

DEPARTMENT OF VETERANS AFFAIRS

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SECTION 01 00 00
GENERAL REQUIREMENTS

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SECTION 01 00 00
GENERAL REQUIREMENTS

1.1 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 implementation of energy conservation measures at Bath VAMC as required by drawings and specifications.
- B. Visits to the site by Bidders may be made only by appointment with the Medical Center Engineering Officer.
- C. Offices of Bergmann Associates, 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 Resident Engineer 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 Resident Engineer.
- 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.
- F. Prior to commencing work, general contractor shall provide proof that a OSHA certified "competent person" (CP) (29 CFR 1926.20(b)(2)) will maintain a presence at the work site whenever the general or subcontractors are present.

G. Training:

1. All employees of general contractor or subcontractors shall have OSHA certified Construction Safety course and other relevant competency training, as determined by VA CP with input from the ICRA team.
2. Submit training records of all such employees for approval before the start of work.

1.2 STATEMENT OF BID ITEM(S)

- A. ITEM I, //GENERAL CONSTRUCTION://Implement ECM's:// Work includes general construction, alterations, mechanical and electrical work, utility systems and necessary removal of existing structures and construction and certain other items.

1.3 SPECIFICATIONS AND DRAWINGS FOR CONTRACTOR

- A. AFTER AWARD OF CONTRACT, 3 sets of specifications and drawings will be furnished.
- B. Additional sets of drawings may be made by the Contractor, at Contractor's expense, from prints furnished by Issuing Office. Such prints shall be returned to the Issuing Office immediately after printing is completed.

1.4 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. For working outside the "regular hours" as defined in the contract, The General Contractor shall give 3 days notice to the Contracting

Officer so that arrangement 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. Key Control:

1. The General Contractor shall provide duplicate keys and lock combinations to the Resident Engineer for the purpose of security inspections of every area of project including tool boxes and parked machines and take any emergency action.
2. The General Contractor shall turn over all permanent lock cylinders to the VA locksmith for permanent installation. See Section 08 71 00, DOOR HARDWARE and coordinate.

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

6. All paper waste or electronic media such as CD's and diskettes shall be shredded and destroyed in a manner acceptable to the VA.
7. Notify Contracting Officer and Site Security Officer immediately when there is a loss or compromise of "sensitive information".
8. 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.

E. 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. Separate permits shall be issued for General Contractor and its employees for parking in designated areas only.

1.5 FIRE SAFETY

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

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

E84-2009.....Surface Burning Characteristics of Building
Materials

2. National Fire Protection Association (NFPA):

10-2010.....Standard for Portable Fire Extinguishers

30-2008.....Flammable and Combustible Liquids Code

51B-2009.....Standard for Fire Prevention During Welding,
Cutting and Other Hot Work

70-2011.....National Electrical Code

241-2009.....Standard for Safeguarding Construction,
Alteration, and Demolition Operations

3. Occupational Safety and Health Administration (OSHA):

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

- B. Fire Safety Plan: Establish and maintain a 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 and Facility Safety Officer for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES Prior to any worker for the contractor or subcontractors beginning work, they shall undergo a safety briefing provided by the general contractor's competent person per OSHA requirements. This briefing shall include information on the construction limits, VAMC safety guidelines, means of egress, break areas, work hours, locations of restrooms, use of VAMC equipment, etc. Documentation shall be provided to the Resident Engineer that individuals have undergone contractor's safety briefing.
- C. 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.
- D. 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).
- 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 and facility Safety Officer.

- G. Egress Routes for Construction Workers: Maintain free and unobstructed egress. Inspect daily. Report findings and corrective actions weekly to Resident Engineer and facility Safety Officer.
- 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.
- I. Flammable and Combustible Liquids: Store, dispense and use liquids in accordance with 29 CFR 1926, NFPA 241 and NFPA 30.
- J. 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 and facility Safety Officer. 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.
- K. Smoke Detectors: Prevent accidental operation. Remove temporary covers at end of work operations each day. Coordinate with Resident Engineer and facility Safety Officer.
- L. Hot Work: Perform and safeguard hot work operations in accordance with NFPA 241 and NFPA 51B. Coordinate with Resident Engineer. Obtain permits from facility Safety Officer at least 48 hours in advance. Designate contractor's responsible project-site fire prevention program manager to permit hot work.
- M. Fire Hazard Prevention and Safety Inspections: Inspect entire construction areas weekly. Coordinate with, and report findings and corrective actions weekly to // Resident // Project // Engineer // and facility Safety // Manager // Officer // .
- N. 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.

- O. Dispose of waste and debris in accordance with NFPA 241. Remove from buildings daily.
- P. Perform other construction, alteration and demolition operations in accordance with 29 CFR 1926.
- Q. If required, submit documentation to the Resident Engineer that personnel have been trained in the fire safety aspects of working in areas with impaired structural or compartmentalization features.

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 Resident Engineer.

- E. Workmen are subject to rules of Medical Center applicable to their conduct.
- F. Execute work so as to interfere as little as possible with normal functioning of 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 Resident Engineer 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. Utilities Services: Where necessary to cut existing pipes, electrical wires, conduits, cables, etc., of utility services, or of fire protection systems or communications systems (except telephone), they shall be cut and capped at suitable places where shown; or, in absence of such indication, where directed by Resident Engineer. All such actions shall be coordinated with the Utility Company involved:
1. 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.
- H. Phasing: To insure such executions, Contractor shall furnish the Resident Engineer 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 Resident Engineer 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, Resident Engineer and Contractor.

- I. Construction Fence: Before outdoor construction operations begin, Contractor shall provide a chain link construction fence, 2.1m (seven feet) minimum height, around the construction area. Provide gates as required for access with necessary hardware, including hasps and padlocks. Fasten fence fabric to terminal posts with tension bands and to line posts and top and bottom rails with tie wires spaced at maximum 375mm (15 inches). Bottom of fences shall extend to 25mm (one inch) above grade. Remove the fence when directed by Resident Engineer.
- J. When a building is turned over to Contractor, Contractor shall accept entire responsibility therefore.
 - 1. Contractor shall maintain normal operating temperatures 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 by Resident Engineer.
 - 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 Resident Engineer. 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 the

Medical Center Director's prior knowledge and written approval. Refer to specification Sections 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, 27 05 11 REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS and 28 05 11, REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATIONS for additional requirements.

2. Contractor shall submit a request to interrupt any such services to Resident Engineer, in writing, 48 hours 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 Resident Engineer.
 5. In case of a contract construction emergency, service will be interrupted on approval of Resident Engineer. 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. 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.
 2. Method and scheduling of required cutting, altering and removal of existing roads, walks and entrances must be approved by the Resident Engineer.
- N. Coordinate the work for this contract with other construction operations as directed by Resident Engineer. 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 Resident Engineer and a representative of VA Supply Service, of areas of buildings in which alterations occur and areas which are anticipated routes of access, and furnish a report, signed by all three, 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 Resident Engineer.
- 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 Resident Engineer, 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 Resident Engineer 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 INFECTION PREVENTION MEASURES

- A. Implement the requirements of VAMC's Infection Control Risk Assessment (ICRA) team. ICRA Group may monitor dust in the vicinity of the construction work and require the Contractor to take corrective action immediately if the safe levels are exceeded.
- B. Establish and maintain a dust control program as part of the contractor's infection preventive measures in accordance with the guidelines provided by ICRA Group. Prior to start of work, prepare a

plan detailing project-specific dust protection measures, including periodic status reports, and submit to Resident Engineer and Facility ICRA team for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.

1. All personnel involved in the construction or renovation activity shall be educated and trained in infection prevention measures established by the medical center.

C. Medical center Infection Control personnel shall monitor for airborne disease (e.g. aspergillosis) as appropriate during construction. A baseline of conditions may 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. In addition:

1. The RE and VAMC Infection Control personnel shall review pressure differential monitoring documentation to verify that pressure differentials in the construction zone and in the patient-care rooms are appropriate for their settings. The requirement for negative air pressure in the construction zone shall depend on the location and type of activity. Upon notification, the contractor shall implement corrective measures to restore proper pressure differentials as needed.
2. In case of any problem, the medical center, along with assistance from the contractor, shall conduct an environmental assessment to find and eliminate the source.

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

1. Dampen debris to keep down dust and provide temporary construction partitions in existing structures where directed by Resident Engineer. Blank off ducts and diffusers to prevent circulation of dust into occupied areas during construction.
2. Do not perform dust producing tasks within occupied areas without the approval of the Resident Engineer. For construction in any areas that will remain jointly occupied by the medical Center and Contractor's workers, the Contractor shall:

- a. Provide dust proof one-hour temporary drywall construction barriers to completely separate construction from the operational areas of the hospital in order to contain dirt debris and dust. Barriers shall be sealed and made presentable on hospital occupied side. Install a self-closing rated door in a metal frame, commensurate with the partition, to allow worker access. Maintain negative air at all times. A fire retardant polystyrene, 6-mil thick or greater plastic barrier meeting local fire codes may be used where dust control is the only hazard, and an agreement is reached with the Resident Engineer and Medical Center.
- b. HEPA filtration is required where the exhaust dust may reenter the breathing zone. Contractor shall verify that construction exhaust to exterior is not reintroduced to the medical center through intake vents, or building openings. Install HEPA (High Efficiency Particulate Accumulator) filter vacuum system rated at 95% capture of 0.3 microns including pollen, mold spores and dust particles. Insure continuous negative air pressures occurring within the work area. HEPA filters should have ASHRAE 85 or other prefilter to extend the useful life of the HEPA. Provide both primary and secondary filtrations units. Exhaust hoses shall be heavy duty, flexible steel reinforced and exhausted so that dust is not reintroduced to the medical center.
- c. Adhesive Walk-off/Carpet Walk-off Mats, minimum 600mm x 900mm (24" x 36"), 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.
- d. 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 they are created. Transport these outside the construction area in containers with tightly fitting lids.
- e. 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.

- f. Using a HEPA vacuum, clean inside the barrier and vacuum ceiling tile prior to replacement. Any ceiling access panels opened for investigation beyond sealed areas shall be sealed immediately when unattended.
- g. 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.
- h. 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.

E. 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.

1.9 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. 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 Resident Engineer.
- 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.

1.10 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.

D. Refer to FAR clause 52.236-7, "Permits and Responsibilities," which is included in General Conditions. A National Pollutant Discharge Elimination System (NPDES) permit is required for this project. The Contractor is considered an "operator" under the permit and has extensive responsibility for compliance with permit requirements. VA will make the permit application available at the (appropriate medical center) office. The apparent low bidder, contractor and affected subcontractors shall furnish all information and certifications that are required to comply with the permit process and permit requirements. Many of the permit requirements will be satisfied by completing construction as shown and specified. Some requirements involve the Contractor's method of operations and operations planning and the Contractor is responsible for employing best management practices. The affected activities often include, but are not limited to the following:

- Designating areas for equipment maintenance and repair;
- Providing waste receptacles at convenient locations and provide regular collection of wastes;
- Locating equipment wash down areas on site, and provide appropriate control of wash-waters;
- Providing protected storage areas for chemicals, paints, solvents, fertilizers, and other potentially toxic materials; and
- Providing adequately maintained sanitary facilities.

1.11 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 Resident Engineer. Existing work to be altered or extended and that is found to be defective in any way, shall be reported to the Resident Engineer 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 indicated on drawings and 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).

1.12 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. Following completion of general mass excavation and before any other permanent work is performed, establish and plainly mark (through use of appropriate batter boards or other means) sufficient additional survey control points or system of points as may be necessary to assure proper alignment, orientation, and grade of all major features of work. Survey shall include, but not be limited to, location of lines and grades of footings, exterior walls, center lines of columns in both directions, major utilities and elevations of floor slabs:
1. Such additional survey control points or system of points thus established shall be checked and certified by a registered land surveyor or registered civil engineer. Furnish such certification to the Resident Engineer before any work (such as footings, floor slabs, columns, walls, utilities and other major controlling features) is placed.
- C. 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 Resident Engineer. Upon completion of the work, the Contractor shall furnish the Resident Engineer, reproducible drawings at the scale of the contract drawings.
- D. 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 Resident Engineer's review, as often as requested.
- C. Contractor shall deliver two approved completed sets of as-built drawings to the Resident Engineer within 15 calendar days after each completed phase and after the acceptance of the project by the Resident Engineer.

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 Resident Engineer, such temporary roads which are necessary in the performance of contract work. Temporary roads shall be constructed 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 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 compliance with the following provisions:
 - 1. Permission to use each unit or system must be given by Resident Engineer. If the equipment is not installed and maintained in accordance with the following provisions, the Resident Engineer 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. 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.
- 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.

1.17 TEMPORARY USE OF EXISTING ELEVATORS

- A. Contractor will not be allowed the use of existing elevators. Outside type hoist shall be used by Contractor for transporting materials and equipment.
- 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 Resident Engineer for use of elevators. The Resident Engineer will ascertain that elevators are in proper condition. Personnel for operating elevators will not be provided by the Department of Veterans Affairs.
 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.

3. Government will accept hoisting ropes of elevator and rope of each speed governor if they are worn under normal operation. However, if these ropes are damaged by action of foreign matter such as sand, lime, grit, stones, etc., during temporary use, they shall be removed and replaced by new hoisting ropes.

1.18 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 amount to be paid by the Contractor for chargeable electrical services shall be the prevailing rates charged to the Government. The Contractor shall carefully conserve any utilities furnished without charge.

B. The Contractor, at Contractor's expense and in a workmanlike manner satisfactory to the Contracting Officer, shall install and maintain all necessary temporary connections and distribution lines, and all meters required to measure the amount of electricity used for the purpose of determining charges. Before final acceptance of the work by the Government, the Contractor shall remove all the temporary connections, distribution lines, meters, and associated paraphernalia.

C. Contractor shall install meters at Contractor's expense and furnish the Medical Center a monthly record of the Contractor's usage of electricity as hereinafter specified.

D. Heat: Furnish temporary heat necessary to prevent injury to work and materials through dampness and cold. Use of open salamanders or any temporary heating devices which may be fire hazards or may smoke and damage finished work, will not be permitted. Maintain minimum temperatures as specified for various materials:

1. Obtain heat by connecting to Medical Center heating distribution system.

a. Steam is available at no cost to Contractor.

1.19 TESTS

- A. 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.
- B. 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.
- C. Mechanical and electrical systems shall be balanced, controlled and coordinated. A system is defined as the entire complex 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 complex 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.
- D. All related components as defined above shall be functioning when any system component is tested. Tests shall be completed within a reasonably short period of time during which operating and environmental conditions remain reasonably constant.
- E. 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.

1.20 INSTRUCTIONS

- A. Contractor shall furnish Maintenance and Operating manuals and verbal instructions when required by the various sections of the specifications and as hereinafter specified.
- B. Manuals: Maintenance and operating manuals (four copies each) for each separate piece of equipment shall be delivered to the Resident Engineer 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 instructions 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 Resident Engineer and shall be considered concluded only when the Resident Engineer is satisfied in regard to complete and thorough coverage. The Department of Veterans Affairs reserves the right to request the removal of, and substitution for, any instructor who, in the opinion of the Resident Engineer, does not demonstrate sufficient qualifications in accordance with requirements for instructors above.

1.21 CONSTRUCTION SIGN

- A. Provide a Construction Sign where directed by the Resident Engineer. 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 Resident Engineer.

1.22 SAFETY SIGN

- A. Provide a Safety Sign where directed by Resident Engineer. 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 Resident Engineer.
- D. Standard Detail Drawing Number SD10000-02 (Found on VA TIL) of safety sign indicating required legend and other characteristics of sign.
- E. Post the number of accident free days on a daily basis.

1.23 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 Resident Engineer verbally, and then with a written follow up.

- - - E N D - - -

SECTION 01 00 00
GENERAL REQUIREMENTS

1.1 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 implementation of energy conservation measures at Bath VAMC as required by drawings and specifications.
- B. Visits to the site by Bidders may be made only by appointment with the Medical Center Engineering Officer.
- C. Offices of Bergmann Associates, 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 Resident Engineer 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 Resident Engineer.
- 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.
- F. Prior to commencing work, general contractor shall provide proof that a OSHA certified "competent person" (CP) (29 CFR 1926.20(b)(2)) will maintain a presence at the work site whenever the general or subcontractors are present.

G. Training:

1. All employees of general contractor or subcontractors shall have OSHA certified Construction Safety course and other relevant competency training, as determined by VA CP with input from the ICRA team.
2. Submit training records of all such employees for approval before the start of work.

1.2 STATEMENT OF BID ITEM(S)

- A. ITEM I, //GENERAL CONSTRUCTION://Implement ECM's:// Work includes general construction, alterations, mechanical and electrical work, utility systems and necessary removal of existing structures and construction and certain other items.

1.3 SPECIFICATIONS AND DRAWINGS FOR CONTRACTOR

- A. AFTER AWARD OF CONTRACT, 3 sets of specifications and drawings will be furnished.
- B. Additional sets of drawings may be made by the Contractor, at Contractor's expense, from prints furnished by Issuing Office. Such prints shall be returned to the Issuing Office immediately after printing is completed.

1.4 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 subcontractors 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. For working outside the "regular hours" as defined in the contract, The General Contractor shall give 3 days notice to the Contracting

Officer so that arrangement 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. Key Control:

1. The General Contractor shall provide duplicate keys and lock combinations to the Resident Engineer for the purpose of security inspections of every area of project including tool boxes and parked machines and take any emergency action.
2. The General Contractor shall turn over all permanent lock cylinders to the VA locksmith for permanent installation. See Section 08 71 00, DOOR HARDWARE and coordinate.

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

6. All paper waste or electronic media such as CD's and diskettes shall be shredded and destroyed in a manner acceptable to the VA.
7. Notify Contracting Officer and Site Security Officer immediately when there is a loss or compromise of "sensitive information".
8. 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.

E. 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. Separate permits shall be issued for General Contractor and its employees for parking in designated areas only.

1.5 FIRE SAFETY

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

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

E84-2009.....Surface Burning Characteristics of Building
Materials

2. National Fire Protection Association (NFPA):

10-2010.....Standard for Portable Fire Extinguishers

30-2008.....Flammable and Combustible Liquids Code

51B-2009.....Standard for Fire Prevention During Welding,
Cutting and Other Hot Work

70-2011.....National Electrical Code

241-2009.....Standard for Safeguarding Construction,
Alteration, and Demolition Operations

3. Occupational Safety and Health Administration (OSHA):

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

- B. Fire Safety Plan: Establish and maintain a 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 and Facility Safety Officer for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES Prior to any worker for the contractor or subcontractors beginning work, they shall undergo a safety briefing provided by the general contractor's competent person per OSHA requirements. This briefing shall include information on the construction limits, VAMC safety guidelines, means of egress, break areas, work hours, locations of restrooms, use of VAMC equipment, etc. Documentation shall be provided to the Resident Engineer that individuals have undergone contractor's safety briefing.
- C. 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.
- D. 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).
- 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 and facility Safety Officer.

