and feedwater -- 38 degrees C (100 degrees F) on insulation jacket surface and 120 degrees C (250 degrees F) on metal pipe surface.
   b. Steam -- 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (375 degrees F) on metal pipe surface.
7. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.

3.7 IDENTIFICATION SIGNS

A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16-inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.

B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.

3.8 MOTOR AND DRIVE ALIGNMENT

A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.

B. Direct-connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

3.9 LUBRICATION

A. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.

B. Equip all devices with required lubrication fittings or devices. Provide a minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application; also provide 12 grease sticks for lubricated plug valves. Deliver all materials to Resident Engineer in unopened containers that are properly identified as to application.

C. Provide a separate grease gun with attachments for applicable fittings for each type of grease applied.

D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.10 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specifications will be tested as part of a larger system. Refer to Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.11 STARTUP AND TEMPORARY OPERATION

Start up equipment as described in equipment specifications. Verify that vibration is within specified tolerance prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.12 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS and submit the test reports and records to the Resident Engineer.

B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.

C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work.

3.13 INSTRUCTIONS TO VA PERSONNEL

Provide in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS, and Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

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SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies the furnishing, installation and connection of motors for HVAC and steam generation equipment.

1.2 RELATED WORK:

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

B. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements common to more than one Section of Division 26.

D. Section 26 29 11, MOTOR CONTROLLERS: Starters, control and protection for motors.

E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUBMITTALS:

A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

B. Shop Drawings:

1. Provide documentation to demonstrate compliance with drawings and specifications.
2. Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.

C. Manuals:

1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.

D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Resident Engineer:

1. Certification that the motors have been applied, installed, adjusted, lubricated, and tested according to manufacturer published recommendations.

E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.4 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. National Electrical Manufacturers Association (NEMA):

MG 1-2006 Rev. 1 2009 ..Motors and Generators

MG 2–2001 Rev. 1 2007...Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

C. National Fire Protection Association (NFPA):

70-2008.................National Electrical Code (NEC)

D. Institute of Electrical and Electronics Engineers (IEEE):

112-04..................Standard Test Procedure for Polyphase Induction Motors and Generators

E. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

90.1-2007...............Energy Standard for Buildings Except Low-Rise Residential Buildings

PART 2 - PRODUCTS

2.1 MOTORS:

A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.

B. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 29 11, MOTOR CONTROLLERS. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors as scheduled. Unless otherwise specified for a particular application, use electric motors with the following requirements.

C. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.

D. Voltage ratings shall be as follows:

1. Single phase:
   a. Motors connected to 120-volt systems: 115 volts.
   b. Motors connected to 208-volt systems: 200 volts.
   c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
2. Three phase:
   a. Motors connected to 208-volt systems: 200 volts.

   b. Motors, less than 74.6 kW (100 HP), connected to 240 volt or 480 volt systems: 208-230/460 volts, dual connection.
   c. Motors, 74.6 kW (100 HP) or larger, connected to 240-volt systems: 230 volts.
   d. Motors, 74.6 kW (100 HP) or larger, connected to 480-volt systems: 460 volts.
   e. Motors connected to high voltage systems (Over 600V): Shall conform to NEMA Standards for connection to the nominal system voltage shown on the drawings.

E. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.

F. Motor Enclosures:
   1. Shall be the NEMA types as specified and/or shown on the drawings.
   2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
      a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
      b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
      c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
   3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

G. Special Requirements:
   1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Government.
   2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
   3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
      a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.

b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.

c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

5. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

H. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.

I. Energy-Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 Watts (1 HP) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 Watts or more with open~~,~~ drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section. Motors not specified as “premium efficiency” shall comply with the Energy Policy Act of 2005 (EPACT).

Minimum Premium Efficiencies Open Drip-Proof				**Minimum Premium Efficiencies Totally Enclosed Fan-Cooled**			
Rating kW (HP)	**1200 RPM**	**1800 RPM**	**3600 RPM**	**Rating kW (HP)**	**1200 RPM**	**1800 RPM**	**3600 RPM**
0.746 (1)	82.5%	85.5%	77.0%	0.746 (1)	82.5%	85.5%	77.0%
1.12 (1.5)	86.5%	86.5%	84.0%	1.12 (1.5)	87.5%	86.5%	84.0%
1.49 (2)	87.5%	86.5%	85.5%	1.49 (2)	88.5%	86.5%	85.5%
2.24 (3)	88.5%	89.5%	85.5%	2.24 (3)	89.5%	89.5%	86.5%
3.73 (5)	89.5%	89.5%	86.5%	3.73 (5)	89.5%	89.5%	88.5%
5.60 (7.5)	90.2%	91.0%	88.5%	5.60 (7.5)	91.0%	91.7%	89.5%
7.46 (10)	91.7%	91.7%	89.5%	7.46 (10)	91.0%	91.7%	90.2%
11.2 (15)	91.7%	93.0%	90.2%	11.2 (15)	91.7%	92.4%	91.0%
14.9 (20)	92.4%	93.0%	91.0%	14.9 (20)	91.7%	93.0%	91.0%
18.7 (25)	93.0%	93.6%	91.7%	18.7 (25)	93.0%	93.6%	91.7%

22.4 (30)	93.6%	94.1%	91.7%	22.4 (30)	93.0%	93.6%	91.7%
29.8 (40)	94.1%	94.1%	92.4%	29.8 (40)	94.1%	94.1%	92.4%
37.3 (50)	94.1%	94.5%	93.0%	37.3 (50)	94.1%	94.5%	93.0%
44.8 (60)	94.5%	95.0%	93.6%	44.8 (60)	94.5%	95.0%	93.6%
56.9 (75)	94.5%	95.0%	93.6%	56.9 (75)	94.5%	95.4%	93.6%
74.6 (100)	95.0%	95.4%	93.6%	74.6 (100)	95.0%	95.4%	94.1%
93.3 (125)	95.0%	95.4%	94.1%	93.3 (125)	95.0%	95.4%	95.0%
112 (150)	95.4%	95.8%	94.1%	112 (150)	95.8%	95.8%	95.0%
149.2 (200)	95.4%	95.8%	95.0%	149.2 (200)	95.8%	96.2%	95.4%

J. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM.

PART 3 - EXECUTION

3.1 INSTALLATION:

Install motors in accordance with manufacturer’s recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

3.2 FIELD TESTS

A. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before start-up. All shall test free from grounds.

B. Perform Load test in accordance with ANSI/IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

C. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

3.3 STARTUP AND TESTING

A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:
   1. Planning systematic TAB procedures.
   2. Design Review Report.
   3. Systems Inspection report.
   4. Duct Air Leakage test report.
   5. Systems Readiness Report.
   6. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
   7. Vibration and sound measurements.
   8. Recording and reporting results.

B. Definitions:
   1. Basic TAB used in this Section: Chapter 38, "Testing, Adjusting and Balancing" of 2011 ASHRAE Handbook, "HVAC Applications".
   2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
   3. AABC: Associated Air Balance Council.
   4. NEBB: National Environmental Balancing Bureau.
   5. Hydronic Systems: Includes chilled water, condenser water, heating hot water and glycol-water systems.
   6. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
   7. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.2 RELATED WORK

A. Section 01 91 00,GENERAL COMMISSIONING REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training

E. Section 23 05 12 GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

1.3 QUALITY ASSURANCE

A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Qualifications:

1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
2. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency’s review shows unsatisfactory work performed by the predecessor agency.
3. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding 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 performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.

4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:
    a. Shall directly supervise all TAB work.
    b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
    c. Would follow all TAB work through its satisfactory completion.
    d. Shall provide final markings of settings of all HVAC adjustment devices.
    e. Permanently mark location of duct test ports.
5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC or NEBB

C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

D. Tab Criteria:
1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, and requirements stated herein shall be the basis for planning, procedures, and reports.
2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
    a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus l0 percent.

b. Air terminal units (maximum values): Minus 2 percent to plus l0 percent.
c. Exhaust hoods/cabinets: 0 percent to plus l0 percent.
d. Minimum outside air: 0 percent to plus 10 percent.
e. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus l0 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.
f. Heating hot water pumps and hot water coils: Minus 5 percent to plus 5 percent.
g. Chilled water and condenser water pumps: Minus 0 percent to plus 5 percent.
h. Chilled water coils: Minus 0 percent to plus 5 percent.

3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and results shall be demonstrated to the Resident Engineer for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the Resident Engineer) and one hydronic system (pumps and three coils) as follows:
a. When field TAB work begins.
b. During each partial final inspection and the final inspection for the project if requested by VA.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.
C. For use by the Resident Engineer staff, submit one complete set of applicable AABC or NEBB publications that will be the basis of TAB work.
D. Submit Following for Review and Approval:
1. Design Review Report within 90 days for conventional design projects after the system layout on air and water side is completed by the Contractor.
2. Systems inspection report on equipment and installation for conformance with design.

3. Duct Air Leakage Test Report.
4. Systems Readiness Report.
5. Intermediate and Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests.
6. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

E. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area.

1.5 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

2011 ....HVAC Applications ASHRAE Handbook, Chapter 38, Testing, Adjusting, and Balancing and Chapter 48, Sound and Vibration Control

C. Associated Air Balance Council (AABC):

2002....................AABC National Standards for Total System Balance

D. National Environmental Balancing Bureau (NEBB):

7th Edition 2005 ....Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

2nd Edition 2006 ....Procedural Standards for the Measurement of Sound and Vibration

3rd Edition 2009 ....Procedural Standards for Whole Building Systems Commissioning of New Construction

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

3rd Edition 2002 ....HVAC SYSTEMS Testing, Adjusting and Balancing

PART 2 - PRODUCTS

2.1 PLUGS

Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to TAB Criteria in Article, Quality Assurance.

B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

The TAB Specialist shall review the Contract Plans and specifications and advise the Resident Engineer of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.3 SYSTEMS INSPECTION REPORT

A. Inspect equipment and installation for conformance with design.

B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.

C. Reports: Follow check list format developed by AABC, NEBB or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 SYSTEM READINESS REPORT

A. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated on drawings. Submit report of findings to resident engineer.

B. Inspect each System to ensure that it is complete including installation and operation of controls. Submit report to RE in standard format and forms prepared and or approved by the Commissioning Agent.

C. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Resident Engineer.

3.5 TAB REPORTS

A. Submit an intermediate report for 50 percent of systems and equipment tested and balanced to establish satisfactory test results.

B. The TAB contractor shall provide raw data immediately in writing to the Resident Engineer if there is a problem in achieving intended results before submitting a formal report.

C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval at no additional cost to the owner.

D. Do not proceed with the remaining systems until intermediate report is approved by the Resident Engineer.

3.6 TAB PROCEDURES

A. Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.

B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB reports for pre construction air and water flow rate and for each phase of the project prior to partial final inspections of each phase of the project. Return existing areas outside the work area to pre constructed conditions.

D. Allow 30 days time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

E. Air Balance and Equipment Test: Include air handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, computer room AC units.

   1. Artificially load air filters by partial blanking to produce air pressure drop of manufacturer’s recommended pressure drop.
   2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.
4. Variable air volume (VAV) systems:
   a. Measure operating pressure control setpoint prior to construction and return system to that valve post constructions to maintain the design flow to each space with the lowest setpoint.
5. Record final measurements for air handling equipment performance data sheets.

F. Water Balance and Equipment Test: Include circulating pumps, convertors, coils, coolers and condensers:

. Set coils and evaporator to values on equipment submittals, if different from values on contract drawings.

3. Primary-secondary (variable volume) systems: Coordinate TAB with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Balance systems at design water flow and then verify that variable flow controls function as designed.
4. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for convertors. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

3.7 MARKING OF SETTINGS

Following approval of Tab final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the Resident Engineer.

3.8 IDENTIFICATION OF TEST PORTS

The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

3.9 PHASING

A. Phased Projects: Testing and Balancing Work to follow project with areas shall be completed per the project phasing. Upon completion of the project all areas shall have been tested and balanced per the contract documents.

B. Existing Areas: Systems that serve areas outside of the project scope shall not be adversely affected. Measure existing parameters where shown to document system capacity.

3.10 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - E N D - - -

SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) appointed by the Department of Veterans Affairs will manage the commissioning process.

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

A. This Section includes requirements for commissioning the HVAC systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

B. The commissioning activities have been developed to support the VA requirements to meet guidelines for Federal Leadership in Environmental, Energy, and Economic Performance.

D. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more specifics regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in this Division is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel, is required in cooperation with the VA and the Commissioning Agent.

B. The following HVAC systems will be commissioned:

1. Direct Digital Control System (BACnet or similar Local Area Network (LAN), Operator Work Station hardware and software, building controller hardware and software, terminal unit controller hardware and software, all sequences of operation, system accuracy and response time).

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of HVAC systems will require inspection of individual elements of the HVAC systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule HVAC systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Resident Engineer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA's operation and maintenance personnel is required in cooperation with the Resident Engineer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Resident

Engineer after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

----- END -----

Addendum 1

This Addendum is issued for the purpose of modifying and /or clarifying the specifications and is to be construed as being as much a part of the original Contract Documents as though originally contained therein.

3. Brand names can be ignored in section 23 09 23, with the exception of the Siemens brand name when it is being used to describe the existing DDC system that is in place. An example of the wording that can be ignored would be: “Sensor shall be Drexel Brook or equal.”

4. Sheet M101 Note 1 of the METERING TO BE ADDED TABLE shall be replaced in its entirety with the following: ELECTRIC METERS TO BE AS SPECIFIED. INSTALL PER MFR’S RECOMMENDATIONS. ELECTRICAL EQUIPMENTS SHALL BE INSTALLED, OPERATED, SERVICED, AND MAINTAINED ONLY BY QUALIFIED PERSONNEL.

SECTION 23 09 23

DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 GENERAL

A. The new extended and upgraded campus controls system is designed as an extension of the existing VAMC campus wide Siemens EMS system and infrastructure to fully integrate all buildings contained in the contract documents & utility monitoring & metering systems. The new system including interface to existing systems and equipment shall operate and function as one complete system including one database of control point objects and global control logic capabilities (trending, logging, metering, etc.). Facility operators shall have complete operations and control capability over all systems, new and existing including, monitoring, trending, graphing, scheduling, alarm management, global point sharing, global strategy deployment, graphical operations interface and custom reporting as specified. Utilize open protocol DDC control for equipment and software, BACnet. This project is open to all controls manufacturers capable of meeting the specifications. Any manufacturer other than Siemens must fully replace existing Siemens equipment in the same manner that these drawings show other existing manufacturer’s equipment being replaced. Any undefined sequences required for a complete control system are to be provided by contractor. All Siemens sequences not shown but existing must be created for any non-Siemens system.

1.2 DESCRIPTION

A. Provide a single campus direct-digital control system for energy management, equipment monitoring and control as indicated on the project documents, point list, interoperability tables, drawings and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty. All actuators installed under this contract shall have electric actuation. It is the intent of this project to completely remove pneumatic actuation. DDC over existing pneumatic control shall only be allowed where specifically stated in the contract documents.

1. The direct-digital control system shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server, and Engineering Control Center (ECC). Provide remote user access using a standard web browser to full access the control system with the proper password.
2. The new system shall be an upgrade and extension of the existing Siemens campus wide EMS or a complete replacement of that system. The upgraded system shall fully control the following buildings:
   a. Building 2: Admin
   b. Building 4: Dietary
   c. Building 6: Admin
   d. Building 7: Main Hospital
   e. Building 8: Canteen
   f. Building 9: Psychiatric Hospital
   g. Building 16: Laundry
   h. Building 45: Nursing Home
   i. Building 46: Chapel
   j. Building 49: Mental Health Rehab
   k. Building 147: Chiller Plant
3. The existing Siemens EMS presently monitors at least a portion of the following buildings, all existing functions not shown in the drawings shall be migrated to the upgraded server:
   a. Building 1 Admin
   b. Building 2 Admin
   c. Building 3 Admin
   d. Building 4 Dietary
   e. Building 7 Main Hospital
   f. Building 45 Nursing Home
   g. Building 49 Mental Health Rehab
   h. Building 147 Chiller Plant
4. The existing Siemens DDC system presently has control of at least a portion of the following buildings, all existing functions not shown in the drawings shall be migrated to the upgraded server:
   a. Building 7 Main Hospital
   b. Building 8 Canteen
   c. Building 9 Psychiatric Hospital
   d. Building 147 Central Chiller Plant

5. The direct-digital control system(s) shall be native BACnet. All new workstations, controllers, devices, and components shall be listed by BACnet Testing Laboratories. All new workstations, controller, devices, and components shall be accessible using a Web browser interface and shall communicate exclusively using the ASHRAE Standard 135 BACnet communications protocol without the use of gateways.
6. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. To accomplish this effectively, system shall be capable of utilizing standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols.
   a. System shall be capable of high speed Ethernet communication using BACnet/IP and TCP/IP protocol.
   b. System shall be capable of BACnet communication according to ANSI/ASHRAE 135-2004 or ANSI/ASHRAE 135-2008.
   c. System shall be capable of OPC server communications according to OPC Data Access 2.0.
   d. System shall be capable of using the LonTalk protocol.
   e. System shall be capable of using the ModBus protocol.
   f. The system shall be capable of supporting both standard and vendor specific protocols to integrate a wide variety of third-party devices and legacy systems.
   g. The system shall be capable of supporting wireless field level networks and sensor communications using a mesh topology and IEEE 802.15.4 network.
   h. The intent is to either use the Operator Workstation provided under this contract to communicate with control systems provided by other vendors or to allow information about the system provided in this contract to be sent to another workstation. This allows the user to have a single seat from which to perform daily operation.
7. Provide hardware, software, and wiring to provide communication interfaces with each of the systems listed below.
   a. UPS System
   b. Advanced Metering System (Schneider & TL Services)
   c. Additional building metering

d. All existing and future Campus wide utility metering including: new switchgear, electrical distribution system, emergency generators, sustaining generators, and PV system.
e. Boiler and chiller plants.
f. PDUs and Static Transfer
g. ATS Switches
h. Computer Room Air Conditioning (CRAC)
i. Electrical Power Generators
j. Lighting Control System
k. Fire Alarm System

8. All wells for water monitoring devices, flow switches, and alarms, as required.
   a. All installation kits for turbine flow meters, allow service and removal under pressure.
9. The work administered by this Section of the technical specifications shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required for complete and fully functional Controls Systems.
10. Provide system graphics for each controlled device and/or integrated systems as required by the owner. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.
11. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that the shop drawings were

prepared by their company and that all temperature control equipment was installed under their direct supervision.

12. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
13. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
14. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
15. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall also be able to send alarm to multiple operator workstations without dependence upon a central or intermediate processing device.
16. DDC Controllers shall be able to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust, or control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. For example, all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators. Passwords and priority levels for every point shall be fully programmable and adjustable.
17. All DDC controllers shall be installed with 25% spare points (of each type) and 25% spare memory capacity for connection of floor work.

18. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.

B. Some products are furnished but not installed by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include but not limited to the following:
   1. Control valves.
   2. Flow switches.
   3. Flow meters.
   4. Sensor wells and sockets in piping.
   5. Terminal unit controllers.

C. Some products are installed but not furnished by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the procurement of the products. These products include but not limited to the following:
   1. Factory-furnished accessory thermostats and sensors furnished with unitary equipment.

D. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the particulars of the products. These products include the following:
   1. Fire alarm systems. If zoned fire alarm is required by the project-specific requirements, this interface shall require multiple relays,

which are provided and installed by the fire alarm system contractor, to be monitored.

2. Advanced utility metering systems. These systems may take information from the control system or its component meters and sensors. There is no command or control action from the advanced utility monitoring system on the control system however.
3. Campus wide utility and power generating system. These systems are comprised of existing systems, such as the main switch gear, electric distribution system and emergency generators, as well as the new sustaining generators and PV system. The contractor will be responsible for interfacing to all of these systems and develop and implement the automated and integrated control of all such systems as part of this project.
4. Chiller controls. These controls, if not native BACnet, will require full integration.
5. Terminal units’ velocity sensors
6. Condenser water quality systems: condenser water high- and low-parts hydrogen (pH) alarms.
7. Unitary HVAC equipment (computer room units, rooftop air conditioning units, split systems, packaged pumping stations) controls. These include:
    a. Discharge temperature control.
    b. Economizer control.
    c. Flowrate control.
    d. Setpoint reset.
    e. Time of day indexing.
    f. Status alarm.
8. Variable frequency drives. These controls, if not native BACnet, will require full integration.
9. The following systems have limited control (as individually noted below) from the ECC:
    a. Constant temperature rooms: temperature out of acceptable range and status alarms.
    b. Emergency generators: status alarms.
    c. Domestic water heating systems: low temperature, high temperature and status alarms.
    d. Building lighting systems: on/off and scene control.
    e. Fume hoods and biological safety cabinets: status alarms

f. Isolation rooms: pressure outside of acceptable limit alarms.

10. Primary DDC panels as follows:

a. Minimum one (1) BMS system Primary DDC panel per floor. The application specific controllers installed for the terminal units on a floor will be connected to the BMS panel on the same floor. DDC Panels serving AHU’s on a floor are not to be used to meet this requirement. Separate panels will be required.

b. It shall be acceptable to combine up to three (3) of the following mechanical equipment into one (1) Primary DDC panel:

1) Exhaust Fans
2) Standalone Supply Fans
3) Package AC Units

c. It is acceptable to wire the following systems into any of the Primary DDC panels:

1) Miscellaneous alarm monitoring (i.e., ATS, leak, temperature, light, etc.).
2) Miscellaneous equipment (i.e., Unit Heater, Domestic Water Heater, Standalone Dampers, etc.).

d. Motors in motor control centers shall be controlled from the DDC controller associated with HVAC system. It shall not be acceptable to control all motors in a MCC from one DDC controller dedicated to the MCC. The intent of this specification is that the loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.

11. Stand-alone Application Specific Controllers (ASCs) for terminal equipment (CAV, FP VAV, and VAV units, and fan coil units).

E. Responsibility Table:

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
Terminal units	23	23	N/A	26
Controllers for terminal units	23 09 23	23	23 09 23	16

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic dampers (not furnished with equipment)	23 09 23	23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
Power distribution system monitoring interfaces	23 09 23	23 09 23	23 09 23	26
Interface with chiller/boiler controls	23 09 23	23 09 23	23 09 23	26
Chiller/boiler controls interface with control system	23	23	23 09 23	26
All control system nodes, equipment, housings, enclosures, and panels.	23 09 23	23 09 23	23 09 23	26
Smoke detectors	28 31 00	28 31 00	28 31 00	28 31 00
Fire/Smoke Dampers	23	23	28 31 00	28 31 00
Smoke Dampers	23	23	28 31 00	28 31 00
Fire Dampers	23	23	N/A	N/A
Chiller/starter interlock	N/A	N/A	26	26

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
wiring				
Chiller Flow Switches	23	23	23	N/A
Boiler interlock wiring	23	23	23	26
Boiler Flow Switches	23	23	23	N/A
Water treatment system	23	23	23	26
VFDs	23 09 23	26	23 09 23	26
Refrigerant monitors	23	23 09 23	23 09 23	26
Laboratory Environmental Controls	23 09 23	23 09 23	23 09 23	26
Fume hood controls	23 09 23	23 09 23	23 09 23	26
Medical gas panels	23	23	26	26
Laboratory Air Valves	23	23	23 09 23	N/A
Computer Room A/C Unit field-mounted controls	23	23	16	26
Control system interface with CRU A/C controls	23 09 23	23 09 23	23 09 23	26
CRU A/C unit controls interface with control system	23	23 09 23	23 09 23	26
Fire Alarm shutdown relay interlock wiring	28	28	28	26
Control system monitoring of fire alarm smoke control relay	28	28	23 09 23	28
Fire-fighter’s smoke control station (FSCS	28	28	28	28
Fan Coil Unit controls (not furnished with	23 09 23	23 09 23	23 09 23	26

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
equipment)				
Unit Heater controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Packaged RTU space-mounted controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Packaged RTU unit-mounted controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Cooling Tower Vibration Switches	23	23	23 09 23	23 09 23
Cooling Tower Level Control Devices	23	23	23 09 23	23 09 23
Cooling Tower makeup water control devices	23	23	23 09 23	23 09 23
Starters, HOA switches	23	23	N/A	26

1.3 RELATED WORK

A. Section 01 00 00 General Requirements
B. Section 01 91 00 General Commissioning Requirements
C. Section 23 05 93 Testing, Adjusting, and Balancing for HVAC
D. Section 23 08 00 Commissioning of HVAC
E. Section 25 10 10, Advanced Utility Metering System.
F. Section 26 05 11, Requirements for Electrical Installations.
G. Section 26 05 19, Low-Voltage Electrical Power Conductors and Cables (600 Volts and Below).
H. Section 26 05 33, Raceway and Boxes for Electrical Systems.
I. Section 26 29 11, Motor Starters.

1.4 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.
B. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
C. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data over and services over a network.
D. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.
E. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may sue different LAN technologies.
F. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.
G. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
H. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.
I. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.
J. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.
K. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).
L. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.

M. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.

N. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.

O. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls

P. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).

Q. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.

R. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

S. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

T. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.

V. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.

W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.

X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.

Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.

Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.

AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

BB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

CC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

DD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

EE. GIF: Abbreviation of Graphic interchange format.

FF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.

GG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.

HH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input

(AI), digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.

II. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to “sockets” without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

JJ. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

KK. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

LL. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

MM. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

NN. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

OO. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

PP. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

QQ. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

RR. Operating system (OS): Software, which controls the execution of computer application programs.

SS. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.

TT. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

UU. Peer-to-Peer: A networking architecture that treats all network stations as equal partners - any device can initiate and respond to communication with other devices.

VV. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

WW. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

XX. Repeater: A network component that connects two or more physical segments at the physical layer.

YY. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

ZZ. Sensors: Devices measuring state points or flows, which are then transmitted, back to the DDC system.

AAA. Thermostats: devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.5 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegates the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, and commissioning of the system. The controls subcontractor shall be in the business of design, installation, and service of such building automation control systems similar in size and complexity.
2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be

manufacturer’s latest standard design and have been tested and proven in actual use.

3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative would observe the control systems in full operation.
4. The controls subcontractor shall have in-place facility within 100 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.
6. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling, and related decisions on behalf of the Controls Contractor.
7. All BAS peer-to-peer building controllers and local user displays shall be UL Listed under Standard UL916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL864, categories UUKL, UDTZ, and QVAX and be so listed at the time of bid. All field level controllers shall comply with UL Standard UL 864 category UUKL; and be so listed at the time of Bid.
8. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.
9. All wireless devices shall conform to:

a. The requirements of Title 47 of the Code of Federal Regulations, FCC Part 15, governing radio frequency intentional radiating devices and be issued a FCC user identification and be so labeled.
b. CE Directive 1999/5/EC

10. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 and ISO-140001. The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.
11. This system shall have a documented history of compatibility by design for a minimum of fifteen years. Future compatibility shall be supported for no less than ten years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

B. Codes and Standards:
1. All work shall conform to the applicable Codes and Standards.
2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.6 PERFORMANCE

A. The system shall conform to the following:
1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per graphic. All current data shall be displayed within ten (10) seconds of the request.
2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be two (2) seconds. Analog objects shall start to adjust within two (2) seconds.