- G. Egress Routes for Construction Workers: Maintain free and unobstructed egress. Inspect daily. Report findings and corrective actions weekly to Resident Engineer and facility Safety Officer.
- 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.
- I. Flammable and Combustible Liquids: Store, dispense and use liquids in accordance with 29 CFR 1926, NFPA 241 and NFPA 30.
- J. 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 and facility Safety Officer. 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.
- K. Smoke Detectors: Prevent accidental operation. Remove temporary covers at end of work operations each day. Coordinate with Resident Engineer and facility Safety Officer.
- L. Hot Work: Perform and safeguard hot work operations in accordance with NFPA 241 and NFPA 51B. Coordinate with Resident Engineer. Obtain permits from facility Safety Officer at least 48 hours in advance. Designate contractor's responsible project-site fire prevention program manager to permit hot work.
- M. Fire Hazard Prevention and Safety Inspections: Inspect entire construction areas weekly. Coordinate with, and report findings and corrective actions weekly to // Resident // Project // Engineer // and facility Safety // Manager // Officer // .
- N. 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.

- O. Dispose of waste and debris in accordance with NFPA 241. Remove from buildings daily.
- P. Perform other construction, alteration and demolition operations in accordance with 29 CFR 1926.
- Q. If required, submit documentation to the Resident Engineer that personnel have been trained in the fire safety aspects of working in areas with impaired structural or compartmentalization features.

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 Resident Engineer.

- E. Workmen are subject to rules of Medical Center applicable to their conduct.
- F. Execute work so as to interfere as little as possible with normal functioning of 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 Resident Engineer 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. Utilities Services: Where necessary to cut existing pipes, electrical wires, conduits, cables, etc., of utility services, or of fire protection systems or communications systems (except telephone), they shall be cut and capped at suitable places where shown; or, in absence of such indication, where directed by Resident Engineer. All such actions shall be coordinated with the Utility Company involved:
1. 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.
- H. Phasing: To insure such executions, Contractor shall furnish the Resident Engineer 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 Resident Engineer 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, Resident Engineer and Contractor.

- I. Construction Fence: Before outdoor construction operations begin, Contractor shall provide a chain link construction fence, 2.1m (seven feet) minimum height, around the construction area. Provide gates as required for access with necessary hardware, including hasps and padlocks. Fasten fence fabric to terminal posts with tension bands and to line posts and top and bottom rails with tie wires spaced at maximum 375mm (15 inches). Bottom of fences shall extend to 25mm (one inch) above grade. Remove the fence when directed by Resident Engineer.
- J. When a building is turned over to Contractor, Contractor shall accept entire responsibility therefore.
 1. Contractor shall maintain normal operating temperatures 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 by Resident Engineer.
 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 Resident Engineer. 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 the

Medical Center Director's prior knowledge and written approval. Refer to specification Sections 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, 27 05 11 REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS and 28 05 11, REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATIONS for additional requirements.

2. Contractor shall submit a request to interrupt any such services to Resident Engineer, in writing, 48 hours 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 Resident Engineer.
 5. In case of a contract construction emergency, service will be interrupted on approval of Resident Engineer. 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. 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.
 2. Method and scheduling of required cutting, altering and removal of existing roads, walks and entrances must be approved by the Resident Engineer.
- N. Coordinate the work for this contract with other construction operations as directed by Resident Engineer. 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 Resident Engineer and a representative of VA Supply Service, of areas of buildings in which alterations occur and areas which are anticipated routes of access, and furnish a report, signed by all three, 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 Resident Engineer.
- 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 Resident Engineer, 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 Resident Engineer 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 INFECTION PREVENTION MEASURES

- A. Implement the requirements of VAMC's Infection Control Risk Assessment (ICRA) team. ICRA Group may monitor dust in the vicinity of the construction work and require the Contractor to take corrective action immediately if the safe levels are exceeded.
- B. Establish and maintain a dust control program as part of the contractor's infection preventive measures in accordance with the guidelines provided by ICRA Group. Prior to start of work, prepare a

plan detailing project-specific dust protection measures, including periodic status reports, and submit to Resident Engineer and Facility ICRA team for review for compliance with contract requirements in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.

1. All personnel involved in the construction or renovation activity shall be educated and trained in infection prevention measures established by the medical center.

C. Medical center Infection Control personnel shall monitor for airborne disease (e.g. aspergillosis) as appropriate during construction. A baseline of conditions may 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. In addition:

1. The RE and VAMC Infection Control personnel shall review pressure differential monitoring documentation to verify that pressure differentials in the construction zone and in the patient-care rooms are appropriate for their settings. The requirement for negative air pressure in the construction zone shall depend on the location and type of activity. Upon notification, the contractor shall implement corrective measures to restore proper pressure differentials as needed.
2. In case of any problem, the medical center, along with assistance from the contractor, shall conduct an environmental assessment to find and eliminate the source.

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

1. Dampen debris to keep down dust and provide temporary construction partitions in existing structures where directed by Resident Engineer. Blank off ducts and diffusers to prevent circulation of dust into occupied areas during construction.
2. Do not perform dust producing tasks within occupied areas without the approval of the Resident Engineer. For construction in any areas that will remain jointly occupied by the medical Center and Contractor's workers, the Contractor shall:

- a. Provide dust proof one-hour temporary drywall construction barriers to completely separate construction from the operational areas of the hospital in order to contain dirt debris and dust. Barriers shall be sealed and made presentable on hospital occupied side. Install a self-closing rated door in a metal frame, commensurate with the partition, to allow worker access. Maintain negative air at all times. A fire retardant polystyrene, 6-mil thick or greater plastic barrier meeting local fire codes may be used where dust control is the only hazard, and an agreement is reached with the Resident Engineer and Medical Center.
- b. HEPA filtration is required where the exhaust dust may reenter the breathing zone. Contractor shall verify that construction exhaust to exterior is not reintroduced to the medical center through intake vents, or building openings. Install HEPA (High Efficiency Particulate Accumulator) filter vacuum system rated at 95% capture of 0.3 microns including pollen, mold spores and dust particles. Insure continuous negative air pressures occurring within the work area. HEPA filters should have ASHRAE 85 or other prefilter to extend the useful life of the HEPA. Provide both primary and secondary filtrations units. Exhaust hoses shall be heavy duty, flexible steel reinforced and exhausted so that dust is not reintroduced to the medical center.
- c. Adhesive Walk-off/Carpet Walk-off Mats, minimum 600mm x 900mm (24" x 36"), 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.
- d. 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 they are created. Transport these outside the construction area in containers with tightly fitting lids.
- e. 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.

- f. Using a HEPA vacuum, clean inside the barrier and vacuum ceiling tile prior to replacement. Any ceiling access panels opened for investigation beyond sealed areas shall be sealed immediately when unattended.
- g. 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.
- h. 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.

E. 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.

1.9 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. 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 Resident Engineer.
- 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.

1.10 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.

D. Refer to FAR clause 52.236-7, "Permits and Responsibilities," which is included in General Conditions. A National Pollutant Discharge Elimination System (NPDES) permit is required for this project. The Contractor is considered an "operator" under the permit and has extensive responsibility for compliance with permit requirements. VA will make the permit application available at the (appropriate medical center) office. The apparent low bidder, contractor and affected subcontractors shall furnish all information and certifications that are required to comply with the permit process and permit requirements. Many of the permit requirements will be satisfied by completing construction as shown and specified. Some requirements involve the Contractor's method of operations and operations planning and the Contractor is responsible for employing best management practices. The affected activities often include, but are not limited to the following:

- Designating areas for equipment maintenance and repair;
- Providing waste receptacles at convenient locations and provide regular collection of wastes;
- Locating equipment wash down areas on site, and provide appropriate control of wash-waters;
- Providing protected storage areas for chemicals, paints, solvents, fertilizers, and other potentially toxic materials; and
- Providing adequately maintained sanitary facilities.

1.11 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 Resident Engineer. Existing work to be altered or extended and that is found to be defective in any way, shall be reported to the Resident Engineer 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 indicated on drawings and 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).

1.12 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. Following completion of general mass excavation and before any other permanent work is performed, establish and plainly mark (through use of appropriate batter boards or other means) sufficient additional survey control points or system of points as may be necessary to assure proper alignment, orientation, and grade of all major features of work. Survey shall include, but not be limited to, location of lines and grades of footings, exterior walls, center lines of columns in both directions, major utilities and elevations of floor slabs:
1. Such additional survey control points or system of points thus established shall be checked and certified by a registered land surveyor or registered civil engineer. Furnish such certification to the Resident Engineer before any work (such as footings, floor slabs, columns, walls, utilities and other major controlling features) is placed.
- C. 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 Resident Engineer. Upon completion of the work, the Contractor shall furnish the Resident Engineer, reproducible drawings at the scale of the contract drawings.
- D. 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 Resident Engineer's review, as often as requested.
- C. Contractor shall deliver two approved completed sets of as-built drawings to the Resident Engineer within 15 calendar days after each completed phase and after the acceptance of the project by the Resident Engineer.

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 Resident Engineer, such temporary roads which are necessary in the performance of contract work. Temporary roads shall be constructed 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 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 compliance with the following provisions:
 - 1. Permission to use each unit or system must be given by Resident Engineer. If the equipment is not installed and maintained in accordance with the following provisions, the Resident Engineer 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. 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.
- 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.

1.17 TEMPORARY USE OF EXISTING ELEVATORS

- A. Contractor will not be allowed the use of existing elevators. Outside type hoist shall be used by Contractor for transporting materials and equipment.
- 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 Resident Engineer for use of elevators. The Resident Engineer will ascertain that elevators are in proper condition. Personnel for operating elevators will not be provided by the Department of Veterans Affairs.
 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.

3. Government will accept hoisting ropes of elevator and rope of each speed governor if they are worn under normal operation. However, if these ropes are damaged by action of foreign matter such as sand, lime, grit, stones, etc., during temporary use, they shall be removed and replaced by new hoisting ropes.

1.18 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 amount to be paid by the Contractor for chargeable electrical services shall be the prevailing rates charged to the Government. The Contractor shall carefully conserve any utilities furnished without charge.
- B. The Contractor, at Contractor's expense and in a workmanlike manner satisfactory to the Contracting Officer, shall install and maintain all necessary temporary connections and distribution lines, and all meters required to measure the amount of electricity used for the purpose of determining charges. Before final acceptance of the work by the Government, the Contractor shall remove all the temporary connections, distribution lines, meters, and associated paraphernalia.
- C. Contractor shall install meters at Contractor's expense and furnish the Medical Center a monthly record of the Contractor's usage of electricity as hereinafter specified.
- D. Heat: Furnish temporary heat necessary to prevent injury to work and materials through dampness and cold. Use of open salamanders or any temporary heating devices which may be fire hazards or may smoke and damage finished work, will not be permitted. Maintain minimum temperatures as specified for various materials:
1. Obtain heat by connecting to Medical Center heating distribution system.
 - a. Steam is available at no cost to Contractor.

1.19 TESTS

- A. 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.
- B. 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.
- C. Mechanical and electrical systems shall be balanced, controlled and coordinated. A system is defined as the entire complex 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 complex 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.
- D. All related components as defined above shall be functioning when any system component is tested. Tests shall be completed within a reasonably short period of time during which operating and environmental conditions remain reasonably constant.
- E. 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.

1.20 INSTRUCTIONS

- A. Contractor shall furnish Maintenance and Operating manuals and verbal instructions when required by the various sections of the specifications and as hereinafter specified.
- B. Manuals: Maintenance and operating manuals (four copies each) for each separate piece of equipment shall be delivered to the Resident Engineer 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 instructions 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 Resident Engineer and shall be considered concluded only when the Resident Engineer is satisfied in regard to complete and thorough coverage. The Department of Veterans Affairs reserves the right to request the removal of, and substitution for, any instructor who, in the opinion of the Resident Engineer, does not demonstrate sufficient qualifications in accordance with requirements for instructors above.

1.21 CONSTRUCTION SIGN

- A. Provide a Construction Sign where directed by the Resident Engineer. 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 Resident Engineer.

1.22 SAFETY SIGN

- A. Provide a Safety Sign where directed by Resident Engineer. 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 Resident Engineer.
- D. Standard Detail Drawing Number SD10000-02(Found on VA TIL) of safety sign indicating required legend and other characteristics of sign.
- E. Post the number of accident free days on a daily basis.

1.23 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 Resident Engineer verbally, and then with a written follow up.

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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. Submittals will receive consideration only when covered by a transmittal letter signed by Contractor. Letter shall be sent via first class mail 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 sample, 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.
 - B. If submittal samples have been disapproved, resubmit new samples as soon as possible after notification of disapproval. Such new samples shall be marked "Resubmitted Sample" in addition to containing other previously specified information required on label and in transmittal letter.
 - C. Approved samples will be kept on file by the Resident Engineer at the site until completion of contract, at which time such samples will be delivered to Contractor as Contractor's property. Where noted in

technical sections of specifications, approved samples in good condition may be used in their proper locations in contract work. At completion of contract, samples that are not approved will be returned to Contractor only upon request and at Contractor's expense. Such request should be made prior to completion of the contract. Disapproved samples that are not requested for return by Contractor will be discarded after completion of contract.

- D. 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 one legible photographic paper or vellum reproducible.
 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 Architect-Engineer under one cover.
- 1-10. Samples, shop drawings, test reports, certificates and manufacturers' literature and data, shall be submitted for approval to

Bergmann Associates

(Architect-Engineer)

224 Harrison Street // Suite 210

(A/E P.O. Address)

Syracuse, NY 13202

(City, State and Zip Code)

1-11. At the time of transmittal to the Architect-Engineer, the Contractor shall also send a copy of the complete submittal directly to the Resident Engineer.

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**SECTION 01 42 19
REFERENCE STANDARDS**

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the availability and source of references and standards specified in the project manual under paragraphs APPLICABLE PUBLICATIONS and/or shown on the drawings.

1.2 AVAILABILITY OF SPECIFICATIONS LISTED IN THE GSA INDEX OF FEDERAL SPECIFICATIONS, STANDARDS AND COMMERCIAL ITEM DESCRIPTIONS FPMR PART 101-29 (FAR 52.211-1) (AUG 1998)

- A. The GSA Index of Federal Specifications, Standards and Commercial Item Descriptions, FPMR Part 101-29 and copies of specifications, standards, and commercial item descriptions cited in the solicitation may be obtained for a fee by submitting a request to - GSA Federal Supply Service, Specifications Section, Suite 8100, 470 East L'Enfant Plaza, SW, Washington, DC 20407, Telephone (202) 619-8925, Facsimile (202) 619-8978.
- B. If the General Services Administration, Department of Agriculture, or Department of Veterans Affairs issued this solicitation, a single copy of specifications, standards, and commercial item descriptions cited in this solicitation may be obtained free of charge by submitting a request to the addressee in paragraph (a) of this provision. Additional copies will be issued for a fee.

1.3 AVAILABILITY FOR EXAMINATION OF SPECIFICATIONS NOT LISTED IN THE GSA INDEX OF FEDERAL SPECIFICATIONS, STANDARDS AND COMMERCIAL ITEM DESCRIPTIONS (FAR 52.211-4) (JUN 1988)

The specifications and standards cited in this solicitation can be examined at the following location:

DEPARTMENT OF VETERANS AFFAIRS

Office of Construction & Facilities Management

Facilities Quality Service (00CFM1A)

425 Eye Street N.W, (sixth floor)

Washington, DC 20001

Telephone Numbers: (202) 632-5249 or (202) 632-5178

Between 9:00 AM - 3:00 PM

1.4 AVAILABILITY OF SPECIFICATIONS NOT LISTED IN THE GSA INDEX OF FEDERAL SPECIFICATIONS, STANDARDS AND COMMERCIAL ITEM DESCRIPTIONS (FAR 52.211-3) (JUN 1988)

The specifications cited in this solicitation may be obtained from the associations or organizations listed below.

AA	Aluminum Association Inc. http://www.aluminum.org
AABC	Associated Air Balance Council http://www.aabchq.com
AAMA	American Architectural Manufacturer's Association http://www.aamanet.org
AAN	American Nursery and Landscape Association http://www.anla.org
AASHTO	American Association of State Highway and Transportation Officials http://www.aashto.org
AATCC	American Association of Textile Chemists and Colorists http://www.aatcc.org
ACGIH	American Conference of Governmental Industrial Hygienists http://www.acgih.org
ACI	American Concrete Institute http://www.aci-int.net
ACPA	American Concrete Pipe Association http://www.concrete-pipe.org
ACPPA	American Concrete Pressure Pipe Association http://www.acppa.org
ADC	Air Diffusion Council http://flexibleduct.org
AGA	American Gas Association http://www.aga.org
AGC	Associated General Contractors of America http://www.agc.org

AGMA American Gear Manufacturers Association, Inc.
<http://www.agma.org>

AHAM Association of Home Appliance Manufacturers
<http://www.aham.org>

AISC American Institute of Steel Construction
<http://www.aisc.org>

AISI American Iron and Steel Institute
<http://www.steel.org>

AITC American Institute of Timber Construction
<http://www.aitc-glulam.org>

AMCA Air Movement and Control Association, Inc.
<http://www.amca.org>

ANLA American Nursery & Landscape Association
<http://www.anla.org>

ANSI American National Standards Institute, Inc.
<http://www.ansi.org>

APA The Engineered Wood Association
<http://www.apawood.org>

ARI Air-Conditioning and Refrigeration Institute
<http://www.ari.org>

ASAE American Society of Agricultural Engineers
<http://www.asae.org>

ASCE American Society of Civil Engineers
<http://www.asce.org>

ASHRAE American Society of Heating, Refrigerating, and
Air-Conditioning Engineers
<http://www.ashrae.org>

ASME American Society of Mechanical Engineers
<http://www.asme.org>

ASSE American Society of Sanitary Engineering
<http://www.asse-plumbing.org>

ASTM American Society for Testing and Materials
<http://www.astm.org>

AWI Architectural Woodwork Institute
<http://www.awinet.org>

AWS American Welding Society
<http://www.aws.org>

AWWA American Water Works Association
<http://www.awwa.org>

BHMA Builders Hardware Manufacturers Association
<http://www.buildershardware.com>

BIA Brick Institute of America
<http://www.bia.org>

CAGI Compressed Air and Gas Institute
<http://www.cagi.org>

CGA Compressed Gas Association, Inc.
<http://www.cganet.com>

CI The Chlorine Institute, Inc.
<http://www.chlorineinstitute.org>

CISCA Ceilings and Interior Systems Construction Association
<http://www.cisca.org>

CISPI Cast Iron Soil Pipe Institute
<http://www.cispi.org>

CLFMI Chain Link Fence Manufacturers Institute
<http://www.chainlinkinfo.org>

CPMB Concrete Plant Manufacturers Bureau
<http://www.cpmb.org>

CRA California Redwood Association
<http://www.calredwood.org>

CRSI	Concrete Reinforcing Steel Institute http://www.crsi.org
CTI	Cooling Technology Institute http://www.cti.org
DHI	Door and Hardware Institute http://www.dhi.org
EGSA	Electrical Generating Systems Association http://www.egsa.org
EEI	Edison Electric Institute http://www.eei.org
EPA	Environmental Protection Agency http://www.epa.gov
ETL	ETL Testing Laboratories, Inc. http://www.etl.com
FAA	Federal Aviation Administration http://www.faa.gov
FCC	Federal Communications Commission http://www.fcc.gov
FPS	The Forest Products Society http://www.forestprod.org
GANA	Glass Association of North America http://www.cssinfo.com/info/gana.html/
FM	Factory Mutual Insurance http://www.fmglobal.com
GA	Gypsum Association http://www.gypsum.org
GSA	General Services Administration http://www.gsa.gov
HI	Hydraulic Institute http://www.pumps.org

HPVA Hardwood Plywood & Veneer Association
<http://www.hpva.org>

ICBO International Conference of Building Officials
<http://www.icbo.org>

ICEA Insulated Cable Engineers Association Inc.
<http://www.icea.net>

\ICAC Institute of Clean Air Companies
<http://www.icac.com>

IEEE Institute of Electrical and Electronics Engineers
<http://www.ieee.org/>

IMSA International Municipal Signal Association
<http://www.imsasafety.org>

IPCEA Insulated Power Cable Engineers Association

NBMA Metal Buildings Manufacturers Association
<http://www.mbma.com>

MSS Manufacturers Standardization Society of the Valve and Fittings
Industry Inc.
<http://www.mss-hq.com>

NAAMM National Association of Architectural Metal Manufacturers
<http://www.naamm.org>

NAPHCC Plumbing-Heating-Cooling Contractors Association
<http://www.phccweb.org>

NBS National Bureau of Standards
See - NIST

NBBPVI National Board of Boiler and Pressure Vessel Inspectors
<http://www.nationboard.org>

NEC National Electric Code
See - NFPA National Fire Protection Association

NEMA National Electrical Manufacturers Association
<http://www.nema.org>

NFPA National Fire Protection Association
<http://www.nfpa.org>

NHLA National Hardwood Lumber Association
<http://www.natlhardwood.org>

NIH National Institute of Health
<http://www.nih.gov>

NIST National Institute of Standards and Technology
<http://www.nist.gov>

NLMA Northeastern Lumber Manufacturers Association, Inc.
<http://www.nelma.org>

NPA National Particleboard Association
18928 Premiere Court
Gaithersburg, MD 20879
(301) 670-0604

NSF National Sanitation Foundation
<http://www.nsf.org>

NWWDA Window and Door Manufacturers Association
<http://www.nwwda.org>

OSHA Occupational Safety and Health Administration
Department of Labor
<http://www.osha.gov>

PCA Portland Cement Association
<http://www.portcement.org>

PCI Precast Prestressed Concrete Institute
<http://www.pci.org>

PPI The Plastic Pipe Institute
<http://www.plasticpipe.org>

PEI Porcelain Enamel Institute, Inc.
<http://www.porcelainenamel.com>

PTI Post-Tensioning Institute
<http://www.post-tensioning.org>

RFCI The Resilient Floor Covering Institute
<http://www.rfci.com>

RIS Redwood Inspection Service
See - CRA

RMA Rubber Manufacturers Association, Inc.
<http://www.rma.org>

SCMA Southern Cypress Manufacturers Association
<http://www.cypressinfo.org>

SDI Steel Door Institute
<http://www.steeldoor.org>

IGMA Insulating Glass Manufacturers Alliance
<http://www.igmaonline.org>

SJI Steel Joist Institute
<http://www.steeljoist.org>

SMACNA Sheet Metal and Air-Conditioning Contractors
National Association, Inc.
<http://www.smacna.org>

SSPC The Society for Protective Coatings
<http://www.sspc.org>

STI Steel Tank Institute
<http://www.steeltank.com>

SWI Steel Window Institute
<http://www.steelwindows.com>

TCA Tile Council of America, Inc.
<http://www.tileusa.com>

TEMA Tubular Exchange Manufacturers Association
<http://www.tema.org>

TPI Truss Plate Institute, Inc.
583 D'Onofrio Drive; Suite 200
Madison, WI 53719
(608) 833-5900

UBC The Uniform Building Code
 See ICBO

UL Underwriters' Laboratories Incorporated
 <http://www.ul.com>

ULC Underwriters' Laboratories of Canada
 <http://www.ulc.ca>

WCLIB West Coast Lumber Inspection Bureau
 6980 SW Varns Road, P.O. Box 23145
 Portland, OR 97223
 (503) 639-0651

WRCLA Western Red Cedar Lumber Association
 P.O. Box 120786
 New Brighton, MN 55112
 (612) 633-4334

WWPA Western Wood Products Association
 <http://www.wwpa.org>

- - - E N D - - -

SECTION 01 91 00**GENERAL COMMISSIONING REQUIREMENTS****PART 1 - GENERAL****1.1 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 23 & 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 23 & Division 26 series 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 contract 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 by at least one of the following entities: the National Environmental Balancing Bureau (NEBB), the Association of Energy Engineers (AEE), the Associated Air Balance Council Commissioning Group (AABC), and the Building Commissioning Association (BCA). 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 and with a commissioning authority to provide commissioning the systems. 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 and the Resident Engineer.

- B. In this structure, 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 23 08 00 COMMISSIONING OF HVAC SYSTEMS.
- C. 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 DEFINITIONS

- A. Architect: Includes Architect identified in the Contract for Construction between the Department of Veterans Affairs and Contractor, plus consultant/design professionals responsible for design of fire suppression, plumbing, HVAC, controls for HVAC systems, electrical, communications, electronic safety and security, as well as other related systems.
- B. CxA: Commissioning Agent.
- C. Commissioning Plan: a document that is an overall plan that outlines the commissioning process, commissioning team responsibilities, schedule for commissioning activities, and commissioning documents.
- D. Commissioning Issue: a condition in the installation or function of a component, piece of equipment or system that affects the system operations, maintenance, and/or repair.
- E. Commissioning Observation: a condition in the installation or function of a component, piece of equipment or system that may not be in compliance with the Contract Documents, or may not be in compliance

with the manufacturer's installation instruction, or may not be in compliance with generally accepted industry standards.

- F. Systems Functional Performance Test: a test, or tests, of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Systems Functional Performance Testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not Systems Functional Performance Testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while System Functional Performance Testing is verifying that the system has already been set up properly and is functioning in accordance with the Construction Documents. The Commissioning Agent develops the Systems Functional Performance Test Procedures in a sequential written form, coordinates, witnesses, and documents the actual testing. Systems Functional Performance Testing is performed by the Contractor. Systems Functional Performance Tests are performed after startups, control systems are complete and operational, TAB functions and Pre-Functional Checklists are complete.
- G. System: A system is defined as the entire set of components, equipment, and subsystems 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 component of an entire system which provides comfort conditions for a building. Other related components are return air, exhaust air, steam supply, chilled water supply, refrigerant supply, hot water supply, controls and electrical service, 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 the fuel supply, combustion

air, controls, steam, feedwater supply, condensate return and other related components.

- H. Pre-Functional Checklist: a list of items provided by the Commissioning Agent to the Contractor that require inspection and elementary component tests conducted to verify proper installation of equipment. Pre-Functional Checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some Pre-Functional Checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three-phase pump motor of a chiller system). The term "Pre-Functional" refers to before Systems Functional Performance Testing. Pre-Functional Checklists augment and are combined with the manufacturer's startup checklist and the Contractor's Quality Control checklists.
- I. Seasonal Functional Performance Testing: a test or tests that are deferred until the system will experience conditions closer to their design conditions.
- J. VA: Includes the Contracting Officer, Resident Engineer, or other authorized representative of the Department of Veterans Affairs.
- K. TAB: Testing, Adjusting, and Balancing.

1.6 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:
 - 1. HVAC (Division 23)
 - a. Air Handling Systems (Fans, motors, Variable Speed Drives, cooling coils and control valves, heating coils and control valves, filters, dampers, safeties such as smoke detectors or freezestats and damper end switches, controls, gages, and vibration isolation).
 - b. Dehumidification Systems (Energy recovery devices - such as enthalpy wheels, fans, motors, Variable Speed Drives, cooling coils and control valves, heating coils and control valves,

filters, dampers, safeties, controls, gages, and vibration isolation).

- c. Heating Hot Water Systems (Boilers, controls, instrumentation and gages, flues, heating water pumps and motors, Variable Speed Drives, mixing valves).
- d. e. Chilled Water Systems (Chilled water pumps and motors, Variable Speed Drives, chiller motor/compressor, controls, instrumentation and safeties, isolation valves, blending valves, side stream water cleaners/scrubbers/filters).
- f. Condenser Water Systems for Chillers (Condenser water pumps and motors, Variable Speed Drives, cooling tower fans, cooling tower sump level controls, open-circuit water treatment system, water treatment injection pumps and motors, water treatment controls, cooling tower basin heaters and controls, side stream water cleaners/scrubbers/filters, tower bypass valves).
- g. Exhaust Fans (Fan, motor, Variable Speed Drives, controls and safeties).
- h. i. 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).
- j. k. Laboratory Ventilation Systems (Supply air terminal units and controls, pressure controls and alarms, fans, motors, and Variable Speed Drives).
- l. OR Air Handling Systems (Fans, motors, Variable Speed Drives, Energy recovery devices - such as heat pipes, cooling coils and control valves, heating coils and control valves, filters, HEPA filter performance, dampers, safeties such as smoke detectors or freezestats and damper end switches, controls, gages, and vibration isolation).
- m. n. o.
- p.
- 2. Electrical (Division 26)
 - a.
- 1. Electronic Safety and Security (Division 28)
 - a. Fire Detection and Alarm (Mechanical systems shutdowns).

1.7 COMMISSIONING TEAM

A. Members Appointed by Contractor:

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

B. 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. Representatives of the facility user and operation and maintenance personnel.
3. Architect and engineering design professionals.

1.8 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.

1.9 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.

1.10 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.

1.11 COMMISSIONING DOCUMENTATION

- A. Commissioning Agent's Certification(s): Commissioning Agent shall submit evidence of valid and current certification(s), as required in Section 1.1(G), to the Contracting Officer.
- B. 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.
- C. 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.
- D. 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.
- E. 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.
- F. 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.
- G. 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.
- H. 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.
- I. 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.

1.12 SUBMITTALS

- A. Preliminary Commissioning Plan Submittal: The Commissioning Agent has prepared a Preliminary Commissioning Plan based on the final Construction Documents. The Preliminary Commissioning Plan is included as an Appendix to this specification section. 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.

1.13 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 30 days of contract award, the Contractor shall designate a specific individual as the Commissioning Manager (CM) 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 45 days of contract award, the Contractor shall ensure that each subcontractor designates specific individuals as Commissioning Representatives (CR) 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.

1.14 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.

1.15 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 will work with the Commissioning Agent and the VA to incorporate the commissioning activities into the construction schedule. The Commissioning Agent will provide sufficient information 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 °C (1.0 °F) and a resolution of + or - 0.1 °C (0.2 °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 when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 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.
 - a) The Commissioning Agent will submit the full startup plan to the VA and Contractor for review. Final approval will be by the VA.
 - b) 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 21, Division 22, Division 23, Division 26, Division 27, and Division 28 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.

3.2 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.

3.3 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.

3.4 TRENDING AND ALARMS

- 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. The following tables indicate the points to be trended and alarmed by system. 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.

Spec Writer Note: The following tables provide guidelines for system trends and alarms. Coordinate the types of systems and point names with the construction

documents. Verify alarm priorities, ranges and delay. The Design Engineer may elect to include trending and alarm information on the DDC Control Schematics and Sequences of Operations in the Construction Drawing set or in the DDC Control Specifications. Verify the control drawings or DDC specification has included reference to this section of 01 91 00. If adequately included in the drawings or specifications, the following tables should be deleted to prevent duplication and possible conflicts.

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
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	AI	None	None	None	N/A		
OA Pre-Filter Status	AI	None	None	None	N/A		
After Filter Status	AI	None	None	None	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		

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 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
Initial UVC Intensity (%)	AI	None	None	None	N/A		
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
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

Dual-Path Air Handling Unit Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
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

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

4-Pipe Fan Coil Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
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		
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 ON/OFF	DO	COV	12 hours	3 days	M	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
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

Hydronic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
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
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
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		

Chilled Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
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
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		

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 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		
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		

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.

3.5 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.

3.6 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.

3.7 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.

3.8 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 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 Videotapes: Submit two copies within seven days of end of each training module.
 - a. Identification: On each copy, provide an applied label with the following information:
 - 1) Name of Project.
 - 2) Name and address of photographer
 - 3) Name of Contractor.
 - 4) Date videotape was recorded.
 - 5) Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
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. 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. switchgear, transformers, switchboards, panelboards, uninterruptible power supplies, and motor controls.
 - j. Packaged engine generators, including synchronizing switchgear/switchboards, and transfer switches.
 - k. Lighting equipment and controls.

1. Communication systems, including intercommunication, surveillance, nurse call systems, public address, mass evacuation, voice and data, and entertainment television equipment.
 - m. 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 02 41 00
DEMOLITION**

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies demolition and removal of buildings, portions of buildings, utilities, other structures and debris from trash dumps shown.

1.2 RELATED WORK:

- A. Demolition and removal of roads, walks, curbs, and on-grade slabs outside buildings to be demolished: // Section 31 20 00, EARTH MOVING // Section 31 20 11, EARTH MOVING (SHORT FORM) //.
- B. Safety Requirements: GENERAL CONDITIONS Article, ACCIDENT PREVENTION.
- C. Disconnecting utility services prior to demolition: Section 01 00 00, GENERAL REQUIREMENTS.
- D. Reserved items that are to remain the property of the Government: Section 01 00 00, GENERAL REQUIREMENTS.
- E. Lead Paint: Section 02 83 33.13, LEAD-BASED PAINT REMOVAL AND DISPOSAL.
- F. Environmental Protection: Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS.
- G. Construction Waste Management: Section 017419 CONSTRUCTION WASTE MANAGEMENT.
- H. Infectious Control: Section 01 00 00, GENERAL REQUIREMENTS, Article 1.7, INFECTION PREVENTION MEASURES.

1.3 PROTECTION:

- A. Perform demolition in such manner as to eliminate hazards to persons and property; to minimize interference with use of adjacent areas, utilities and structures or interruption of use of such utilities; and to provide free passage to and from such adjacent areas of structures. Comply with requirements of GENERAL CONDITIONS Article, ACCIDENT PREVENTION.
- B. Provide safeguards, including warning signs, barricades, temporary fences, warning lights, and other similar items that are required for protection of all personnel during demolition and removal operations. Comply with requirements of Section 01 00 00, GENERAL REQUIREMENTS, Article PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES AND IMPROVEMENTS.
- C. Maintain fences, barricades, lights, and other similar items around exposed excavations until such excavations have been completely filled.
- D. Provide enclosed dust chutes with control gates from each floor to carry debris to truck beds and govern flow of material into truck. Provide

overhead bridges of tight board or prefabricated metal construction at dust chutes to protect persons and property from falling debris.

- E. Prevent spread of flying particles and dust. Sprinkle rubbish and debris with water to keep dust to a minimum. Do not use water if it results in hazardous or objectionable condition such as, but not limited to; ice, flooding, or pollution. Vacuum and dust the work area daily.
- F. In addition to previously listed fire and safety rules to be observed in performance of work, include following:
 - 1. No wall or part of wall shall be permitted to fall outwardly from structures.
 - 2. Wherever a cutting torch or other equipment that might cause a fire is used, provide and maintain fire extinguishers nearby ready for immediate use. Instruct all possible users in use of fire extinguishers.
 - 3. Keep hydrants clear and accessible at all times. Prohibit debris from accumulating within a radius of 4500 mm (15 feet) of fire hydrants.
- G. Before beginning any demolition work, the Contractor shall survey the site and examine the drawings and specifications to determine the extent of the work. The contractor shall take necessary precautions to avoid damages to existing items to remain in place, to be reused, or to remain the property of the Medical Center; any damaged items shall be repaired or replaced as approved by the Resident Engineer. The Contractor shall coordinate the work of this section with all other work and shall construct and maintain shoring, bracing, and supports as required. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract. Do not overload structural elements. Provide new supports and reinforcement for existing construction weakened by demolition or removal works. Repairs, reinforcement, or structural replacement must have Resident Engineer's approval.
- H. The work shall comply with the requirements of Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS.
- I. The work shall comply with the requirements of Section 01 00 00, GENERAL REQUIREMENTS, Article 1.7 INFECTION PREVENTION MEASURES.

1.4 UTILITY SERVICES:

- A. Demolish and remove outside utility service lines shown to be removed.
- B. Remove abandoned outside utility lines that would interfere with installation of new utility lines and new construction.

PART 2 - PRODUCTS (NOT USED)**PART 3 - EXECUTION****3.1 DEMOLITION:**

- A. Completely demolish and remove buildings and structures, including all appurtenances related or connected thereto, as noted below:
 - 1. As required for installation of new utility service lines.
 - 2. To full depth within an area defined by hypothetical lines located 1500 mm (5 feet) outside building lines of new structures.
- B. Debris, including brick, concrete, stone, metals and similar materials shall become property of Contractor and shall be disposed of by him daily, off the Medical Center to avoid accumulation at the demolition site. Materials that cannot be removed daily shall be stored in areas specified by the Resident Engineer. Break up concrete slabs below grade that do not require removal from present location into pieces not exceeding 600 mm (24 inches) square to permit drainage. Contractor shall dispose debris in compliance with applicable federal, state or local permits, rules and/or regulations.
- C. Remove and legally dispose of all materials, other than earth to remain as part of project work, from any trash dumps shown. Materials removed shall become property of contractor and shall be disposed of in compliance with applicable federal, state or local permits, rules and/or regulations. All materials in the indicated trash dump areas, including above surrounding grade and extending to a depth of 1500mm (5feet) below surrounding grade, shall be included as part of the lump sum compensation for the work of this section. Materials that are located beneath the surface of the surrounding ground more than 1500 mm (5 feet), or materials that are discovered to be hazardous, shall be handled as unforeseen. The removal of hazardous material shall be referred to Hazardous Materials specifications.
- D. Remove existing utilities as indicated or uncovered by work and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by the Resident Engineer. When Utility lines are encountered that are not indicated on the drawings, the Resident Engineer shall be notified prior to further work in that area.

3.2 CLEAN-UP:

On completion of work of this section and after removal of all debris, leave site in clean condition satisfactory to Resident Engineer. Clean-up shall include off the Medical Center disposal of all items and

materials not required to remain property of the Government as well as all debris and rubbish resulting from demolition operations.

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**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. Spray applied fireproofing: Section 07 81 00, APPLIED FIREPROOFING
- B. Sealants and application: Section 07 92 00, JOINT SEALANTS.
- C. Fire and smoke damper assemblies in ductwork: Section 23 31 00, HVAC DUCTS AND CASINGS // Section 23 37 00, AIR OUTLETS AND INLETS.

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 m² (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 specified in Section 07 92 00, JOINT SEALANTS.
- 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.

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. COTR: Contracting Officer's Technical Representative.

1.2 RELATED WORK

- A. Section 00 72 00, GENERAL CONDITIONS
- B. Section 01 00 00, GENERAL REQUIREMENTS
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES
- D. Section 31 20 00, EARTH MOVING: Excavation and Backfill
- E. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout
- F. Section 05 50 00, METAL FABRICATIONS
- G. Section 07 84 00, FIRESTOPPING
- H. Section 09 91 00, PAINTING
- I. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION
- J. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC
- K. Section 23 07 11, HVAC, PLUMBING, and Boiler Plant Insulation
- L. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC
- M. Section 23 21 13, HYDRONIC PIPING
- N. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING
- O. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
- P. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS

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 than 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 50 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. 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.
- G. 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.
- H. 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. 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 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.