4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C (±1°F)
Ducted air temperature	±0.5°C [±1°F]
Outdoor air temperature	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water temperature	±0.5°C [±1°F]
Relative humidity	±2% RH
Water flow	±1% of reading
Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
Carbon Monoxide (CO)	±5% of reading

Carbon Dioxide (CO_2)	±50 ppm
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Water pressure	±2% of full scale *Note 1
Electrical Power	±0.5% of reading

Note 1: for both absolute and differential pressure

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	**Control Accuracy**	**Range of Medium**
Air Pressure	±50 Pa (±0.2 in. w.g.)	0–1.5 kPa (0–6 in. w.g.)
Air Pressure	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi)	0–1 MPa (1–150 psi)
Fluid Pressure	±250 Pa (±1.0 in. w.g.)	0–12.5 kPa (0–50 in. w.g.) differential

11. Extent of direct digital control: control design shall allow for at least the points indicated on the points list on the drawings.

1.7 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to or connect via (through password-limited access) VPN through the internet monitor and control the facility’s building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekend, and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 12 hours after the problem is reported.

D. Controls and Instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.8 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer’s literature and data for all components including the following:

1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.
2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers, and the associated point names.
3. Control dampers and control valves schedule, including the size and pressure drop.
4. Catalog cut sheets of all equipment used. This includes, but is not limited to software (by manufacturer and by third parties), DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer’s cut sheets apply to a product series rather than a specific product, the

data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.

5. Sequence of operations for each HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
6. Color prints of proposed graphics with a list of points for display.
7. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
8. Schematic wiring diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers’ model numbers and functions. Show all interface wiring to the control system.
9. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
10. Riser diagrams of wiring between central control unit and all control panels.
11. Scaled plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
12. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.
13. Quantities of submitted items may be reviewed but are the responsibility of the contractor administered by this Section of the technical specifications.

C. Product Certificates: Compliance with Article, QUALITY ASSURANCE.

D. Licenses: Provide licenses for all software residing on and used by the Controls Systems and transfer these licenses to the Owner prior to completion.

E. Schedules:

1. Schedule of work provided within one month of contract award indicating:
   a. Intended sequence of work item.

b. Start dates of each work item.
c. Duration of each work item.
d. Planned delivery dates for ordered material and equipment and expected lead times.
e. Milestones indicating possible restraints on work by other trades or situations

2. Monthly written status reports indicating work completed and revisions to expected delivery. Include updated schedule of work.

F. As Built Control Drawings:

1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
2. Furnish one (1) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.
3. Furnish one (2) CD-ROM in CAD DWG and .DXF format for the drawings noted in subparagraphs above.

G. Operation and Maintenance (O/M) Manuals):

1. As-built versions of the submittal product data.
2. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
3. Operator’s Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
4. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
5. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
6. Documentation of all programs created using custom programming language, including setpoints, tuning parameters, and object database.

7. Graphic files, programs, and database on electronic media.
8. List of recommended spare parts with part numbers and suppliers.
9. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
10. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
11. Licenses, guarantees, and warranty documents for equipment and systems.
12. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

H. Submit Performance Report to Resident Engineer prior to final inspection.

1.9 INSTRUCTIONS

A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below. Contractor shall also video tape instruction sessions noted below.
1. First Phase: Formal instructions to the VA facilities personnel for a total of 32 hours, given in multiple training sessions (each no longer than four hours in length), conducted sometime between the completed installation and prior to the performance test period of the control system, at a time mutually agreeable to the Contractor and the VA. Contractor to work with VA to provide sufficient training to all maintenance personnel shifts. Maintenance personnel are on-site 24 hrs/day.
2. Second Phase: This phase of training shall comprise of on the job training during start-up, checkout period, and performance test period. VA facilities personnel will work with the Contractor’s installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls subcontractor will provide 32 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel. Contractor to work with VA to provide sufficient training to all maintenance personnel shifts. Maintenance personnel are on-site 24 hrs/day.

3. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.
4. Training shall be given by direct employees of the controls system subcontractor.

1.10PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.
B. The CUs used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at –40 to 65°C (-40 to 150°F).
C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.
D. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.11 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
B. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   Standard 135-10.........BACNET Building Automation and Control Networks
C. American Society of Mechanical Engineers (ASME):
   B16.18-01...............Cast Copper Alloy Solder Joint Pressure Fittings.
   B16.22-01...............Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
D. American Society of Testing Materials (ASTM):
   B32-08..................Standard Specification for Solder Metal
   B88-09..................Standard Specifications for Seamless Copper Water Tube
   B88M-09.................Standard Specification for Seamless Copper Water Tube (Metric)

B280-08.................Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service

D2737-03................Standard Specification for Polyethylene (PE) Plastic Tubing

E. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2001 Part 15: Radio Frequency Devices.

F. Institute of Electrical and Electronic Engineers (IEEE):

802.3-11................Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks- Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access method and Physical Layer Specifications

G. National Fire Protection Association (NFPA):

70-11...................National Electric Code

90A-09..................Standard for Installation of Air-Conditioning and Ventilation Systems

H. Underwriter Laboratories Inc (UL):

94-10...................Tests for Flammability of Plastic Materials for Parts and Devices and Appliances

294-10..................Access Control System Units

486A/486B-10............Wire Connectors

555S-11.................Standard for Smoke Dampers

916-10..................Energy Management Equipment

1076-10.................Proprietary Burglar Alarm Units and Systems

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project specific software and documentation shall become Owner’s property. This includes, but is not limited to:
   1. Graphics
   2. Record drawings
   3. Database
   4. Application programming code

B. Project Specific Documentation shall become Owner’s property.

1. General
   a. Provide complete Web-based electronic project documentation in addition to the hard copy owner’s manual by utilizing Internet Web access. The electronic project documentation shall be accessible for authorized personnel anytime from anywhere requiring only a simple Internet access.
   b. Submit two (2) draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and submit four (4) interim final copies.
   c. Submit four (4) copies of owner’s manuals upon completion of project.
   d. Submit two (2) electronic copies of complete as-built documentation. All drawings shall be in standard AutoCAD format, other documentation shall be in standard MS Office format.
   e. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above for "as-built" manuals.
   f. Assemble owner's manuals into multi-volume sets as necessary and required by the owner.
   g. Protect each volume with a binder. Volumes to have printed dividers between major sections and have oversized binders to accommodate up to ½ inch thick set of additional information.
   h. Each binder to be printed with project name and volume title on front cover and binder.
   i. On the first page of each manual identify with project name, manual title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.
2. Web-based project documentation system shall serve as an off-site plan archive and provide access to any project-related documentation from a single source. The Web archive system shall comply with the following requirements:
   a. The Web-based archive shall store all project related documentation on the contractor’s document server.
   b. The database management and maintenance shall be the contractor’s responsibility.
   c. The archive shall be accessible using a high-speed Internet access by simply visiting a password protected Web address. User

shall be able to access all information utilizing standard MS Office applications.

d. The system shall have advanced security and support custom access levels as defined by the administrator using the latest encryption technology.
e. The project archive shall be capable to update documentation to reflect new revisions.
f. The project documentation archive shall provide access to all project related documentation that includes, but not limited to contractual, specification and as-built documents, such as mechanical control drawings, and electrical wiring schematics, sequences of operation, point lists.
g. Provide electronic device lists and product specification/data sheets.
h. Contractor shall provide Web-based part ordering system.
i. The project archive shall be expandable to incorporate future projects as necessary.
j. The system shall provide access to the building service information. The user shall be able to request a service, view account activities, contracts, share files, and generate custom reports.

C. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
1. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.
2. Description of manual override operation of all control points in system.
3. BMS system manufacturers complete operating manuals.

D. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:
1. Complete as-built installation drawings for each building system.
2. Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.

3. Photographs and/or drawings showing installation details and locations of equipment.
4. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.
5. Parts list with manufacturer's catalog numbers and ordering information.
6. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.
7. Manufacturer's operation, set-up, maintenance, and catalog literature for each piece of equipment.
8. Maintenance and repair instructions.
9. Recommended spare parts.

E. Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum include the following:
1. Complete programming manuals, and reference guides.
2. Details of any custom software packages and compilers.
3. Information and access required for independent programming of system.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. All products used in this project installation shall be new and currently manufactured and shall have been applied in similar installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION:

A. The design of the BMS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet based primary network for all operator workstations, servers, and primary DDC controllers along with secondary Field Level Networks for terminal equipment application specific controllers.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

C. Operator Workstation Communication:
   1. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.
   2. The servers will act as the central database for system graphics and databases to provide consistency throughout all system workstations.
   3. The network shall allow concurrent use of multiple BMS software site licenses.

D. Workstation Level Network Communication
   1. All PCs shall simultaneously direct connect to the Ethernet Management Level Network without the use of an interposing device.
   2. Operator Workstation shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC, and TCP/IP corporate level networks without the use of interposing devices.
   3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
   4. Any controller residing on the primary building level networks shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
   5. Any PC on the Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet.
   6. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in a notification at the PC.
   7. The standard client and server workstations on the Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
   8. System software applications will run as a service to allow communication with Primary Network Controllers without the need for user log in. Closing the application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.
   9. Any break in Ethernet communication between the standard client and server workstations on the Management Level Network shall result in a notification at each workstation.
   10. Access to the system database shall be available from any standard client workstation on the Management Level Network.

11. Client access to client-server workstation configurations over the Internet network shall be available via Web browser interface.
12. Client access to client-server workstation configurations over the Intranet or Internet shall be available via 3 client options:
    a. Web Browser. Client runs in a browser as a Full Trust client applications
    b. Dedicated Installed Application. Client runs as a fully installed software installation that can lockdown desktop space and prevent the ability for the software to be minimized or covered by other applications.
    c. Windows Desktop App. An app that is downloaded to the client from the server PC, that runs like an installed application, and is automatically updated whenever new apps are available at the server.

E. Primary Network - Panel to Panel Communication:
1. The primary network is the fiber network shown on drawing M100.
2. All Building Controllers shall directly reside on the primary BACnet/IP Ethernet network such that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.
3. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.
4. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
5. The primary network shall use BACnet/IP over Ethernet. All devices must:
    a. Auto-sense 10/100 Mbps networks.
    b. Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.
    c. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.

d. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.

6. The primary network shall provide the following minimum performance:
   a. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building Controllers, and other alarm printers within 15 seconds.
   b. Message and alarm buffering to prevent information from being lost.
   c. Error detection, correction, and re-transmission to guarantee data integrity.
   d. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.
   e. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building Controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
   f. The primary network controllers shall back up and restore their own current database including programs, and points without the requirement for connection to a mass storage device.
   g. The primary network controllers shall provide system-wide wild card point search, command, and access direct from any building controller on the network.
   h. The primary network shall allow the Building Controllers to access on-demand display and reports regarding system-wide information including point names, point status, present value, command priority array, trend information, and field panel configuration information.

i. The primary network shall allow the Building Controllers to be configured system-wide by software based tools, and by direct access from any Building Controller on the network. Proprietary vendor specific software shall not be required for system configuration.

j. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust, and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g., all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

k. Devices containing custom programming may reside on the Primary Network.

F. Secondary Network – Application Specific Controller Communication:

1. Communication over the secondary network shall be BACnet MS/TP protocol. When possible. Otherwise the manufacturer’s standard protocol shall be used.
2. This level communication shall support a family of application specific controllers for terminal equipment.
3. The Application Specific Controllers shall communicate bi-directionally with the primary network through Building Controllers for transmission of global data.
4. A maximum of 96 terminal equipment controllers may be configured on individual secondary networks to ensure adequate global data and alarm response times.

G. Internet Based Communication:

1. Server Hosted Web Based Operator Interface

a. The BMS shall provide a Web-based graphical interface that allows users to access the BMS data via the Internet, extranet, or Intranet. Functionality of web-based clients shall provide the same functionality and user interface provided by installed client consoles.

b. A Web server computer will be supplied. The Web server shall use Microsoft's IIS server with Windows 2008 R2 Server, or later, and support browser access via Microsoft Internet Explorer.

c. All information exchanged over Internet shall be optionally encrypted and secure via SSL (provided by Owner).

d. Access to the Web interface may be password protected. Users' rights and privileges to points and graphics will be the same as those assigned at any other workstation, or may be differentiated from privileges at installed workstations.

e. The Web interface shall not require modification or creation of HTML or ASP pages using an HTML editor. All graphics shall be available with the same look and functionality whether they are displayed at an installed client console or in a browser.

f. The Web based interface shall provide the same functionalities as those available at any other workstation, including operation and configuration capabilities.

g. The Web server client licensing shall be from the same pool of client licenses available or installed client consoles or Windows desktop app clients.

h. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support the Web access feature.

2. Field Panel Hosted Web Based Operator Interface (Field Panel Web Server)

a. The BMS shall provide a Field Panel Embedded Web-based graphical interface that allows users to access the BMS data via the Internet, extranet, or Intranet (TCP/IP). The interface shall use Web Services to send and receive data from the BMS to a Web browser.

b. Web Server shall reside on a building controller and not require a separate box or server to run and must reside on a BACnet IP network and support a BACnet MS/TP network.

c. The Web Server shall run on a standard controller, without the need for separate "web appliances" or dedicated web servers. The field panel will serve as an automation controller, with full building automation and I/O features, and provide the user with system information and access via a web browser.

d. The Web Server will allow system-wide access through a single log-in. Web pages will be populated with data from any BACnet IP-enabled DDC controller and associated Field Level Network (FLN) devices.

e. The Web Server shall be secured from IT security threats by means of encrypted password-protected operator access. User accounts shall be individually configured for customized access privileges.

f. The interface shall provide the following functionality to the user based on their access level:

1) Logon Screen - Allows the user to enter their name, password, and domain name for logging into the Web server.

2) Alarm Display - Display of current BMS alarms. Users will be able to acknowledge and erase active alarms.

3) Display of system graphics, including animated motion will be available for viewing over the web browser. A graphic selector list will allow users to select any graphics to which they have access. Graphics displays will automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user account rights.

4) Point Commanding - Allows the user to override and command points they have access to via the Web browser interface.

5) Online Database Editors – Users will be able to add/delete/modify any database object (point, schedules, etc) and custom programs through the browser without the need for separate tools.

3. Graphics creation – user shall be able to add/delete/modify system graphics from standard user interface without the need of any external or specialized tools.

H. Remote Notification:

1. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.

2. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit

on the number of remote devices which can receive messages from the system.

3. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
4. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to a second device after a configurable time has elapsed.
5. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.

I. Wireless Communications

1. Wireless communications shall take place using modular wireless transceivers at each device that eliminate the need for a physical network communication cable.
   a. The wireless transceiver shall utilize 2.4 GHz in the license free global Industrial Scientific & Medical (ISM) band for greater bandwidth.
   b. The wireless transceiver shall be encased in a plenum-rated enclosure. If the application dictates, the wireless transceiver shall be able to be installed in a metal enclosure utilizing a remote mounted antenna.
   c. The wireless transceiver channel shall be factory set and capable of being field set to a different channel if interference with IEEE 802.11 devices or other 2.4 GHz products is encountered.
   d. The wireless transceiver shall be 24 Vac powered.
   e. The wireless transceiver shall give a visual indication that it is powered and communicating.
   f. The wireless transceiver shall have a field settable network identifier that allows multiple networks to occupy the same channel for maximum scalability.

2.3 OPERATOR INTERFACE:

A. Workstation hardware (ECC):

1. Five personal computer operator workstations shall be provided for command entry, information management, system monitor, event management, and database management functions. All real-time control functions shall be resident in the Building Controllers to facilitate greater distribution, fault tolerance, and reliability of

the building automation control. Workstations will be installed in the following locations: Bldg. 5 Room G09, Bldg. 147 Control Room, Bldg. 14 Control Room, Bldg. 7 Room to be determined, and the designer’s station in Bldg. 5 G18a.

a. Provide workstation(s) of equal capability as located on plans.
b. Workstation shall consist of a personal computer with minimum 8 GB RAM, hard drive with 320 GB available space, video card with 5126 MB RAM capable of supporting a minimum of (3) monitors with minimum 1920 × 1080 resolution with a minimum of 32-bit color, DVD-RW Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows 7 64-bit or Windows 2008 R2 and shall include an Intel I7 or similar processor.
c. The PC monitors shall be of flat panel type and shall support a minimum display resolution of no less than 1920 × 1080 pixels. Each workstation shall have two displays with a minimum of 26-inch visible area in diagonal measurement. The displays for the main interface (Bldg 5 Room G09) and designer’s station (Bldg 5 Room G18a) shall have third monitor with a minimum of a 48-inch visible area in diagonal measurement. Separate controls shall be provided for color, contrasts, and brightness. The screen shall be non-reflective. The 48-inch monitors are intended to display system graphics while the 26-inch monitor shall display text. This should be easily reconfigurable by the operator.
d. Provide an Epson FX-870 or equivalent printer at each workstation location or on the network (Ethernet) for recording alarms, operator transactions.
e. Provide a color printer for printing of dynamic trend graph report, Excel reports, graphics, and any other screen displays.
f. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

B. Server hardware:
   1. The Server hardware shall be of equal or better capability as that of Workstation and shall be equipped as follows.
      a. Locate server as located on plans.

b. Provide a minimum 8 GB RAM, with two hard drives of 320 GB available space each, a video card with 256 MB RAM capable of supporting a minimum of 1920 × 1080 resolution with a minimum of 32 Bit color, DVD-RW, mouse and 101-key enhanced keyboard. Server shall be a Windows 2008R2 Server, and shall include a dual core processor or better.

c. Provide a monitor of flat panel type and shall support a minimum display resolution of no less than 1920 × 1080 pixels. The display shall have a minimum of 21-inch visible area in diagonal measurement. Separate controls shall be provided for color, contrasts, and brightness. The screen shall be non-reflective.

C. Operator Interface Software:

1. Basic Interface Description

a. Operator interface functions must be available in clients running in a browser, installed client console, or Windows desktop app.

b. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 256-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between Ethernet-connected building level networks.

c. The user interface shall display relevant information for a selection in multiple panes of a single window without the need for opening multiple overlapping windows on the desktop

d. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.

e. The navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded links to graphics, documents, drawings, trends, schedules, as well as external documents (.doc, .pdf, .xls, etc.) or web addresses that are related to any selected object.

f. Primary selection of objects in the operator interface software shall be available from user defined hierarchical Views, from graphics, or from events in an Event List.

g. Secondary selection of objects in the operator interface software shall be available from links to any objects or external documents related to the primary selection. Links to relate items shall be automatically defined based on where an object is used in the system.
h. The operator workstation shall be capable of displaying web pages and common document formats (.doc, .xls, .pdf) within the operator workstation application.
i. The Operator Workstation Software shall be capable of BACnet IP communications. The BACnet Advanced Workstation (B-AWS) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL B-AWS device classification through BTL listing as specified in ANSI/ASHRAE 135.
j. Control product shall support the following BACnet Interoperability Building Blocks to facilitate an open and interoperable system:
   1) [INSERT: BIBB-AWS Table.doc]
   2) BACnet Life Safety Points and BACnet Life Safety Zones
k. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software clients shall run on a Windows XP, Windows 7 or comparable 32/64-bit operating system. System database parameters shall be stored within an object-oriented database. Standard Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.
l. The software shall provide, as a minimum, the following functionality:
   1) Real-time graphical viewing and control of the BMS environment.
   2) Reporting of both real-time and historical information.
   3) Scheduling and override of building operations.
   4) Collection and analysis of historical data.

5) Point database editing, storage and downloading of controller databases.
6) Configuration of and navigation through default and personalized hierarchical “tree” views that include workstation and control system objects.
7) Event reporting, routing, messaging, and acknowledgment.
8) Definition and construction of dynamic color graphic displays.
9) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
10) On-screen access to User Documentation, via online help or PDF-format electronic file.
11) Automatic database backup at the operator interface for database changes initiated at Building Controllers.
12) Display dynamic trend data graphical plot.
    a) Must be able to run multiple plots simultaneously.
    b) Each plot must be capable of supporting 10 pts/plot minimum.
    c) Must be able to command points from selection on dynamic trend plots.
    d) Must be able to plot real-time data without prior configuration.
    e) Must be able to plot both real-time and historical trend data simultaneously.
13) Program editing.
14) Transfer trend data to third-party spreadsheet software
15) Scheduling reports
16) Operator Activity Log

m. Security
    1) Operator-specific password access protection shall be provided to allow the administrator/manager to limit users’ workstation control, display, and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password.
    2) Operator privileges shall "follow" the operator to any workstation logged onto.

3) The administrator or manager shall be able to further limit operator privileges based on which console an operator is logged on to.
4) The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application.

n. The operator interface software shall include reports to track the actions of each individual operator. The application shall allow querying based on object name, operator, action, or time range.

o. Dynamic Color Graphics application shall include the following:
1) Must include graphic editing and modifying capabilities.
2) All necessary tools and procedures for the user to create their own graphics
3) A library of standard control application graphics and symbols must be included.
4) Must be able to command points directly off graphics application.
5) Graphic display shall include the ability to depict real-time point values dynamically with text or animation.
6) Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure.
7) Graphics viewing shall include dynamic pan zoom capabilities.
8) Graphics viewing shall include the ability to switch between multiple layers with different information on each layer.
9) Graphics shall include a decluttering capability that allows layers to be programmatically hidden and displayed based on zoom level.
10) Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
11) Ability to create dashboard views that graphically display system and/ or energy performance. Dashboards will consist of gauges and charts.

p. Reports shall be generated on demand or via pre-defined schedule. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1) A general listing of all or selected points in the network
2) List of all points currently in alarm
3) List of all points currently in override status
4) List of all disabled points
5) System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
6) List of alarm strategy definitions
7) List of Building Control panels
8) Point totalization report
9) Point Trend data listings
10) Initial Values report
11) User activity report
12) Event history reports

q. Scheduling and override

1) Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation and in the Building Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:
   a) Fully support all BACnet Schedule, Calendar, and Command objects.
   b) Daily and Weekly schedules
   c) Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., Building 1 lights)
   d) Schedule predefined reports.
   e) Ability to schedule for a minimum of up to ten (10) years in advance.
2) Additionally, the scheduling application shall:
   a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule.
   b) Provide sorting capabilities of schedules, based on name, time, and type of schedule.

r. Collection and Analysis of Historical Data

1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data shall be collected and stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of equipment. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
2) System shall support trending in the same device as the monitor point or in an external device.
3) Panels shall have a trending level above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space).
4) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points.
5) Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of ten points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of ten (10) dynamic graphs shall run simultaneously. Operator shall be able to command points by selecting them on the trend plot. Operator shall be able to zoom in on a specific time range within a plot.

s. Dynamic Color Graphic Displays
1) Capability to create color graphic floor plan displays and system schematics for each piece of mechanical equipment,

including, but not limited to, air handling units, chilled water systems, hot water boiler systems, and room level terminal units.

2) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.
3) Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
   a) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Provide users the ability to depict various positions in relation to assigned point values or ranges. A library (set) of animated symbols shall be included within the operator interface software’s graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for animation speed.
   b) Ability to add custom gauges and charts to graphic pages.
   c) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
   d) State text for digital points can be user-defined.
4) Colors or other visual changes shall be available to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5) The Windows environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

6) All required software shall be provided to allow the user to add, modify, or delete system graphic background displays.
7) A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of at least100 graphic background templates shall be provided.
8) The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller’s control values and parameters, without the need to create separate and individual graphic files for each controller.
9) The Graphics application shall be capable of automatically assigning the appropriate symbol for an object (point) selected to be displayed on the graphic based on what the object represents (fan, duct sensor, damper, etc.)

t. System Configuration & Definition

1) The system shall be fully configurable from clients running in a browser, installed client console, or Windows desktop app.
2) Users must be able to build multiple, separate, personalized hierarchical “tree” views that represent the workstation, control systems, geographical facility layouts, and mechanical equipment relationships.
3) Network wide control strategies shall not be restricted to a single Building Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
4) Provide automatic backup and restore of all Building Controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Building Controller. Changes made at the user-interface of Building Controllers shall be

automatically uploaded to the workstation, ensuring system continuity.

5) System configuration, programming, editing, graphics generation shall be performed on-line from the operator workstation software.
6) User shall be able to edit point configuration online within a dedicated editor application. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database.
7) User shall be able to edit point configuration of any configurable BACnet point that resides in a devices that supports external editing.
8) The software shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the ability for editing the point database directly online with the Building Controllers.
9) The operator interface software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points.
10) Control program configuration shall be available to the user within a dedicated control program editor application. The editor shall allow for creation, modification, and deletion of control programs. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the Building Controllers. The editor shall provide the ability to selectively enable or disable the live program execution within the Building Controllers.
11) Users shall have the ability to view the program(s) that is\are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

u. Event Management
1) Event Routing shall allow the user to send event notification to selected printers or workstation location(s) based on event severity, or point type.
2) Event Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each event: name, value, event time and date,

event status, priority, acknowledgement information, and alarm count. Each event shall have the ability to sound an audible notification based on the category of the event.

3) Event List shall have the ability to list and sort the events based on event status, point name, ascending or descending activation time.
4) Directly from the Event List, the user shall have the ability to acknowledge, silence the event sound, print, or erase each event. The interface shall also have the option to inhibit the erasing of active acknowledged events, until they have returned to normal status. The user shall also have the ability to navigate to all information related to a selected point in order to command, launch an associated graphic or trended graphical plot, or run a report on a selected point directly from the Event List.
5) Each event shall have a direct link from the Event List to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each event.

D. Historical Data Historian

1. System must provide a means to gather, archive, and retrieve trend, alarm, and operator/system activity records. Archived information shall be available for the life of the system.
2. Historian may reside on the same physical server as the BMS software or on a separate computer. The data historian shall seamlessly integrate to the BMS software without the need for a third-party application.
3. Historian must have 5 simultaneous user licenses.
4. Users will use the same Login ID/Password combination as to log into the corporate network to access the software.
5. Historian shall have the ability to retrieve data from the BMS database for any available time period. A loss of communication between the historian and the BMS server will not result in data loss; the historian will have the ability to automatically collect data after the communications is restored.
6. System must allow archival to/from a corporate mass storage device.

7. Historian shall homogeneously combined historical data from multiple collection intervals for a given point (e.g., 15 minute and change of value trends shall be blended into a common view).
8. The system must provide statistical formula capability and trend analysis graphical tools. The following shall be supported:
   a. Mean Kinetic Temperature (MKT) calculation on an array of data values.
   b. Standard Deviation value determination of on an array of data values.
   c. Average value determination of on an array of data values.
   d. Minimum value determination of on an array of data values.
   e. Maximum value determination of on an array of data values.
   f. Sum of value an array of data values.
   g. Delta value determination of on an array of data values.
9. Capability to create formulas using the trend data of BMS points. The following formulas must be supported: +, -, *, /, ABS (Absolute Value), COS (Cosine), COT (Cotangent), EXP (Exponential value), LOG, LOG10, PI, Power, Round, SIN, SQRT, and TAN (Tangent).
10. Historian shall have the ability to calculate Mean Kinetic Temperature (MKT) using the calculation formula from the USP.
11. Historian shall have a reporting package capable of displaying the following charts: Bar, Scatter (single and dual Y), Histogram, and Pie.
12. System shall be able to perform exception reporting (e.g., show all values below or above a certain value).
13. System shall be able to perform advanced analysis of BMS alarms to include the following information:
   a. Number of alarms for a given period
   b. Detailed alarm information; initial alarm, alarm cleared, duration, and highest level achieved during alarm
   c. Statistical information: longest alarm duration, average duration, and total duration.
14. System shall be able to compare to ranges of values for a given point in a scatter chart (e.g., energy usage for this month and the same period last year).
15. System shall have the ability to report on green house gases based on energy consumption data.