2.4 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; Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and, Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). 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.

2.5 VARIABLE SPEED MOTOR CONTROLLERS

- A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS 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. Provide thermal magnetic circuit breaker or fused switch with external operator and incoming line fuses. Unit shall be rated for

minimum 25,000 AIC. Provide AC input line reactors (3% impedance) on incoming power line. Provide output line reactors on line between drive and motor for motors over 50 HP or where the distance between the breaker and motor exceeds 50 feet.

2.6 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals. In addition, provide bar code identification nameplate for all equipment which will allow the equipment identification code to be scanned into the system for maintenance and inventory tracking. Identification for piping is specified in Section 09 91 00, PAINTING.
- 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 specified in Section 09 91 00, PAINTING 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 other than for equipment in Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.
 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.

2.7 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. Refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION, for firestop pipe and duct insulation.

2.8 GALVANIZED REPAIR COMPOUND

Mil. Spec. DOD-P-21035B, paint form.

2.9 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- B. Supports for Roof Mounted Items:
 - 1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 mm by 100 mm (2 by 4) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 280 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
 - 2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.
- C. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-69. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.
- D. 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.
- E. 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.
- F. Attachment to existing structure: Support from existing floor/roof frame.
- G. Attachment to Wood Construction: Wood screws or lag bolts.
- H. 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.

- I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2-inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.
- J. Supports for Piping Systems:
1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
 2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15. Preinsulate.
 - g. U-bolt clamp: Type 24.
 - h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted or plastic coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
 - i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

3. High and Medium Pressure Steam (MSS SP-58):

- a. Provide eye rod or Type 17 eye nut near the upper attachment.
- b. Piping 50 mm (2 inches) and larger: Type 43 roller hanger. For roller hangers requiring seismic bracing provide a Type 1 clevis hanger with Type 41 roller attached by flat side bars.
- c. Piping with Vertical Expansion and Contraction:
 - 1) Movement up to 20 mm (3/4-inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 20 mm (3/4-inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.

4. Converter and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.

K. Pre-insulated Calcium Silicate Shields:

- 1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
- 2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
- 3. Shield thickness shall match the pipe insulation.
- 4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
 - a. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 1 inch past the sheet metal. Provide for an adequate vapor barrier in chilled lines.
 - b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psi) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36) wear plates welded to the bottom sheet metal jacket.
- 5. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

L. Seismic Restraint of Piping and Ductwork: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Comply with MSS SP-127.

2.10 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 intended 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.

2.11 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. Electrical and Pneumatic Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.
- I. 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. Concrete and Grout: Use concrete and shrink compensating grout 25 MPa (3000 psi) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- K. 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.
- L. Install steam piping expansion joints as per manufacturer's recommendations.
- M. 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.
- O. 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).
- P. 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 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.
4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.4 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 COTR 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.
- E. Asbestos Insulation Removal: Conform to Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.

3.5 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. Refer to Section 09 91 00, PAINTING.
- 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.

3.6 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.
- C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

3.7 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.

3.8 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.

3.9 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.

3.10 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.

3.11 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.

3.12 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.

- - - E N D - - -

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 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements common to more than one Section of Division 26.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. 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.

F. Number of phases shall be as follows:

1. Motors, 373 W (1/2 HP) and larger: 3 phase.
2. Exceptions:
 - a. Hermetically sealed motors.
 - b. Motors for equipment assemblies, less than 746 W (one HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

G. Motors shall be designed for operating the connected loads continuously in a 40°C (104°F) environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 40°C (104°F), the motors shall be rated for the actual ambient temperatures.

H. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.

I. 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.

J. 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.
- K. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.
- L. 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%

M. 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:

- A. 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.
- B. Confirm location, rating and voltage of each motor noted to be replaced.

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.

- - - E N D - - -

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. Systems Readiness Report.
 - 5. Balancing of selected air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
 - 6. Recording and reporting results.
- B. Definitions:
 - 1. Basic TAB used in this Section: Chapter 37, "Testing, Adjusting and Balancing" of 2007 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, 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 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.
- B. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Piping and Equipment Insulation.
- C. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Controls and Instrumentation Settings.
- D. Section 23 21 13, HYDRONIC PIPING
- E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training

F. 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 10 percent.
- b. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
- c. Exhaust hoods/cabinets: 0 percent to plus 10 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 10 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 30 days 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):
- 2007HVAC Applications ASHRAE Handbook, Chapter 37, Testing, Adjusting, and Balancing and Chapter 47, 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 2005Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
- 2nd Edition 2006Procedural Standards for the Measurement of Sound and Vibration
- 3rd Edition 2009Procedural Standards for Whole Building Systems Commissioning of New Construction
- E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
- 3rd Edition 2002HVAC 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

See Section 23 07 11, HVAC and BOILER PLANT INSULATION 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 25 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 Return existing areas outside the work area to pre constructed conditions.
- D. Allow 15 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, and laboratory fume hoods and biological safety cabinets.
 - 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. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
 - b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set. Check and readjust ATU flow rates if necessary. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the ATU is in the maximum heating mode. Record and report outdoor air flow rates under all operating conditions (The test shall demonstrate that the minimum outdoor air ventilation rate shall remain constant under all operating conditions).
 - c. Adjust operating pressure control setpoint 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:
1. Coordinate water chiller flow balancing with Section 23 64 00, PACKAGED WATER CHILLERS.
 2. Adjust flow rates for equipment. 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 07 11
HVAC AND BOILER PLANT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field applied insulation for thermal efficiency and condensation control for
 - 1. HVAC piping, ductwork and equipment, associated with disturbed HVAC insulation as part of this project.
- B. Definitions
 - 1. ASJ: All service jacket, white finish facing or jacket.
 - 2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
 - 3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
 - 4. Concealed: Ductwork and piping above ceilings and in chases, interstitial space, and pipe spaces.
 - 5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
 - 6. FSK: Foil-scrim-kraft facing.
 - 7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F); HVAC equipment or piping handling media above 41 degrees C (105 degrees F).
 - 8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
 - 9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
 - 10. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watt per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).
 - 11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
13. HPS: High pressure steam (415 kPa [60 psig] and above).
14. HPR: High pressure steam condensate return.
15. MPS: Medium pressure steam (110 kPa [16 psig] thru 414 kPa [59 psig]).
16. MPR: Medium pressure steam condensate return.
17. LPS: Low pressure steam (103 kPa [15 psig] and below).
18. LPR: Low pressure steam condensate gravity return.
19. PC: Pumped condensate.
20. HWH: Hot water heating supply.
21. HWHR: Hot water heating return.
22. GH: Hot glycol-water heating supply.
23. GHR: Hot glycol-water heating return.
24. R: Pump recirculation.
25. CW: Cold water.
26. SW: Soft water.
27. HW: Hot water.
28. CH: Chilled water supply.
29. CHR: Chilled water return.
30. GC: Chilled glycol-water supply.
31. GCR: Chilled glycol-water return.
32. RS: Refrigerant suction.
33. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING
- D. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM and CONDENSATE HEATING PIPING: Piping and equipment.

E. Section 23 21 13, HYDRONIC PIPING: Hot water, chilled water, and glycol piping.

F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training.

1.3 QUALITY ASSURANCE

A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

4.3.3.1 Pipe insulation and coverings, duct coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.1 or 4.3.3.1.2, shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. (See 4.2.4.2.)

4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

(1) UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors

(2) UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors

4.3.3.3 Air duct, panel, and plenum coverings and linings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

4.3.3.5* Air duct linings shall be interrupted at fire dampers to prevent interference with the operation of devices.

4.3.3.6 Air duct coverings shall not be installed so as to conceal or prevent the use of any service opening.

4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

4.3.10.2.6.2 Pneumatic tubing for control systems shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 1820, Standard for Safety Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics.

4.3.10.2.6.4 Optical-fiber and communication raceways shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 2024, Standard for Safety Optical-Fiber Cable Raceway.

4.3.10.2.6.6 Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

- (1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides
- (2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

2. Test methods: ASTM E84, UL 723, or NFPA 255.

3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For

- pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.
4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.
- C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Shop Drawings:
 1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
 - a. Insulation materials: Specify each type used and state surface burning characteristics.
 - b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.
 - c. Insulation accessory materials: Each type used.
 - d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
 - e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 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 basic designation only.

B. Federal Specifications (Fed. Spec.):

L-P-535E (2)- 99.....Plastic Sheet (Sheeting): Plastic Strip; Poly
(Vinyl Chloride) and Poly (Vinyl Chloride -
Vinyl Acetate), Rigid.

C. Military Specifications (Mil. Spec.):

MIL-A-3316C (2)-90.....Adhesives, Fire-Resistant, Thermal Insulation

MIL-A-24179A (1)-87.....Adhesive, Flexible Unicellular-Plastic
Thermal Insulation

MIL-C-19565C (1)-88.....Coating Compounds, Thermal Insulation, Fire-and
Water-Resistant, Vapor-Barrier

MIL-C-20079H-87.....Cloth, Glass; Tape, Textile Glass; and Thread,
Glass and Wire-Reinforced Glass

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

A167-99(2004).....Standard Specification for Stainless and
Heat-Resisting Chromium-Nickel Steel Plate,
Sheet, and Strip

B209-07.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate

C411-05.....Standard test method for Hot-Surface
Performance of High-Temperature Thermal
Insulation

C449-07.....Standard Specification for Mineral Fiber
Hydraulic-Setting Thermal Insulating and
Finishing Cement

C533-09.....Standard Specification for Calcium Silicate
Block and Pipe Thermal Insulation

C534-08.....Standard Specification for Preformed Flexible
Elastomeric Cellular Thermal Insulation in
Sheet and Tubular Form

C547-07.....Standard Specification for Mineral Fiber pipe
Insulation

C552-07.....Standard Specification for Cellular Glass
Thermal Insulation

C553-08.....Standard Specification for Mineral Fiber
Blanket Thermal Insulation for Commercial and
Industrial Applications

- C585-09.....Standard Practice for Inner and Outer Diameters
of Rigid Thermal Insulation for Nominal Sizes
of Pipe and Tubing (NPS System) R (1998)
- C612-10.....Standard Specification for Mineral Fiber Block
and Board Thermal Insulation
- C1126-04.....Standard Specification for Faced or Unfaced
Rigid Cellular Phenolic Thermal Insulation
- C1136-10.....Standard Specification for Flexible, Low
Permeance Vapor Retarders for Thermal
Insulation
- D1668-97a (2006).....Standard Specification for Glass Fabrics (Woven
and Treated) for Roofing and Waterproofing
- E84-10.....Standard Test Method for Surface Burning
Characteristics of Building
Materials
- E119-09c.....Standard Test Method for Fire Tests of Building
Construction and Materials
- E136-09b.....Standard Test Methods for Behavior of Materials
in a Vertical Tube Furnace at 750 degrees C
(1380 F)
- E. National Fire Protection Association (NFPA):
- 90A-09.....Standard for the Installation of Air
Conditioning and Ventilating Systems
- 96-08.....Standards for Ventilation Control and Fire
Protection of Commercial Cooking Operations
- 101-09.....Life Safety Code
- 251-06.....Standard methods of Tests of Fire Endurance of
Building Construction Materials
- 255-06.....Standard Method of tests of Surface Burning
Characteristics of Building Materials
- F. Underwriters Laboratories, Inc (UL):
- 723.....UL Standard for Safety Test for Surface Burning
Characteristics of Building Materials with
Revision of 09/08
- G. Manufacturer's Standardization Society of the Valve and Fitting
Industry (MSS):
- SP58-2009.....Pipe Hangers and Supports Materials, Design,
and Manufacture

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

- A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m³ (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.
- B. ASTM C553 (Blanket, Flexible) Type I, Class B-5, Density 32 kg/m³ (2 pcf), k = 0.04 (0.27) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.
- C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

- A. Comply with Standard ASTM C612, Class 3, 450 degrees C (850 degrees F).

2.3 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance \leq 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
- B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.
- D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork

as well as on interior piping and ductwork exposed to outdoor air (i.e.; in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity areas conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

- E. Glass Cloth Jackets: Presized, minimum 0.18 kg per square meter (7.8 ounces per square yard), 2000 kPa (300 psig) bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.
- F. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.
- G. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

2.4 REMOVABLE INSULATION JACKETS

- A. Insulation and Jacket:
 - 1. Non-Asbestos Glass mat, type E needled fiber.
 - 2. Temperature maximum of 450°F, Maximum water vapor transmission of 0.00 perm, and maximum moisture absorption of 0.2 percent by volume.
 - 3. Jacket Material: Silicon/fiberglass and LFP 2109 pure PTFE.
 - 4. Construction: One piece jacket body with three-ply braided pure Teflon or Kevlar thread and insulation sewn as part of jacket. Belt fastened.

2.5 PIPE COVERING PROTECTION SADDLES

- A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long
350 (14), 400 (16)	300 (12) long
450 through 600 (18 through 24)	350 (14) long

- B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).
- C. Boiler Plant Pipe supports: MSS SP58, Type 39. Apply at all pipe support points, except where MSS SP58, Type 3 pipe clamps provided as part of the support system.

2.6 ADHESIVE, MASTIC, CEMENT

- A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
- B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.
- C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.
- D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.
- E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
- F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
- G. Other: Insulation manufacturers' published recommendations.

2.7 MECHANICAL FASTENERS

- A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
- B. Staples: Outward clinching monel or galvanized steel.
- C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.
- D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.8 REINFORCEMENT AND FINISHES

- A. Glass fabric, open weave: ASTM D1668, Type III (resin treated) and Type I (asphalt treated).
- B. Glass fiber fitting tape: Mil. Spec MIL-C-20079, Type II, Class 1.
- C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
- D. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.
- E. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.
- F. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.9 FIRESTOPPING MATERIAL

Other than pipe and duct insulation, refer to Section 07 84 00
FIRESTOPPING.

2.10 FLAME AND SMOKE

Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the Resident Engineer for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.
- B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.
- C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous

through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

- D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.
- E. Construct insulation on parts of equipment such as chilled water pumps and heads of chillers, convertors and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.
- F. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.
- G. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- H. HVAC work not to be insulated:
 - 1. Internally insulated ductwork and air handling units.
 - 2. Relief air ducts (Economizer cycle exhaust air).
 - 3. Exhaust air ducts and plenums, and ventilation exhaust air shafts.
 - 5. In hot piping: Unions, flexible connectors, control valves, safety valves and discharge vent piping, vacuum breakers, thermostatic vent valves, steam traps 20 mm (3/4 inch) and smaller, exposed piping through floor for convectors and radiators. Insulate piping to within approximately 75 mm (3 inches) of uninsulated items.
- I. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.
- J. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting

insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.

K. Firestop Pipe and Duct insulation:

1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe or duct chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions

L. Freeze protection of above grade outdoor piping (over heat tracing tape): 26 mm (10 inch) thick insulation, for all pipe sizes 75 mm(3 inches) and smaller and 25 mm(1inch) thick insulation for larger pipes. Provide metal jackets for all pipes. Provide for cold water make-up to cooling towers and condenser water piping and chilled water piping as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).

M. Provide vapor barrier jackets over insulation as follows:

1. All piping and ductwork exposed to outdoor weather.
2. All interior piping and ducts conveying fluids exposed to outdoor air (i.e. in attics, ventilated (not air conditioned) spaces, etc.) below ambient air temperature in high humidity areas.

N. Provide metal jackets over insulation as follows:

1. All piping and ducts exposed to outdoor weather.
2. Piping exposed in building, within 1800 mm (6 feet) of the floor, that connects to sterilizers, kitchen and laundry equipment. Jackets may be applied with pop rivets. Provide aluminum angle ring escutcheons at wall, ceiling or floor penetrations.
3. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

A. Mineral Fiber Board:

1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from

each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.

2. Plain board:

- a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
- b. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.
- c. For cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.
- d. Chilled water pumps: Insulate with removable and replaceable 1 mm thick (20 gage) aluminum or galvanized steel covers lined with insulation. Seal closure joints/flanges of covers with gasket material. Fill void space in enclosure with flexible mineral fiber insulation.

3. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics:

- a. 40 mm (1-1/2 inch) thick insulation faced with ASJ (white all service jacket): Supply air duct and after filter housing.
- b. 40 mm (1-1/2 inch) thick insulation faced with ASJ: Return air duct, mixed air plenums and prefilter housing.
- c. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a maximum water vapor permeability of 0.001 perms.

4. Supply air duct in the warehouse and in the laundry: 25 mm (one inch) thick insulation faced with ASJ.

5. Cold equipment: 40 mm (1-1/2inch) thick insulation faced with ASJ.
 - a. Chilled water pumps, water filter, chemical feeder pot or tank.
 - b. Pneumatic, cold storage water and surge tanks.
6. Hot equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
 - a. Convertors, air separators, steam condensate pump receivers.
 - b. Reheat coil casing and separation chambers on steam humidifiers located above ceilings.
 - c. Domestic water heaters and hot water storage tanks (not factory insulated).
 - d. Booster water heaters for dietetics dish and pot washers and for washdown grease-extracting hoods.
7. Laundry: Hot exhaust ducts from dryers and from ironers, where duct is exposed in the laundry.

B. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.
3. Concealed supply air ductwork.
 - a. Above ceilings at a roof level, in attics, and duct work exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with FSK.
 - b. Above ceilings for other than roof level: 40 mm (1 ½ inch) thick insulation faced with FSK.
4. Concealed return air duct:

- a. In attics (where not subject to damage) and where exposed to outdoor weather: 50mm (2 inch) thick insulation faced with FSK.
 - b. Above ceilings at a roof level, unconditioned areas, and in chases with external wall or containing steam piping; 40 mm (1-1/2 inch) thick, insulation faced with FSK.
 - c. Concealed return air ductwork in other locations need not be insulated.
- 5. Concealed outside air duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.
 - 6. Exhaust air branch duct from autopsy refrigerator to main duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.
- C. Molded Mineral Fiber Pipe and Tubing Covering:
- 1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
 - 2. Contractor's options for fitting, flange and valve insulation:
 - a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
 - b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
 - c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
 - d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

D. Flexible Elastomeric Cellular Thermal Insulation:

1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
2. Pipe and tubing insulation:
 - a. Use proper size material. Do not stretch or strain insulation.
 - b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC //and Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION//.
 - c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section).
5. Minimum 20 mm (0.75 inch) thick insulation for pneumatic control lines for a minimum distance of 6 m (20 feet) from discharge side of the refrigerated dryer.
6. Use Class S (Sheet), 20 mm (3/4 inch) thick for the following:
 - a. Chilled water pumps
 - b. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
 - c. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.
 - d. Piping inside refrigerators and freezers: Provide heat tape under insulation.

7. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.

3.3 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.