16. Historian reporting package shall allow the user to create custom design reports that can be printed, scheduled to run at a future time, saved to file, and/or emailed.
17. Historian will have a schedule functionality that allows the user to schedule when reports run and where the output is directed (printer, file, or email).
18. Provide Web-based access to the reporting functionality. Web-based access will have the same capabilities as in the historian software.

E. Portable Operator’s Terminal (POT)

1. Provide Notebook style industry standard, commercially available portable operator terminals with a LCD display and a full-featured keyboard. The POT shall be handheld and plug directly into all Building Controllers as described below. Provide a user-friendly, English language-prompted interface for quick access to system information, and not codes requiring look-up charts.
2. Functionality of the portable operator's terminal connected at any Building Controller:
    a. Access all Building Controllers and Application Specific Controllers (ASCs) on the network.
    b. Back up and/or restore Building Controller databases for all system panels, not just the Building Controller connected to.
    c. Display all point, selected point and alarm point summaries.
    d. Display trending and totalization information.
    e. Add, modify, and/or delete any existing or new system point.
    f. Command, change, and enable/disable any system point.
    g. Program and load custom control sequences as well as standard energy management programs.
    h. Acknowledge alarms.
3. Functionality of the portable operator's terminal connected to any application specific controller:
    a. Provide connection capability at either the Field Level Network Controller or a related room sensor to access controller information.
    b. Provide status, setup and control reports.
    c. Modify, select, and store controller database.
    d. Command, change, and enable/disable any controller point.
4. Connection of a POT to a Building or ASC Controller shall not interrupt nor interfere with normal network operation in any way,

prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

5. Portable operator terminal access to controller shall be password-controlled. Password protection shall be configurable for each operator based on function, points (designating areas of the facility), and edit/view capability.

F. Web-based Operator Interface

1. Operator shall be able to access the field panel embedded Web server remotely using Microsoft® Internet Explorer, Mozilla Firefox, Safari, or any browser capable of running and displaying Adobe Flash Player Plug-in 10.1 or later.
2. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the Web access feature.

2.4 BUILDING CONTROLLER SOFTWARE

A. General:

1. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.
2. The software programs specified in this section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.
3. All points, panels, and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
4. All digital points shall have a user defined two-state status indication with 8 characters minimum (e.g., summer, Enabled, Disabled, and Abnormal).
5. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004.
6. Control product shall support all applicable BACnet Interoperability Building Blocks to facilitate an open and interoperable system:

7. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
8. The Building Controllers shall have the ability to perform the following pre tested control algorithms:
   a. Two position control
   b. Proportional control
   c. Proportional plus integral control
   d. Proportional, integral, plus derivative control
   e. Automatic tuning of control loops
   f. Model-free adaptive control
9. Each controller shall be provided with an interactive HELP function to assist operators using POTs and remote connected operators.
10. Building Controllers shall not be susceptible to Microsoft Windows operating systems based viruses.

B. Web-based Operator Interface:
1. The BAS shall provide a Field Panel embedded Web-based graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet (TCP/IP). The Field Panel embedded Web-based graphical interface shall use HTML-based pages to send and receive data directly from a network of BAS Field Panels to a Web browser.
2. The Web server shall allow monitor and control to any field panels networked together on the same automation level TCP/IP Ethernet network.
   a. The Web server must provide a common alarm display that shows alarms in all field panels on the network.
   b. The Web Server must provide a common display that shows all Out of Service, Faults, and device failures for all field panels on the network.
   c. The Web server must be able to provide common graphics that simultaneously display the current value and status for points residing in multiple field panels.

d. The Web server must be able to display daily schedules for points from multiple field panels simultaneously.
e. User shall have the ability to add and modify graphics remotely. Any special tools will be provided.
f. Users must have the ability to edit the system database remotely. The Web enabled configuration access includes all; physical and virtual I/O points, trend objects, event enrollment objects, schedules objects, and custom programming.
g. System must provide automated backup of the controller database and any associated graphics. The web server will automatically recover from a power outage without operator interaction.
h. The Web server allows system-wide access through a single log-in. Web pages are populated with data from any BACnet IP-enabled Field Panels and associated supervised devices.
i. The Web server runs on standard IP based Field Panel hardware, eliminating the need for separate high-cost “web appliances” or dedicated web servers. Field panels with embedded Web server provides full building automation and I/O features, and provides the user with system information and access via a web browser.
j. The use of web services for communication ensures that any web browser with Adobe® Flash® is able to access the Field Panel Web server graphics.

3. The Web server shall support browser access via Microsoft® Internet Explorer, Mozilla Firefox, Safari, or any browser capable of running and displaying Adobe Flash 10.1 or later.
4. Access to the Web interface shall be username and password protected. A user’s rights and privileges to database objects within the BAS shall be configurable on a per-user basis. An option shall exist to only allow users “read” access to BAS objects via the Web browser. Operator sessions shall be configurable for “auto-logoff” after a designated period of user inactivity.
5. The embedded Web server shall support an unlimited number of simultaneous users.
6. The embedded Web server shall be compatible with and allow coexistence within standard IT security policies and tools (e.g., Firewall protection).
7. The embedded Web server shall provide the following functionality to users via Web browser, based on their access and privilege rights:

a. Logon Screen – allows the user to enter his user name and password for logging into the Web server.
b. Alarm Display – displays current BAS alarms to which the user has access. Users will be able to acknowledge active alarms, and directly link to the Point Commanding feature.
   1) The alarm display must display all alarms whether acknowledged or not.
   2) The alarm display must display only alarms that have not yet been acknowledged.
   3) The alarm display must provide a persistent indication whenever there is one or more unacknowledged alarm in any connected field panel.
c. Graphic Display – Display of system graphics shall be available for viewing over the Web browser. A graphic selector list will allow users to select any graphics to which they have access. Graphic displays will automatically refresh with the latest change of values. Users will have the ability to command and override points directly from the graphic display as determined by their user accounts rights. The Graphic Display shall allow an unlimited number of graphics.
   1) Graphics will support live animations.
   2) Graphics will support links to other graphics, system schedules, historical trends, and web sites.
   3) Graphics will display real-time point values and status.
d. Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
e. Network Layout – The web server will provide a logical network view of the system. Network layout features:
   1) View IP and BACnet MS/TP devices in logical layout
   2) Allow wild card searching for individual points.
f. Point Commanding – users will be able to override and command points via the Web browser interface. Users will be able to place points Out of Service. Users will be able to command BACnet MS/TP points directly.

g. Scheduling – allows operators, depending on their current user privileges, to override schedules selected by date, and to modify the properties of a selected schedule.
   1) The scheduler display must be able to represent facility schedules in a graphical format.
   2) Schedules are viewable in daily, work week, weekly or monthly formats.
h. Point Status Report – allows users to run and print a point log report through a web interface client that shows the point name, descriptor, command priority, alarm status, and current value. The report shall allow selection of individual points or wildcard search and selection of points. Report will support the following filters: In-Alarm, Fault, Out of Service, Overridden, and Unacknowledged Alarms.
i. Graphical Trend Display - Allow the user to view one or more trends on a single graphical display.
   1) Users will be able to drag points onto the trend display.
   2) User will have the ability to delete points and bring points to focus on the display.
   3) The ability to switch between the graphical view and raw data values.
   4) Ability to print the trend graph to network printers and export the raw data values to .CSV.
j. Online Database Editing Features
   1) Ability to add/delete/modify points, trend definitions, Event Enrollment Objects, and Notification Class Objects.
   2) Add/ Modify/ Delete schedules, Command Objects, Calendar Objects
   3) Add/ Modify/ Delete custom programs
   4) Add/ Modify/ Delete FLN Devices and database
   5) Add/ Modify/ Delete User accounts, including individual access levels
k. Ability to set network time from the web browser
l. Graphics Creation and Editing features
   1) Graphics configuration tool that allows remote\offline creation, modification, and deletion of graphics. Any tools required must be provided.
   2) Library of predefined graphic backgrounds

3) Ability to import standard image formats (.png,.jpg, and, .gif)

m. Auto backup and restore feature for the panel database, configuration, custom control programs, and the system graphics. User modifications to the system must be automatically tracked and the backup must be updated automatically.

n. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the Web access feature.

C. System Security

1. User access shall be secured using individual security passwords and user names.
2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust, and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
4. User Log On/Log Off attempts shall be recorded.
5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

D. User Defined Control Applications:

1. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
2. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
3. Any process shall be able to issue commands to points in any and all other controllers in the system.

4. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
5. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
6. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

E. Alarm Management:

1. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic, and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device, or communications with other panels on the network.
2. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
3. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
4. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
5. Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
6. All alarm or point change reports shall include the point's user-defined language description and the time and date of occurrence.
7. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.
8. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200-character alarm

message to more fully describe the alarm condition or direct operator response.

9. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.
   a. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

F. Scheduling:
   1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
   2. Schedules shall reside in the building controller and shall not rely on external processing or network.
   3. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
   4. The operator shall be able to define the following information:
      a. Time, day
      b. Commands such as on, off, auto, etc.
      c. Time delays between successive commands.
   5. There shall be provisions for manual overriding of each schedule by an authorized operator.
   6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
      a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, and stop.
      b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

G. Peak Demand Limiting (PDL):
   1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
   2. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand

meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.

3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

H. Temperature-compensated duty cycling.
   1. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
   2. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

I. Automatic Daylight Savings Time Switchover. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

J. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

K. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint and the outside air enthalpy is less than the return air enthalpy the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

L. Loop Control. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be user-selectable.

M. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

N. Staggered Start:
   1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order, in which

equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.

2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

O. Totalization:

1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
2. Consumption totalization. Building Controllers shall automatically sample, calculate, and store consumption totals on a daily, weekly, or monthly basis for all analog and digital pulse input type points.
3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

P. Data Collection:

1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.
5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
6. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the

trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

7. Loop Tuning. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a <monthly, seasonal, quarterly, annual> period.
8. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
9. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
   a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains, and input these values into the selected LOOP statement.
   b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

2.5 Building Controllers (BC)

A. Building Controllers shall be 32-bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.
B. Each Building Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.

C. Provide Universal I/O capability, including software configurable universal inputs and universal outputs.

D. Shall support a minimum of one directly connected Secondary Network.

E. Building Controller shall have an integral real-time clock.

F. Each Building Controller shall support firmware upgrades without the need to change hardware.

G. Each Building Controller shall support:

1. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.
2. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

H. Spare Point Capacity. Each Building Controller shall have a minimum of 10 percent spare point capacity.

1. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.
2. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
   a. Expansion modules
   b. Sensor/actuator
   c. Field wiring/tubing

I. Serial Communication. Building Controllers shall provide at least one EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals. A USB port shall alternatively be available to support local HMI tools connection.

J. Printer support. A USB port shall be available to support printers for printed alarm record keeping.

K. Manual Override. The operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, integral hand/off/auto operator override switches for all digital control type points, and gradual switches for all analog control type points. These override switches shall be operable whether the panel processor is operational or not.

Each Building Controller shall monitor and alarm the hand, off and auto positions of integral HOA switches.

L. I/O Status and Indication. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.

M. Shall provide I/O modules with LCD’s capable of displaying information faults including but not limited to open circuit, short circuit, unreliable input signal, signal under range, and signal over range via informative symbols.

N. Self Diagnostics. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

O. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

P. Environment.
   1. Controller hardware shall be suitable for the anticipated ambient conditions.
   2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
   3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

Q. Immunity to power and noise.
   1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
   2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
   b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
   c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
   d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
4. Isolation shall be provided at all Building Controller’s AC input terminals to suppress induced voltage transients consistent with:
   a. IEEE Standard 587 1980
   b. UL 864 Supply Line Transients
   c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

R. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display.

2.6 Advanced Application Controller Software

A. General:
1. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.
2. The software programs specified in this section shall be provided as an integral part of Advanced Application Controllers and shall not be dependent upon any higher level computer or another controller for execution.
3. The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004.
4. Control product shall support all applicable BACnet Interoperability Building Blocks to facilitate an open and interoperable system:
5. Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to scheduling,

calendar-based scheduling, holiday scheduling, temporary schedule overrides, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

6. The Advanced Application Controllers shall have the ability to perform the following pre tested control algorithms:
   a. Two position control
   b. Proportional control
   c. Proportional plus integral control
   d. Proportional, integral, plus derivative control
   e. Automatic tuning of control loops
   f. Model-free adaptive control

B. System Security
   1. User access shall be secured using individual security passwords and user names.
   2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
   3. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
   4. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

C. User Defined Control Applications:
   1. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
   2. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
   3. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

2.7 Advanced Application Controllers (AAC)

A. Advanced Application Controllers shall be 32-bit, multi-tasking, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

B. Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.

1. Provide Universal I/O capability, including software configurable universal inputs and universal outputs
2. Advanced Application Controller shall have an integral real-time clock.
3. Each Advanced Application Controller shall support firmware upgrades without the need to change hardware.
4. Each Advanced Application Controller shall support:
   a. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the controller cabinet.
   b. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the controller cabinet.
5. Spare Point Capacity. Each Advanced Application Controller shall have a minimum of 10 percent spare point capacity.
   a. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.
   b. Provide all processors, power supplies, so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
      1) Sensor/actuator
      2) Field wiring/tubing
6. Serial Communication. Advanced Application Controllers shall provide at least one EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Advanced Application Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently

connected printers or terminals. A USB port shall alternatively be available to support local HMI tools connection.

7. Printer support. A USB port shall be available to support printers for printed alarm record keeping.

C. Manual Override. The operator shall have the ability to manually override automatic or centrally executed commands at the controller via local, point discrete, integral hand/off/auto operator override switches for all digital control type points, and gradual switches for all analog control type points. These override switches shall be operable whether the panel processor is operational or not. Each controller shall monitor and alarm the hand, off and auto positions of integral HOA switches.

D. I/O Status and Indication. Advanced Application Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output.

E. Self Diagnostics. Each Advanced Application Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

F. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

G. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

H. Immunity to power and noise.
   1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
   2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
   3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
      a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
      b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
      c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
      d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
   4. Isolation shall be provided at all Advanced Application Controller's AC input terminals to suppress induced voltage transients consistent with:
      a. IEEE Standard 587 1980
      b. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

I. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display.

2.8 Application Specific Controllers (ASC)

A. General:
   1. Provide for control of each piece of equipment, including, but not limited to the following:
      a. Variable Air Volume (VAV) boxes
      b. Constant Air Volume (CAV) boxes
      c. Dual Duct
      d. Reheat Coils (RH)
      e. Fan Coil Units (FCU)
      f. Fan Powered Boxes (FPB)
      g. Unit Conditioners
      h. Heat Pumps
      i. Unit Ventilators

   j. Room Pressurization
   k. Supplemental AC units
   l. Digital Energy Monitors
2. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.
3. The use of Secondary Network controllers with custom program applications to control AHU’s, water systems, etc. is not acceptable.
4. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall provide standard applications and programmability to provide both reliability and flexibility. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
5. The Application Specific Controller Software shall be capable of BACnet communications. The BACnet Application Specific Controller (B-ASC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004.
6. Control product shall support all applicable BACnet Interoperability Building Blocks to facilitate an open and interoperable system.
7. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control output signals shall not be acceptable. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.
8. Space Temperature Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
   a. The space temperature sensor shall be available in wired versions.

b. Wired temperature sensor specifications. The sensing element for the space temperature sensor must be IC-based and provide the following:
   1) Digitally communicating with the Application Specific Controller.
   2) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
   3) IC Element Accuracy: +/- 0.9°F
   4) Operating Range: 55 to 95°F
   5) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
   6) NO Display of temperature setpoint with numerical temperature values.
   7) Calibration: Single point, field adjustable at the space sensor to +/- 5°F
   8) Installation: Up to 100 ft. from controller
   9) Auxiliary Communications Port: included
   10) Local OLED Temperature Display: included
   11) Display of Temperature to one decimal place
   12) Temperature Setpoint Adjustment included
   13) Occupancy Override Function included with adjustable time

c. Setpoint Modes:
   1) Independent Heating, Cooling
   2) Night Setback-Heating
   3) Night Setback-Cooling

d. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.

e. LCD Display. Interactive, two-line liquid crystal display shall allow the operator to query and modify operating parameters of the local room terminal unit from the room sensor. The display shall indicate the space temperature and associated ASC point when not being used to query or modify operating parameters.

f. Setpoint Adjustment Dial. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

g. Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable). The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

9. Space Combination Temperature and Humidity Sensors. Each controller performing space humidity control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

10. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

11. Control Algorithms. The controller shall receive its real-time data from the Building Controller time clock to ensure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator’s terminal as

specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

12. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.
13. Programmability. Application Specific Controllers shall be programmable, using software provided by the BMS manufacturer. Software shall be field-installable on any standard laptop or Portable Operator’s Terminal. Program language shall be text-based and allow up to 200 lines of code for programming. Programming shall allow for changing sequence of operation, commanding and releasing points, additional monitoring, and command priority management within the Application Specific Controller.
14. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and ensuring against drift over time.
    a. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.
    b. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.
    c. Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.
15. Memory.
    a. Provide each ASC with sufficient memory to accommodate point databases, operating programs, programming capability, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM, and PROM, or minimum of 72-

hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

b. Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation.

16. Power Supply. The ASCs shall be powered from a 24 Vac source and shall function normally under an operating range of 18 to 28 Vac, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 Vac power to the terminal units by utilizing:
    a. The existing line voltage power trunk and installing separate isolation transformers for each controller.
    b. Dedicated line voltage power source and isolation transformers at a central location and installing 24 Vac power trunk to supply multiple ASCs in the area.
17. Environment. The controllers shall function normally under ambient conditions of 32 to 122°F (0 to 50°C) and 10% to 95% rh (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.
18. Immunity to noise. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
19. Manufacturer Installed Controls.
    a. BMS manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.
    b. Cost of factory mounting shall be borne by equipment manufacturer.
    c. For VAV terminals, equipment manufacturer shall provide and install flow-cross sensor, 24 Vac transformer, controls enclosure, fan relay, SCR and factory install, wire and tube ASC controller and actuator.
    d. Fan powered VAV terminals shall be equipped with a fan speed controller and relay to change summer and winter speed setpoint.

B. Controllers for VAV terminals.
    1. All VAV terminal control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of

control. In addition to the field selectable applications, additional programming flexibility to meet sequences of control is required in all ASCs. ASCs that require factory application changes are not acceptable. The VAV terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:

a. VAV cooling only

b. VAV with hot water or electric reheat

c. Fan-powered VAV

d. Fan-powered VAV with hot water or electric reheat

2. VAV applications shall be able to monitor relative space humidity and CO_2.

3. The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual airflow. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of +5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary airflow conditions shall be controlled and maintained to within +5% of setpoint at the specified parameters. The BMS contractor shall provide the velocity sensor if required to meet the specified functionality.

C. Controllers for CV terminals.

1. Constant volume ASCs shall meet all requirements of paragraphs as previously specified for VAV terminals. The controllers shall have a minimum and maximum flow setpoint, which shall be selected based on interior ventilation requirements. Under normal conditions, the setpoint shall be set to minimum setpoint. When the floor area requires additional ventilation (high CO_2 level, manual command, etc.) the setpoint shall be set to maximum setpoint.

2. Constant volume applications shall be able to monitor relative space humidity and CO_2.

D. Controllers for Dual Duct terminals.

1. All Dual Duct terminal control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. In addition to the field selectable applications, additional programming flexibility to meet sequences

of control is required in all ASCs. ASCs that require factory application changes are not acceptable. The Dual Duct terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:

a. Constant Volume – Hot Duct and Cold Duct Air Velocity Sensors
b. Constant Volume – Cold Duct and Outlet Air Velocity Sensors
c. Variable Air Volume – Hot Duct and Cold Duct Air Velocity Sensors
d. Variable Air Volume – Cold Duct and Outlet Air Velocity Sensors

2. Dual Duct applications shall be able to monitor relative space humidity and CO2.

E. Controllers for Fan Coil Unit terminals.

1. All Fan Coil Unit terminal control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. In addition to the field selectable applications, additional programming flexibility to meet sequences of control is required in all ASCs. ASCs that require factory application changes are not acceptable. The Fan Coil Unit terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:

a. Cooling and/or Heating
b. Two-stage Cooling and Electric/Hot Water Heat

2. Fan Coil Unit applications shall be able to monitor relative space humidity and CO2.

F. Controllers for Fan Powered Boxes (FPB) terminals.

1. FPB ASCs shall monitor the primary air and return airflows with separate flow sensors and sum the flows to read total airflow.
2. The ASC shall have the capability to control the speed of the fan speed through the BMS system.
3. VAV applications shall be able to monitor relative space humidity and CO2.
4. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up to three (3) stages of electric reheat via an SCR to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the

respective Building Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

G. Controllers for Unit Conditioner terminals.
   1. All Unit Conditioner terminal control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. In addition to the field selectable applications, additional programming flexibility to meet sequences of control is required in all ASCs. ASCs that require factory application changes are not acceptable. The Unit Conditioner terminal ASC shall support the following types of pressure dependent terminal boxes as a minimum:
      a. Cooling or Heating
      b. Hot Water Heat
   2. Unit Conditioner applications shall be able to monitor relative space humidity and CO2.
H. Controllers for Heat Pump terminals.
   1. All Heat Pump terminal control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. In addition to the field selectable applications, additional programming flexibility to meet sequences of control is required in all ASCs. ASCs that require factory application changes are not acceptable. The Heat Pump terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:
      a. Single-stage heat pump control
      b. Multiple-stage compressor with reversing valve and mixed air
      c. Heating and cooling compressors and mixed air
   2. Heat Pump applications shall be able to monitor relative space humidity and CO2.
I. Controllers for Unit Ventilator terminals.
   1. All Unit Ventilator terminal control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. In addition to the field selectable

applications, additional programming flexibility to meet sequences of control is required in all ASCs. ASCs that require factory application changes are not acceptable. The Unit Ventilator terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:

a. ASHRAE Cycle I, II, or III

b. Nesbitt Cycle W

c. Heating via hot water, steam or electric

d. Cooling via chilled water or DX coils

2. Unit Ventilator applications shall be able to monitor relative space humidity and CO2.

J. Controllers for Supplemental AC Units.

1. Supplemental AC unit ASCs shall meet all requirements of paragraphs as previously specified for VAV terminal ASCs except for velocity/cfm control.

K. Digital Energy Monitors:

1. Provide three phase digital Watt-meters with pre-wired current transmitters (CT). All Watt-meter electronics shall be housed within the CTs. CTs shall include sizes capable of mounting directly on a power bus. Diagnostics visible to the installing electrician (without an operator tool) shall indicate: proper operation, defective wiring or low power-factor, device malfunction, and over-load condition. The meters shall include the following:

a. The device shall be UL Listed, and shall comply with ANSI C12.1 accuracy specification. The minimum CT/meter combined accuracy shall be no greater than 1% of reading over the range of 5% to 100% of rated load. The meter shall not require calibration.

b. The Watt-meter shall directly connect to power from 208 through 480 with no potential transformer. In-line fuses for each voltage tap phase shall be included.

c. The Watt-meter CTs shall be split-core and at minimum be sized to accommodate loads ranging from 100 to 2400 Amps. The CTs shall be volt-signal type, and shall not require shorting blocks.

d. The Watt-meter shall reside directly on the Secondary Network along with other Secondary Network devices. Data transferred shall include:

1) kW and kWh

2) Consumption

3) Demand
4) Power Factor
5) Current
6) Voltage
7) Apparent Power
8) Reactive Power

2.9 Input/Output Interface:

A. Hardwired inputs and outputs may tie into the system through building or application specific controllers.

B. Modular, “hot-swappable” I/O so that the electronics of a small portion of the I/O can be replaced without effecting the power or communication for the other points.

C. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

D. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

E. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

F. Analog inputs shall allow the monitoring of low-voltage (0 to 10 Vdc), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to—commonly available sensing devices.

G. 24 Vdc shall be available next to the point signal for powering the output device.

H. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

I. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 Vdc, or 4 to 20 mA signals as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

J. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

K. Point name labels. It shall be possible to print customized name labels for each I/O point and install on an existing holder on the I/O device.

L. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.10 Power Supplies and Line Filtering

A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.

C. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

D. Line voltage units shall be UL recognized and CSA approved.

E. Power line filtering.

1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
   a. Dielectric strength of 1000 volts minimum,
   b. Response time of 10 nanoseconds or less,
   c. Transverse mode noise attenuation of 65 dB or greater,
   d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.11 Auxiliary Control Devices

A. General

1. Specified in this section are the following hard wired input/output devices connected to the Building Controller or ASC:
   a. Automatic Dampers
   b. Fire/Smoke Dampers
   c. Electric Damper Actuators
   d. Motorized Isolation Valves
   e. Ball Valves
   f. Automatic Control Valves
   g. Air Velocity Sensors
   h. Airflow Measuring Stations
   i. Binary Temperature Devices
   j. Temperature Sensors
   k. Dew Point/Humidity Sensors
   l. Pressure Sensors
   m. Water Differential Pressure Sensors
   n. Differential Pressure Switches
   o. Analog Water Level Sensors
   p. Water Leak Detection Systems
   q. Audio/Visual Alarm Units
   r. Fuel Oil Meters
   s. Water BTU Meters
   t. Vortex Shedding Flow Meters
   u. Water Flow Switches
   v. Indoor Air Quality (CO2/VOC/TEMP/RH) Space Sensors
   w. Solar Impact Sensor]
   x. Relays
   y. Override Timers
   z. Current Transformers

aa. Voltage Transmitters

bb. Voltage Transformers

cc. Power Monitors

dd. Current Switches

ee. Pressure Electric Switches

ff. Local Control Panels

gg. Local User Display

2. Specified in this section are the following devices connected to the BMS using serial communication.
   a. Water BTU Meters
   b. Variable Frequency Drives (VFD)
   c. Indoor Air Quality (CO2/VOC) Space Sensors
   d. Power Monitors

B. Automatic Dampers

1. Dampers shall have 13 gauge galvanized frames of not less than 3 inches wide and blades of 14 gauge, equivalent thickness, galvanized steel roll formed airfoil type for low pressure drop and low noise generation and shall be adequately braced to from a rigid assembly where required in galvanized duct work. Dampers shall have blades not more than 8 inches wide. Linkage and hardware shall be zinc plated steel and shall be concealed out of airstream within the damper frame. Damper blades and rods shall be installed in horizontal position.
2. In copper, aluminum, and stainless steel ductwork, damper material shall match the ductwork material.
3. All dampers shall be of the proportioning or opposed blade type, and shall be motor operated. Dampers shall have continuous elastomer or stainless steel stops to avoid leakage. Bearings shall be corrosion resistant oil tight stainless steel sleeve type. All dampers shall be provided with continuous 3/16" x 1/2" closed cell neoprene gasket around perimeter of the frame and at interlocking blade edges to form an air tight seal. Blade seals shall be suitable for -76°F to 350°F mechanically locked into blade edge. Adhesive of clip on type are not acceptable. Axles shall be square or hexagonal positively locked into damper blade. Linkage shall be concealed out of airstream within the damper blade.
4. All dampers shall be constructed to provide a maximum leakage of 3-1/2%, with an approach velocity of 1500 fpm when closed against a

pressure of 4 inches of water. Submit leakage and flow characteristic data for all dampers.

5. All outside air dampers, with the exception of the emergency generator dampers, shall automatically close in the event of a loss of power. Dampers on emergency generators shall automatically open on a loss of power.
6. All smoke dampers shall be constructed in accordance with UL Standard 555S.
7. Dampers shall be Greenheck, Imperial Model 800 or approved equal.

C. Fire/Smoke Dampers

1. Dampers shown on drawings designated as “F/SM” shall comply with the following. They shall have a U.L. label. Dampers shall be electronically operated combination fire and smoke Greenheck Imperial or approved equal, provided with factory installed U.L. rated full sleeves. Provide air foil or “V” blade damper blades supported with shafts and stainless steel bearings to allow daily operation. Provide intermediate supports and bearings for damper blades more than 36” long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems when closed shall be the equivalent of a 1-1/2 hour fire damper. Leakage shall conform to Class 2 with maximum leakage of 10 cfm/Sq. Ft. at 1” W.G. Damper actuators shall be provided with position indicator switches to enable remote status of open or closed positions (only those dampers designated in the electrical trade plans and specifications will be provided with position switches and will be wired for remote status and remote open/closed operation, but all dampers will be provided with position indicators for possible future use). Note that dampers which are controlled from a central fire command station shall be provided with a 212°F heat sensor with normally closed contacts (manual reset) to close and lock damper if open. Additionally, dampers shall be factory equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F to 350°F, depending on the actuator utilized). The second sensor is wired through a manual override switch on the central fire command station. Dampers which are not controlled from a central fire command station shall have a fusible link which melts on heat causing damper to close and lock in a closed position. The following will be accepted in lieu of the two

firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150°F or less.

2. Dampers shown on drawings designated “SM” shall comply in all respects to F/S damper description including position indicating switches except they shall not be provided with a heat sensor or fusible link.

D. Electric Damper Actuators
   1. General
      a. All actuators shall be manufactured; brand labeled, or distributed by BMS contractor.
      b. All damper actuators having more then 100 lb-in torque output shall have a self-centering damper shaft clamp. V-bolt type damper shaft clamp is not acceptable.
      c. The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.
      d. Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing. Alternatively, an uninterruptible power supply (UPS) may be provided. On terminal unit valves actuators and 2-second timing damper actuators capacitor driven fail action is permitted.
      e. Modulating actuator shall accept a 0-10 Vdc control signal and provide a 0-10 Vdc operating range.
      f. All 24 Vac/Vdc actuators shall operate on Class 2 wiring.
      g. All actuators over 20 lb-in torque capacity shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered and spring-return actuators shall have a manual crank for this purpose.
      h. Upon start up and after power loss, the actuator must immediately respond to control signals. Actuators requiring calibration to determine end stops are not acceptable.
      i. Electric actuators for emergency generator damper control shall be rated for 350°F maximum operating temperature and capable to drive fully open and close within 15 seconds.

j. All actuators that provide a factory mounted electrical appliance or plenum rated cabling must be marked with numbers on the wires as well as color coded.
k. Provide built-in dual end switches as required for the sequence of operation.
l. Control damper actuators shall be RoHS Part A complaint.

E. Motorized Isolation Valves
1. Butterfly Valves.
a. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein. All butterfly valves shall have body ratings in accordance with the piping specifications. Valves shall be high performance, fully lugged with carbon steel body ANSI 150/300. Valves shall be rated for bubble tight dead end closure, with 316 stainless steel disc, stainless steel shaft and reinforced Teflon® seat and seals.
b. Motorized valves located outdoors or in areas subject to outdoor air conditions provide fail in place, electric operators with water proof enclosure, crankcase heater, and open and closed position limit switches. Valve and all accessories shall be constructed for outdoor use. All electrical devices shall be weather proof and NEMA 4 rated.
c. All valves shall be provided with external position indicators and a speed control device to prevent to rapid closure.
d. All valves shall be provided with manual override hand wheels for operating the valve.
e. The valves shall be line size as shown on plans.
f. Motorized isolation valves shall be Jamesbury 815/830L, Fisher, DeZurik Model HP II, Tyco/Siemens or Bray.

F. Ball Valves
1. Furnish automatic full port ball valves for isolation requirements on line sizes up to 2 inches as shown on the drawings or required herein. All ball valves shall have ANSI 250 body rating. Valves shall bronze body and stainless steel trim.
2. Valves shall close against a differential pressure equal to the design pump head pressure plus 10%.
3. The valves shall fail to their safe position upon power loss as specified in the sequence of operation.
4. All valves shall be provided with manual override.

5. Provide valve position indicator end switches with the actuator.
6. The valves shall be line size as shown on plans.
7. Motorized isolation valves shall be Neptronic, Dezurik, or Siemens Industry, Inc.

G. Automatic Control Valves

1. General:
   a. Control valves shall be two-way or three-way type single seated globe type for two-position or modulating service as shown. Valves shall meet ANSI Class IV leakage rating.
   b. Body pressure rating and connection type construction shall conform to pipe, fitting, and valve schedules. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided.
   c. Valve actuators shall be of electric type.
   d. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of power failure.
   e. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
   f. Furnish differential pressure control valves for all water systems as shown on plans and/or specified in the sequence of operations.
   g. Provide valves 2 inches and smaller with screwed end bronze bodies and stainless steel trim. Provide valves 2-1/2 inches and larger with flanged ends, cast iron body and stainless steel trim.
   h. For modulating service that require large valve size (above 6 inches), such as cooling tower temperature bypass, chiller head pressure ,etc. where proper control with globe type control valve cannot be achieved or the application is not economical butterfly or v-port ball valves are allowed.
2. Water Valves:
   a. Control valves shall be of equal percentage flow characteristics for modulating service.
   b. Sizing Criteria:

1) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through the coil, 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
2) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil, 5 psi maximum.
3) Differential pressure service: 70% of design flow and 50% of pump head.
4) Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
   a) Heating coils in air handlers: normally open.
   b) Chilled water control valves: normally closed.
   c) Differential pressure valves: normally open.
   d) Terminal units: normally closed.
   e) Other applications: as required by sequences of operation.

3. Steam Valves:
   a. Control valves shall be of linear flow characteristics for modulating service.
   b. Sizing Criteria:
      1) 15 psig or less; pressure drop 80% of inlet psig.
      2) 16 to 50 psig; pressure drop 50% of inlet psig.
      3) Over 50 psig; pressure drop as scheduled on plans.
      4) Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:
         a) Heating coils in air handlers: normally open.
         b) Steam to hot water heat exchanger: normally closed.
         c) Other applications: as required by sequences of operation.

4. Valve Specification for Distribution Valves
   a. Flanged Valves, line size 2 ½” to 6”
      1) Controlled Media Specific Items
         a) Steam control valve shall be suitable for saturated steam to a maximum temperature of 337°F (170°C) and a maximum pressure of 100 psig (690 kPa). A Linear flow characteristic and stainless steel trim is recommended.

b) Water control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

c) Glycol Solutions control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 20°F (-7°C) and hot glycol/water solutions to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

2) General Construction Materials/Applicable

a) Standards Pressure Class 125 control valve bodies shall be constructed of gray cast iron according to ASTM A126B, and shall meet requirements of ANSI B16.1, pressure class ANSI 125.

b) Pressure Class 250 control valve bodies shall be constructed of gray cast iron according to ASTM A126B, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.

c) For Class 125 and Class 250 valve assemblies, flange dimensions shall be according to ANSI B16.1, and valve body flange-to-flange dimensions shall be according to ANSI/ISA S75.03.

d) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

e) The control valve shall have a linear flow characteristic, according to ANSI/ISA S75.11.

f) The control valve shall have a modified equal percentage flow characteristic.

g) The control valve shall have a minimum rangeability of 100:1.

h) Valve shall meet the requirements of seat leakage Class IV (0.01%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.
i) Chilled and Hot water valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings.
j) Steam valve stem packing shall be of a spring-loaded cartridge type and shall contain at least seven Teflon v-rings and one EPDM o-ring
k) Control valve seat shall be made of stainless steel according to UNS S30300 or ASTM A582 Type 303, and plug shall be made of bronze according to UNS C84400.
l) Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.
m) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

3) Service Parts
a) Chilled and Hot water valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings. The cartridge type packing shall be replaceable as a unit.
b) Steam valve stem packing shall be of a spring-loaded cartridge type and shall contain at least three Teflon v-rings and one EPDM o-ring.

c) The control plug and stem shall be replaceable as a unit.

b. Threaded Valves, line size ½” to 2”
1) Controlled Media Specific Items
a) The control valve shall be suitable for saturated steam to a maximum temperature of 337°F (170°C) and a maximum pressure of 100 psig (690 kPa). A Linear flow characteristic and stainless steel trim is recommended.
b) The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

c) The control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 20°F (-7°C) and hot glycol/water solutions to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of cast bronze according to UNS C84400 or forged brass according to UNS C37700, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.

b) Threaded connection specifications shall be according to ANSI B2.1.

c) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

d) The control valve shall have a linear flow characteristic, according to ANSI/ISA S75.11.

e) The control valve shall have a modified equal percentage flow characteristic.

f) The control valve shall have a minimum rangeability of 100:1.

g) Valve shall meet the requirements of seat leakage Class IV (0.01%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

h) Valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings.

i) Valve stem packing shall be of a spring-loaded cartridge type and shall contain at least three Teflon v-rings and one EPDM o-ring.

j) Control valve seat shall be made of bronze according to UNS C84400 or stainless steel according to UNS S30300 or ASTM A582 Type 303, and plug shall be made of bronze according to UNS C84400 and/or brass according to UNS C36000 or C37700.

k) Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.

l) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

3) Service Parts

a) Chilled and Hot water valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings. The cartridge type packing shall be replaceable as a unit.

b) Steam valve stem packing shall be of a spring-loaded cartridge type and shall contain at least three Teflon v-rings and one EPDM o-ring.

c) The control plug and stem shall be replaceable as a unit.

5. Valve Specification for Terminal Unit Valve

a. Threaded Valves, line size ½” to 1”

1) Controlled Media Specific Items

a) The control valve shall be suitable for saturated steam to a maximum temperature of 250°F (120°C) and a maximum pressure of 15 psig (103.5 kPa). A linear flow characteristic and stainless steel trim is recommended.

b) The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

c) The control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 32°F (0°C) and hot glycol/water solutions to a maximum temperature of 250°F (120°C). Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of cast bronze according to UNS C84400 or forged brass according to UNS C37700, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.

b) Threaded connection specifications shall be according to ANSI B2.1.

c) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

d) The control valve shall have a modified equal percentage flow characteristic, according to ANSI/ISA S75.11.

e) The control valve shall have a minimum rangeability of 100:1 on valves with a Cv value greater than or equal to 1.0 and a minimum rangeability of 50:1 on valves with a Cv value less than 1.0.

f) Valve shall meet the requirements of seat leakage Class IV (0.01%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

g) Chilled water, Hot water, and Steam valve stem packing shall contain at least two EPDM o-rings.

h) Control valve seat shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303 and plug shall be made of bronze according to UNS C84400 and/or brass according UNS C36000 or C37700.

i) Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.

j) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A

6. Valve Specification for Zone Valves

a. Threaded or Sweat Connection Valves, line size ½” to 1”

1) Controlled Media Specific Items

a) The control valve shall be suitable for chilled water to a minimum of 34°F (1°C) and hot water to a maximum temperature of 230°F (110°C).

b) The control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 34°F (1°C) and hot glycol/water solutions to a maximum temperature of 230°F (110°C).

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of forged brass and shall meet requirements of ANSI B16.1, pressure class ANSI 125.

b) Threaded connection specifications shall be according to ANSI B2.1.

c) Sweat connection specifications shall be according to ANSI B16.22.

d) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

e) The control valve shall have a linear flow characteristic, according to ANSI/ISA S75.11.

f) Valve shall meet the requirements of seat leakage Class III (0.1%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

g) Chilled and Hot water valve stem packing shall contain at least two EPDM o-rings.

h) Control valve seat and plug shall be made of brass according UNS C36000.

i) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

7. Valve Specification for Characterized Ball Valves

a. Threaded Valves, line size ½” to 2”

1) Controlled Media Specific Items

a) The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C).

b) The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C).

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of forged brass according to ASTM B283 (CuZn39Pb2 or equivalent), and shall meet requirements of ANSI 250 and 600WOG pressure classes.

b) Inlets and outlets shall be clearly marked on the valve bodies.

c) Valve ball shall consist of nickel-plated brass, chrome-plated brass, or stainless steel.

d) End connections shall be NPT internally threaded according to ANSI B1.20.1.

e) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

f) The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A glass filled PTFE V port insert shall establish the flow coefficient of the valve. The V port shall be retained by the valve body itself, not requiring additional retainers components. Manufacturer may also provide a glass filled polymer ball insert, as an integral part of the ball, for modulating flow applications. Flow coefficient adapters installed after final assembly of the valve shall not be allowed.

g) Valve shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure.

h) Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.

i) Valve stem shall be made of brass or stainless steel.

j) Valve shall have the ability to be manually operated in the event of a power failure.

8. Automatic Control Valve Actuators:

a. Electronic Valve Actuators

1) Applicable Standards

a) 24V valve actuator shall be identified as a Class 2 operating device, according to NEC, Article 725.

b) 120V valve actuator shall be identified as a Class 1 operating device, according to NEC, Article 725.

c) The valve actuator shall be tested and listed by Underwriters Laboratories according to UL873, and shall bear the UL and cUL approval symbols.

d) The valve actuator shall be designed and tested to NEMA 1 standards, according to NEMA 250.

e) The valve actuator shall bear the CE mark, and shall be designed and tested according to EU directives 89/336/EWG and 72/23/EWG.

2) Direct Coupled

a) The control valve actuator shall be directly coupled to the valve, with no intermediary linkage kit required, to facilitate repair and/or replacement.

b) The control valve actuator shall be equipped with a manual override feature, allowing operation of the control valve upon loss of control power or signal, without the aid of a separate tool or auxiliary power supply.

3) Fail Safe operation

a) Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by means of a mechanical spring.

b) Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by self-contained electronic means.

c) Upon power failure, the valve actuator shall maintain its last controlled position (fail in place).

4) Visual position indication

a) The valve actuator shall provide indication of valve stem position, clearly visible from a distance of 15ft. (4.5m).

5) Ball Valve Actuators Torque Requirement

a) The control valve actuator shall provide minimum torque required for full valve shutoff position.

H. Air Velocity Sensors

1. Air velocity sensors shall make measurements using a thin film thermal anemometer. Sensor shall deliver a 0 to 10 volt output signal, corresponding to a range of 0 to 3000 fpm. Sensor measuring range shall be DIP switch adjustable to optimize reading.

I. Airflow Measuring Stations

1. Fan Inlet Type:

a. Provide where indicated on the plans, airflow measuring stations of fan inlet type. Airflow traverse probes shall be suitable for mounting in the inlet bell(s) of the indicated fan.

b. Probes shall be provided with the appropriate end support brackets for mounting in the inlet bell(s). Where fans are of dual inlet type, two sets of inlet probes must be provided.

c. Fan inlet probes shall be provided with the fittings to allow for the connection of control tubing to the probe assemblies.

d. Probes shall be capable of operating with an accuracy of 3% of actual volume over the fan operating range.

e. The installation of the airflow measuring stations shall be coordinated with sheet metal contractor to ensure actual accuracy and accessibility for maintenance.

f. The installation of the airflow measuring stations shall be coordinated with sheet metal contractor to ensure actual accuracy and accessibility for maintenance.

g. Fan inlet probes shall be Tek-Air T-FP7000.

2. Duct Mounted Type:

a. Provide where indicated on the plans, airflow traverse probes of the insertion type, capable of continuously measuring air volume in the duct served.

b. Probes shall utilize multiple total and suction pressure measurement points, located along the length of the probe surface in accordance with ASHRAE recommendations for duct traversing.

c. The probes shall provide measurement accuracy within ± 2% of actual velocity when used with the appropriate conversion formula.

d. Probes shall be of cylindrical cross section and shall indicate no more than a ± 3% percent deviation from the centerline velocity at a yaw angles up to 30 degrees.

e. Probes shall be constructed of extruded aluminum, unless dictated otherwise by service requirements. Probes over sixteen inches long shall be supported on the insertion end.

f. Probe quantities for each location shall be sufficient to meet ASHRAE recommendations.

g. The pressure drop created by the traverse probes shall not be greater ten percent of the velocity pressure at the maximum design flow.

h. The probes shall not amplify sound levels in the duct. The manufacturer shall provide submittal data indicating the developed differential pressure and pressure loss at the minimum and maximum design air flows for each duct location.

i. Traverse probes shall be Tek-Air model T-FP5000.

J. Binary Temperature Devices

1. Line-voltage space thermostat:

a. Line-voltage thermostats shall be bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating. The thermostat cover shall provide exposed setpoint adjustment knob. The thermostat shall operate within the 55°F to 85°F setpoint range, with 2°F maximum differential.

2. Low-temperature safety thermostat:

a. Low-limit air stream thermostats shall be UL listed, vapor pressure type, with a sensing element of 20 ft. minimum length. Element shall respond to the lowest temperature sensed by any 1 ft. section. The low-limit thermostat shall be automatic reset, SPDT type.

3. Aquastat:

a. Strap-on type thermostats shall be provided for low or high temperature limit service on hot water or steam condensate pipes. The thermostats shall be UL Listed, with a liquid-filled bulb type sensing element and capillary tubing. The thermostat shall operate within the 20°F to 120°F, or 100°F to 240°F, setpoint range, with an adjustable 6°F differential.

b. The low-limit thermostat shall be automatic reset, snap acting SPDT type with concealed setpoint adjustment.

K. Temperature Sensors

1. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensors shall use platinum RTD elements only, nickel or silicon is not acceptable. All control signals shall be via a 4-20 mA loop.

2. Room Temperature:

a. Temperature monitoring range	+40/+90°F (+40/120°F for high temp alarms)
b. Output signal	4-20 mA
c. Installation adjustments	none required
d. Calibration adjustments	none required
e. Factory calibration point	32°F
f. Accuracy at calibration point	+/- 0.7°F

3. Liquid Immersion Temperature

a. Temperature monitoring range	+30/+250°F, +20/+70°F or +32/+212°F
b. Output signal	4-20 mA
c. Installation adjustment	none required

d. Calibration adjustments	none required
e. Factory calibration point	32°F
f. Accuracy at calibration point	+/- 0.54°F
4. Duct (Single Point) Temperature	
a. Temperature monitoring range	+20/+120°F or +30/+250°F
b. Output signal	4-20 mA
c. Installation adjustments	none required
d. Calibration adjustments	none required
e. Factory calibration point	70°F
f. Accuracy at calibration point	+/- 0.54°F
5. Duct (Averaging) Temperature	
a. Temperature monitoring range	+20/+120°F
b. Output signal	4-20 mA
c. Installation adjustments	none required
d. Calibration adjustments	none required
e. Factory calibration point	32°F
f. Accuracy at calibration point	+/- 0.54°F
6. Outside Air Temperature	
a. Temperature monitoring range	-58/+122°F
b. Output signal	4-20 mA
c. Installation adjustments	none required
d. Calibration adjustments	none required
e. Factory calibration point	32°F
f. Accuracy at calibration point	+/- 0.54°F

L. Dew Point/Humidity Sensors

Outside Air Dew Point Temperature

a. Dew point monitoring range	-40/+115°F DP, 12% to 99% rh
b. Output signal	4-20 mA
c. Calibration adjustments	none required
d. Factory calibration point	70°F
e. Accuracy at calibration point	+2.0°F DP
1. Room/duct Relative Humidity	
a. Sensor Humidity range	0 to 100%
b. Operating temperature	15°F to +170°F
c. Accuracy	+2% rh
d. Sensing element	Capacitive sensor

e. Output signal	4-20 mA DC
f. Installation adjustments	none required
g. Operating temperature	15°F to +170°F
h. Voltage requirement	12-36 Vdc

2. Room Hygrostat

a. Humidity setpoint range	30 to 90%
b. Accuracy	+/- 5%
c. Output signal	On/off
d. Setpoint	Exposed or concealed
e. Switch type	Single pole microswitch
f. Operating temperature	32 to 104°F
g. Agency listing	UL (low voltage)

3. Duct Hygrostat

a. Humidity setpoint range	15 to 95%
b. Switching differential	+/- 4%
c. Output signal	On/off
d. Setpoint	Exposed or concealed
e. Switch type	Single pole microswitch
f. Operating temperature	32 to 158°F
g. Agency listing	UL (low voltage)

4. Condensation Sensor

a. Switching point on RH increase	95%
b. Operating Voltage	24 Vac/Vdc
c. Operating Temperature	-12 to 122°F
d. Operating Humidity	5 to 95%
e. Relay Output	NO/NC dry contact
f. Switching Differential	5% rh
g. Response time (max)	3 minutes
h. Power Consumption (max)	1 VA

M. Pressure Sensors

1. Air Static Pressure Sensor

a. Duct Static range	-.5 to + 7.5" wg
b. Accuracy	+ .05" wg
c. Output signal	4-20 mA

N. Water Differential Pressure Sensor

1. Transducer shall have linear output signal. Zero and span shall be field adjustable.

2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.
4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Overrange limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and three valve manifold.
5. Provide industrial grade differential pressure sensors for all differential pressure bypass valves. Sensor shall be factory calibrated for operating range and rated for system pressure. Provide manufacturers standard 316 stainless steel, 3 valve manifold, and pressure gauges for supply and return pressures. Output shall be 4-20 mA. Sensor shall be Rosemount 1151DP, with 316 stainless steel or approved equal.

O. Differential Pressure Switches
1. Water Differential Pressure Switch
   a. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.
   b. The differential switches shall meet the following requirements:

1) Range	8 to 70 psi
2) Differential	3 psi
3) Maximum differential pressure	200 psi
4) Maximum pressure	325 psi

2. Air Differential Pressure Switch
   a. Differential pressure switches shall be diaphragm type, with die-cast aluminum housing and adjustable setpoint. Switch rating shall be a minimum 5 amps at 120 Vac. Switches shall be SPDT and be used for fan status as specified in the point schedule. Switch pressure range shall be suited for application (e.g., filter 0-2.0", fan status 0-5.0", etc.).

P. Analog Water Level Sensors
   1. Furnish and install full height, analog level sensors for each location as specified. Sensor shall provide 4-20 mA signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required. Sensor shall be Drexel Brook or equal.

Q. Water Leak Detection System
   1. General:
      a. Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cables length, sound an alarm, and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide pre-connectorized sensing cable and components. The system shall be UL listed and FM approved.
      b. The system shall be as manufactured by Raychem Corporation or equal.
   2. Locating leak detection panel (TTB-FA).
      a. The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 mA signal to the BMS, and displaying the distance from the start of the sensing cable to the start of the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.
      b. The alarm module shall be capable of detecting the presence of a 1–inch leak anywhere along the cable with a repeatability of +/- 1%.
      c. The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay, and activate a "continuity" LED on the face of the module.

d. The alarm module shall have LED's indicating "power" (green), "alarm" (red), and "continuity" (yellow). The module shall be equipped with exposed test, reset, and silence buttons. All other functions shall require key access.
e. The alarm module shall be powered by Emergency power.
f. The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

3. Single point leak detector
   a. The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall remain activated until the cable is dry and the module is reset.
   b. The alarm module shall be capable of detecting the presence of a 1–inch leak anywhere along the cable with a repeatability of +/- 1%.
   c. The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay, and activate a "continuity" LED on the face of the module.
   d. The alarm module shall have LED's indicating "power" (green), "alarm" (red), and "continuity" (yellow).
   e. The alarm module shall be powered by Emergency power.
   f. The module shall be mounted in a field equipment cabinet.
4. Water sensing cable
   a. The water sensing cable (TT-1000) shall detect the presence of water and pinpoint its location. The cable shall consist of four wires: Two sensor wires, a continuity wire, and a return wire. All four wires shall be coated and insulated with a fluoropolymer and wound helically around a flouropolymer core. The cable shall have a breaking strength, including connectors, of at least 70 pounds, per ASTM D-638. The cable shall have an abrasion resistance of >65 cycles, per UL 719.
   b. The sensing cable shall offer distributed sensing with the ability to detect the location of water at any point along the length of the cable. The cable shall be flexible, and carry less than 24 Vdc under normal conditions.

c. The system shall not alarm when in contact with any metallic equipment such as drip pans, floor tile supports, conduit, etc.
d. The cable shall be available in modular, preconnectorized lengths of 5, 10, 15, 25, and 50 feet. Field splicing shall not be acceptable.
e. The cable shall be UL 910 rated and plenum rated per NEC 725-2(b).
f. Provide two sets of test instrumentation to owner.

5. Jumper cable
   a. Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum rated and jacketed with fluoropolymer materials, per NEC 725-2(b). The jumper cable shall consist of four different colors (Y, B, R, G), insulated 18 AWG wires, and shall be available in preconnectorized lengths of 5, 10, 15, 25, and 50 feet.
6. Accessories
   a. Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.
7. Graphic display map
   a. Provide a graphic display map for each room served. The map shall be a 1/8 in. = 1.0 ft scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.
   b. A dynamic graphic display, equivalent to the aforementioned map, shall be duplicated on the BMS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.
8. Performance
   a. A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.
   b. The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.
   c. The cable shall be capable of being cleaned with a clean dry cloth, in place.

d. The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping, or mechanical action shall be required.

9. Installation

a. All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.

b. The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and retested, at no additional cost.

c. The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

10. Warranty

a. All equipment shall be warranted to the same extent as the BMS system, or per the manufacturer's warranty, whichever is greater.

R. Audio/Visual Alarm Units

1. Provide 1" x 3" translucent illuminated rectangular alarm light ("BMS Alarm"), sonalert horn (hidden), silence switch with stainless steel cover plate to match desk surface. When any BMS alarm occurs (as coordinated with facilities personnel), the alarm light shall flash once per second (adjustable) and the horn shall sound. When the silence switch is pushed, the horn will silence and the pilot light shall light continuously until alarm is cleared.

2. The BMS shall monitor the alarm light, horn and silence switch status.

3. Provide 1/8 inch high engraved and painted lettering for operational instructions as required by the owner on the cover plate.

S. Fuel Oil Meters

1. Provide fuel oil flow meter on fuel oil supply for each duplex fuel oil pump set. Meters shall be contacting head type approved for use in fuel oil systems. Monitor total accumulated flow, current flow, monthly total flow, and yearly total flow for each duplex pump set and jockey pump specified or shown.

2. Meter shall be intrinsically safe, explosion proof with a minimum resolution of 10 gallons with GPM range appropriate for application.