3.4 PIPE INSULATION SCHEDULE

Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 - 32 (1 - 1¼)	38 - 75 (1½ - 3)	100 (4) and Above
122-177 degrees C (251-350 degrees F) (HPS, MPS)	Mineral Fiber (Above ground piping only)	75 (3)	100 (4)	113 (4.5)	113 (4.5)
93-260 degrees C (200-500 degrees F) (HPS, HPR)	Calcium Silicate	100 (4)	125 (5)	150 (6)	150 (6)
100-121 degrees C (212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Mineral Fiber (Above ground piping only)	62 (2.5)	62 (2.5)	75 (3.0)	75 (3.0)
100-121 degrees C (212-250 degrees F)	Rigid Cellular Phenolic Foam	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)

(HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)					
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-99 degrees C (100-211 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
39-99 degrees C (100-211 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	----	----
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	----	----
4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH and CHR within chiller room and pipe chase and underground)	Cellular Glass Closed-Cell	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)
4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Cellular Glass Closed-Cell	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
(40-60 degrees F) (CH, CHR, GC, GCR	Flexible Elastomeric	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)

and RS for DX refrigeration)	Cellular Thermal (Above ground piping only)				
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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.

~~SPEC WRITER NOTE: Paragraph C is for LEED projects. Delete paragraph or subparagraphs as necessary for specific projects.~~

- ~~C. The commissioning activities have been developed to support the United States Green Building Council (USGBC) LEED™ rating program and to support delivery of project performance in accordance with the Contract Documents developed with the approval of the VA.~~
 - ~~1. Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" prerequisite of "Fundamental Building Systems Commissioning".~~
 - ~~2. Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" requirements for the "Enhanced Building System Commissioning" credit.~~

~~3. Activities and documentation for the LEED™ section on "Measurement and Verification" requirements for the Measurement and Verification credit.~~

- ~~DC~~. 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.

~~SPEC WRITER NOTE: Paragraph B should list the specific systems that will be commissioned. Edit the list as necessary for specific projects. The list below should match the list included in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. It is recommended that the list included in Section 01 91 00 be developed first and then copied/pasted into the list below. Both lists should be identical to prevent confusion.~~

- B. The following HVAC systems will be commissioned:
1. Air Handling Systems (including terminal units and energy recovery units)
 2. Air Handling Systems (Fans, motors, Variable Speed Drives, cooling coils and control valves, heating coils and control valves, filters, dampers, safeties such as smoke detectors or freezestats and damper end switches, controls, gages, and vibration isolation).
 3. Dehumidification Systems (Energy recovery devices - such as enthalpy wheels, fans, motors, Variable Speed Drives, cooling coils and control valves, heating coils and control valves, filters, dampers, safeties, controls, gages, and vibration isolation).
 4. Heating Hot Water Systems (Boilers, controls, instrumentation and gages, flues, heating water pumps and motors, Variable Speed Drives, mixing valves).

- ~~5. Condensate Return Systems (Condensate receivers and transfer pumps, motors, controls, pump alternator, alarms and instrumentation, deaerators, boiler feed pumps and motors, safeties).~~
6. Chilled Water Systems (Chilled water pumps and motors, Variable Speed Drives, chiller motor/compressor, controls, instrumentation and safeties, isolation valves, blending valves, side stream water cleaners/scrubbers/filters).
7. Condenser Water Systems for Chillers (Condenser water pumps and motors, Variable Speed Drives, cooling tower fans, cooling tower sump level controls, open-circuit water treatment system, water treatment injection pumps and motors, water treatment controls, cooling tower basin heaters and controls, side stream water cleaners/scrubbers/filters, tower bypass valves).
8. Exhaust Fans (Fan, motor, Variable Speed Drives, controls and safeties).
9. Steam System (Boilers, controls, gages and instrumentation, safety relief valves, combustion burners/fans/motors, fuel delivery pumps and motors, flues).
10. 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).
- ~~11. Laboratory Exhaust Systems (Fume hoods, pressure controls, system alarms, fans, motors, and Variable Speed Drives).~~
13. Laboratory Ventilation Systems (Supply air terminal units and controls, pressure controls and alarms, fans, motors, and Variable Speed Drives).
14. OR Air Handling Systems (Fans, motors, Variable Speed Drives, Energy recovery devices - such as heat pipes, cooling coils and control valves, heating coils and control valves, filters, HEPA filter performance, dampers, safeties such as smoke detectors or freezestats and damper end switches, controls, gages, and vibration isolation).
- ~~15. Radiology/Imaging Cooling Systems (Fans, motors, Variable Speed Drives, cooling coils and control valves, filters, dampers, safeties, controls, gages, and vibration isolation).~~

- ~~16. Computer Room Air Conditioning Systems (CRAC units — including fans, motors, Variable Speed Drives, cooling coils and control valves, heating coils and control valves, humidifiers, compressors and liquid-cooled condensers, filters, safeties, controls, gages, vibration isolation, condensate pumps, water/leak detection system and alarms, and shunt trip shut down).~~
- ~~17. Room Pressurization Equipment (Pressure sensors, terminal units/dampers, and controls and alarms).~~
- ~~18. HVAC Water Treatment Systems (Closed circuits — including shot feeders and final water analysis, open circuits — including water analysis, chemical/biocide tanks, injection piping, chemical/biocide pumps and motors, controls, water meter, and automatic blowdown).~~
- ~~19. Commercial Kitchen Hoods & Associated Fire Suppression Systems (Fans, motors, Variable Speed Drives, automatic shut down on fire suppression discharge, and gas valve operation).~~
- ~~20. Fuel Delivery and Storage Systems for Boilers and Standby Generators (Fuel level monitoring/controls/alarms, transfer pumps and motors, leak detection monitoring/alarms, and fill systems).~~

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 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.

3.2 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. The Commissioning Agent will witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.3 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.

3.4 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 -----

SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide (a) direct-digital control system(s) 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.
1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server, and an Engineering Control Center. Provide a remote user using a standard web browser to access the control system graphics and change adjustable set points with the proper password.
 2. 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, unless otherwise allowed by this Section of the technical specifications, specifically shown on the design drawings and specifically requested otherwise by the VA.
 - a. If used, gateways shall support the ASHRAE Standard 135 BACnet communications protocol.
 - b. If used, gateways shall provide all object properties and read/write services shown on VA-approved interoperability schedules.
 3. 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.

4. 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.
 5. The control system shall accommodate 1 Engineering Control Center and the control system shall accommodate 10 web-based Users simultaneously, and the access to the system should be limited only by operator password.
- 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 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 the following:
1. Refrigerant leak detection system.
 2. 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. Chiller and other packaged HVAC equipment controls. These controls, if not native BACnet, will require a BACnet Gateway.
 4. Terminal units' velocity sensors
 5. Unitary HVAC equipment (rooftop air conditioning units, split systems, packaged pumping stations) controls. These include:

- a. Discharge temperature control.
 - b. Economizer control.
 - c. Flowrate control.
 - d. Set point reset.
 - e. Time of day indexing.
 - f. Status alarm.
6. Variable frequency drives. These controls, if not native BACnet, will require a BACnet Gateway.
7. 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. Isolation rooms: pressure outside of acceptable limit alarms.

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
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

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
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 wiring	N/A	N/A	26	26
Chiller Flow Switches	23	23	23	N/A
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
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

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
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
Fan Coil Unit controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
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
Starters, HOA switches	23	23	N/A	26

F. This facility's existing direct-digital control systems are manufactured by various manufactures including Trane, Siemens, Alerton, Automated Logic and Johnson Controls, and there is no existing control ECC with the exception of a DDC control station in Building 15 that will not be reused. The existing DDC system's top-end controllers (not installed for all buildings) were installed within the last ten years. The contractor administered by this Section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control systems prior to beginning work.

1. Provide a new BACnet ECC, communications network, and controllers. Provide a programmable internetworking gateways allowing for real-time communication between the existing direct-digital control system and the new BACnet control system. Real-time communication shall provide all

object properties and read/write services shown on VA-approved interoperability schedules. The contractor administered by this Section of the technical specifications shall provide all necessary investigation and site-specific programming to execute the interoperability schedules.

- a. The combined system shall operate and function as one complete system including one database of control point objects and global control logic capabilities. Facility operators shall have limited operations and control capability over the legacy systems, as described in the VA-approved interoperability schedules.

G. Unitary standalone systems including Unit Heaters, Cabinet Unit Heaters, Fan Coil Units, Base Board Heaters, thermal comfort ventilation fans, and similar units for control of room environment conditions may be equipped with integral controls furnished and installed by the equipment manufacturer or field mounted. Refer to equipment specifications and as indicated in project documents. Application of standalone unitary controls is limited to at least those systems wherein remote monitoring, alarm and start-up are not necessary. Examples of such systems include:

- 1. Light-switch-operated toilet exhaust
- 2. Vestibule heater
- 3. Exterior stair heater
- 4. Attic heating and ventilation
- 5. Mechanical or electrical room heating and ventilation.

H. The direct-digital control system shall start and stop equipment, move (position) damper actuators and valve actuators, and vary speed of equipment to execute the mission of the control system. Use electricity as the motive force for all damper and valve actuators, unless use of pneumatics as motive force is specifically granted by the VA.

1.2 RELATED WORK

- A. Section 23 21 13, Hydronic Piping.
- B. Section 23 22 13, Steam and Condensate Heating Piping.
- C. Section 26 05 21, Low-Voltage Electrical Power Conductors and Cables (600 Volts and Below).
- D. Section 26 05 26, Grounding and Bonding for Electrical Systems.
- E. Section 26 05 33, Raceway and Boxes for Electrical Systems.
- F. Section 26 09 23, Lighting Controls.
- G. Section 26 27 26, Wiring Devices.
- H. Section 26 29 11, Motor Starters.
- I. Section 27 15 00, Communications Horizontal Cabling

1.3 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. ARCNET: ANSI/ATA 878.1 - Attached Resource Computer Network. ARCNET is a deterministic LAN technology; meaning it's possible to determine the maximum delay before a device is able to transmit a message.
- C. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
- D. 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.
- E. 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.
- F. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may sue different LAN technologies.

- G. 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.
- H. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
- I. 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.
- J. 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.
- K. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.
- L. 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).
- M. 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.
- N. 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.
- O. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.
- P. 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

- Q. 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).
- R. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.
- S. 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.
- T. 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.
- U. 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.
- V. 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.
- W. 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.

- X. 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.
- Y. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.
- Z. 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.
- AA. 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.
- BB. 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.
- CC. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
- DD. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.
- EE. 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.
- FF. GIF: Abbreviation of Graphic interchange format.
- GG. 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.

- HH. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.
- II. 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.
- JJ. 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.
- KK. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.
- LL. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.
- MM. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.
- NN. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3). It is not an acceptable LAN option for VA health-care facilities. It uses twisted-pair wiring for relatively low speed and low cost communication.
- OO. 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.

- PP. 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.
- QQ. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.
- RR. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.
- SS. 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.
- TT. Operating system (OS): Software, which controls the execution of computer application programs.
- UU. 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.
- VV. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.
- WW. 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.
- XX. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.
- YY. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a set point.
- ZZ. Repeater: A network component that connects two or more physical segments at the physical layer.
- AAA. 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.

- BBB. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.
- CCC. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.4 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegate 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 50 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.

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.

1.5 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	$\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$)
Ducted air temperature	$\pm 0.5^{\circ}\text{C}$ [$\pm 1^{\circ}\text{F}$]
Outdoor air temperature	$\pm 1.0^{\circ}\text{C}$ [$\pm 2^{\circ}\text{F}$]
Dew Point	$\pm 1.5^{\circ}\text{C}$ [$\pm 3^{\circ}\text{F}$]
Water temperature	$\pm 0.5^{\circ}\text{C}$ [$\pm 1^{\circ}\text{F}$]
Relative humidity	$\pm 2\%$ RH
Water flow	$\pm 1\%$ of reading

Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
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 set point 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 lists on the drawings.

1.6 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 24 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.

1.7 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. Control air-supply components, and computations for sizing compressors, receivers and main air-piping, if pneumatic controls are furnished.
5. 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.
6. Sequence of operations for each HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
7. Color prints of proposed graphics with a list of points for display.
8. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
9. 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.
10. 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.
11. Riser diagrams of wiring between central control unit and all control panels.

12. Scaled plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
 13. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.
 14. 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. 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 (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.
- F. Operation and Maintenance (O/M) Manuals):
1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS.
 2. Include the following documentation:
 - a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
 - b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.

- c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
 - d. Complete troubleshooting procedures and guidelines for all systems.
 - e. Complete operating instructions for all systems.
 - f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
 - g. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.
 - h. Licenses, guaranty, and other pertaining documents for all equipment and systems.
- G. Submit Performance Report to Resident Engineer prior to final inspection.

1.8 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.
- 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.

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 16 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel.
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.

1.9 PROJECT 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.

1.10 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 135-10BACNET 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-10Wire Connectors
 - 555S-11 Standard for Smoke Dampers
 - 916-10 Energy Management Equipment
 - 1076-10 Proprietary Burglar Alarm Units and Systems

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations.

Spare parts shall be available for at least five years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General

1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.
2. The ECC, building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels - not "Clones" assembled by a third-party subcontractor.
3. The networks shall, at minimum, comprise, as necessary, the following:
 - a. A fixed ECC at one designated building and a portable operator's terminal at each building included in the project work. Two portable laptop computers and associated software will be provided as part of this project.
 - b. Network computer processing, data storage and BACnet-compliant communication equipment including Servers and digital data processors.
 - c. BACnet-compliant routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.
 - d. Active processing BACnet-compliant building controllers connected to other BACNet-compliant controllers together with their power supplies and associated equipment.
 - e. Addressable elements, sensors, transducers and end devices.
 - f. Third-party equipment interfaces and gateways as described and required by the Contract Documents.
 - g. Other components required for a complete and working Control Systems as specified.

- B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the Contract Documents.
- C. Network Architecture
 - 1. The Controls communication network shall utilize BACnet/IP communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.
 - 2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations. They may also utilize digital wireless technologies as appropriate to the application and if approved by the VA.
 - 3. All necessary telephone lines, ISDN lines and internet Service Provider services and connections will be provided by the VA.
- D. Third Party Interfaces:
 - 1. The contractor administered by this Section of the technical specifications shall include necessary hardware, equipment, software and programming to allow data communications between the controls systems and building systems supplied by other trades.
 - 2. Other manufacturers and contractors supplying other associated systems and equipment shall provide their necessary hardware, software and start-up at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.
- E. Servers:
 - 1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs.

2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration.
3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).
4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network information management, for alarm annunciation, for operator interface tasks, for controls application management and similar. These server(s) shall utilize IT industry standard database platforms which utilize a database declarative language designed for managing data in relational database management systems (RDBMS) such as SQL.

2.3 COMMUNICATION

- 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.
 1. The Data link / physical layer protocol (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3) and BACnet/IP.
 2. The MS/TP data link / physical layer protocol is not acceptable to the VA in any new BACnet network or sub-network in its healthcare or lab facilities.

- B. Each controller shall have a communication port for connection to an operator interface.
- C. Project drawings indicate remote buildings or sites to be connected by a nominal 56,000 baud modem over voice-grade telephone lines. In each remote location a modem and field device connection shall allow communication with each controller on the internetwork as specified in Paragraph D.
- D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
 - 1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.
 - 2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.
- E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.
- F. ECCs and Controllers with real-time clocks shall use the BACnet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.4 ENGINEERING CONTROL CENTER (ECC)

- A. The ECC shall reside on a high-speed network with controllers as shown on system drawings. The ECC and each standard browser

connected to server shall be able to access all system information.

- B. ECC and controllers shall communicate using BACnet protocol. ECC and control network 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.
- C. Hardware: ECC shall conform to the BACnet Advanced Workstation (B-AWS) Profile and shall be BTL-Listed as a B-AWS device.
 - 1. ECC shall be commercial standard with supporting 32- or 64-bit hardware (as required by the direct-digital control system software) and software enterprise server. Internet Explorer v6.0 SP1 or higher, Windows Script Hosting version 5.6 or higher, Windows Message Queuing, Windows Internet Information Services (IIS) v5.0 or higher, minimum 2.8 GHz processor, minimum 4GB DDR3 SDRAM (minimum 1333 Mhz) memory, 512 MB video card, and 16 speed high density DVD-RW+/- optical drive.
 - a. The hard drive shall be at the minimum 1 TB 7200 rpm SATA hard drive with 16 MB cache, and shall have sufficient memory to store:
 - 1) All required operator workstation software
 - 2) A DDC database at least twice the size of the delivered system database
 - 3) One year of trend data based on the points specified to be trended at their specified trend intervals.
 - b. Real-time clock:
 - 1) Accuracy: Plus or minus 1 minute per month.
 - 2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
 - 3) Clock shall function for one year without power.
 - 4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.

- c. Serial ports: Four USB ports and two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
 - d. Parallel port: Enhanced.
 - e. Sound card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
 - f. Color monitor: PC compatible, not less than 22 inches, LCD type, with a minimum resolution of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 mm.
 - g. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
 - h. Mouse: Standard, compatible with installed software.
 - i. Removable disk storage: Include the following, each with appropriate controller:
 - 1) Minimum 1 TB removable hard disk, maximum average access time of 10 ms.
 - j. Network interface card (NIC): integrated 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX Ethernet NIC with an SC/ST connector.
2. Cable modem: 42.88 MBit/s, DOCSIS 2.0 Certified, also backwards compatible with DOCSIS 1.1/1.0 standards. Provide Ethernet or USB connectivity.
 3. Optical modem: full duplex link, for use on 10 GBase-R single-mode and multi-mode fiber with a XENPAK module.
 4. Auto-dial modem: 56,600 bps, full duplex for asynchronous communications. With error detection, auto answer/autodial, and call-in-progress detection. Modem shall comply with requirements in ITU-T v.34, ITU-T v.42, ITU-T v.42 Appendix VI for error correction, and ITU-T v.42 BIS for data compression standards; and shall be suitable for operating on unconditioned voice-grade telephone lines complying with 47 CFR 68.

5. Audible Alarm: Manufacturer's standard.
6. Printers:
 - a. Provide a dedicated, minimum resolution 600 dpi, color laser printer, connected to the ECC through a USB interface.
 - 1) If a network printer is used instead of this dedicated printer, it shall have a 100Base-T interface with an RJ45 connection and shall have a firmware print spooler compatible with the Operating System print spooler.
 - 2) RAM: 512 MB, minimum.
 - 3) Printing Speed: Minimum twenty six pages per minute (color); minimum 30 pages per minute (black/white).
 - 4) Paper Handling: Automatic sheet feeder with 250-sheet x 8.5 inch x 11 inch paper cassette and with automatic feed.
 - b. Provide a dedicated black/white tractor-feed dot matrix printer for status/alarm message printing, minimum 10 characters per inch, minimum 160 characters per second, connected to the ECC through a USB interface.
 - 1) Paper: One box of 2000 sheets of 8-1/2x11 multi-fold type printer paper.
7. RS-232 ASCII Interface
 - a. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels, dial-up modems, and alarm transmitters.
 - b. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.