T. Water BTU Meters

1. Provide insertion type water flow meters designed to mount through a fully open 1 inch full bore ball valve supplied by flow meter manufacturer. Meter flow range shall be 2-40 feet/second for liquid service. Meter linearity shall be +/-1% for a 10:1 range. Repeatability shall be .10%. All wetted parts shall be constructed of stainless steel, bearings shall be tungsten carbide. Housing and flange shall be carbon steel. Housing pressure rating shall be 350 psig. A DC powered transmitter shall be mounted on the flow meter. Flow transmitter output shall be 4-20 mA linear with flow. Transmitter input shall be from magnetic pickup. Transmitter accuracy shall be .25% of span. The water flow meter shall be Onicon F 1220 or equal.
2. Provide supply and return temperature sensors for "Delta-T" calculation of BTU consumption. Monitor total accumulated BTUs, current BTUs, monthly total BTUs, and yearly total BTUs for each location specified or shown.
3. Provide isolation valve kit to allow removal and servicing of meter while system is operating.
4. All devices associated with the BTU meters serving the chilled water system shall be suitable for the extreme environmental conditions. The devices shall properly operate with the specified accuracy and shall not be affected by the media, or by the environment that includes but not limited to low temperatures (10°F), temperature fluctuations and condensation. Control panel enclosures and electronics shall meet the aforementioned requirements or located strategically to ensure proper operation.

U. Vortex Shedding Flow Meters

1. Provide vortex shedding flow meter for steam metering locations. Meter shall be pressure and temperature compensated, rated for service conditions and be manufactured by Endress and Hauser model FTV 1810 or approved equal. Provide remote readout of pressure, flow, MLb/Hr and total MLb.
2. Coordinate location to provide proper straight run of pipe, pipe size, etc.

3. BMS system shall monitor Mlb/Hr, Mlb total, pressure and temperature values.

V. Water Flow Switches
   1. Shall use either a microswitch type (QVE1900U) or magnetic reed contact type (OVE1901U) flow switch.
   2. UL Listed for low voltage.
   3. Supports media temperature up to 230°F.

W. Indoor Air Quality (CO2/TEMP/RH) Sensors
   1. Provide indoor air quality sensors to monitor Carbon Dioxide (CO2) and /or Temperature and Humidity.
   2. The CO2 sensor shall be of microprocessor-based non-dispersive infrared type (NDIR) with an additional integrated reference light source.
   3. The CO2 sensors shall have no more than 1% drift during the first year of operation and minimal drift thereafter so that no calibration will be required.
   4. The units shall be wall or duct mounted type as indicated on plans and in the sequence of operation.
   5. Wall mounted sensors shall be provided with white plastic cover, without LED indicators.
   6. Wall mounted sensors shall be provided with an LCD display.
   7. Duct and Wall mounted sensors shall be suitable for zones with 24/7 occupancy.
   8. Duct and Wall mounted sensors with Temperature shall have an option for active or passive temperature outputs (based on part number).
   9. Duct mounted sensors shall be provided without the need for a separate aspirator box.
   10. The VOC sensor shall have automatic self calibrating capability to ensure accuracy.
   11. The sensor shall meet the following requirements:

a. Operating voltage:	24 Vac +/- 20%, or 15 to 35Vdc
b. Frequency:	50/60 Hz
c. Power consumption:	max. 6 VA
d. CO2 measuring range:	0–2000 ppm
e. Tolerance:	+/- 50 ppm
f. Output:	0–10 Vdc or 0–5 Vdc Field configurable

g. Output (passive T, selectable) pt100, pt1000, Ni1000, NTC 10K
h. Calibration: none required
i. VOC measurement range: 0–10V VOC
j. Permissible air velocity in duct: <26.2 ft/s.

12. The sensors shall be equal to model Siemens QPA1000, QPA2000, QPM2100, or QPM1100 Series or equal.

X. Relays
1. Control relays shall be UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from setpoint shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

Y. Override Timers
1. Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0- to 6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

Z. Current Transmitters.
1. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10A, 20A, 50A, 100A, 150A, and 200A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

AA. Current Transformers
1. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5A full-scale output.

3. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.

BB. Voltage Transmitters

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
2. Two (2) Ranges shall include 100 to 130 Vac, 200 to 250 Vac, 250 to 330 Vac and 400 to 600 Vac full-scale, adjustable, with ±1% full-scale accuracy with 500 ohm maximum burden.
3. Transmitters shall be UL/CSA Recognized at 600 Vac rating and meet or exceed ANSI/ISA S50.1 requirements.

CC. Voltage Transformers

1. AC voltage transformers shall be UL/CSA Recognized, 600 Vac rated, complete with built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ±0.5% accuracy at 24 Vac and a 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.

DD. Power Monitors

1. Power monitors shall be the three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers, and UL Listed split-core current transformers.
2. They shall provide a selectable rate pulse output for kWh reading and a 4 to 20 mA output for kW reading. They shall operate with 5A current inputs with a maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

EE. Current Switches

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

FF. Local Control Panels

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable sub panels. A single key shall be common to all field panels and sub panels.
2. Interconnections between internal and face mounted devices shall be prewired with color-coded stranded conductors neatly installed in

plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

GG. Local User Display

1. Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.
2. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
3. The LCD display shall be a minimum of a 2-line, 40-character display.
4. The LCD display shall include the full point name, value (numeric, digital, or state text), point priority, and alarm status on one screen.
5. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
6. The display shall be mounted either on the door of the enclosure or remote from the controller.

2.12 Communication and Control Wiring

A. General:

1. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.
2. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

B. Wire Sizing and Insulation

1. Wiring shall comply with minimum wire size and insulation based on services listed below:

	Service:	Minimum Gage/Type:	Insulation Class:
a.	AC 24V Power	12 Ga Solid	600 Volt
b.	DC 24V Power	10 Ga Solid	600 Volt
c.	Class 1	14 Ga Stranded	600 Volt
d.	Class 2	18 Ga Stranded	300 Volt

e. Class 3 18 Ga Stranded 300 Volt

2. Provide plenum-rated cable when open cable is permitted in supply or return air plenum where allowed per execution.

C. Power Wiring:

1. 115V power circuit wiring above 100 feet distance shall use minimum 10 gage.
2. 24V control power wiring above 200 feet distance shall use minimum 12 gage.

D. Control Wiring:

1. Digital Input/Output wiring shall use Class 2 twisted pair, insulated.
2. Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
3. Actuators with tri-state control shall use three (3) conductors with same characteristics.

E. Communication Wiring

1. Ethernet Cable shall be minimum CAT5.
2. Secondary level network shall be 24 gage, TSP, low capacitance cable.

F. Approved Cable Manufacturers:

1. Wiring from the following manufacturers which meet the above criteria shall be acceptable:
   a. Anixter
   b. Belden

2.13 Fiber Optic Cable System

A. See specifications on Sheet M100.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to Resident Engineer for resolution before proceeding for installation.
2. Install equipment, piping, wiring, /conduit parallel to or at right angles to building lines.
3. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.

4. Mount control devices, tubing, and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
7. Install equipment level and plum.

B. Electrical Wiring Installation:

1. All wiring cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.
2. Install analog signal and communication cables in conduit. Install digital communication cables in conduit.
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.
5. Install all system components in accordance with local Building Code and National Electric Code.
   a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.

c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
8. Grounding: ground electrical systems per manufacturer’s written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. Temperature Sensors:
a. Install all sensors and instrumentation according to manufacturer’s written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
b. Calibrate sensors to accuracy specified, if not factory calibrated.
c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.
e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.
f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
g. All pipe mounted temperature sensors shall be installed in wells.
h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.

i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:
   a. Install duct static pressure sensor tips facing directly downstream of airflow.
   b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
   c. Install snubbers and isolation valves on steam pressure sensing devices.
3. Actuators:
   a. Mount and link damper and valve actuators according to manufacturer’s written instructions.
   b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
   c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.
4. Flow Switches:
   a. Install flow switch according to manufacturer’s written instructions.
   b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
   c. Assure correct flow direction and alignment.
   d. Mount in horizontal piping-flow switch on top of the pipe.

D. Installation of network:
1. Ethernet:
   a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.
   b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between

the Building Controller and the B-BC and the B-AAC controllers. See sheet M100 for Fiber Optic cable that shall be used between buildings.

2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.

E. Installation of digital controllers and programming:
1. Provide a separate digital control panel for each major piece of equipment, such as air handling unit, chiller, pumping unit etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature could be located on any of the remote control units.
2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.
3. System point names shall be modular in design, permitting easy operator interface without the use of a written point index.
4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.
5. Provide graphics for each piece of equipment and floor plan in the building. This includes each chiller, cooling tower, air handling unit, fan, terminal unit, boiler, pumping unit etc. These graphics shall show all points dynamically as specified in the point list.

F. Fiber Optic Cable System:
1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.
2. All cabling and associated components shall be installed in accordance with manufacturer's instructions.

G. Warnings Labels and Identifications Tags:
1. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
   a. Labels shall use white lettering (12-point type or larger) on a red background.
   b. Warning labels shall read as follows: **C A U T I O N This equipment is operating under automatic control and may start or**

stop at any time without warning. Switch disconnect to "Off" position before servicing.

2. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
   a. Labels shall use white lettering (12-point type or larger) on a red background.
   b. Warning labels shall read as follows: **C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.**
3. Equipment and Device labeling:
   a. Labels and tags shall be keyed to the unique identifiers shown on the as-built drawings.
   b. All Enclosures and DDC Hardware shall be labeled.
   c. All sensors and actuators not in occupied areas shall be tagged.
   d. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
   e. Duct static pressure taps shall be tagged at the location of the pressure tap.
   f. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire.
   g. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to the enclosure or DDC Hardware.
   h. Labels inside protective enclosures may be attached using adhesive, but shall not be hand written.
   i. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
   j. Identify room sensors relating to terminal box or valves with nameplates.
   k. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
4. Identification of Wiring
   a. All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

b. Permanently label or code each point of field terminal strips to show the instrument or item served.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of all aspects of the controls and instrumentation system.

B. Validation

1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall address all specified functions of the ECC and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification. Explain the method for simulating the necessary conditions of operation used to demonstrate performance of the system. Test plan shall include a test check list to be used by the Installer’s agent to check and initial that each test has been successfully completed. Deliver test plan documentation for the performance verification tests to the owner’s representative 30 days prior to start of performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.
2. After approval of the validation test plan, installer shall carry out all tests and procedures therein. Installer shall completely check out, calibrate, and test all connected hardware and software to insure that system performs in accordance with approved specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

1. System operation and calibration to be demonstrated by the installer in the presence of the Architect or VA's representative on random samples of equipment as dictated by the Architect or VA’s representative. Should random sampling indicate improper commissioning, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the VA.
2. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.

3. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.
4. The following witnessed demonstrations of field control equipment shall be included:
   a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.
   b. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.
   c. Demonstrate the software ability to edit the control program off-line.
   d. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms are received at the assigned location, including operator workstations.
   e. Demonstrate ability of software program to function for the intended applications-trend reports, change in status etc.
   f. Demonstrate via graphed trends to show the sequence of operation is executed in correct manner, and that the HVAC systems operate properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.
   g. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.
   h. Prepare and deliver to the VA graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.
   i. Demonstrate that each control loop responds to set point adjustment and stabilizes within one (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.
5. Witnessed demonstration of ECC functions shall consist of:
   a. Running each specified report.
   b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
   c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
   d. Execute digital and analog commands in graphic mode.

e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).

f. Demonstrate EMS performance via trend logs and command trace.

g. Demonstrate scan, update, and alarm responsiveness.

h. Demonstrate spreadsheet/curve plot software, and its integration with database.

i. Demonstrate on-line user guide, and help function and mail facility.

j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.

k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

l. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

----- END -----

SECTION 25 10 10
ADVANCED UTILITY METERING SYSTEM

PART 1 - ENERAL

1.1 DESCRIPTION

A. This Section includes the following for the advanced metering of the systems of the facility. The metered systems include the electrical power, natural gas distribution, fuel gas and fuel oil, steam, steam condensate, chilled water, heating water, domestic water, recovered water and makeup water systems. The metering systems in this project shall be tied into the campus DDC control system. in:

1. Communication network and interface modules for RS-232, RS-485, Modbus TCP/IP, IEEE 802.3 data transmission protocols.
2. Electric meters.
3. Volumetric flowmeters, temperature sensors and pressure transducers.
4. Mass flowmeters.

1.2 RELATED WORK

A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION: General mechanical requirements, common to more than one section in mechanical.

C. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Flowmeters and communications

D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.

E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage cable.

F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

1.3 DEFINITIONS

A. AMR: Automatic meter reading is the technology of automatically collecting consumption, diagnostic, and status data from water and energy metering devices (water, gas, electric, steam) and transferring that data to a central database for billing, troubleshooting, and analyzing.

B. AUMS: Advanced Utility Metering System: the system described by this Section.

C BACnet: BACnet is a Data Communications Protocol for Building Automation and Control Networks. It is defined by ASHRAE/ANSI Standard 135 (ISO 16484-5) standard protocol.

D. Data Over Cable Service Interface Specification (DOCSIS): an international standard defining communications and operation support interface requirements for a data over cable system, by the Cable Television Laboratories, Inc. consortium

E. Data Head (on meters): converts analog and pulse signals to digital signals for transmission to the Site Data Aggregation Device. Also provides for limited storage of the digital signals.

F. Device Accuracy: accuracy in this section is based on actual flow, not full scale or full range. Device accuracy measures the conversion of flow information to analog or pulse signals.

G. Ethernet: Local area network, based on IEEE 802.3 standards.

H. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

I. Gateway: Bi-directional protocol translator connecting control systems that use different communication protocols.

J. GB: gigabyte. When used to describe data storage, "GB" represents 1024 megabytes.

K. HTML: Hypertext markup language.

L. I/O: Input/output.

M. KB: Short for kilobyte. When used to describe data storage, "KB" represents 1024 bytes.

N. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

O. LAN: Local area network. Sometimes plural as "LANs."

P. LCD: Liquid crystal display.

Q. LonMark: An association comprising of suppliers and installers of LonTalk products. The Association provides guidelines for the implementation of the LonTalk protocol to ensure interoperability through Standard implementation.

R. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a “Neuron Chip” for communication.

S. LonWorks: Network technology developed by the Echelon Corporation.

T. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less that 50 V or remote-control, signaling and power-limited circuits.

U. MB: megabyte. When used to describe data storage, "MB" represents 1024 kilobytes.

V. Mbps: Megabytes per second, equal to 8 megabits per second

W. Modbus TCP/IP: An open protocol for exchange of process data.

X. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

Y. OTDR: Optical Time Domain Reflectometer. A test instrument that analyzes the light loss in an optical fiber. Used to find faults, splices and bends in the line, it works by sending out a light pulse and measuring its reflection. Such devices can measure fiber lines that are longer than 150 miles

Z. PC: Personal computer

AA. PICS, Protocol Implementation Conformance Statement: A written document that identifies the particular options specified by BACnet that are implemented in a device.

BB. REO: Resident Engineer Office: the VA office administering the construction contract.

CC. Reporting Accuracy: this is the root-mean-square sum of all of the metering devices’ inaccuracies: measurement inaccuracy, mechanical inaccuracy, analog-to-digital or pulse integration inaccuracy, etc., up to the meter’s data head.

DD. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

EE. Router: A device that connects two or more networks at the network layer.

FF. RS-232: A Telecommunications Industry Association standard for asynchronous serial data communications between terminal devices.

GG. RS-485: A Telecommunications Industry Association standard for multipoint communications using two twisted-pairs.

HH. TB: terrabyte. When used to describe data storage, "TB" represents 1024 gigabytes.

II. TCP/IP: Transport control protocol/internet protocol.

JJ. Turn-down: the maximum flow divided by the minimum flow through a meter; used along with accuracy requirements. For example, a meter shall be accurate to within 2% of actual flow with throughout a 20:1 turndown

KK. THD: Total harmonic distortion.

LL. UPS: Uninterruptible power supply; used both in singular and plural context.

MM. UTP: Unshielded twisted pair cabling, used to limit crosstalk and electromagnetic interference from the environment

NN. WAN: Wide area network.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A firm experienced at least three years in manufacturing and installing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency, and marked for intended use.

D. System Modifications: Make recommendations for system modification in writing to the VA. No system modifications shall be made without prior written approval of the VA. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected. Provide to the VA software updates for all software furnished under this specification during this contract’s construction and verification periods and for the first two years after government acceptance. All updated software shall be verified as part of this contract.

1.5 PERFORMANCE

A. The advanced utility metering system shall conform to the following:

1. Site Data Aggregation Device Graphic Display: The system shall display up to 4 graphics on a single screen with a minimum of (20) dynamic points per graphic. All current data shall be displayed within (10) seconds of the request.

2. Site Data Aggregation Device Graphic Refresh: The system shall update all dynamic points with current data within ten seconds. Data refresh shall be automatic, without operator intervention.
3. Meter Scan: All changes of metered values shall be transmitted over the high-speed network such that any data used or displayed at a controller or Site Data Aggregation Device will be current, within the prior ten seconds.
4. Alarm Response Time: The maximum time from when meter goes into alarm to when it is annunciated at the workstation shall not exceed ten seconds.
5. Reporting Accuracy: Listed below are minimum acceptable reporting accuracies for all values within the below minimum turn-down envelope reported by the meters:

Measured Variable	**Units Measured**	**Minimum Turn-Down of Meter**	**Reporting Accuracy (Note 1)**
Electricity	V, A, W, etc.	n/a	±0.5% of measured value
Natural Gas	l/s (CFH)	10:1	±2%
Liquefied Petroleum Gas	l/s (CFH)	10:1	±2%
Steam	kW (MBH)	20:1	±2%
Condensate	kW (MBH)	20:1	±2%
Domestic Water flow	l/s (GPH)	20:1	±2%
Reclaimed Water flow	l/s (GPH)	20:1	±2%
Make-up Water to Boilers flow	l/s (GPH)	10:1	±2%
Make-up Water to Cooling Towers flow	l/s (GPH)	10:1	±2%
No. 2 Heating Oil	l/s (GPH)	10:1	±2%
No. 6 Heating Oil	l/s (GPH)	10:1	±2%
Heating Water	kW (MBH)	20:1	±2%
Chilled Water	kW (MBH)	20:1	±2%
Outside Air Temperature	°C (°F)	n/a	±2%
Outside Air Relative Humidity	% rh	n/a	±2.5%

Table 1.5: Meter Performance Criteria

Table Notes:

1. This table shows reporting accuracy, not merely the meter's accuracy. Reporting accuracy includes meter accuracy and data

conversion accuracy. See Article 1.3 in this Section for definition. Accuracy is shown against the measured value, not against the full range of the meter.

2. l/s: liter per second
   CFH: cubic feet per hour
   kW: kilowatt
   MBH: 1000’s British Thermal Units per hour
   GPH: gallons per hour

1.6 WARRANTY

A. Labor and materials for advanced utility metering systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Advance utility metering system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and metering devices.

1.7 SUBMITTALS

A. Product Data: for each type of product indicated, Attach copies of approved Product Data submittals for products (such as flowmeters, temperature sensors and pressure transmitters, switchboards and switchgear) that describe advance utility metering features to illustrate coordination among related equipment and utility metering and control.

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

1. Outline Drawings: Indicate arrangement of meters, components and clearance and access requirements. Clearly identify system components, internal connections, and all field connections.
2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Wiring Diagrams: Power, signal, and communications wiring. Coordinate nomenclature and presentation with a block diagram. Show all communications network components and include a communications

single-line diagram indicating device interconnection and addressing information for all system devices. Identify terminal blocks used for interconnections and wire type to be used.

5. UPS sizing calculations for workstation.

C. Software and Firmware Operational Documentation:

1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
2. Software operating and upgrade manuals.
3. Software Backup: On a compact disc, complete with Owner-selected options.
4. Device address list and the set point of each device and operator option, as set in applications software.
5. Graphic file and printout of graphic screens and related icons, with legend.
6. "Quick-Start" guide to describe a simple, three-step commissioning process for setting the equipment’s Ethernet address, and ensuring trouble-free data access from any PC on the network, using a standard web browser.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future utility metering system revisions.

E. Firmware Upgrade Kit: For Owner to use in modifying firmware to suit future power system revisions or advanced utility metering system revisions. Firmware updates, and necessary software tools for firmware updates, shall be downloadable from the internet. VA shall be able to update firmware, in equipment, without removing device from the equipment. VA shall be capable of updating firmware over the utility metering communication network or through local communication ports on the device.

F. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

G. Qualification Data: For installer and manufacturer

H. Other Informational Submittals:

1. System installation and setup guides, with data forms to plan and record options and setup decisions.

I. Revise and update the Contract Drawings to include details of the system design. Drawings shall be on 17 by 11 inches sheets. Details to be shown on the Design Drawing include:
   1. Details on logical structure of the network. This includes logical location of all network hardware.
   2. Manufacturer and model number for each piece of computer and network hardware.
   3. Physical location for each piece of network or computer hardware.
   4. Physical routing of LAN cabling.
   5. Physical and qualitative descriptions of connectivities.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For advanced utility metering system components and meters, to include in emergency, operation, and maintenance manuals. Include the following:
   1. Operating and applications software documentation.
   2. Software licenses.
   3. Software service agreement.
   5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
   6. In addition to the copies required by 01 00 00, provide 5 bound paper copies of the Operation and Maintenance Data and two compact disks (CD), with all Instructions as Acrobat PDF files. The pdf files shall identical to the paper copies and shall Acrobat navigation tools including Bookmarks for each Chapter.
   7. The advanced utility metering system Operation and Maintenance Instructions shall include:
      a. Procedures for the AUMS system start-up, operation and shut-down.
      b. Final As-Built drawings, including actual LAN cabling routing shown on architectural backgrounds.
         1) IP address(es) as applicable for each piece of network hardware.
         2) IP address for each computer server, workstation and networked printer.
         3) Network identifier (name) for each printer, computer server and computer workstation.
         4) CEA-709.1B address (domain, subnet, node address) for each CEA-709.1B TP/FT-10 to IP Router.

c. Routine maintenance checklist, rendered in a Microsoft Excel format. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall list each device's node identifier/address, the third column shall describe each device's physical location, the fourth column shall state the maintenance activity or state no maintenance required, the fifth column shall state the frequency of the maintenance activity, frequency of calibration and the sixth column for additional comments or reference.
d. Qualified service organization list.
e. In addition to the requirements in Section 01 33 23, the submittal shall include manufacturer Installation Requirements.
f. Include complete instructions for calibration of each meter type and model.
g. Start-Up and Start-Up Testing Report.
h. Performance verification test procedures and reports.
i. Preventive Maintenance Work Plan.
j. In addition to factory-trained manufacturers' representatives requirements in 01 00 00, provide signed letter by factory-trained manufacturers' representatives stating that the system and components are installed in strict accordance with the manufacturers' recommendations.

B. Field quality-control test reports.

1.9 LICENSING AGREEMENT

A. Licenses procured as part of this work become the property of the government upon acceptance of the work. Licenses shall have no expiration.

B. Technical Support: Beginning with Government Acceptance, provide software support for one year.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Government Acceptance. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.

1. Provide 30-day notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.10 MAINTENANCE AND SERVICE

A. Preventive Maintenance Requirements: provide a preventative maintenance plan with attached procedures indicated by meter and component manufacturers. Perform maintenance procedures for a period of 1 year after government acceptance, at frequencies and using procedures required by the meter and component manufacturers. At a minimum and if the manufacturer is silent on its preventative maintenance requirements, frequencies, deliverables and activities shall comply with the following:

1. Preventive Maintenance Work Plan: prepare a Preventive Maintenance Work Plan to schedule all required preventive maintenance. VA approval of the Work Plan shall be obtained. Adhere to the approved work plan to facilitate VA verification of work. If the Contractor finds it necessary to reschedule maintenance, a written request shall be made to the VA detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates shall be changed only with the prior written approval of the REO.
2. Semiannual Maintenance: perform the following Semiannual Maintenance as specified:
   a. Perform data backups on all Server Hardware.
   b. Run system diagnostics and correct diagnosed problems.
   c. Perform fan checks and filter changes for AUMS hardware.
   d. Perform all necessary adjustments on printers.
   e. Resolve all outstanding problems.
   f. Install new ribbons, ink cartridges and toner cartridges into printers, and ensure that there is at least one spare ribbon or cartridge located at each printer.
3. Maintenance Procedures
   a. Maintenance Coordination: Any scheduled maintenance event by Contractor that will result in component downtime shall be coordinated with the VA as follows. Time periods shall be measured as actual elapsed time from beginning of equipment off-line period, including working and non-working hours.
      1) For non-redundant computer server hardware, provide 14 days notice, components shall be off-line for no more than 8 hours.
      2) For redundant computer server hardware, provide 7 days notice, components shall be off-line for no more than 36 hours.

3) For active (powered) network hardware, provide 14 days notice, components shall be off-line for no more than 6 hours.
4) For cabling and other passive network hardware, provide 21 days notice, components shall be off-line for no more than 12 hours.

b. Software/Firmware: Software/firmware maintenance shall include operating systems, application programs, and files required for the proper operation of the advanced utility metering system regardless of storage medium. User- (project site-) developed software is not covered by this contract, except that the advanced utility metering system software/firmware shall be maintained to allow user creation, modification, deletion, and proper execution of such user-developed software as specified. Perform diagnostics and corrective reprogramming as required to maintain total advanced utility metering system operations as specified. Back up software before performing any computer hardware and software maintenance. Do not modify any parameters without approval from the VA. Any approved changes and additions shall be properly documented, and the appropriate manuals shall be updated.

c. Network: Network maintenance shall include testing transmission media and equipment to verify signal levels, system data rates, errors and overall system performance.

B. Service Call Reception

1. A VA representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the VA.
2. The Contractor shall have procedures for receiving and responding to service calls during regular working hours. A single telephone number shall be provided for receipt of service calls during regular working hours. Service calls shall be considered received by the Contractor at the time and date the telephone call is placed by the VA.

3. Separately record each service call request, as received on the Service Call Work Authorization form.Complete the Service Call Work Authorization form for each service call. The completed form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.
4. Respond to each service call request within two working hours. The status of any item of work must be provided within four hours of the inquiry during regular working hours, and within sixteen hours after regular working hours or as needed to repair equipment.

1.11 SPARE PARTS

A. Furnish spare parts described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Addressable Relays: One for every ten installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every ten of each type installed. Furnish at least one of each type.

B. Furnish spare parts shall not be used for any warranty-required remediation.

1.12 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced, unless otherwise noted. Publications are referenced in the text by the basic designation only.