- c. Alarm System Interface: RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.
 - d. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.
 - e. Cables: provide Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 1) NFPA 70, Type CMP.
 - 2) Flame Resistance: NFPA 262, Flame Test.
8. Self-contained uninterruptible power supply (UPS):
- a. Size: Provide a minimum of six hours of operation of ECC equipment, including two hours of alarm printer operation.
 - b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
 - c. Accessories:
 - 1) Transient voltage suppression.
 - 2) Input-harmonics reduction.
 - 3) Rectifier/charger.
 - 4) Battery disconnect device.
 - 5) Static bypass transfer switch.
 - 6) Internal maintenance bypass/isolation switch.
 - 7) External maintenance bypass/isolation switch.
 - 8) Output isolation transformer.
 - 9) Remote UPS monitoring.

10) Battery monitoring.

11) Remote battery monitoring.

D. ECC Software:

1. Provide for automatic system database save and restore on the ECC's hard disk a copy of the current database of each Controller. This database shall be updated whenever a change is made in any system panel. In the event of a database loss in a building management panel, the ECC shall automatically restore the database for that panel. This capability may be disabled by the operator.
2. Provide for manual database save and restore. An operator with proper clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
3. Provide a method of configuring the system. This shall allow for future system changes or additions by users with proper clearance.
4. Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications. Acceptable operating systems are Windows XP, Windows System 7, Linux, and UNIX.
5. System Graphics. The operator workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics

shall have the ability to show animation by shifting image files based on the status of the object.

6. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.
7. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
8. The Controls Systems Operator Interfaces shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the ECC. The operating system shall be Windows XP or better, and shall support the third party software.
9. Provide graphical user software, which shall minimize the use of keyboard through the use of the mouse and "point and click" approach to menu selection.
10. The software shall provide a multi-tasking type environment that will allow the user to run several applications simultaneously. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able automatically export data to and

work in Microsoft Word, Excel, and other Windows based software programs, while concurrently on-line system alarms and monitoring information.

11. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
12. User access shall be protected by a flexible and Owner re-definable software-based password access protection. Password protection shall be multi-level and partition able to accommodate the varied access requirements of the different user groups to which individual users may be assigned. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a project specific Master Password. Provide an audit trail of all user activity on the Controls Systems including all actions and changes.
13. The system shall be completely field-programmable from the common operator's keyboard thus allowing hard disk storage of all data automatically. All programs for the CUs shall be able to be downloaded from the hard disk. The software shall provide the following functionality as a minimum:
 - a. Point database editing, storage and downloading of controller databases.
 - b. Scheduling and override of building environmental control systems.
 - c. Collection and analysis of historical data.
 - d. Alarm reporting, routing, messaging, and acknowledgement.
 - e. Definition and construction of dynamic color graphic displays.

- f. Real-time graphical viewing and control of environment.
 - g. Scheduling trend reports.
 - h. Program editing.
 - i. Operating activity log and system security.
 - j. Transfer data to third party software.
14. Provide functionality such that using the least amount of steps to initiate the desired event may perform any of the following simultaneously:
- a. Dynamic color graphics and graphic control.
 - b. Alarm management.
 - c. Event scheduling.
 - d. Dynamic trend definition and presentation.
 - e. Program and database editing.
 - f. Each operator shall be required to log on to the system with a user name and password to view, edit or delete the data. System security shall be selectable for each operator, and the password shall be able to restrict the operator's access for viewing and changing the system programs. Each operator shall automatically be logged off the system if no keyboard or mouse activity is detected for a selected time.
15. Graphic Displays:
- a. The workstation shall allow the operator to access various system schematics and floor plans via a graphical penetration scheme, menu selection, or text based commands. Graphic software shall permit the importing of AutoCAD or scanned pictures in the industry standard format (such as PCX, BMP, GIF, and JPEG) for use in the system.
 - b. System Graphics shall be project specific and schematically correct for each system. (ie: coils, fans, dampers located per equipment supplied with project.) Standard system graphics that do not match equipment or system configurations are not acceptable.

Operator shall have capability to manually operate the entire system from each graphic screen at the ECC. Each system graphic shall include a button/tab to a display of the applicable sequence of operation.

- c. Dynamic temperature values, humidity values, flow rates, and status indication shall be shown in their locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh values.
 - d. Color shall be used to indicate status and change in status of the equipment. The state colors shall be user definable.
 - e. A clipart library of HVAC equipment, such as chillers, boilers, air handling units, fans, terminal units, pumps, coils, standard ductwork, piping, valves and laboratory symbols shall be provided in the system. The operator shall have the ability to add custom symbols to the clipart library.
 - f. A dynamic display of the site-specific architecture showing status of the controllers, the ECC and network shall be provided.
 - g. The windowing environment of the workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of graphic associated with an alarm to be viewed without interrupting work in progress. The graphic system software shall also have the capability to split screen, half portion of the screen with graphical representation and the other half with sequence of operation of the same HVAC system.
16. Trend reports shall be generated on demand or pre-defined schedule and directed to monitor display, printers or disk. As a minimum, the system shall allow the operator to easily obtain the following types of reports:

- a. A general list of all selected points in the network.
 - b. List of all points in the alarm.
 - c. List of all points in the override status.
 - d. List of all disabled points.
 - e. List of all points currently locked out.
 - f. List of user accounts and password access levels.
 - g. List of weekly schedules.
 - h. List of holiday programming.
 - i. List of limits and dead bands.
 - j. Custom reports.
 - k. System diagnostic reports, including, list of digital controllers on the network.
 - l. List of programs.
17. ASHRAE Standard 147 Report: Provide a daily report that shows the operating condition of each chiller as recommended by ASHRAE Standard 147. At a minimum, this report shall include:
- a. Chilled water (or other secondary coolant) inlet and outlet temperature
 - b. Chilled water (or other secondary coolant) flow
 - c. Chilled water (or other secondary coolant) inlet and outlet pressures
 - d. Evaporator refrigerant pressure and temperature
 - e. Condenser refrigerant pressure and liquid temperature
 - f. Condenser water inlet and outlet temperatures
 - g. Condenser water flow
 - h. Refrigerant levels
 - i. Oil pressure and temperature
 - j. Oil level
 - k. Compressor refrigerant discharge temperature
 - l. Compressor refrigerant suction temperature
 - m. Addition of refrigerant
 - n. Addition of oil
 - o. Vibration levels or observation that vibration is not excessive

- p. Motor amperes per phase
 - q. Motor volts per phase
 - r. PPM refrigerant monitor level
 - s. Purge exhaust time or discharge count
 - t. Ambient temperature (dry-bulb and wet-bulb)
 - u. Date and time logged
18. Weather Reports
- a. Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum, and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month.
19. Scheduling and Override:
- a. Provide override access through menu selection from the graphical interface and through a function key.
 - b. Provide a calendar type format for time-of-day scheduling and overrides of building control systems. Schedules reside in the ECC. The digital controllers shall ensure equipment time scheduling when the ECC is off-line. The ECC shall not be required to execute time scheduling. Provide the following spreadsheet graphics as a minimum:
 - 1) Weekly schedules.
 - 2) Zone schedules, minimum of 100 zones.
 - 3) Scheduling up to 365 days in advance.
 - 4) Scheduled reports to print at workstation.
20. Collection and Analysis of Historical Data:
- a. Provide trending capabilities that will allow the operator to monitor and store records of system activity over an extended period of time. Points may be trended automatically on time based intervals or change of value, both of which shall be user

definable. The trend interval could be five (5) minutes to 120 hours. Trend data may be stored on hard disk for future diagnostic and reporting. Additionally trend data may be archived to network drives or removable disk media for off-site retrieval.

- b. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow pre-defined groups of up to 250 trended points to be easily accessible by other industry standard word processing and spreadsheet packages. The reports shall be time and date stamped and shall contain a report title and the name of the facility.
- c. System shall have the set up to generate spreadsheet reports to track energy usage and cost based on weekly or monthly interval, equipment run times, equipment efficiency, and/or building environmental conditions.
- d. Provide additional functionality that will allow the operator to view real time trend data on trend graph displays. A minimum of 20 points may be graphed regardless of whether they have been predefined for trending. In addition, the user may pause the graph and take snapshots of the screens to be stored on the workstation disk for future reference and trend analysis. Exact point values may be viewed and the graph may be printed. Operator shall be able to command points directly on the trend plot by double clicking on the point.

21. Alarm Management:

- a. Alarm routing shall allow the operator to send alarm notification to selected printers or operator workstation based on time of day, alarm severity, or point type.
- b. Alarm notification shall be provided via two alarm icons, to distinguish between routine, maintenance

type alarms and critical alarms. The critical alarms shall display on the screen at the time of its occurrence, while others shall display by clicking on their icon.

- c. 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 in English language. The operator shall be able to sort out the alarms.
 - d. Alarm messages shall be customized for each point to display detailed instructions to the operator regarding actions to take in the event of an alarm.
 - e. An operator with proper security level access may acknowledge and clear the alarm. All that have not been cleared shall be archived at workstation disk.
22. Remote Communications: The system shall have the ability to dial out in the event of an alarm. Receivers shall include operator workstations, e-mail addresses, and alpha-numeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself.
23. System Configuration:
- a. Network control strategies shall not be restricted to a single digital controller, but shall be able to include data from all other network devices to allow the development of global control strategies.
 - b. Provide automatic backup and restore of all digital controller databases on the workstation hard disk. In addition to all backup data, all databases shall be performed while the workstation is on-line without disturbing other system operations.

2.5 PORTABLE OPERATOR'S TERMINAL (POT)

- A. Provide two portable operator's terminals (POT) that shall be capable of accessing all system data. POT may be connected to any point on the system network or may be connected directly to any controller for programming, setup, and troubleshooting. POT shall communicate using BACnet protocol. POT may be connected to any point on the system network or it may be connected directly to controllers using the BACnet PTP (Point-To-Point) Data Link/Physical layer protocol. The terminal shall use the Read (Initiate) and Write (Execute) BACnet Services. POT shall be an IBM-compatible notebook-style PC including all software and hardware required.
- B. Hardware: POT shall conform to the BACnet Advanced Workstation (B-AWS) Profile and shall be BTL-Listed as a B-AWS device.
 - 1. POT shall be commercial standard with supporting 32- or 64-bit hardware (as limited by the direct-digital control system software) and software enterprise server. Internet Explorer v6.0 SP1 or higher, Windows Script Hosting version 5.6 or higher, Windows Message Queuing, Windows Internet Information Services (IIS) v5.0 or higher, minimum 2.8 GHz processor, minimum 500 GB 7200 rpm SATA hard drive with 16 MB cache, minimum 2GB DDR3 SDRAM (minimum 1333 Mhz) memory, 512 MB video card, minimum 16 inch (diagonal) screen, 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX Ethernet NIC with an SC/ST connector, 56,600 bps modem, an ASCII RS-232 interface, and a 16 speed high density DVD-RW+/- optical drive.
- C. Software: Each POT shall include software equal to the software on the ECC.

2.6 BACNET PROTOCOL ANALYZER

- A. For ease of troubleshooting and maintenance, provide a BACnet protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The BACnet protocol analyzer shall be able to, at a minimum: capture

and store to a file all data traffic on all network levels;
measure bandwidth usage; filter out (ignore) selected traffic.

2.7 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC's or VA campus' assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internet work.
2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:
 - a. FFF = Facility code (see below)
 - b. NN = 00-99 This allows up to 100 networks per facility or building

B. Device Instances

1. BACnet allows 4194305 unique device instances per BACnet internet work. Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNNDD" where
 - a. FFF and N are as above and
 - b. DD = 00-99, this allows up to 100 devices per network.
2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnetworks. The device number can be expanded to DDD and the network number N can become a single digit. In NO case shall the network number N and the device number D exceed 4 digits.
3. Facility code assignments:
4. 000-400 Building/facility number
5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes above 400 will be assigned in the range 000-399.

C. Device Names

1. Name the control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. Generally, the naming convention for equipment shall match the equipment tags as shown on the Contract Drawings. The intent of the device naming is to be easily recognized. Names can be up to 254 characters in length, without embedded spaces. Provide the shortest descriptive, but unambiguous, name. For example, in building #76 prefix the number with the building number, followed by the floor or level of the building that the equipment is located in followed by the sequential number of the equipment. In the case of unitary controllers, for example a VAV box controller, a name might be "B76.VAV.1.31". These names should be used for the value of the "Object_Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the EMCS name are the same.

2.8 BACNET DEVICES

- A. All BACnet Devices - controllers, gateways, routers, actuators and sensors shall conform to BACnet Device Profiles and shall be BACnet Testing Laboratories (BTL) -Listed as conforming to those Device Profiles. Protocol Implementation Conformance Statements (PICSS), describing the BACnet capabilities of the Devices shall be published and available of the Devices through links in the BTL website.
 1. BACnet Building Controllers, historically referred to as NACs, shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device's PICS shall be submitted.
 2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile, and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device's PICS shall be submitted.

3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile, and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device's PICS shall be submitted.
4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile, and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device's PICS shall be submitted.
5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile, and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device's PICS shall be submitted.
6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device's PICS shall be submitted.

2.9 CONTROLLERS

- A. General. Provide an adequate number of BTL-Listed B-BC building controllers and an adequate number of BTL-Listed B-AAC advanced application controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these controllers shall meet the following requirements.
 1. The controller shall have sufficient memory to support its operating system, database, and programming requirements.
 2. The building controller shall share data with the ECC and the other networked building controllers. The advanced application controller shall share data with its building controller and the other networked advanced application controllers.
 3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
 4. Controllers that perform scheduling shall have a real-time clock.

5. The controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a. assume a predetermined failure mode, and
 - b. generate an alarm notification.
6. The controller shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute and Initiate) and Write (Execute and Initiate) Property services.
7. Communication.
 - a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
 - b. The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal.
8. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. Provide a system security password shall be available to prevent unauthorized use of the keypad and display.
9. 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.
10. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
11. The controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Controller 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).

- B. Provide BTL-Listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.
1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
 2. Each B-ASC will contain sufficient I/O capacity to control the target system.
 3. Communication.
 - a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
 - b. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown.
 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 application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.
 6. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be

protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

7. Transformer. 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.

C. Direct Digital Controller Software

1. The software programs specified in this section shall be commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under DOS or Microsoft Windows.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.
3. All control functions shall execute within the stand-alone control units via DDC algorithms. The VA shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters.
4. All controllers shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, or by loss of bus communication. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the ECC. Each ACU and RCU shall have capability for local readouts of all functions. The UCUs shall be read remotely.
5. All DDC control loops shall be able to utilize any of the following control modes:
 - a. Two position (on-off, slow-fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.

- d. Proportional plus integral plus derivative (PID) control. All PID programs shall automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time initiated program.
 - e. Automatic tuning of control loops.
6. System Security: Operator access shall be secured using individual password and operator's name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned to him. A minimum of six (6) levels of security for operator access shall be provided.
7. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator's terminal, when it is necessary, to access directly the programmable unit.
- a. Economizer: An economizer program shall be provided for VAV systems. This program shall control the position of air handler relief, return, and outdoors dampers. If the outdoor air dry bulb temperature and humidity fall below changeover set point the energy control center will modulate the dampers to provide 100 percent outdoor air. The operator shall be able to override the economizer cycle and return to minimum outdoor air operation at any time.
 - b. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation.
 - c. Optimum Start/Stop (OSS): Optimum start/stop program shall automatically be coordinated with event scheduling. The OSS program shall start HVAC equipment at the latest possible time that will allow

the equipment to achieve the desired zone condition by the time of occupancy, and it shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions. The OSS program shall consider both outside weather conditions and inside zone conditions. The program shall automatically assign longer lead times for weekend and holiday shutdowns. The program shall poll all zones served by the associated AHU and shall select the warmest and coolest zones. These shall be used in the start time calculation. It shall be possible to assign occupancy start times on a per air handler unit basis. The program shall meet the local code requirements for minimum outdoor air while the building is occupied. Modification of assigned occupancy start/stop times shall be possible via the ECC.

- d. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. This program shall provide the capability to individually command a point or group of points. When points are assigned to one common load group it shall be possible to assign variable time advances/delays between each successive start or stop within that group. Scheduling shall be calendar based and advance schedules may be defined up to one year in advance. Advance schedule shall override the day-to-day schedule. The operator shall be able to define the following information:

- 1) Time, day.
- 2) Commands such as on, off, auto.
- 3) Time delays between successive commands.
- 4) Manual overriding of each schedule.
- 5) Allow operator intervention.

- e. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the ECC based on time and events. An alarm shall be able to start programs, login the event, print and display the messages. The system shall allow the operator to prioritize the alarms to minimize nuisance reporting and to speed operator's response to critical alarms. A minimum of six (6) priority levels of alarms shall be provided for each point.
- f. Remote Communications: The system shall have the ability to dial out in the event of an alarm to the ECC and alpha-numeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system using dial up communications. Remote access shall allow the operator to function the same as local access.
- g. Maintenance Management (PM): The program shall monitor equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or calendar date limits. A preventative maintenance alarm shall be printed indicating maintenance requirements based on pre-defined run time. Each preventive message shall include point description, limit criteria and preventative maintenance instruction assigned to that limit. A minimum of 480-character PM shall be provided for each component of units such as air handling units.

2.10 SPECIAL CONTROLLERS

- A. Room Differential Pressure Controller: The differential pressure in laboratory rooms, operating rooms and isolation rooms shall be maintained by controlling the quantity of air exhausted from or supplied to the room. A sensor-controller shall measure and

control the velocity of air flowing into or out of the room through a sampling tube installed in the wall separating the room from the adjacent space, and display the value on its monitor.

The sensor-controller shall meet the following as a minimum:

1. Operating range: -0.25 to +0.25 inches of water column
2. Resolution: 5 percent of reading
3. Accuracy: +/- 10 percent of reading +/- 0.005 inches of water column
4. Analog output: 0-10 VDC or 4-20 ma
5. Operating temperature range: 32°F-120°F

2.11 SENSORS (AIR, WATER AND STEAM)

- A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.
- B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.
 1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral transmitter type for all other sensors.
 - a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear ft of sensing element for each sq ft of cooling coil face area.
 - b. Immersion sensors shall be provided with a separable well made of stainless steel, bronze or monel material. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.
 - c. Space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and communication port. Match room thermostats. Provide a tooled-access cover.

- 1) Public space sensor: set point adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.
- 2) Psychiatric patient room sensor: sensor shall be flush with wall, shall not include an override switch, numerical temperature display on sensor cover, shall not include a communication port and shall not allow in-space User set-point adjustment. Set point adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Provide a stainless steel cover plate with an insulated back and security screws.
 - d. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.
 - e. Room security sensors shall have stainless steel cover plate with insulated back and security screws.
 - f. Wire: Twisted, shielded-pair cable.
 - g. Output Signal: 4-20 ma.
2. Humidity Sensors: Bulk polymer sensing element type.
 - a. Duct and room sensors shall have a sensing range of 20 to 80 percent with accuracy of ± 2 to ± 5 percent RH, including hysteresis, linearity, and repeatability.
 - b. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100 percent RH.
 - c. 4-20 ma continuous output signal.
- C. Static Pressure Sensors: Non-directional, temperature compensated.
 1. 4-20 ma output signal.
 2. 0 to 5 inches wg for duct static pressure range.