B. American Society of Mechanical Engineers (ASME):

B16.1-1998..............Cast Iron Pipe Flanges and Flanged Fittings
B31.1-2007..............Power Piping
B31.8-2007..............Gas Transmission and Distribution Piping Systems
B31.9-2008..............Building Services Piping
B40.100-1998............Pressure Gauges and Gauge Attachments

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE 135-2008.........A Data Communication Protocol for Building Automation and Control Networks (ANSI)

D. American Society for Testing and Materials (ASTM)

A53-2006................Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106-2006...............Seamless Carbon Steel Pipe for High Temperature Service

E. Consumer Electronics Association (CEA)

709.1B-2002.............Control Network Protocol Specification

709.3-1999..............Free-Topology Twisted-Pair Channel Specification

852-A-2004..............Tunneling Component Network Protocols Over Internet Protocol Channels

F. Federal Communications Commission (FCC)

EMC-2002................FCC Electromagnetic Compliance Requirements

G. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

81-1983.................IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

100-2000................The Authoritative Dictionary of IEEE Standards Terms

802.1D-2004.............Media Access Control Bridges

802.2-2003..............Standards for Local Area Networks: Logical Link Control

802.3-2005..............Information Technology - Telecommunications and Information Exchange between Systems. Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications (ANSI)

1100-2005...............Recommended Practice for Powering and Grounding Electronic Equipment (ANSI)

C37.90.1-2002...........Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

C57.13-2008.............Standard Requirements for Instrument Transformers

C62.41.1-2002..........Guide on the Surges Environment in Low-Voltage(1000 V and Less) AC Power Circuits

C62.41.2-2002..........Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

H. International Electrotechnical Commission (IEC)

IEC 61000-2005.........Electromagnetic Compatibility (EMC)- Part 4-5: Testing and Measurement Techniques; Surge Immunity Test

I. National Electrical Contractors Association

NECA 1-2006............Good Workmanship in Electrical Construction

J. National Electrical Manufacturers Association (NEMA)

250-2008................Enclosures for Electrical Equipment (1000 Volts Maximum)

C12.1-2008..............Electric Meters; Code for Electricity Metering

C12.20-2002.............Electricity Meter - 0.2 and 0.5 Accuracy Classes

C62.61-1993.............Gas Tube Surge Arresters on Wire Line Telephone Circuits

ICS 1-2008..............Standard for Industrial Control and Systems General Requirements

K. National Institute of Standards and Technology (NIST)

800, Part 39-2008.......[DRAFT] Managing Risk from Information Systems: An Organizational Perspective

800, Part 46-2009.......Guide to Enterprise Telework and Remote Access Security

800, Part 52-2009.......Recommended Security Controls for Federal Information Systems and Organizations

(FIPS) 200-2006.........Minimum Security Requirements for Federal Information and Information Systems

L. National Fire Protection Association (NFPA)

30-08...................Flammable and Combustible Liquids Code

70-2008.................National Electrical Code (NEC)

54-06...................National Fuel Gas Code

85-07...................Boiler and Combustion Systems Hazard Code

101-06..................Life Safety Code

262-2007................Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

M. NSF International

14-03..................Plastics Piping Components and Related Materials

61-02..................Drinking Water System Components-Health Effects (Sections 1-9)

N. Telecommunications Industry Association, (TIA/EIA)

H-088C3................Pathway Design Handbook

232-F-2002.............Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

485-A-2003.............Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint System

568-C.1-2009...........Commercial Building Telecommunications Cabling Standard

606-A-2002.............Administration Standard for the Telecommunications Infrastructure

607-A-2002.............Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

O. Underwriters Laboratories, Inc. (UL):

916-2007...............Energy Management Equipment

5085-3-2007............UL Standard for Safety Standard Low Voltage

1244-2000..............Electrical and Electronic Measuring and Testing Equipment

1581-2006..............Electrical Wires, Cables, and Flexible Cords

PART 2 - PRODUCTS

2.1 ADVANCED UTILITY METERING SYSTEM

A. Functional Description

1. Meter and record load profiles. Chart energy and water consumption patterns.
    a. Calculate and record the following:
        1) Load factor.
        2) Peak demand periods.
        3) Consumption correlated with facility activities.
    b. Measure and record metering data for the following:
        1) Electricity.
        2) Steam and condensate
        3) Domestic water.

4) Natural gas.
5) Oil.
6) Liquefied Petroleum Gas.
7) Used, Boiled/Evaporated, Reclaimed and Recovered water.
8) Chilled water
9) Heating water

d. Electric Power Quality Monitoring: Identify power system anomalies and measure, display, capture waveforms, and record trends and alarms of the following power quality parameters:
1) Voltage regulation and unbalance.
2) Continuous three-phase rms voltage.
3) Periodic max./min./avg. samples.
4) Harmonics.
5) Voltage excursions.

e. Emergency Load Shedding. Preserve critical loads or avoid total shutdown due to unforeseen loss of power sources according to the following logic:
1) Determine system topology.
2) Evaluate remaining loads and sources.
3) Shed loads in less than 100 ms.

f. Demand Management:
1) Peaking or co-generator control.
2) Load interlocking.
3) Load shedding.
4) Load trimming.

g. System: Report equipment status and power system control.

B. Communications Components and Networks

1. Site Data Aggregation Device and its networked meters shall communicate using BACNet protocol. Backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135-2008, BACnet Annex J.

a. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2008, BACnet.

b. Each controller shall have a communication port for connection to an operator interface.

2. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard LAN and WAN and Internetworked LAN.
3. Communication protocol; LANs complying with RS-485 or RS-485 accessed through Ethernet, 100 Base-TX Ethernet, and Modbus TCP/IP.
4. Network Hardware
   a. Building Point of Connection Hardware
      1) Active equipment and communication interfaces.
      2) Switches, hubs, bridges, routers and servers.
   b. IP Network Hardware
      1) Wire and Cables, copper connectivity devices.
      2) Fiber Optic Patch Panel.
      3) Fiber Optic Media Converter
      4) Ethernet Switch
      5) IP Router
5. Communication Security
   a. Remote teleworking and remote access of the network shall be through a firewall, at the Site Data Aggregation Device, complying with the requirements associated with Level 1 security in the Federal Information Processing Standard 140-2 (2002), Security Requirements for Cryptographic Modules.
   b. Direct access to network shall be restricted as described in

2.2 SITE DATA AGGREGATION DEVICE

A. All metering shall be displayed through the campus DDC control system.
   1. Metering Software
      a. Basic Requirements:
         1) Fully compatible with and based on the approved operating system.
         2) Password-protected operator login and access; three levels, minimum.
         3) Password-protected setup functions.
         4) Context sensitive on-line help.
         5) Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
         6) Capability for importing custom icons into graphic views to represent alarms and I/O devices.

7) Automatic and encrypted backups for database and history; automatically stored at the Site Data Aggregation Device and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
8) Operator audit trail for recording and reporting all changes made to user-defined system options.

b. Workstation and Server Functions:
   1) Support other client PCs on the LAN and WAN.
   2) Maintain recorded data in databases accessible from other PCs on the LAN and WAN.

c. Data Formats:
   1) User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
   2) Option to convert reports and graphics to HTML format.
   3) Interactive graphics.
   4) Option to send preprogrammed or operator designed e-mail reports.
   5) Option to serve information to third-party applications via Object Linking and Embedding for Process Control using open standards.

d. Metered data: Display metered values in real time with a rigid time-stamp. Couple all metered data with measured outside air conditions at the relevant facility.

e. Metered Data alarms: Provide generic alarm modules to notify Users and highlight metered data gaps, data spikes outside of range, and data timestamp errors.
   1) Customize the generic alarm modules to the application.
   2) Modules shall allow for user adjustment of alarm criteria.
   3) Alarm notices shall be shown via hyperlinks on the graphical User interface, and shall also be shown by flags within the data set.

f. Automatic Data Scrubbing: Provide tools for User-programming of rules to scrub the data of the followings errors: data gaps, data spikes outside of range, and data timestamp errors. Use these rules to scrub the raw metered data. Flag all data which has been so scrubbed.

g. Remote control:
   2) User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.

h. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.

i. User-Defined Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
   1) Operator log on/off.
   2) Attempted operator log on/off.
   3) All alarms.
   4) Equipment operation counters.
   5) Out-of-limit, pickup, trip, and no-response events.

j. (for electrical power monitoring) Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event; include the graphic displays of the following, based on user-specified criteria:
   1) Phase voltages, phase currents, and residual current.
   2) Overlay of three-phase currents, and overlay each phase voltage and current.
   3) Waveforms ranging in length from 2 cycles to 5 minutes.
   4) Disturbance and steady-state waveforms up to 512 points per cycle.
   5) Transient waveforms up to 83,333 points per cycle on 60-Hz base.
   6) Calculated waveform on a minimum of four cycles of data of the following:
      a) THD.
      b) rms magnitudes.
      c) Peak values.
      d) Crest factors.
      e) Magnitude of individual harmonics.

k. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software on the local server.

l. Activity Tracking Software:

1) Automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand integrated over user-defined interval.
2) Intervals shall be same as used by electric utilities, including current vendor.
3) Import metered data from saved records that were generated by metering and monitoring software.
4) Maintain separate directory for each activity's historical billing information.
5) Prepare summary reports in user-defined formats and time intervals.

m. Passwords

n. Protocol Drivers

o. System Graphic Displays: provide interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:
1) Site plan.
2) Floor plans.
3) Equipment elevations.
4) Single-line diagrams.
5) Custom graphic screens configured, not programmed, using drag-and-drop tools available within the software.

p. Alarms: display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
1) Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.

q. Trending: display and record data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
1) Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
2) Charting, statistical, and display functions of standard Windows-based spreadsheet.

r. Report Generation: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.

1) Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.

a) Sort and report by device name and by function.

b) Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.

c) Differentiate alarm signals from other indications.

d) When system is reset, report reset event with same information concerning device, location, date, and time.

7. BACnet: Site Data Aggregation Device shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2001, BACnet

2.3 CABLE SYSTEMS - TWISTED PAIR AND FIBER OPTIC

A. General:

1. All metallic cable sheaths, etc. (i.e.: risers, underground, station wiring, etc. shall be grounded.
2. Install temporary cable and wire pairs so as to not present a pedestrian safety hazard. Provide for all associated work for any temporary installation and for removal when no longer necessary. Temporary cable installations are not required to meet Industry Standards; but, must be reviewed and approved by the VA prior to installation.
3. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.
4. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.
5. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.
6. Label system’s cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing.

Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges specified. The cable tests shall demonstrate the operation of this cable at not less than 10 mega (m) Hertz (Hz) full bandwidth, fully channel loaded and a Bit Error Rate of a minimum of 10-6 at the maximum rate of speed. Make available all cable installation and test records at acceptance testing by the VA and shall thereafter be maintained in the Facility's Engineering Office. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.

7. Coordinate with the Electrical Contractor to install the telephone entrance cable to the nearest point of entry into the Facility and as shown on the drawings. Coordinate with the VA and the Electrical Contractor to provide all cable pairs/circuits from the Facility point of entry to the Telephone Switch Room all telephone, FTS, DHCP, ATM, Frame Relay, data, pay stations, patient phones, and any low voltage circuits as described herein.
8. Provide all cable pairs/circuits from the Server Room and establish circuits throughout the Facility for all cabling as described herein.
9. Provide proper test equipment to demonstrate that cable pairs meet each OEM's standard transmission requirements, and guarantee the cable will carry data transmissions at the required speeds, frequencies, and fully loaded bandwidth.

B. LAN COPPER CABLES

1. 2. RS-485 Cable:
   a. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
3. Unshielded Twisted Pair Cables: Category 5e or 6 for horizontal cable for data service."
4. Cabling products shall be tested and certified for use at data speeds up to at least 100 Mbps. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media. Short lengths of media and transceivers may be used in these applications. Provide separately orderable media, taps and connectors.

5. Ethernet Switch shall be IEEE Std 802.3 bridges which shall function as the center of a distributed-star architecture and shall be "learning" bridges with spanning tree algorithms in accordance with IEEE Std 802.1D. The switch shall support the connected media types and shall have a minimum of 150% the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port.
6. Provide IP router network equipment. The routers shall be fully configurable for protocol types, security, and routing selection of sub-networks. The router shall meet all requirements of RFC 1812.

C. LOW-VOLTAGE WIRING

1. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
   a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
   b. Ordinary Switching Circuits: Three conductors, unless otherwise indicated.
   c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

2.4 GROUNDING

A. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

2.5 METER COMMUNICATION

A. Provide a BACNet network allowing communication from the meters’ data heads to the Campus DDC control system.

B. Provide data heads at each meter, converting analog and pulsed information to digital information. Data heads shall allow for up to 24 hours of data storage (including time stamp, measured value, and scaling factor).

1. Each data head shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol. Each data head shall have a communication port for connection to an operator interface.
2. Environment: Data Head hardware shall be suitable for the conditions ranging from -29°C to 60°C (-20°F to 140°F). Data Heads used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at conditions ranging from -29°C to 60°C (-20°F to 140°F).

3. Provide a local keypad and display for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
5. Memory. The building controller shall maintain all BIOS and data in the event of a power loss for at least 72 hours.
6. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.6 ELECTRICAL POWER METERS AND SUB-METERS

A. ELECTRICAL METER APPLICATIONS
   1. Energy meters in the advanced utility metering system shall have models available for amperage ranges of 100-2400 amperes.
      a. The RS-485 communications shall provide communications links up to 10,000 feet long.
   2. Power meters shall be installed as part of the advanced utility metering system.
      a. All setup parameters required by the power meter shall be stored in nonvolatile memory and retained in the event of a control power interruption.
      b. The power meter may be applied in three-phase, three- or four-wire systems.
      c. The power meter shall be capable of being applied without modification at nominal frequencies of 50, 60, or 400 Hz.
      d. The power meter shall provide for onboard data logging, able to log data, alarms, waveforms and events.

B. Physical and Common Requirements
   1. Electrical power meters shall be separately mounted, and enclosed in a NEMA 250, Type 1 enclosure. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

a. Ambient conditions of 0 to 140 deg F dry bulb and 20 to 95 percent relative humidity, noncondensing.

C. Current and voltage ratings:

1. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.
2. Withstand ratings shall be not less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
3. Voltage inputs from standard instrument potential transformers with 120 volt secondary output. The power meter shall support PT primaries through 3.2 MV.
4. The power meter shall operate properly over a wide range of control power including 90-457 VAC or 100-300 VDC.

D. Electrical measurements and calculated values

1. Power meters shall include the following rms Real-Time Measurements:
   a. Current: Each phase, neutral, average of three phases, percent unbalance.
   b. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
   c. Power: Per phase and three-phase total.
   d. Reactive Power: Per phase and three-phase total.
   e. Apparent Power: Per phase and three-phase total.
   f. True Power Factor: Per phase and three-phase total.
   g. Displacement Power Factor: Per phase and three-phase total.
   h. Frequency.
   i. THD: Current and voltage.
   j. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
   k. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
   l. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
2. Power meters shall perform the following demand current calculations, per phase, three-phase average and neutral:
   a. Present.
   b. Running average.

c. Last completed interval.

d. Peak.

3. Power meters shall perform the following demand real power calculations, three-phase total:

   a. Present.

   b. Running average.

   c. Last completed interval.

   d. Predicted.

   e. Peak.

   f. Coincident with peak kVA demand.

   g. Coincident with kVAR demand.

4. Power meters shall perform the following demand reactive power calculations, three-phase total:

   a. Present.

   b. Running average.

   c. Last completed interval.

   d. Predicted.

   e. Peak.

   f. Coincident with peak kVA demand.

   g. Coincident with kVAR demand.

5. Power meters shall perform the following demand apparent power calculations, three-phase total:

   a. Present.

   b. Running average.

   c. Last completed interval.

   d. Predicted.

   e. Peak.

   f. Coincident with peak kVA demand.

   g. Coincident with kVAR demand.

6. Power meters shall perform the following average true power factor calculations, demand coincident, three-phase total:

   a. Last completed interval.

   b. Coincident with kW peak.

   c. Coincident with kVAR peak.

   d. Coincident with kVA peak.

7. Power Analysis Values:

   a. THD, Voltage and Current: Per phase, three phase, and neutral.

   b. Displacement Power Factor: Per phase, three phase.

c. Fundamental Voltage, Magnitude and Angle: Per phase.
d. Fundamental Currents, Magnitude and Angle: Per phase.
e. Fundamental Real Power: Per phase, three phase.
f. Fundamental Reactive Power: Per phase.
g. Harmonic Power: Per phase, three phase.
h. Phase rotation.
i Unbalance: Current and voltage.
j. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 31st harmonic.

8. Power meters shall perform one of the following demand calculations, selectable by the User; meters shall be capable of performance of all of the following demand calculations.
   a. Block interval with optional subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
      1) Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
      2) Fixed block that calculates demand at end of the interval.
      3) Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
   b. Demand calculations initiated by a Utility-furnished synchronization signal:
      1) Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
      2) Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
      3) Demand can be synchronized with clock in the power meter.
   c. Minimum and maximum values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
      1) Line-to-line voltage.
      2) Line-to-neutral voltage.
      3) Current per phase.
      4) Line-to-line voltage unbalance.
      5) Line-to-neutral voltage unbalance.

6) Power factor.
7) Displacement power factor.
8) Total power.
9) Total reactive power.
10) Total apparent power.
11) THD voltage L-L.
12) THD voltage L-N.
13) THD current.
14) Frequency.

d. Harmonic calculation: display and record the following:

1) Harmonic magnitudes and angles for each phase voltage and current through 31st harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.
2) Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by the VA.

E. Waveform Capture:

1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.
2. Capture and store disturbance waveform captures of voltage and current channels, initiated automatically based on an alarm event. Each capture shall be fully configurable for duration with resolution of at least 128 data points per cycle, for all channels simultaneously. Waveform shall be configurable to capture pre-event cycles for analysis.
3. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

F. Meter accuracy:

1. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters.
2. Accuracy from Light to Full Rating:
   a. Power: Accurate to 0.5 percent of reading.
   b. Voltage and Current: Accurate to 0.5 percent of reading.
   c. Power Factor: Plus or minus 0.005, from 0.5 leading to 0.5 lagging.

d. Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.

G. Meter input, sampling, display, output, recording and reading Capabilities

1. Input: One digital input signal.
   a. Normal mode for on/off signal.
   b. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.
   c. Conditional energy signal to control conditional energy accumulation.
   d. GPS time synchronization.
2. Sampling:
   a. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
   b. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.
3. Display Monitor:
   a. Backlighted LCD to display metered data with touch-screen or touch-pad selecting device.
   b. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
   c. Display four values on one screen at same time.
      1) Coordinate list below with meter capabilities specified in subparagraphs above.
      2) Current, per phase rms, three-phase average //and neutral//.
      3) Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
      4) Real power, per phase and three-phase total.
      5) Reactive power, per phase and three-phase total.
      6) Apparent power, per phase and three-phase total.
      7) Power factor, per phase and three-phase total.
      8) Frequency.
      9) Demand current, per phase and three-phase average.
      10) Demand real power, three-phase total.
      11) Demand apparent power, three-phase total.
      12) Accumulated energy (MWh and MVARh).
      13) THD, current and voltage, per phase.

d. Reset: Allow reset of the following parameters at the display:
   1) Peak demand current.
   2) Peak demand power (kW) and peak demand apparent power (kVA).
   3) Energy (MWh) and reactive energy (MVARh).
4. Outputs:
   a. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.
   b. Closed in either a momentary or latched mode as defined by user.
   c. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.
   d. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V rms isolation.
   e. One relay output module, providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.
   f. Output Relay Control:
      1) Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
      2) Normally open and normally closed contacts, field configured to operate as follows:
         a) Normal contact closure where contacts change state for as long as signal exists.
         b) Latched mode when contacts change state on receipts of a pickup signal; changed state is held until a dropout signal is received.
         c) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
         d) End of power demand interval when relay operates as synchronization pulse for other devices.
         e) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
         f) Output controlled by multiple alarms using Boolean-type logic.
5. Onboard Data Logging:

a. Store logged data, alarms, events, and waveforms in 2 MB of onboard nonvolatile memory.

b. Stored Data:

1) Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 to 52 days of 15-minute interval data, depending on number of quantities selected.

2) Custom Data Logs: three user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:

a) Schedule interval.

b) Event definition.

c) Configured as "fill-and-hold" or "circular, first-in first-out."

3) Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.

4) Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."

c. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

6. Alarms.

a. User Options:

1) Define pickup, dropout, and delay.

2) Assign one of four severity levels to make it easier for user to respond to the most important events first.

3) Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.

b. Alarm Events:

1) Over/undercurrent.

2) Over/undervoltage.

3) Current imbalance.

4) Phase loss, current.

5) Phase loss, voltage.

6) Voltage imbalance.

7) Over kW demand.

8) Phase reversal.

9) Digital input off/on.

10)End of incremental energy interval.

11)End of demand interval.

2.7 WATER, OIL, GAS METER DEVICES

A. Water, oil and gas meter applications:

1. Steam Meters: provide vortex-shedding flowmeters, along with temperature sensors and pressure transducers to develop the energy flow.

3. Natural Gas Meters: provide vortex-shedding flowmeters with pressure sensors.

5. Potable (Domestic) Water: provide a magnetic flowmeter in new installations; provide an ultrasonic or vortex-shedding flowmeter with pressure sensor in existing installations which service interruption is not allowed.

9. HVAC Hydronic System Water Meters

   a. Chilled Water Systems: provide vortex-shedding flowmeters with pressure and temperature sensors to determine energy flow.

   b. Heating Water Systems: provide vortex-shedding flowmeters with pressure and temperature sensors to determine energy flow.

B. Associated Devices (to provide outside air conditions as well as energy metering, not merely flow metering):

1. Temperature Sensors: Resistance Temperature Device (RTD) with an integral transmitter type.

   a. Immersion sensors shall be provided with a separable thermowell. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.

   b. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.

   c. Output Signal: 4-20 ma or digital.

2. Humidity Sensors: Bulk polymer sensing element type.

   a. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100 percent RH.

   b. Output Signal: 4-20 ma continuous output signal.

3. Pressure sensors.

   a. Gas Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

b. Water Pressure Transmitters: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

4. Thermowells.

a. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting. Stepped shank unless straight or tapered shank is indicated. ASME B40.200.Bore diameter required to match thermometer bulb or stem. Insertion length required to match thermometer bulb or stem. Provide a lagging extension on thermowells for insulated piping and tubing. Provide bushings. Use a mixture of graphite and glycerin for the thermowell’s heat transfer medium.

1) Material for Use with Copper Tubing: copper nickel (90-10).

2) Material for Use with Steel Piping: stainless steel.

C. Turbine flowmeters (natural gas duty).

1. All meter bearings and gearing shall be in areas sealed from metered fluid and contaminants. Metering transducers shall be operated through magnetic coupling. The measuring devices shall be contained within a module that can be removed from the meter body for service and calibration without breaking the system piping connections. Meter shall be constructed for measured fluid’s chemical characteristics. Construct meter of corrosion-resistant materials, or provide a corrosion-resistant coating.

2. Provide a data head on the meter.

3. Straightening Vanes: Provide as recommended by the meter manufacturer for the actual installation arrangement.

4. Performance:

a. Transmitted signal from flowmeter and its transmitter shall have a total (rms) accuracy plus or minus 0.5% of flow rate.

b. Flowmeter accuracy shall be no more than plus or minus 0.1%. Flowmeter repeatability shall be no more than 0.3% of actual flow rate. Meter shall be designed to minimize vibration effect and to provide elimination of this effect.

c. Minimum turndown capability shall be 10:1.

d. Pressure drop shall not exceed 1.25 kPa (5 inches WC).

5. Calibration: Factory calibrated. Furnish three-point curve spanning required flow range on actual meter furnished.

6. Accessories:

a. Filter: Shall have replaceable glass-fiber or cellulose cartridge with ten micron or smaller particle retention. Filter enclosure shall be the pipe size of the meter or larger as required by pressure drop considerations. Static pressure capability shall be at least twice lockup pressure of service supply regulators. Maximum pressure loss 1.25 kPa (5 inches WC) at maximum design flow rate of meter. Plug all drains or instrumentation outlets. Provide vent with cock for relieving pressure in filter.

D. Turbine flowmeters (water duty).

1. Sensor shall be insertion turbine type with turbine element, retractor and preamplifier/transmitter mounted on a two-inch full port isolation valve; assembly easily removed or installed as a single unit under line pressure through the isolation valve without interference with process flow; calibrated scale shall allow precise positioning of the flow element to the required insertion depth within plus or minute 0.05 inch; wetted parts shall be constructed of stainless steel. Operating power shall be nominal 24 VDC. Local instantaneous flow indicator shall be LED type in NEMA 4 enclosure with 3-1/2 digit display, for wall or panel mounting.

   a. Ambient conditions: -40 to 60 degrees C (-40 to 140 degrees F), 5 to 100 percent humidity

   b. Operating conditions: 850 kPa (125 psig), 0 to 120 degrees C (30 to 250 degrees F), 0.15 to 12 m per second (0.5 to 40 feet per second) velocity.

2. Performance:

   a. Transmitted signal from flowmeter and its transmitter shall have a total (rms) accuracy plus or minus 1% of actual flow rate.

   b. Flowmeter accuracy shall be no more than plus or minus 0.1% of actual flow rate. Flowmeter repeatability shall be no more than 0.3% of actual flow rate. Meter shall be designed to minimize vibration effect and to provide elimination of this effect.

   c. Minimum turndown capability shall be 20:1.

   d. Pressure drop shall be as scheduled, maximum 1% of line pressure in lines sized 4 inches and larger.

   e. Ambient temperature effects, less than 0.005 percent calibrated span per degree C (degree F) temperature change.

   f. RFI effect - flow meter shall not be affected by RFI.

g. Power supply effect less than 0.02 percent of actual flow rate for a variation of plus or minus 10 percent power supply.

3. Provide a data head on the meter.
   a. Preamplifier mounted on meter shall provide 4-20 ma divided pulse output or switch closure signal for units of volume or mass per a time base. Signal transmission distance shall be a minimum of 1,800 meters (6,000 feet)..
4. Straightening Vanes: Provide as recommended by the meter manufacturer for the actual installation arrangement.

E. Screw type flowmeters (No. 2 oil duty)
   1. Meters shall have cast iron cases, nitrided steel spindles, Viton seals, threaded pipe connections, designed for pressure exceeding set pressure, plus 25 percent, of nearest upstream relief valve. Meters shall be rated for 121 degrees C (250 degrees F) if utilized for heated oil.
   2. Provide a meter data head.
      a. Meter Registers: Hermetically sealed flow computer with digital flow rate readout and digital register for totalizer with at least five digits located at meter, positioned for easy viewing. Provide a data head on the meter.
   3. Performance:
      a. Transmitted signal from flowmeter and its transmitter shall have a total (rms) accuracy plus or minus 1% of flow rate.
      b. Flowmeter accuracy shall be no more than plus or minus 0.1%, over the required flow range. Flowmeter repeatability shall be no more than 0.2% of actual flow rate. Meter shall be designed to minimize vibration effect and to provide elimination of this effect.
      c. Minimum turndown capability shall be 10:1. Its maximum fluid pressure drop through meter shall be as scheduled.

F. Vortex-shedding flowmeters.
   1. Meter shall have an all-welded flanged 316 stainless steel meter body with no seals. No sensor parts shall be exposed to the flow stream. Provide a 316 stainless steel trapezoidal shedder bar, sensing by detecting stresses in the shedder bar caused by vortices, and dual piezoelectric crystals located outside the process flow sense the shed vortices (dual crystal alignment cancels effects of noise and vibration). Design meter for Schedule 40 piping.

a. Meter shall be suitable for 25% warmer than the fluid operating temperature and for 25% higher than either the fluid’s operating pressure or 25% higher than the piping system’s safety valve set pressure, whichever is higher.
b. Meter flanges shall be Class 300 or higher, if required by the piping system’s temperature and pressure Class.
c. Meter shall be suitable for installation in ambient conditions ranging from -29 to 60 degrees C (-20 to 140 degrees F).

2. Provide meter data head.
   a. Meters shall have digital readout of pressure-compensated flow rate and totalization located at transmitter and transmit flow rate and totalization digital signals to the Site Data Aggregation Device and recorders. As an option, pressure compensation and the compensated flow rate may be performed and displayed by the Site Data Aggregation Device receiving signals from the flow meter and from a pressure transmitter.
   b. Provide programmable microprocessor electronics with on-board programming. Output signals shall be immune to ambient temperature swings. Processor shall include continuous self-diagnostic routines that identify electronics problems and provide a warning. Electronics shall be replaceable in the field without affecting metering accuracy. Provide power supply as recommended by meter manufacturer. Mount electronics in a NEMA 4 enclosure separate from meter body in position accessible from platform or floor without the use of a portable ladder.
      1) Power supply to meter and transmitter shall be 120V/60hz. Provide a Class 2 control voltage transformer for 24VDC power to meter as needed.
      2) Provide an internal battery, provided for 24-month retention of RAM contents when all other power sources are removed.
3. Performance:
   a. Transmitted signal from flowmeter and its transmitter shall have a total (rms) accuracy plus or minus 1.5% of flow rate.
   b. Flowmeter accuracy shall be no more than plus or minus 1% of span for gasses and plus or minus 0.7% of span for liquids. Flowmeter repeatability shall be no more than 0.2% of actual flow rate. Meter shall be designed to minimize vibration effect and to provide elimination of this effect.

c. Minimum turndown ratio shall be 20:1 for gasses and liquids. Maximum fluid pressure drop shall be as scheduled.

G. Ultrasonic (Doppler and time of travel) flowmeters.

1. Provide a clamp-on flowmeter precluding the requirement of penetrating into the process pipe. The flowmeter shall be completely microprocessor based utilizing the transit-time flow measurement technique. The flowmeter shall employ the phase detection multiple pulse transmit principle in conjunction with multiple frequency axial beam transducer technology to insure operation on liquids with solids and or bubbles. In addition, the flowmeter shall incorporate an alternate Doppler method measurement mode for highly aerated or heavy solid bearing liquids.

2. Provide a meter data head.

a. The flowmeter shall provide automatic transducer spacing for clamp-on transducers utilizing a prefabricated mounting frame or mounting track (ruler scales shall not be acceptable), the meter shall also support in-line transducers. The meter shall also provide automatic Reynolds Number and liquid sonic velocity variation compensation and live zero flow measurement.

1) By use of either transit-time or Doppler modes of operation, the flowmeter shall be capable of measuring all liquids in full sonically conductive pipes.

b. The flowmeter shall have the ability to indicate flow rate, flow velocity, total flow, signal strength, liquid sonic velocity, Reynolds Number and liquid aeration level.

c. The flowmeter shall be equipped with an integral front panel keypad and multifunction 240 X 128 pixel LCD display. In addition, the flowmeter shall provide self and application diagnostics to isolate any fault conditions to either equipment failure or abnormal process conditions.

d. The flowmeter shall have full HELP menu routines corresponding to all levels of programming and operation.

e. The flowmeter electronics shall be housed in a NEMA 4X enclosure and powered by 90-240VAC, 50-60Hz. Two isolated 4 to 20 maDC and two 0 to 5000 Hz pulse outputs proportional to flow shall be provided. The current outputs must be capable of driving a 1000-ohm resistive load. In addition, the unit shall provide two 0 to 10 volt outputs and four SPDT alarm relays assignable to flow velocity, liquid sonic velocity, signal strength or liquid aeration.

f. Provide an internal 1 MB data logger shall be provided to allow storage of all measured and calculated variables and alarms in intervals of 10 minutes.

g. Two each bi-directional communications ports shall be provided.

1) One each RS-485 with Modbus RTU or BACnet protocol.

3. Performance:

a. The flowmeter shall have an accuracy of plus or minus 1% of flow over span. Repeatability shall be 0.25% of flow.

b. Meter shall have a flow sensitivity of 0.001 fps at any flow rate including no flow conditions.

H. Magnetic flowmeters.

1. Meter shall have an all-welded flanged 316 stainless steel engineered flow tube with no seals. No sensor parts shall be exposed to the flow stream. Design meter for mating with Schedule 40 piping.

a. Meter shall be suitable for 25% warmer than the fluid operating temperature and for 25% higher than either the fluid’s operating pressure or 25% higher than the piping system’s safety valve set pressure, whichever is higher.

b. Meter flanges shall be Class 150 Class 300 or higher, if required by the piping system’s temperature and pressure Class.

c. Meter shall be suitable for installation in ambient conditions ranging from -29 to 60 degrees C (-20 to 140 degrees F).

2. Provide meter data head.

a. Meters shall have digital readout of pressure-compensated flow rate and totalization located at transmitter and transmit flow rate and totalization digital signals to the Site Data Aggregation Device. As an option, pressure compensation and the compensated flow rate may be performed and displayed by the Site Data Aggregation Device receiving signals from the flow meter and from a pressure transmitter.

b. Provide programmable microprocessor electronics with on-board programming. Output signals shall be immune to ambient temperature swings. Processor shall include continuous self-diagnostic routines that identify electronics problems and provide a warning. Electronics shall be replaceable in the field without affecting metering accuracy. Provide power supply as recommended by meter manufacturer. Mount electronics in a NEMA 4 enclosure separate from meter body in position accessible from platform or floor without the use of a portable ladder.

1) Power supply to meter and transmitter shall be 120V/60hz. Provide a Class 2 control voltage transformer for 24VDC power to meter as needed.

3. Performance:
   a. Transmitted signal from flowmeter and its transmitter shall have a total (rms) accuracy plus or minus 1.5% of flow rate.
   b. Flowmeter accuracy shall be no more than plus or minus 1.5% of actual flow rate for gasses and plus or minus 1% of actual flow rate for liquids. Flowmeter repeatability shall be no more than 0.2% of actual flow rate. Meter shall be designed to minimize vibration effect and to provide elimination of this effect.
   c. Minimum turndown ratio shall be 20:1 for gasses and liquids. Maximum fluid pressure drop shall be as scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Cabling
1. Install Category 5e UTP, Category 6 UTP, and optical fiber cabling system as detailed in TIA-568-C.1, TIA/EIA-568-B.2, or TIA-568-C.3.
2. Screw terminals shall not be used except where specifically indicated on plans.
3. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations.
4. Do not untwist Category 5e, Category 6 UTP cables more than 12 mm (1/2 inch) from the point of termination to maintain cable geometry.
5. Provide service loop on each end of the cable, 3 m (10 feet) at the server rack and 304 mm (12 inches) at the meter.
6. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables.
7. Provide a device to monitor cable pull tensions. Do not exceed 110 N (25 pounds) pull tension for four pair copper cables.
8. Do not chafe or damage outer jacket materials.
9. Use only lubricants approved by cable manufacturer.
10. Do not over cinch cables, or crush cables with staples.

11. For UTP cable, bend radii shall not be less than four times the cable diameter.
12. Cables shall be terminated; no cable shall contain unterminated elements.
13. Cables shall not be spliced.
14. Label cabling in accordance with paragraph Labeling in this section.

B. Labeling

1. Labels: Provide labeling in accordance with TIA/EIA-606-A. Handwritten labeling is unacceptable. Stenciled lettering for all circuits shall be provided using laser printer.
2. Cables: Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA/EIA-606-A.

C. Grounding: ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and grounding conductor of nonmetallic sheathed cables, as well as equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Surge Protection

1. Provide surge protective devices on all metallic cables entering and leaving an interior environment to an exterior environment or vice versa, i.e. surge protective device at each interior location of a penetration to the exterior environment.

E. Network Hardware

1. System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable wired or wireless data transmission system shall be provided and shall be fully integrated with the configured network chosen for the project.

F. Electrical Meters

1. Power monitoring and control components shall all be factory installed, wired and tested prior to shipment to the job site.
2. All control power, CT, PT and data communications wire shall be factory wired and harnessed within the equipment enclosure.
3. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer’s drawings must clearly

identify the interconnection requirements including wire type to be used.

4. All wiring required to externally connect separate equipment lineups shall be furnished and installed at the site as part of the contractor’s responsibility.
5. Contractor interconnection wiring requirements shall be clearly identified on the power monitoring and control system shop drawings.

G. Water, Oil and Gas Meters
   1. Thermowells
      a. Install thermowells with socket extending a minimum of 2 inches into fluid or one-third of pipe diameter and in vertical position in piping tees.
      b. Install thermowells of sizes required to match temperature sensor connectors. Include bushings if required to match sizes.
      c. Install thermowells with extension on insulated piping.
      d. Fill thermowells with heat-transfer medium.
   2. Provide a test plug beside each temperature sensor.
   3. Flow meters, general
      a. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.
      b. Connect flowmeter-system elements to meters, connect flowmeter transmitters to meters, and connect thermal-energy meter transmitters to meters.
      c. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
      d. Install flowmeter elements in accessible positions in piping systems.
      e. Install flowmeter, with minimum 20 x pipe diameter straight lengths of pipe upstream and minimum 10 x pipe diameter straight lengths of pipe downstream from flowmeter unless otherwise indicated by manufacturer’s written instructions.
      f. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

3.2 ADJUSTING AND IDENTIFICATION

A. Install a permanent wire marker on each wire at each termination.

B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.

C. Wire markers shall retain their markings after cleaning.

3.3 FIELD QUALITY CONTROL

A. The power monitoring and control system vendor must be able to provide development, integration and installation services required to complete and turn over a fully functional system including:

1. Project management to coordinate personnel, information and on-site supervision for the various levels and functions of suppliers required for completion of the project.
2. All technical coordination, installation, integration, and testing of all components.
3. Detailed system design and system drawings.

B. Cabling, equipment and hardware manufacturers shall have a minimum of 5 years experience in the manufacturing, assembly, and factory testing of components which comply with EIA TIA/EIA-568-B.1, EIA TIA/EIA-568-B.2 and EIA TIA/EIA-568-B.3.

C. The network cabling contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified network cabling systems and equipment. The contractor shall demonstrate experience in providing successful systems within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful network cabling system installations.

1. Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

3.4 ACCEPTANCE TESTING

A. Develop testing procedures to address all specified functions and components of the Advanced Utility Metering System (AUMS). Testing shall demonstrate proper and anticipated responses to normal and abnormal operating conditions.

1. Provide skilled technicians to start and operate equipment.
2. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified in testing.
4. Provide all tools to start, check-out and functionally test equipment and systems.
5. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified in any testing
6. Review test procedures, testing and results with Government.

B. Testing checklists: Develop project-specific checklists to document the systems and all components are installed in accordance with the manufacturers recommendation and the Contract Documents.

C. Before testing, the following prerequisite items must be completed.
1. All related equipment has been started and start-up reports and checklists submitted and approved as ready for testing:
2. All associated system functions for all interlocking systems are programmed and operable per contract documents.
3. All punchlist items for the AUMS and equipment are corrected.
4. The test procedures reviewed and approved.
5. Safeties and operating ranges reviewed.

D. The following testing shall be included:
1. Demonstrate reporting of data and alarm conditions for each point and ensure that alarms are received at the assigned location, including Site Data Collection Device.
2. Demonstrate ability of software program to function for the intended application.
3. Demonstrate via graphed trends to show the reports are executed in correct manner.
4. Demonstrate that the meter readings are accurate using portable NIST traceable portable devices and calibrated valves in the piping system
5. Demonstrate that the systems perform during power loss and resumption of power.

E. Copper cables: Contractor shall provide all necessary testing equipment to test all copper network circuit cables. Tests shall conform to EIA/TIA 568B Permanent Link testing criteria. All testers are to be EIA/TIA 568B, Level IIe compliant. The primary field test parameters are:
1. Wire map: The wire map test is intended to verify pair to pin termination at each end and check for installation connectivity

errors. For each of the conductors in the cable, the wire map indicates:

a. Continuity to the remote end

b. Shorts between any two or more conductors

c. Crossed pairs

d. Reversed pairs

e. Split pairs

f. Any other mis-wiring

2. Length requirements: The maximum physical length of the basic link shall be 94 meters (including test equipment cords).
3. Insertion Loss: Worst case insertion loss relative to the maximum insertion loss allowed shall be reported.
4. Near-end crosstalk (NEXT) loss: Field tests of NEXT shall be performed at both ends of the test configuration.
5. Power sum near-end crosstalk (PSNEXT) loss
6. Equal-level far-end crosstalk (ELFEXT: Field tests of ELFEXT shall be performed at both ends of the test configuration
7. Power sum equal-level far-end crosstalk (PSELFEXT): Must be determined from both ends of the cable. Power sum Near End Crosstalk is not a category 3 parameter. For all frequencies from 1 to 100 MHz, the category 5e PSELFEXT of the cabling shall be measured in accordance with annex E of ANSI/TIA/EIA-568-B.2 and shall meet the values determined using equations (12) and (13) for the permanent link. PSELFEXT is not a required category 3 measurement parameter.
8. Return loss: Includes all the components of the link. The limits are based on the category of components and cable lengths. Return loss must be tested at both ends of the cable. Cabling return loss is not a required measurement for category 3 cabling.
9. Propagation delay and delay skew: Propagation delay is the time it takes for a signal to propagate from one end to the other. Propagation delay shall be measured in accordance with annex D of ANSI/TIA/EIA-568 B.2. The maximum propagation delay for all category permanent link configurations shall not exceed 498 ns measured at 10 MHz. Delay skew is a measurement of the signaling delay difference from the fastest pair to the slowest. Delay skew shall be measured in accordance with annex D of ANSI/TIA/EIA-568-B.2. The maximum delay skew for all category permanent link configurations shall not exceed 44 ns.

10. Administration: In addition to Pass/Fail indications, measured values of test parameters should be recorded in the administration system. Any reconfiguration of link components after testing may change the performance of the link and thus invalidates previous test results. Such links shall require retesting to regain conformance.
11. Test equipment connectors and cords: Adapter cords that are qualified and determined by the test equipment manufacturer to be suitable for permanent link measurements shall be used to attach the field tester to the permanent link under consideration.
12. Test setup: The permanent link test configuration is to be used by installers and users of data telecommunications systems to verify the performance of permanently installed cabling. A schematic representation of the permanent link is illustrated in figure 1. The permanent link consists of up to 90 m (295 ft) of horizontal cabling and one connection at each end and may also include an optional transition/consolidation point connection. The permanent link excludes both the cable portion of the field test instrument cord and the connection to the field test instrument.
13. Replace or repair and cables, connectors, and/or terminations found to be defective.
14. Repair, replace, and/or re-work any or all defective components to achieve cabling tests which meet or exceed 568B permanent link requirements prior to acceptance of the installation or payment for services.

F. Optical Fiber cables: Contractor shall provide all necessary testing equipment to test all optical fiber cables.

1. Attenuation Testing:
   a. Singlemode testing shall conform to TIA/EIA 526-7 Method A.1 single jumper reference and TIA/EIA 568-B-1 requirements for link segment testing.
   b. Multimode testing shall conform to TIA/EIA 526-14-A Method B single jumper reference and TIA/EIA 568-B-1 requirements for link segment testing.
   c. Attenuation testing shall be performed in one direction at each operating wavelength.
   d. Testing of backbone fiber optic cabling shall be performed from main telecommunications room to each telecommunications room.

e. Testing of horizontal fiber optic cabling shall be performed from telecommunications room to station outlet location.

f. Tester shall be capable of recording and reporting test reading in an electronic format.

2. OTDR Testing:

a. OTDR testing is required on all backbone fiber optic cables

b. The test shall be preformed as per the EIA/TIA 455-61.

c. Multimode testing shall be performed with a minimum 80 meter launch cable.

d. Singlemode testing shall be performed with a minimum of 500 meter launch cable.

e. Tests shall be performed on each fiber in each direction at both operating wavelengths.

3. Test report data shall reference cables by cable labeling standards. Tests shall be submitted on a 1.5mb, 3.5" DOS formatted floppy disk. Contractor shall provide tests in the native file format of the tester. Contractor shall provide all software needed to view, print, and edit tests.

4. Replace or repair and defective cables, connectors, terminations, etc.

5. Mated connector pairs shall have no more than 0.5dB loss. Fusion splices shall have no more than .15dB loss per splice. Cable attenuation shall be no more than 2% more than the attenuation of the cable on the reel as certified at the factory. Repair, replace, and/or rework any or all defective components to achieve specified test results prior to acceptance of the installation or payment for services.

G. Wireless Modems: Test system by sending 100,000 commands. Frame error rate shall not be greater than 5 out 100,000 commands.

3.5 DEMONSTRATION AND INSTRUCTION

A. Furnish the services of a factory-trained engineer or technician for a total of two four-hour classes to instruct designated Facility Information Technologies personnel. Instruction shall include cross connection, corrective, and preventive maintenance of the wired network system and connectivity equipment.

B. Before the System can be accepted by the VA, this training must be provided and executed. Training will be scheduled at the convenience of the Facilities Contracting Officer and Chief of Engineering Service.

C. On-site start-up and training of the advanced utility metering system shall include a complete working demonstration of the system with simulation of possible operating conditions that may be encountered.
   1. Include any documentation and hands-on exercises necessary to enable electrical and mechanical operations personnel to assume full operating responsibility for the advanced utility monitoring system after completion of the training period.
D. Include 6 days on-site start-up assistance and 3 days on-site training in two sessions separated by minimum 1 month.
E. Regularly schedule and make available factory training for VA staff training on all aspects of advanced utility metering system including:
   1. Comprehensive software and hardware setup, configuration, and operation.
   2. Advanced monitoring and data reporting.
   3. Advanced power quality and disturbance monitoring.
F. Before the system is accepted by the VA, the contractor shall walk-through the installation with the VA's representative and the design engineer to verify proper installation. The contractor may be requested to open enclosures and terminal compartments to verify cable labeling and/or installation compliance.
G. As-built drawings shall be provided noting the exact cable path and cable labeling information. Drawings in .DWG format will be available to the contractor. As-builts shall be submitted to the VA on disk saved as .DXF or .DWG files. Redline hardcopies shall be provided as well. CAD generated as-built information shall be shown on a new layer named AS_BUILT.

----- END -----

SECTION 26 05 11
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section applies to all sections of Division 26.

B. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, conductors and cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on the drawings.

C. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2 RELATED WORK

A. Section 01 91 00,GENERAL COMMISSIONING REQUIREMENTS.

B. Section 26 08 00,COMMISSIONING OF ELECTRICAL SYSTEMS.

1.3 MINIMUM REQUIREMENTS

A. The International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.

B. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.4 TEST STANDARDS

A. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:
   1. Listed: Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
   2. Labeled: Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
   3. Certified: Materials and equipment which:
      a. Have been tested and found by a NRTL to meet nationally recognized standards or to be safe for use in a specified manner.
      b. Are periodically inspected by a NRTL.
      c. Bear a label, tag, or other record of certification.
   4. Nationally Recognized Testing Laboratory: Testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

1.5 QUALIFICATIONS (PRODUCTS AND SERVICES)

A. Manufacturer’s Qualifications: The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.

B. Product Qualification:
   1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.
   2. The Government reserves the right to require the Contractor to submit a list of installations where the materials and equipment have been in operation before approval.

1.6 APPLICABLE PUBLICATIONS

A. Applicable publications listed in all Sections of Division 26 are the latest issue, unless otherwise noted.

B. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.7 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available.

B. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.
2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
3. Components shall be compatible with each other and with the total assembly for the intended service.
4. Constituent parts which are similar shall be the product of a single manufacturer.

D. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.

1.8 VARIATIONS FROM CONTRACT REQUIREMENTS

A. Where the Government or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.9MATERIALS AND EQUIPMENT PROTECTION

a. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.

i. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.

ii. During installation, equipment shall be protected against entry of foreign matter, and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.

iii. Damaged equipment shall be repaired or replaced, as determined by the Resident Engineer.

iv. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.

v. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.10WORK PERFORMANCE

A. All electrical work shall comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J – General Environmental Controls, OSHA Part 1910 subpart K – Medical and First Aid, and OSHA Part 1910 subpart S – Electrical, in addition to other references required by contract.

B. Job site safety and worker safety is the responsibility of the Contractor.

C. Electrical work shall be accomplished with all affected circuits or equipment de-energized.

C. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of the facility. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.

D. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.

E. Coordinate location of equipment and conduit with other trades to minimize interference.

1.11 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Equipment location shall be as close as practical to locations shown on the drawings.

B. Working clearances shall not be less than specified in the NEC.

C. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the

equipment shall be removed and reinstalled as directed at no additional cost to the Government.

2. "Readily accessible” is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

D. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company’s system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company’s system, and obtain electric utility company approval for sizes and settings of these devices.

1.12 EQUIPMENT IDENTIFICATION

A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers, fused and non-fused safety switches, generators, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.

B. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

C. Install adhesive arc flash warning labels on all equipment as required by NFPA 70E. Label shall indicate the arc hazard boundary (inches), working distance (inches), arc flash incident energy at the working distance (calories/cm2), required PPE category and description including the glove rating, voltage rating of the equipment, limited approach distance (inches), restricted approach distance (inches), prohibited approach distance (inches), equipment/bus name, date prepared, and manufacturer name and address.

1.13 SUBMITTALS

A. Submit to the Resident Engineer in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. The Government's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.

C. All submittals shall include six copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Government to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.

D. The submittals shall include the following:

   1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.

E. Maintenance and Operation Manuals:

   1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.

   2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the material or equipment.

   3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.

   4. The manuals shall include:

a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
b. A control sequence describing start-up, operation, and shutdown.
c. Description of the function of each principal item of equipment.
d. Installation instructions.
e. Safety precautions for operation and maintenance.
f. Diagrams and illustrations.
g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.
h. Performance data.
i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.
j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

F. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.

1.14 ACCEPTANCE CHECKS AND TESTS

A. The Contractor shall furnish the instruments, materials, and labor for tests.

B. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various manufacturer’s representatives and technicians so that a complete, functional, and operational system is delivered to the Government.

C. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment, and repeat the tests. Repair, replacement, and retesting shall be accomplished at no additional cost to the Government.

1.15 WARRANTY

A. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer for the Government.

1.16 INSTRUCTION

A. Instruction to designated Government personnel shall be provided for the particular equipment or system as required in each associated technical specification section.

PART 2 - PRODUCTS (Not used)

PART 3 - EXECUTION (NOT USED)

---END---

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2 RELATED WORK

A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
B. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-resistant rated construction.
C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for conductors and cables.
E. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. Conductors and cables shall be thoroughly tested at the factory per NEMA to ensure that there are no electrical defects. Factory tests shall be certified.

1.5 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
   1. Shop Drawings:
      a. Submit sufficient information to demonstrate compliance with drawings and specifications.
      b. Submit the following data for approval:
         1) Electrical ratings and insulation type for each conductor and cable.
         2) Splicing materials and pulling lubricant.
   2. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.
b. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.

B. American Society of Testing Material (ASTM):

D2301-10................Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

D2304-10................Test Method for Thermal Endurance of Rigid Electrical Insulating Materials

D3005-10................Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

C. National Electrical Manufacturers Association (NEMA):

WC 70-09................Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

D. National Fire Protection Association (NFPA):

70-11...................National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

44-10...................Thermoset-Insulated Wires and Cables

83-08...................Thermoplastic-Insulated Wires and Cables

467-07..................Grounding and Bonding Equipment

486A-486B-03............Wire Connectors

486C-04.................Splicing Wire Connectors

486D-05.................Sealed Wire Connector Systems

486E-09.................Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

493-07..................Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables

514B-04.................Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Conductors and cables shall be in accordance with NEMA, UL, as specified herein, and as shown on the drawings.

B. All conductors shall be copper.

C. Single Conductor and Cable:

1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.
2. No. 8 AWG and larger: Stranded.
3. No. 10 AWG and smaller: Solid; except shall be stranded for final connection to motors, transformers, and vibrating equipment.
4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

D. Color Code:

1. No. 10 AWG and smaller: Solid color insulation or solid color coating.
2. No. 8 AWG and larger: Color-coded using one of the following methods:
   a. Solid color insulation or solid color coating.
   b. Stripes, bands, or hash marks of color specified.
   c. Color using 19 mm (0.75 inches) wide tape.
4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.
5. Conductors shall be color-coded as follows:

208/120 V	Phase	480/277 V
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

2.2 SPLICES

A. Splices shall be in accordance with NEC and UL.

B. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.

2.3 CONNECTORS AND TERMINATIONS

A. Mechanical type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.

B. Long barrel compression type of high conductivity and corrosion-resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

C. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be zinc-plated cadmium-plated steel.

2.4 CONTROL WIRING

A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG.

B. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5 WIRE LUBRICATING COMPOUND

A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.

PART 3 - EXECUTION

3.1 GENERAL

A. Install conductors in accordance with the NEC, as specified, and as shown on the drawings.

B. Install all conductors in raceway systems.

C. Splice conductors only in outlet boxes, junction boxes, pullboxes, manholes, or handholes.

D. Conductors of different systems (e.g., 120 V and 277 V) shall not be installed in the same raceway.

E. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.

F. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic ties.

G. For connections to motors, transformers, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, transformers, or vibrating equipment.

H. Use expanding foam or non-hardening duct-seal to seal conduits entering a building, after installation of conductors.

I. Conductor and Cable Pulling:

   1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.
   2. Use nonmetallic pull ropes.
   3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.
   4. All conductors in a single conduit shall be pulled simultaneously.
   5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

J. No more than three branch circuits shall be installed in any one conduit.

K. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2 SPLICE AND TERMINATION INSTALLATION

A. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer's published torque values using a torque screwdriver or wrench.

B. Where the Government determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Government.

3.3 CONDUCTOR IDENTIFICATION

A. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes, pullboxes, and manholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

3.4 FEEDER CONDUCTOR IDENTIFICATION

A. In each interior pullbox and each underground manhole and handhole, install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

3.5 EXISTING CONDUCTORS

A. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.6 CONTROL WIRING INSTALLATION

A. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings.

B. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.9 DIRECT BURIAL CABLE INSTALLATION

A. Work with extreme care near existing ducts, conduits, cables, and other utilities to prevent any damage.

B. Provide horizontal slack in the cables for contraction during cold weather.

C. Install the cables in continuous lengths. Splices within cable runs shall not be accepted.

D. Connections and terminations shall be listed submersible-type designed for the cables being installed.

3.10 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests: Inspect physical condition.
2. Electrical tests:
    a. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors phase-to-phase and phase-to-ground resistance with an insulation resistance tester. Existing conductors to be reused shall also be tested.

---END---

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.

B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

B. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.

C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.

D. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:
   a. Size and location of main feeders.
   b. Size and location of panels and pull-boxes.
   c. Layout of required conduit penetrations through structural elements.
   d. Submit the following data for approval:
      1) Raceway types and sizes.
      2) Conduit bodies, connectors and fittings.
      3) Junction and pull boxes, types and sizes.
2. Certifications: Two weeks prior to final inspection, submit the following:
   a. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

C80.1-05 Electrical Rigid Steel Conduit

C80.3-05 ....Steel Electrical Metal Tubing

C80.6-05 ....Electrical Intermediate Metal Conduit

C. National Fire Protection Association (NFPA):

70-11.............National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

1-05 Flexible Metal Conduit

5-11 Surface Metal Raceway and Fittings

6-07 Electrical Rigid Metal Conduit - Steel

50-95 Enclosures for Electrical Equipment

360-13 Liquid-Tight Flexible Steel Conduit

467-13 Grounding and Bonding Equipment

514A-13 Metallic Outlet Boxes

514B-12 Conduit, Tubing, and Cable Fittings

514C-07...........Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers

651-11............Schedule 40 and 80 Rigid PVC Conduit and Fittings

651A-11 Type EB and A Rigid PVC Conduit and HDPE Conduit

797-07 Electrical Metallic Tubing

1242-06 Electrical Intermediate Metal Conduit - Steel

E. National Electrical Manufacturers Association (NEMA):

TC-2-13 ....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

TC-3-13 PVC Fittings for Use with Rigid PVC Conduit and Tubing

FB1-12 Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

FB2.10-13 Selection and Installation Guidelines for Fittings for use with Non-Flexible Conduit or Tubing (Rigid Metal Conduit, Intermediate

Metallic Conduit, and Electrical Metallic Tubing)

FB2.20-12.........Selection and Installation Guidelines for Fittings for use with Flexible Electrical Conduit and Cable

F. American Iron and Steel Institute (AISI):

S100-2007 North American Specification for the Design of Cold-Formed Steel Structural Members

PART 2 - PRODUCTS

2.1 MATERIAL

A. Conduit Size: In accordance with the NEC, but not less than 0.5 in 13 mm] unless otherwise shown. Where permitted by the NEC, 0.5 in [13 mm] flexible conduit may be used for tap connections to recessed lighting fixtures.