3. 0 to 0.25 inch wg for Building static pressure range.
- D. Water flow sensors:
1. Type: Insertion vortex type with retractable probe assembly and 2 inch full port gate valve.
 - a. Pipe size: 3 to 24 inches.
 - b. Retractor: ASME threaded, non-rising stem type with hand wheel.
 - c. Mounting connection: 2 inch 150 PSI flange.
 - d. Sensor assembly: Design for expected water flow and pipe size.
 - e. Seal: Teflon (PTFE).
 2. Controller:
 - a. Integral to unit.
 - b. Locally display flow rate and total.
 - c. Output flow signal to BMCS: Digital pulse type.
 3. Performance:
 - a. Turndown: 20:1
 - b. Response time: Adjustable from 1 to 100 seconds.
 - c. Power: 24 volt DC
 4. Install flow meters according to manufacturer's recommendations. Where recommended by manufacturer because of mounting conditions, provide flow rectifier.
- E. Water Flow Sensors: 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 minus 1 mm (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.
1. Performance characteristics:

- a. Ambient conditions: -40°C to 60°C (-40°F to 140°F), 5 to 100% humidity.
- b. Operating conditions: 850 kPa (125 psig), 0°C to 120°C (30°F to 250°F), 0.15 to 12 m per second (0.5 to 40 feet per second) velocity.
- c. Nominal range (turn down ratio): 10 to 1.
- d. 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). Preamplifier for bi-directional flow measurement shall provide a directional contact closure from a relay mounted in the preamplifier.
- e. Pressure Loss: Maximum 1 percent of the line pressure in line sizes above 100 mm (4 inches).
- f. Ambient temperature effects, less than 0.005 percent calibrated span per °C (°F) temperature change.
- g. RFI effect - flow meter shall not be affected by RFI.
- h. Power supply effect less than 0.02 percent of span for a variation of plus or minus 10 percent power supply.

F. Flow switches:

- 1. Shall be either paddle or differential pressure type.
 - a. Paddle-type switches (liquid service only) shall be UL Listed, SPDT snap-acting, adjustable sensitivity with NEMA 4 enclosure.
 - b. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap acting, NEMA 4 enclosure, with scale range and differential suitable for specified application.

G. Current Switches: Current operated switches shall be self powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. The switches shall be selected to match the current of the application and output requirements of the DDC systems.

2.12 CONTROL CABLES

A. General:

1. 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. Comply with Sections 27 05 26 and 26 05 26.
2. 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.
3. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.
4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.
5. 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 used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.
6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

B. Analogue control cabling shall be not less than No. 18 AWG solid, with thermoplastic insulated conductors as specified in Section 26 05 21.

C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e

or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 15 00.

1. 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.

- D. Optical digital communication fiber, if used, shall be Multimode or Singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode micron with SC or ST connectors as specified in TIA-568-C.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 27 15 00. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

2.13 THERMOSTATS AND HUMIDISTATS

- A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Thermostats for patient bedrooms shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have polished or brushed aluminum or satin chrome finish, set point range and temperature display and external adjustment:
 1. Electronic Thermostats: Solid-state, microprocessor based, programmable to daily, weekend, and holiday schedules.
 - a. Public Space Thermostat: Public space thermostat shall have a thermistor sensor and shall not have a visible means of set point adjustment. Adjustment shall be via the digital controller to which it is connected.
 - b. Patient Room Thermostats: thermistor with in-space User set point adjustment and an on-casing room temperature numerical temperature display.
 - c. Psychiatric Patient Room Sensors: Electronic duct sensor as noted under Article 2.4.
 - d. Battery replacement without program loss.

- B. Strap-on thermostats shall be enclosed in a dirt-and-moisture proof housing with fixed temperature switching point and single pole, double throw switch.
- C. Freezestats shall have a minimum of 300 mm (one linear foot) of sensing element for each 0.093 square meter (one square foot) of coil area. A freezing condition at any increment of 300 mm (one foot) anywhere along the sensing element shall be sufficient to operate the thermostatic element. Freezestats shall be manually-reset.
- D. Room Humidistats: Provide fully proportioning humidistat with adjustable throttling range for accuracy of settings and conservation. The humidistat shall have set point scales shown in percent of relative humidity located on the instrument. Systems showing moist/dry or high/low are not acceptable.

2.14 FINAL CONTROL ELEMENTS AND OPERATORS

- A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.
- B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.
- C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All new replacement modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.
 - 1. Leakage: Except as specified in subparagraph 2 below, maximum leakage in closed position shall not exceed 7 L/S (15 CFMs) differential pressure for outside air and exhaust dampers and 200 L/S/ square meter (40 CFM/sq. ft.) at 50 mm (2 inches) differential pressure for other dampers.
 - 2. Frame shall be galvanized steel channel with seals as required to meet leakage criteria.

3. Blades shall be galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed as required.
4. Bearing shall be nylon, bronze sleeve or ball type.
5. Hardware shall be zinc-plated steel. Connected rods and linkage shall be non-slip. Working parts of joints shall be brass, bronze, nylon or stainless steel.
6. Maximum air velocity and pressure drop through free area the dampers:
 - a. Smoke damper in air handling unit: 305 meter per minute (1000 fpm).
 - b. Duct mounted damper: 600 meter per minute (2000 fpm).
 - c. Maximum static pressure loss: 50 Pascal (0.20 inches water gage).

D. Control Valves:

1. Valves shall be rated for a minimum of 150 percent of system operating pressure at the valve location but not less than 900 kPa (125 psig).
2. Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.
3. Valves 60 mm (2 1/2 inches) and larger shall be bronze or iron body with flanged connections.
4. Brass or bronze seats except for valves controlling media above 100 degrees C (210 degrees F), which shall have stainless steel seats.
5. Flow characteristics:
 - a. Three way modulating valves shall be globe pattern. Position versus flow relation shall be linear relation for steam or equal percentage for water flow control.
 - b. Two-way modulating valves shall be globe pattern. Position versus flow relation shall be linear for steam and equal percentage for water flow control.
 - c. Two-way 2-position valves shall be ball, gate or butterfly type.
6. Maximum pressure drop:

- a. Two position steam control: 20 percent of inlet gauge pressure.
 - b. Modulating Steam Control: 80 percent of inlet gauge pressure (acoustic velocity limitation).
 - c. Modulating water flow control, greater of 3 meters (10 feet) of water or the pressure drop through the apparatus.
- 7. Two position water valves shall be line size.
- E. Damper and Valve Operators and Relays:
 - 1. Pneumatic operators, spring return type with non-ferrous metal bellows or diaphragm of neoprene or other elastomer. Bellows or diaphragm shall be of sufficient size so that a change in operating pressure of not more than two (2) percent of the total motor operating pressure range will be required to start the valve or damper moving. Provide positive positioning or sequencing relays with adjustable operating range and starting point for operators sequenced with other operators to permit adjustment of control sequences, except for control valves in confined spaces in terminal units, which may use springs with range selected to provide necessary sequencing. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel.
 - 2. Electric operator shall provide full modulating control of dampers and valves. A linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.

- a. Minimum valve close-off pressure shall be equal to the system pump's dead-head pressure, minimum 50 psig for valves smaller than 4 inches.
3. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
 - a. VAV Box actuator shall be mounted on the damper axle or shall be of the air valve design, and shall provide complete modulating control of the damper. The motor shall have a closure torque of 35-inch pounds minimum with full torque applied at close off to attain minimum leakage.
4. See drawings for required control operation.

2.15 AIR FLOW CONTROL

- A. Airflow and static pressure shall be controlled via digital controllers with inputs from airflow control measuring stations and static pressure inputs as specified. Controller outputs shall be analog or pulse width modulating output signals. The controllers shall include the capability to control via simple proportional (P) control, proportional plus integral (PI), proportional plus integral plus derivative (PID), and on-off. The airflow control programs shall be factory-tested programs that are documented in the literature of the control manufacturer.
- B. Air Flow Measuring Station -- Pneumatic Type:
 1. Airflow measuring stations shall measure airflow by the pitot tube traverse method. Each unit shall consist of a network of static and total pressure sensors, factory positioned and connected in parallel, to produce an equalized velocity pressure. The measured velocity pressure converted to airflow (cfm) shall have accuracy within 2

percent of the full scale throughout the velocity range from 200 to 1,200 meter per minute (700 to 4,000 fpm).

2. Airflow measuring stations shall consist of 16-gauge sheet metal casing, an aluminum air velocity treatment and air straightening section with an open face area not less than 97 percent and a total and static pressure sensing manifold made of copper. Each station shall contain noncombustible sensors which shall be incapable of producing toxic gases or fumes in the event of elevated duct temperatures. All interconnecting tubing shall be internal to the unit with the exception of one total pressure and one static pressure meter connection.
 3. Each air flow measuring station shall be installed to meet at least the manufacturer's minimum installation conditions and shall not amplify the sound level within the duct. The maximum resistance to airflow shall not exceed 0.3 times the velocity head for the duct stations and 0.6 times the velocity head for the fan stations. The unit shall be suitable for continuous operation up to a temperature of 120°C (250°F).
 4. Differential pressure transducers shall measure and transmit pressure signals to the direct digital controller.
- C. Static Pressure Measuring Station: shall consist of one or more static pressure sensors and transmitters along with relays or auxiliary devices as required for a complete functional system. The span of the transmitter shall not exceed two times the design static pressure at the point of measurement. The output of the transmitter shall be true representation of the input pressure with plus or minus 25 Pascal (0.1 inch) W.G. of the true input pressure:
1. Static pressure sensors shall have the same requirements as Airflow Measuring Devices except that total pressure sensors are optional, and only multiple static pressure

sensors positioned on an equal area basis connected to a network of headers are required.

2. For systems with multiple major trunk supply ducts, furnish a static pressure transmitter for each trunk duct. The transmitter signal representing the lowest static pressure shall be selected and this shall be the input signal to the controller.
 3. The controller shall receive the static pressure transmitter signal and CU shall provide a control output signal to the supply fan capacity control device. The control mode shall be proportional plus integral (PI) (automatic reset) and where required shall also include derivative mode.
 4. In systems with multiple static pressure transmitters, provide a switch located near the fan discharge to prevent excessive pressure during abnormal operating conditions. High-limit switches shall be manually-reset.
- D. Constant Volume Control Systems shall consist of an air flow measuring station along with such relays and auxiliary devices as required to produce a complete functional system. The transmitter shall receive its air flow signal and static pressure signal from the flow measuring station and shall have a span not exceeding three times the design flow rate. The CU shall receive the transmitter signal and shall provide an output to the fan volume control device to maintain a constant flow rate. The CU shall provide proportional plus integral (PI) (automatic reset) control mode and where required also inverse derivative mode. Overall system accuracy shall be plus or minus the equivalent of 2 Pascal (0.008 inch) velocity pressure as measured by the flow station.
- E. Airflow Synchronization:
1. Systems shall consist of an air flow measuring station for each supply and return duct, the CU and such relays, as required to provide a complete functional system that will maintain a constant flow rate difference between supply and return air to an accuracy of $\pm 10\%$. In systems where there

is no suitable location for a flow measuring station that will sense total supply or return flow, provide multiple flow stations with a differential pressure transmitter for each station. Signals from the multiple transmitters shall be added through the CU such that the resultant signal is a true representation of total flow.

2. The total flow signals from supply and return air shall be the input signals to the CU. This CU shall track the return air fan capacity in proportion to the supply air flow under all conditions.

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 and in accordance with Specification Section 26 05 21. Install digital communication cables in conduit and in accordance with Specification Section 27 15 00, Communications Horizontal Cabling.
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 building DDC controllers and the B-BC and the B-AAC controllers.
 - 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.

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.

1. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

3.3 SEQUEANCE OF OPERATIONS

3.3.1 Common Sequence of Operations: (common sequences referenced for various building buildings)

- A. C.RAD.1: Steam Radiator with Override Thermostat
 1. Units shall operate according to user definable time schedules in the following modes:
 2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
 3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
 4. Alarms shall be provided as follows:
 1. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
 5. On a call for heating, the two-position steam control valve (normally closed) shall be powered open.
 6. Space temperature sensors shall be provided with an override pushbutton that will enable radiator operation for 1 hour (adj.) period.
- B. C.RAD.2: Steam Radiator
 1. Units shall operate according to user definable time schedules in the following modes:
 2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
 3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
 4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
 5. On a call for heating, the two-position steam control valve (normally closed) shall be powered open.

C. C.RAD.3: Steam Fin Tube Radiator with Control Valve

1. Units shall operate according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. On a call for heating from the DDC, the modulating steam control valve (normally closed) shall be powered open.

D. C.FT-HW.1: Fin Tube Radiation with Control Valve

1. Units shall operate according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. On a call for heating, the two-position hot water control valve (normally closed) shall be powered open.
6. Space temperature sensors shall be provided with an override pushbutton that will fin tube unit operation for 1 hour (adj.) period.

E. C.FT-HW.2: Fin Tube Radiation with Control Valve

1. Units shall operate according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:

- a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
- 5. On a call for heating, the two-position hot water control valve (normally closed) shall be powered open.
- F. C.UH-STM.1: Steam Unit Heater with Control Valve
 - 1. Units shall run according to user definable time schedules in the following modes:
 - 2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
 - 3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
 - 4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
 - 5. On a call for heating from the space thermostat, the respective two-position steam control valve (normally closed) shall be powered open and the unit fan shall be energized.
- G. C.UH-STM.2: Steam Unit Heater
 - 1. Units shall run according to user definable time schedules in the following modes:
 - 2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
 - 3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
 - 4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
 - 5. On a call for heating from the space thermostat, the unit fan shall be energized.
- H. C.UH-HW.1: Hot Water Unit Heater with Control Valve
 - 1. Units shall run according to user definable time schedules in the following modes:
 - 2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.

3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. On a call for heating from the space thermostat, the respective two-position hot water control valve (normally closed) shall be powered open and the unit fan shall be energized.

I. C.UH-HW.2: Hot Water Unit Heater

1. Units shall run according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. On a call for heating from the space thermostat, the unit fan shall be energized.

J. C.CUH-STM.1: Steam Cabinet Unit Heater

1. Units shall run according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. On a call for heating from the space thermostat, the two-position steam control valve (normally closed) shall be powered open and the unit fan shall be energized.

K. C.CUH-HW.1: Hot Water Cabinet Heater

1. Units shall run according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. On a call for heating from the space thermostat, the two-position hot water control valve (normally closed) shall be powered open and the unit fan shall be energized.

L. C.FCU-HW-CW.1: Hot Water/Chilled Water Fan Coil Unit

1. Units shall run according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 74°F (adj.) cooling set point and 70°F (adj.) heating set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain 85°F (adj.) cooling set point and 65°F (adj.) heating set point.
4. Alarms shall be provided as follows:
 - a. High zone temperature: If the zone temperature is greater than the cooling set point by a user definable amount (adj.)
 - b. Low zone temperature: If the zone temperature is less than the heating set point by a user definable amount (adj.)
5. Whenever the individual zone is scheduled by the DDC system to be occupied, the fan coil fan shall be energized. When in the unoccupied mode, the fan coil fan shall only be energized on a call for heating or cooling. Space temperature shall be as sensed from the space/zone temperature sensor. On a call for heating, the hot water coil three-way valve (normally in the bypass position) shall modulate to maintain space heating set point. On a call for cooling, the chilled water coil three-way valve (normally in the bypass position) shall modulate to maintain space cooling set point.
6. Space temperature sensors shall be provided with an override pushbutton that will enable radiator operation for 1 hour (adj.) period.

M. C.GER.1 Glycol Energy Recovery Loop w/ Pumps

1. Heating mode: the circulating pump(s) shall operate for heat recovery whenever:
 - a. exhaust air temperature is 5°F (adj.) or more above the outside air temperature.
 - b. the zone temperature is above the cooling set point.
 - c. the supply and return fans are on.
2. The DDC controller shall measure the return water temperature to the exhaust air recovery coil and modulate the energy recovery 3-way control valve to maintain the return water temperature above 35°F (adj.) To prevent frosting the coil.
3. Cooling mode: the circulating pump(s) shall operate for heat rejection whenever:
 - a. exhaust air temperature is 5°F (adj.) or more below the outside air temperature.
 - b. the zone temperature is above the cooling set point.
 - c. the supply and return fans are on.
4. The DDC controller shall position the 3-way control for 100% fluid flow through the outside air recovery coil.
5. Pump Control: If the lead pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but the status is on, an alarm will be generated. For systems with a single pump, the DDC system shall operate as above with the exception of pump alternation. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):
 - a. Manually through software switch
 - b. Pump runtime (adj.) is exceeded
 - c. Daily
 - d. Weekly
 - e. Monthly

N. C.HTNG-HW.1 Hot Water Heating Loop with 1 Steam Valve

1. Steam to Hot Water Converter, Hot Water Pumps and Single Steam Control Valve
 - a. Main Hot Water Supply Temperature Set Point Reset: The hot water supply temperature set point during occupied periods shall reset based on outside air temperature. As outside air temperature, rises from 0°F (adj.) to 70°F (adj.) the hot water supply

- temperature set point shall reset downwards from 180°F (adj.) to 110°F (adj.).
 - b. The hot water supply temperature set point during building warm-up periods shall reset, as outside air temperature, rises from 0°F (adj.) to 70°F (adj.) the hot water supply temperature set point shall reset downwards from 195°F (adj.) to 125°F (adj.).
 - c. Alarms shall be provided as follows:
 - 1) High Hot Water Supply Temp: If greater than 200°F (adj.).
 - 2) Low Hot Water Supply Temp: If less than 100°F (adj.).
- 2. Heat Exchanger Steam Valve - Hot Water Control: The controller shall measure the hot water supply temperature and modulate the steam valve to maintain its set point. The steam valve shall be enabled whenever hot water supply temperature is below set point. The steam valve shall close whenever the hot water supply temperature rises from 180°F to 200°F (adj.).
- 3. Hot Water Pump Run Conditions: The hot water pumps shall be enabled whenever outside air temperature is less than 54°F. (adj.) To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable). Pump status and Hand-Off-Auto status to be monitored.

Two pumps: Shall operate in a lead/lag fashion. The lead pump shall run first. On failure of the lead pump, the lag pump shall run and the lead pump shall turn off. Lead/lag pump selection shall be automatically alternated weekly.

The hot water pumps shall have a user adjustable delay on start and a user adjustable delay on stop. The delay times shall be set appropriately to allow for orderly hot water system start-up, shutdown and sequencing.
- 4. Alarms shall be provided as follows:
 - a. Hot Water Pump Failure: Commanded on, but the status is off
 - b. Hot Water Pump Running in Hand: Commanded off, but the status is on
 - c. Hot Water Pump Runtime Exceeded: Status runtime exceeds a user definable limit
 - d. Monitoring: Hot water supply and return temperature.
- O. C.HTNG-HW.2 Hot Water Heating Loop with 2 Steam Valves

1. Steam to Hot Water Converter, Hot Water Pumps and 1/3 and 2/3 Steam Control Valves
 - a. Sequence of operation shall be the same as C.HTNG-HW.1. In addition, 1/3 and 2/3 steam control valves shall be controlled instead of a single steam control valve as described below.
 - b. 1/3 - 2/3 Steam Control Valve Control: The DDC system shall modulate the 1/3 and 2/3 steam control valves to maintain hot water supply temperature set point leaving the heat exchanger. When the 1/3 control valve is open to 75% (adj.) and if the hot water supply temperature is not met for a 30 second (adj.) period, the DDC system shall modulate the 2/3 control valve to meet set point temperature. If the set point temperature is exceeded by 5 degrees (adj.), the DDC system shall close the 2/3 control valve. If the set point temperature is still exceeded, the 1/3 control valve shall close.