B. Conduit:

1. Electrical metallic tubing (EMT): Shall conform to UL 797 and ANSI C80.3. Maximum size not to exceed 4 in [105 mm] and shall be permitted only with cable rated 600 V or less.
2. Liquid-tight flexible metal conduit: Shall conform to UL 360.
3. Surface metal raceway: Shall conform to UL 5.

C. Conduit Fittings:

1. Electrical metallic tubing fittings:
   a. Fittings and conduit bodies shall meet the requirements of UL 514B, ANSI C80.3, and NEMA FB1.
   b. Only steel or malleable iron materials are acceptable.
   c. Setscrew couplings and connectors: Use setscrews of case-hardened steel with hex head and cup point, to firmly seat in wall of conduit for positive grounding.
   d. Indent-type connectors or couplings are prohibited.
   e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
2. Flexible steel conduit fittings:
   a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
   b. Clamp-type, with insulated throat.
3. Liquid-tight flexible metal conduit fittings:
   a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
   b. Only steel or malleable iron materials are acceptable.
   c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.

4. Direct Burial Plastic Conduit Fittings: Fittings shall meet the requirements of UL 514C and NEMA TC3
5. Surface metal raceway fittings: As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.
6. Expansion and deflection couplings:
   a. Conform to UL 467 and UL 514B.
   b. Accommodate a 0.75 in [19 mm] deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
   c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the NEC tables for equipment grounding conductors.
   d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.

D. Conduit Supports:
1. Parts and hardware: Zinc-coat or provide equivalent corrosion protection.
2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
3. Multiple conduit (trapeze) hangers: Not less than 1.5 x 1.5 in [38 mm x 38 mm], 12-gauge steel, cold-formed, lipped channels; with not less than 0.375 in [9 mm] diameter steel hanger rods.
4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.

E. Outlet, Junction, and Pull Boxes:
1. UL-50 and UL-514A.
2. Cast metal where required by the NEC or shown, and equipped with rustproof boxes.
3. Sheet metal boxes: Galvanized steel, except where otherwise shown.
4. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.

F. Wireways: Equip with hinged covers, except where removable covers are shown. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

A. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.

3.2 INSTALLATION, GENERAL

A. In accordance with UL, NEC, NEMA, as shown on drawings, and as specified herein.

B. Raceway systems used for Essential Electrical Systems (EES) shall be entirely independent of other raceway systems.

C. Install conduit as follows:

1. In complete mechanically and electrically continuous runs before pulling in cables or wires.
2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.
3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new undamaged material.
4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
5. Cut square, ream, remove burrs, and draw up tight.
6. Independently support conduit at 8 ft [2.4 M] on centers. Do not use other supports, i.e., suspended ceilings, suspended ceiling supporting members, lighting fixtures, conduits, mechanical piping, or mechanical ducts.
7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.
8. Support within 12 in [300 mm] of changes of direction, and within 12 in [300 mm] of each enclosure to which connected.
9. Close ends of empty conduit with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
10. Conduit installations under fume and vent hoods are prohibited.
11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts.
12. Flashing of penetrations of the roof membrane shall be performed as specified in roof manufacturer’s recommendations.

13. Conduit bodies shall only be used for changes in direction, and shall not contain splices.

D. Conduit Bends:
   1. Make bends with standard conduit bending machines.
   2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.
   3. Bending of conduits with a pipe tee or vise is prohibited.

3.3 CONCEALED WORK INSTALLATION

A. Above Furred or Suspended Ceilings and in Walls:
   1. Align and run conduit parallel or perpendicular to the building lines.
   2. Tightening setscrews with pliers is prohibited.
   3. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 457 mm (18 inches). Cuts or notches in flanges or return lips shall not be permitted.

3.4 EXPOSED WORK INSTALLATION

A. Unless otherwise indicated on the drawings, exposed conduit is only permitted in mechanical and electrical rooms.

C. Conduit for Conductors 600 V and Below: EMT. Mixing different types of conduits indiscriminately in the system is prohibited.

D. Align and run conduit parallel or perpendicular to the building lines.

E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.

F. Support horizontal or vertical runs at not over 8 ft [2.4 M] intervals.

G. Surface metal raceways: Use only where shown.

3.7 WET OR DAMP LOCATIONS

A. Use rigid steel or IMC conduits unless as shown on drawings.

B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.

C. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

D. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.8 MOTORS AND VIBRATING EQUIPMENT

A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.

B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water. Provide a green equipment grounding conductor with flexible metal conduit.

C. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.9 EXPANSION JOINTS

A. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.

B. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.

C. Install expansion and deflection couplings where shown.

3.10 CONDUIT SUPPORTS, INSTALLATION

A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.

B. Use pipe straps or individual conduit hangers for supporting individual conduits.

C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and 200 lbs [90 kg]. Attach each conduit with U-bolts or other approved fasteners.

D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.

E. Fasteners and Supports in Solid Masonry and Concrete:

   1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.

2. Existing Construction:
   a. Steel expansion anchors not less than 0.25 in [6 mm] bolt size and not less than 1.125 in [28 mm] embedment.
   b. Power set fasteners not less than 0.25 in [6 mm] diameter with depth of penetration not less than 3 in [75 mm].
   c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.

E. Hollow Masonry: Toggle bolts.

F. Bolts supported only by plaster or gypsum wallboard are not acceptable.

G. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

H. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.

I. Chain, wire, or perforated strap shall not be used to support or fasten conduit.

J. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.

K. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION

A. Boxes for Concealed Conduits:
   1. Flush-mounted.
   2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.

B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.

C. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.

D. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.

E. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 24 in [600 mm] center-to-center lateral spacing shall be maintained between boxes.

F. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall.

Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.

G. Minimum size of outlet boxes for ground fault interrupter (GFI) receptacles is 4 in [100 mm] square x 2.125 in [55 mm] deep, with device covers for the wall material and thickness involved.

H. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."

I. On all branch circuit junction box covers, identify the circuits with black marker.

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SECTION 26 05 36
CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
   1. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
   2. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS.

1.2 SUMMARY

A. Section Includes:

   1. Ladder cable trays.
   2. Wire-basket cable trays.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

   1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

   1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

C. Delegated-Design Submittal: For seismic restraints.

   1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.
   3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.
4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.5.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAYS

A. Manufacturers:

1. Cooper B-Line, Inc.
2. Or equal.

B. Description:

1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
2. Rung Spacing: 6 inches (150 mm) o.c.
3. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
5. No portion of the rungs shall protrude below the bottom plane of side rails.
6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
7. Minimum Usable Load Depth: 6 inches (150 mm).
8. Straight Section Lengths: 20 feet (6 m) except where shorter lengths are required to facilitate tray assembly.
9. Width: 24 inches (600 mm) unless otherwise indicated on Drawings.
10. Fitting Minimum Radius: 24 inches (600 mm).
11. Class Designation: Comply with NEMA VE 1, Class 20C.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Hardware and Fasteners: Hot dipped galvanized steel.
14. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
15. Materials: Hot-dipped galvanized steel.

2.4 WIRE-BASKET CABLE TRAYS

A. Manufacturers: Cablofil/Legrande.
2. Or equal.

B. Description:

1. Configuration: Wires are formed into a standard 2-by-4-inch (50-by-100-mm) wire mesh pattern with intersecting wires welded

together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.

2. Materials: High-strength-steel longitudinal wires with no bends. (Hot-dipped galvanized).
3. Safety Provisions: Wire ends along wire-basket sides (flanges) rounded during manufacturing to maintain integrity of cables and installer safety.
4. Sizes:

    a. Straight sections shall be furnished in standard 118-inch (3000-mm) lengths.
    b. Wire-Basket Depth: 2-inch (50-mm) usable loading depth by 12 inches (300 mm) wide.

5. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings.
6. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
7. Hardware and Fasteners: Hot-dipped galvanized.

2.5 MATERIALS AND FINISHES

A. Aluminum:
    1. Finish: Aluminum.

2.6 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Covers: Solid 2-in-3 pitch type made of same materials and with same finishes as cable tray where indicated.

C. Barrier Strips: Same materials and finishes as for cable tray.

D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.7 WARNING SIGNS

A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA VE 2.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Fasten cable tray supports to building structure and install seismic restraints.

F. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb (90 kg).

G. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

I. Support bus assembly to prevent twisting from eccentric loading.

J. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

K. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.

L. Support wire-basket cable trays with center support hangers.

M. Support center support hangers for wire-basket trays with 3/8-inch- (10-mm-) diameter rods.

N. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

O. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.

P. Make changes in direction and elevation using manufacturer's recommended fittings.

Q. Make cable tray connections using manufacturer's recommended fittings.

R. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 84 00 "FIRESTOPPING."

S. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

T. Install cable trays with enough workspace to permit access for installing cables.

U. Install barriers as indicated on drawings, such as power, communications, and data processing.

V. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified.

B. Bond cable trays to power source and panels for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

C. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage as recommended by cable tray manufacturer.

END OF SECTION

SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of underground ducts and raceways, and precast manholes and pullboxes to form a complete underground electrical raceway system.

B. The terms “duct” and “conduit” are used interchangeably in this section.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Coordinate layout and installation of ducts, manholes, and pullboxes with final arrangement of other utilities, site grading, and surface features.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:
    a. Submit sufficient information to demonstrate compliance with drawings and specifications.
    b. Submit information on manholes, pullboxes, ducts, and hardware. Submit manhole plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories.
    c. Proposed deviations from the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes, pullboxes, or duct banks at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit to the Resident Engineer for approval prior to construction.
2. Certifications: Two weeks prior to the final inspection, submit the following.

a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
b. Certification by the Contractor that the materials have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Concrete Institute (ACI):
Building Code Requirements for Structural Concrete
318-11/318M-11..........Building Code Requirements for Structural Concrete & Commentary
SP-66-04................ACI Detailing Manual

C. American National Standards Institute (ANSI):
77-10...................Underground Enclosure Integrity

D. American Society for Testing and Materials (ASTM):
C478-12.................Standard Specification for Precast Reinforced Concrete Manhole Sections
C858-10e1...............Underground Precast Concrete Utility Structures
C990-09.................Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.

E. National Electrical Manufacturers Association (NEMA):
TC 2-03.................Electrical Polyvinyl Chloride (PVC) Conduit
TC 3-04.................Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit And Tubing
TC 6 & 8-03.............Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installations
TC 9-04.................Fittings For Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installation

F. National Fire Protection Association (NFPA):
70-11...................National Electrical Code (NEC)
70E-12..................National Electrical Safety Code

G. Underwriters Laboratories, Inc. (UL):
6-07....................Electrical Rigid Metal Conduit-Steel
467-07..................Grounding and Bonding Equipment

651-11..................Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

651A-11.................Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit

651B-07.................Continuous Length HDPE Conduit

PART 2 - PRODUCTS

2.1 PULLBOXES

A. General: Size as indicated on the drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC or SIGNAL as applicable. Pullboxes shall comply with the requirements of ANSI 77 Tier 5 or Tier 8. Tier 15 for driveways and paking lots. Provide pulling irons, 22 mm (0.875 inch) diameter galvanized steel bar with exposed triangular-shaped opening.

B. Fiberglass Pullboxes: Shall be sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

2.3 DUCTS

A. Number and sizes shall be as shown on the drawings.

B. Ducts (concrete-encased):

1. Plastic Duct:
   a. UL 651 and 651A Schedule 40 PVC conduit.
   b. Duct shall be suitable for use with 90˚ C (194˚ F) rated conductors.
2. Conduit Spacers: Prefabricated plastic.

2.4 GROUNDING

A. Ground Rods and Ground Wire: NFPA 70.

2.5 CONCRETE DYEE

A. All concrete shall be dyed red.

2.6 PULL ROPE FOR SPARE DUCTS

A. Plastic with 890 N (200 lb) minimum tensile strength.

PART 3 - EXECUTION

3.1 PULLBOX INSTALLATION

A. Assembly and installation shall be per the requirements of the manufacturer.

1. Install pullboxes level and plumb.

2. Units shall be installed on a 300 mm (12 inches) thick level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inches) sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.

B. Access: Ensure the top of frames and covers are flush with finished grade.

3.2 TRENCHING

A. Before performing trenching work at existing facilities, a Ground Penetrating Radar Survey shall be carefully performed by a certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.

B. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.

C. Cut the trenches neatly and uniformly.

D. For Concrete-Encased Ducts:

1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1.2 M (4 foot) intervals to establish the grade and route of the duct bank.
2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.
3. The walls of the trench may be used to form the side walls of the duct bank, provided that the soil is self-supporting and that the concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.
4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.

E. Individual conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place using rigid metal conduit, or bored using plastic utilities duct or PVC conduit, as approved by the Resident Engineer.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC, as shown on the drawings, and as specified.
2. Join and terminate ducts with fittings recommended by the manufacturer.

3. Slope ducts to drain towards pullboxes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inch) in 30 M (100 feet).
4. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) outside the building foundation. Tops of conduits below building slab shall be minimum 610 mm (24 inches) below bottom of slab.
5. Stub-ups and sweeps to equipment mounted on outdoor concrete slabs shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.
6. Install insulated grounding bushings on the conduit terminations.
7. Radius for sweeps shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 1.5 M (5 feet). Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during concrete pour. Tie wires shall not act as substitute for spacers.
9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, chilled water.
10. Clearances between individual ducts:
    a. For similar services, not less than 75 mm (3 inches).
    b. For power and signal services, not less than 150 mm (6 inches).
12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
14. Spare Ducts: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
15. Duct Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts before backfilling

trenches. Warning tape shall be preprinted with proper identification.

16. Duct Sealing: Seal ducts, including spare ducts, at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of foreign objects and material, moisture, and gases.
17. Use plastic ties to secure cables to insulators on cable arms. Use minimum two ties per cable per insulator.

B. Concrete-Encased Ducts:

1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
2. Duct banks shall be single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
3. Tops of concrete-encased ducts shall be:
   a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
   b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
   c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
   d. Conduits crossing under grade slab construction joints shall be installed a minimum of 1.2 M (4 feet) below slab.
4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts.
5. Within 3 M (10 feet} of building and manhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
7. Where new ducts and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 150 mm (6 inches) vertically.

9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 19 mm (0.75 inch) reinforcing rod dowels extending 450 mm (18 inches) into concrete on both sides of joint near corners of envelope.
10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by Resident Engineer.

C. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.

D. Partially-Completed Ducts: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable plugs. Fit concrete envelope of a partially completed ducts with reinforcing steel extending a minimum of 600 mm (2 feet) back into the envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (12 inches) apart. Restrain reinforcing assembly from moving during pouring of concrete.

3.4 ACCEPTANCE CHECKS AND TESTS

A. Duct Testing and Cleaning:

1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct, and to test for out-of-round conditions.
2. The mandrel shall be not less than 300 mm (12 inches) long, and shall have a diameter not less than 13 mm (0.5 inch) less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.
3. If testing reveals obstructions or out-of-round conditions, the Contractor shall replace affected section(s) of duct and retest to the satisfaction of the Resident Engineer at no cost to the Government.

4. Mandrel pulls shall be witnessed by the Resident Engineer.

---END---

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 26.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIRMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

A. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

1.3 SUMMARY

A. This Section includes requirements for commissioning the Facility electrical systems, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.

B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 26 is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 26, is required in cooperation with the VA and the Commissioning Agent.

B. The Facility electrical systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of Electrical systems will require inspection of individual elements of the electrical systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule electrical systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 26 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Resident Engineer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the Resident Engineer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 26 Sections for additional Contractor training requirements.----- END -----

SECTION 26 29 11

MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of motor controllers, including all low- and medium-voltage motor controllers and manual motor controllers, indicated as motor controllers in this section, and low-voltage variable speed motor controllers.

B. Motor controllers, whether furnished with the equipment specified in other sections or otherwise (with the exception of elevator motor controllers specified in Division 14 and fire pump controllers specified in Division 21), shall meet this specification and all related specifications.

1.2 RELATED WORK

A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

D. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:

    a. Submit sufficient information to demonstrate compliance with drawings and specifications.

    b. Include electrical ratings, dimensions, weights, mounting details, materials, overcurrent protection devices, overload relays, sizes of enclosures, wiring diagrams, starting characteristics, interlocking, and accessories.

2. Manuals:

a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
   1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
   2) Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.
   3) Elementary schematic diagrams shall be provided for clarity of operation.
   4) Include the catalog numbers for the correct sizes of overload relays for the motor controllers.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the motor controllers conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the motor controllers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

B. Institute of Electrical and Electronic Engineers (IEEE):

519-92..................Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

C37.90.1-02.............Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

C. International Code Council (ICC):

IBC-12..................International Building Code

D. National Electrical Manufacturers Association (NEMA):

ICS 1-08................Industrial Control and Systems: General Requirements

ICS 1.1-09..............Safety Guidelines for the Application, Installation and Maintenance of Solid State Control

ICS 2-05................Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts

ICS 4-05................Industrial Control and Systems: Terminal Blocks

ICS 6-06................Industrial Control and Systems: Enclosures

ICS 7-06................Industrial Control and Systems: Adjustable-Speed Drives

ICS 7.1-06..............Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems

MG 1 Part 31............Inverter Fed Polyphase Motor Standards

E. National Fire Protection Association (NFPA):

70-11...................National Electrical Code (NEC)

F. Underwriters Laboratories Inc. (UL):

508A-07.................Industrial Control Panels

508C-07.................Power Conversion Equipment

UL 1449-06..............Surge Protective Devices

PART 2 - PRODUCTS

2.1 MOTOR CONTROLLERS

A. Motor controllers shall comply with IEEE, NEMA, NFPA, UL, and as shown on the drawings.

B. Motor controllers shall be separately enclosed, unless part of another assembly. For installation in motor control centers, provide plug-in, draw-out type motor controllers up through NEMA size 4. NEMA size 5 and above require bolted connections.

C. Motor controllers shall be combination type, with magnetic controller per Paragraph 2.3 below and with circuit breaker disconnecting means, with external operating handle with lock-open padlocking positions and ON-OFF position indicator.

1. Circuit Breakers:

   a. Bolt-on thermal-magnetic type with a minimum interrupting rating as indicated on the drawings.

   b. Equipped with automatic, trip free, non-adjustable, inverse-time, and instantaneous magnetic trips for less than 400A. The magnetic trip shall be adjustable from 5x to 10x for breakers 400A and greater.

c. Additional features shall be as follows:
   1) A rugged, integral housing of molded insulating material.
   2) Silver alloy contacts.
   3) Arc quenchers and phase barriers for each pole.
   4) Quick-make, quick-break, operating mechanisms.
   5) A trip element for each pole, a common trip bar for all poles, and one operator for all poles.

D. Enclosures:
1. Enclosures shall be NEMA-type rated 1, 3R, or 12 as indicated on the drawings or as required per the installed environment.
2. Enclosure doors shall be interlocked to prevent opening unless the disconnecting means is open. A "defeater" mechanism shall allow for inspection by qualified personnel with the disconnect means closed. Provide padlocking provisions.
3. All metal surfaces shall be thoroughly cleaned, phosphatized, and factory primed prior to applying light gray baked enamel finish.

E. Motor control circuits:
1. Shall operate at not more than 120 Volts.
2. Shall be grounded, except where the equipment manufacturer recommends that the control circuits be isolated.
3. For each motor operating over 120 Volts, incorporate a separate, heavy duty, control transformer within each motor controller enclosure.
4. Incorporate primary and secondary overcurrent protection for the control power transformers.

F. Overload relays:
1. One for each pole.
2. External overload relay reset pushbutton on the door of each motor controller enclosure.
3. Overload relays shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
4. Thermal overload relays shall be tamperproof, not affected by vibration, manual reset, sensitive to single-phasing, and shall have selectable trip classes of 10, 20 and 30.//

G. Hand-Off-Automatic (H-O-A) switch is required unless specifically stated on the drawings as not required for a particular controller. H-O-A switch shall be operable without opening enclosure door. H-O-A switch is not required for manual motor controllers.

H. Incorporate into each control circuit a 120 Volt, electronic time-delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection. Time-delay relay is not required where H-O-A switch is not required.

I. Unless noted otherwise, equip each motor controller with not less than two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts.

J. Provide green (RUN) and red (STOP) pilot lights.

K. Motor controllers incorporated within equipment assemblies shall also be designed for the specific requirements of the assemblies.

L. Additional requirements for specific motor controllers, as indicated in other specification sections, shall also apply.

2.2 LOW-VOLTAGE VARIABLE SPEED MOTOR CONTROLLERS (VSMC)

A. VSMC shall be in accordance with applicable portions of 2.1 above.

B. VSMC shall be electronic, with adjustable frequency and voltage, three phase output, capable of driving standard NEMA B three-phase induction motors at full rated speed. The control technique shall be pulse width modulation (PWM), where the VSMC utilizes a full wave bridge design incorporating diode rectifier circuitry. Silicon controlled rectifiers or other control techniques are not acceptable.

C. VSMC shall be suitable for variable torque loads, and shall be capable of providing sufficient torque to allow the motor to break away from rest upon first application of power.

D. VSMC shall be capable of operating within voltage parameters of plus 10 to minus 15 percent of line voltage, and be suitably rated for the full load amps of the maximum watts (HP) within its class.

E. Minimum efficiency shall be 95 percent at 100 percent speed and 85 percent at 50 percent speed.

F. The displacement power factor of the VSMC shall not be less than 95 percent under any speed or load condition.

G. VSMC current and voltage harmonic distortion shall not exceed the values allowed by IEEE 519.

H. VSMC shall have the following features:

1. Isolated power for control circuits.

2. Manually resettable overload protection for each phase.
3. Adjustable current limiting circuitry to provide soft motor starting. Maximum starting current shall not exceed 200 percent of motor full load current.
4. Independent acceleration and deceleration time adjustment, manually adjustable from 2 to 2000 seconds. Set timers to the equipment manufacturer's recommended time in the above range.
5. Control input circuitry that will accept 4 to 20 mA current or 0-10 VDC voltage control signals from an external source.
6. Automatic frequency adjustment from 1 Hz to 300 Hz.
7. Circuitry to initiate an orderly shutdown when any of the conditions listed below occur. The VSMC shall not be damaged by any of these electrical disturbances and shall automatically restart when the conditions are corrected. The VSMC shall be able to restart into a rotating motor operating in either the forward or reverse direction and matching that frequency.
   a. Incorrect phase sequence.
   b. Single phasing.
   c. Overvoltage in excess of 10 percent.
   d. Undervoltage in excess of 15 percent.
   e. Running overcurrent above 110 percent (VSMC shall not automatically reset for this condition.)
   f. Instantaneous overcurrent above 150 percent (VSMC shall not automatically reset for this condition).
   g. Short duration power outages of 12 cycles or less (i.e., distribution line switching, generator testing, and automatic transfer switch operations.)
11. Bidirectional Autospeed Search: Capable of starting VSMC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to VSMC, motor, or load.

I. VSMC shall include an input circuit breaker which will disconnect all input power, interlocked with the door so that the door cannot be opened with the circuit breaker in the closed position.

J. VSMC shall include a 5% line reactor and a RFI/EMI filter.

K. Surge Suppression: Provide three-phase protection against damage from supply voltage surges in accordance with UL 1449.

L. VSMC shall include front-accessible operator station, with sealed keypad and digital display, which allows complete programming, operating, monitoring, and diagnostic capabilities.
   1. Typical control functions shall include but not be limited to:
      a. HAND-OFF-AUTOMATIC-RESET, with manual speed control in HAND mode.
      b. NORMAL-BYPASS.
      c. NORMAL-TEST, which allows testing and adjusting of the VSMC while in bypass mode.
   2. Typical monitoring functions shall include but not be limited to:
      a. Output frequency (Hz).
      b. Motor speed and status (run, stop, fault).
      c. Output voltage and current.
   3. Typical fault and alarm functions shall include but not be limited to:
      a. Loss of input signal, under- and over-voltage, inverter overcurrent, motor overload, critical frequency rejection with selectable and adjustable deadbands, instantaneous line-to-line and line-to-ground overcurrent, loss-of-phase, reverse-phase, and short circuit.
      b. System protection indicators indicating that the system has shutdown and will not automatically restart.

M. VSMC shall include two N.O. and two N.C. dry contacts rated 120 Volts, 10 amperes, 60 Hz.

N. Hardware, software, network interfaces, gateways, and programming to control and monitor the VSMC by control systems specified in other specification sections, including but not limited to Divisions 22 and 23.

O. Network communications ports: As required for connectivity to control systems specified in other specification sections, including but not limited to Divisions 22 and 23.

P. Communications protocols: As required for communications with control systems specified in other specification sections, including but not limited to Divisions 22 and 23.

Q. Bypass controller: Provide contactor-style bypass, arranged to bypass the inverter.
   1. Inverter Output Contactor and Bypass Contactor: Load-break NEMA-rated contactor.
   2. Motor overload relays.

3. HAND-OFF-AUTOMATIC bypass control.

R. Bypass operation: Transfers motor between inverter output and bypass circuit, manually, automatically, or both. VSMC shall be capable of stable operation (starting, stopping, and running), and control by fire alarm and detection systems, with motor completely disconnected from the inverter output. Transfer between inverter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.

S. Inverter Isolating Switch: Provide non-load-break switch arranged to isolate inverter and permit safe troubleshooting and testing of the inverter, both energized and de-energized, while motor is operating in bypass mode. Include padlockable, door-mounted handle mechanism.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor controllers in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.

C. Install manual motor controllers in flush enclosures in finished areas.

D. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and electronic overload relay pickup and trip ranges.

E. Program variable speed motor controllers per the manufacturer’s instructions and in coordination with other trades so that a complete and functional system is delivered.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical, electrical, and mechanical condition.
   c. Verify appropriate anchorage, required area clearances, and correct alignment.
   d. Verify that circuit breaker, motor circuit protector, and fuse sizes and types correspond to approved shop drawings.
   e. Verify overload relay ratings are correct.
   f. Vacuum-clean enclosure interior. Clean enclosure exterior.
   g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
   h. Test all control and safety features of the motor controllers.

i. For low-voltage variable speed motor controllers, final programming and connections shall be by a factory-trained technician. Set all programmable functions of the variable speed motor controllers to meet the requirements and conditions of use.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the motor controllers are in good operating condition and properly performing the intended functions.

3.4 SPARE PARTS

A. Two weeks prior to the final inspection, provide one complete set of spare fuses for each motor controller.

3.5 INSTRUCTION

A. Furnish the services of a factory-trained technician for two 4-hour training periods for instructing personnel in the maintenance and operation of the motor controllers, on the dates requested by the Resident Engineer.

---END---