- P. C.HTNG-GLY.1 Hot Water (Glycol) Heating Loop with 1 Steam Valve
 1. Sequence of operation shall be the same as C.HTNG-HW.1. In addition, the static pressure of glycol system shall be monitored as outlined in C.GLY.1.

- Q. C.HTNG-GLY.2 Hot Water Heating (Glycol) Loop with 2 Steam Valves
 1. Sequence of operation shall be the same as C.HTNG-HW.2. In addition, the static pressure of glycol system shall be monitored as outlined in C.GLY.1.

- R. C.GLY.1 Glycol Loop Pressure Monitoring
 1. The DDC system shall monitor the static pressure of the glycol loop near the glycol makeup connection to the glycol makeup tank and pump. If the static pressure in the glycol system drops below 10 psig (adj.), a glycol system low pressure alarm will be initiated.

- S. C.VAV.1, VAV Box with Reheat Coil
 1. During occupied mode and when space temperature exceeds set point of 74°F, the air terminal unit shall modulate open to maintain set point. If space temperature drops below 70°F, the supply terminal unit shall modulate to minimum position to maintain set point. If space temperature drops below set point and supply air terminal unit is at minimum airflow setting, the reheat hot water control valve shall modulate to maintain set point at 70°F.
 2. If the VAV box is in cooling mode and the discharge air temperature is 65°F or above as sensed by the discharge air temperature sensor, a reheat valve failure alarm shall be indicated by the DDC system.

T. C.VAV.2 VAV Box without Reheat Coil

1. During occupied mode and when space temperature exceeds set point of 74°F, the air terminal unit shall modulate open to maintain set point. If space temperature drops below 70°F, the supply terminal unit shall modulate to minimum position to maintain set point.

U. C.RHC.1 Duct Mounted Hot Water Reheat Coil

1. During occupied mode, the reheat valve will modulate to maintain occupied heating set point (adj.). During unoccupied mode, the reheat valve will modulate in sequence with associated air handling unit to maintain unoccupied heating set point (adj.).

V. C.RHC.2 Duct Mounted Steam Reheat Coil

1. During occupied mode, the reheat valve will modulate to maintain occupied heating set point (adj.). During unoccupied mode, the reheat valve will modulate in sequence with associated air handling unit to maintain unoccupied heating set point (adj.).

W. C.DSFCU.1 Ductless Split Fan Coil Unit

1. Units shall run according to user definable time schedules in the following modes:
2. Occupied Mode: Unit operation shall be enabled.
3. Unoccupied Mode: (Night/weekend setback): Unit operation shall be disabled.
4. Whenever the individual zone is scheduled by the DDC system to be occupied, the fan coil fan shall be enabled. When enabled to operate by the DDC system, the unit shall maintain space set point temperature as controlled by the unit's existing self-contained or remote temperature control devices.
5. Alarms shall be provided as follows:
 - a. High zone temperature: If the zone temperature is greater than the cooling set point by a user definable amount (adj.)
6. Monitoring and Set Point Override: The DDC system shall monitor the space temperature. Space temperature sensors shall be provided with an override pushbutton that will enable fan coil unit operation for 1 hour (adj.) period.

X. C.IU.1 & .2: Induction Units

1. Units shall run according to user definable time schedules in the following modes:
2. Occupied Mode: Unit shall maintain a 55°F (adj.) cooling set point.
3. Unoccupied Mode: (Night/weekend setback): Unit shall maintain 60°F (adj.) cooling set point.
4. Valves: A 2-way valve is used for C.IU.1 and a 3 way valve is used for C.IU.2.

Y. C.CH.1, Chilled Water System Sequence of Operation

1. Primary Pumps (P1 & P2) Control: When the outside air temperature is greater than a cooling enable set point of 54°F (adj.), lead chilled water pump will be enabled to operate continuously. If the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but the status is on, an alarm will be generated. For systems with a single chilled water pump, the DDC system shall operate as above with the exception of pump alternation. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):
 - a. Manually through software switch
 - b. Pump runtime (adj.) is exceeded
 - c. Daily
 - d. Weekly
 - e. Monthly
2. Chiller Control: Upon proof of chilled water flow, as determined by the flow switch and a proof via aux contact at the pump starter, the chiller will be commanded on. The chiller will maintain a chilled water supply temperature set point as determined by its own internal controls. The chilled water set point will be adjustable from the head end. If the chiller fails, an alarm will be generated. The chiller's chilled water inlet and outlet temperatures will be continuously monitored. The chiller will run for and be off for a minimum adjustable times (adj.). If the chiller fails to start when commanded to run, an alarm will be generated. If the chiller is commanded off but the status is on, an alarm will be generated. Status runtime for the chiller will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

3. If the chilled water supply temperature rises above a high limit set point of 55°F (adj.) or falls below a low limit set point of 38°F (adj.) an alarm will be generated. If the chilled water return temperature rises above a high limit set point of 68°F (adj.) or falls below a low limit set point of 47°F (adj.) an alarm will be generated.

Z. C.PRE.1: Power Roof Exhaust Fan

1. Exhaust Fan Control: During the occupied mode and upon a proof of its associated air handler, the exhaust fan will be enabled to operate. During the unoccupied mode the fan shall be off.

AA. C.PRE.2: Power Roof Exhaust Fan with Exhaust Damper

1. Exhaust Fan Control: During the occupied mode and upon a proof of its associated air handler, the exhaust fan will be enabled to operate. During the unoccupied mode the fan shall be off. Whenever the exhaust fan is energized, the unit's exhaust damper (normally closed) shall be powered open.

BB. C.MREF.1, Exhaust Fan- Thermostat Control (Mechanical Room)

1. General: Exhaust fan shall cycle to provide ventilation cooling to mechanical rooms.
2. Space temperature sensor, or line voltage thermostat shall cycle exhaust fan to maintain space high limit space temperature of 85°F (adj.).
3. Where applicable, outdoor air and exhaust air dampers (normally closed) shall be powered to the open position whenever the exhaust fan is energized.

3.3.2 Building Fire Alarm Control Panel Controls Verification and Integration (see control summary drawing for buildings with fire/smoke dampers)

- A. The Contractor shall maintain all existing control interlocks between existing building Fire Alarm and Control Panels (FACP) and all new DDC controls.
- B. Prior to conducting any controls work for individual buildings, the Contractor, through coordination with the facility Fire Marshall, shall field verify and document all fire/smoke shutdowns of all building mechanical equipment including air handling equipment and fire/smoke dampers.

- C. All new and integrated control systems shall maintain the preexisting fire/smoke alarm interlocks that were verified or as indicated in the following building equipment sequence of operations.

3.3.3 Building 15 Sequence of Operations

- A. 15.UH.1.1-8, Steam Unit Heaters
 - 1. See Control Sequence C.UH-STM.2
- B. 15.DSFCU.1.1, Ductless Split Fan Coil Unit
 - 1. See Control Sequence C.DSFCU.1
- C. 15.SCV.B.1, Building Steam Control Valve
 - 1. The existing Spence building steam control valve will receive a contact closure output from the DDC system to open and close based on outside air temperature. The control valve (normally open) will close whenever the outside air temperature is above 65°F (adjustable).

3.3.4 Building 17 Sequence of Operations

- A. 17.CVAHU.1, Constant Volume Air Handling Unit
 - 1. Run Conditions - Scheduled: The unit shall run according to a user definable time schedule in the following modes:
 Occupied Mode: The unit shall maintain 74°F (adj.) cooling set point (where applicable) and 70°F (adj.) heating set point. Zone exhaust fan shall be energized and outside air damper and return air damper shall be positioned for minimum outside air.
 Unoccupied Mode (night setback): The unit shall maintain 85°F (adj.) cooling set point (where applicable) and 55°F (adj.) heating set point. Zone exhaust fan shall be off and outside air damper and return air damper shall be positioned for 100% return air.
 - 2. Zone Set point Adjust and Override: The occupant shall be able to adjust the zone temperature heating and cooling set points at the zone sensor. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period. At the expiration of this time, control of the unit shall automatically return to the schedule.
 - 3. Supply Fan: The supply fan shall run continuously in occupied mode, unless shut down on safeties. To prevent short cycling, the supply fan shall have a user definable

(adj.) minimum runtime, unless shutdown on safeties. Fan status to be monitored.

4. Alarms shall be provided as follows:
 - a. Supply Fan Failure: Commanded on, but the status is off.
 - b. Supply Fan in Hand: Commanded off, but the status is on.
 - c. Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.)
4. Economizer: The economizer controls shall be active during the unoccupied mode when the zone exhaust fan is typically off. The controller shall measure the mixed air temperature and position the outside air and return air dampers to the occupied mode setting. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied or when a min. outside air damper is utilized and the zone exhaust fan shall be energized.

The economizer shall be enabled whenever:

- a. Outside air temperature is less than 65°F (adj.).
 AND the outside air temperature is less than the return air temperature.
 AND the supply fan status is on.
 The economizer shall close and the zone exhaust fan shall shut down whenever:
- b. Mixed air temperature drops from 40°F to 35°F (adj.).
 OR on loss of supply fan status.
 OR the freezestat (if present) is on.
 The outside air damper shall close and the return air damper shall open and the zone exhaust fan shall shut down when the unit is off.
 The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.
5. Heating Coil Valve: The controller shall measure the heated air temperature and modulate the heating coil steam valve(s) to maintain the heating set point.
 - a. The heating coil valve(s) shall be enabled whenever:

Outside air temperature is less than 65°F (adj.)

AND the supply fan status is on

AND cooling is not active

- b. The heating coil valve shall open for freeze protection whenever:
Mixed air temperature drops from 40°F to 35°F (adj.).
OR the freezestat (if present) is on.
- 6. Cooling Coil Valve: The controller shall measure the discharge air temperature and modulate the cooling coil valve to maintain its cooling set point. The cooling coil valve shall be enabled whenever:
 - a. Outside air temperature is greater than 75°F (adj.)
AND the economizer (if present) is disabled or fully open
AND the supply fan status is on.
AND the zone temperature is above the cooling set point.
AND heating is not active
 - b. The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

The discharge air temperature set point shall be reset using a trim and respond algorithm based on zone cooling requirements. If there is a demand for cooling then the set point shall be reset to a lower value (adj.). If the demand for cooling decreases then the set point shall reset to a higher value (adj.). Once the zone is satisfied then the set point shall gradually moderate over time to reduce cooling energy use.
 - c. The discharge air temperature set point shall be reset based on zone cooling requirements as follows:
 - The initial supply air temperature set point shall be 55°F (adj.).
 - As cooling demand increases, the set point shall incrementally reset down to a minimum of 53°F (adj.).
 - As cooling demand decreases, the set point shall incrementally reset up to a maximum of 75°F (adj.).
- 7. Filter: The controller shall monitor the filter status. Alarms shall be provided as follows: Filter Change
Required: Filter differential pressure exceeds a user definable limit (adj.).
- 8. Discharge Air Temperature: The controller shall measure the discharge air temperature.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
 - Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).
9. Mixed and Return Air Temperature: The controller shall monitor the mixed air temperature and use as required for economizer control or preheating control.
- Alarms shall be provided as follows:
- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
 - Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).
10. Freeze Protection: The unit shall be hard wired for a shut down from the freezestat and generate an alarm upon receiving a freezestat status from the auxiliary contact..
11. Monitoring: The controller shall monitor additional points not noted in the sequence as indicted on the points list and flow diagrams.
- B. 17.EF.1.2, Zone Exhaust Fan with Variable Speed Switch
1. Unit shall be interlocked with the operation of the first floor air handling unit such that the exhaust fan is energized whenever the air handling unit is in operation in the occupied mode. The exhaust fan speed will be set manually at the unit's existing variable speed controller.
- C. 17.CH.1.1, Packaged Chiller with Chilled Water Pump
1. See control sequence C.CH.1 for control of packaged chiller with chilled water pump.
- D. 17.GLY.B.1, Glycol System Pressure Monitoring
1. See control sequence C.GLY.1.
- E. 17.VRV.2.1, Variable Refrigerant Volume System
1. The variable refrigerant volume (VRV) system serving selected 2nd floor spaces is controlled by the VRV system manufacturer's packaged control system to provide heating and cooling to each space that has a VRV fan coil unit. The packaged control system shall control the operation of the various system components including heat recovery units (HRUs) and branch selector boxes and fan coil units to meet the heating and cooling set points as scheduled by the DDC system.
2. Run Conditions - Scheduled: The systems shall run according to a user definable time schedule in the following modes:

- a. Occupied Mode: Fan coil units shall maintain 68°F (adj.) cooling set point and 72°F (adj.) heating set point.
 - b. Unoccupied Mode (night setback): Fan coil units shall maintain 72°F (adj.) with the exception of the Offset Printing room which will maintain 85°F (adj.) cooling set point and 55°F (adj.) heating set point (all spaces).
- F. 17.EF.1.1 & 2.1, Mechanical Room Exhaust Fans
 - 1. General: Exhaust fan shall cycle to provide ventilation cooling to mechanical rooms.
 - 2. Space temperature sensor, or line voltage thermostat shall cycle exhaust fan to maintain space high limit space temperature of 85°F (adj.).
 - 3. Outdoor air dampers (normally closed) shall be powered to the open position whenever the exhaust fan is energized.
- G. 17.CUH.3.1, Steam Cabinet Unit Heaters
 - 1. See control sequence C.CUH-STM.1 for control of cabinet unit heaters.
- H. 17.BCU.1 C2.1, Blower Coil Units
 - 1. Units shall run according to user definable time schedules in the following modes:
 - Occupied Mode: Unit shall maintain a 68°F (adj.) heating set point.
 - Unoccupied Mode: (Night/weekend setback): Unit shall maintain a 55°F (adj.) heating set point.
 - 2. On a call for heating from the DDC system, the unit fan will be energized and the steam coil valve (normally closed) will modulate to maintain space temperature.
- I. 17.UH.1.1-3: Steam Unit Heaters
 - 1. See control sequence C.UH-STM.2 for control of steam unit heaters.
- J. 17.FT.2.1 & 2: Steam Fin Tube Convectors
 - 1. See control sequence C.RAD.2 for control of steam fintube convectors.
- K. 17.ERU.2.1 Constant Volume Energy Recovery Unit Control
 - 1. Run Conditions - Scheduled: The unit will run whenever the building is occupied, unless shutdown on safeties.
 - 2. Outside Air Damper: The outside air damper will open anytime the unit runs and will close anytime the unit stops. The supply fan will start only after the damper

status has proven the damper is open. The outside air damper will close after the supply fan stops.

3. **Cooling Recovery Mode:** The controller will measure the heat wheel discharge air temperature and modulate the heat wheel speed to maintain a set point of 2°F (adj.) less than the unit supply air temperature set point. The ERU will run for cool recovery whenever:
 - Unit return air temperature is 5°F (adj.) or more below the outside air temperature.
 - AND the unit is in cooling mode.
 - AND the supply fan is on.
4. **Heating Recovery Mode:** The controller will measure the discharge air temperature and modulate the control valve to maintain a set point of 2° F (adj.) greater than the unit supply air temperature set point. The ERU will run for heat recovery whenever:
 - Unit return air temperature is 5°F (adj.) or more above the outside air temperature.
 - AND the unit is in heating mode.
 - AND the supply fan is on.
5. **Recirculation Mode:**
 - The unit will continue to run in unoccupied mode.
 - The exhaust air fan will shutdown.
 - The outside air damper will close.
 - The return air automatic damper will open.
6. **Supply Fan:** The supply fan will run anytime the unit is commanded to run. To prevent cycling, the supply fan will have a user definable (adj.) minimum runtime unless shutdown on safeties.
 - Alarms will be provided as follows:
 - Supply Fan Failure: Commanded on, but the status is off.
 - Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.)
7. **Exhaust Fan:** The exhaust fan will run whenever the supply fan runs, unless shutdown on safeties.
 Alarms will be provided as follows:
 - Exhaust Fan Failure: Commanded on, but the status is off.
 - Exhaust Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.)

8. Supply Air Temperature Fixed:
The controller will monitor the supply air temperature and will maintain a fixed supply air temperature set point of 55° (adj.).
9. Outside Air and Return Air Differential Pressure Monitor:
The controller will monitor the different pressure across the two filters.
10. Alarms will be provided as follows:
 - Filter Change Required: filter differential pressure exceeds a user definable limit (adj.).
11. Supply Air Temperature: The controller will monitor the supply air temperature.
Alarms will be provided as follows:
 - High Supply Air Temperature: If the supply air temperature is greater than 120°F (adj.).
 - Low Supply Air Temperature: If the supply air temperature is less than 45°F (adj.).
12. Return Air Humidity: The controller will monitor the return air humidity and use as required for set point control.
Alarms will be provided as follows:
 - High Return Air Humidity: If the supply air temperature is greater than 65% (adj.).
 - Low Return Air Humidity: If the supply air temperature is less than 35% (adj.).
13. Return Air Temperature: The controller will monitor the return air temperature and use as required for set point control.
Alarms will be provided as follows:
 - High Return Air Temperature: If the supply air temperature is greater than 90°F (adj.).
 - Low Return Air Temperature: If the supply air temperature is less than 45°F (adj.).
14. Heating Coil: The controller will modulate the heating coil control valve to maintain the discharge air temperature set point downstream of the coil.

3.3.5 Building 24 Sequence of Operations

- A. 24.CVAHU.M.1, Constant Volume Air Handling Unit

1. Run Conditions - Scheduled: The unit shall run according to a user definable time schedule in the following modes:

Occupied Mode: The unit shall run continuously and maintain 74°F (adj.) cooling set point and 70°F (adj.) heating set point. Outside air damper and return air damper shall be positioned for minimum (20%) outside air.

Unoccupied Mode (night setback): The unit shall maintain 85°F (adj.) cooling set point and 55°F (adj.) heating set point. Outside air damper and return air damper shall be positioned for 100% return air.

If any one of the five kitchen fume hoods is on, unit operation will default to Occupied Mode operating sequence.

2. Zone Set point Adjust and Override: The occupant shall be able to adjust the zone temperature heating and cooling set points at the zone sensor. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period. At the expiration of this time, control of the unit shall automatically return to the schedule.
3. Supply Fan: The supply fan shall run continuously in occupied mode, unless shut down on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime, unless shutdown on safeties. Fan status to be monitored.

Alarms shall be provided as follows:

Supply Fan Failure: Commanded on, but the status is off.

Supply Fan in Hand: Commanded off, but the status is on.

Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.)

4. Heating Coil Valve: The controller shall measure the heated air temperature and modulate the heating coil steam valve(s) to maintain the heating set point.

The heating coil valve(s) shall be enabled whenever:

Outside air temperature is less than 65°F (adj.)

AND the supply fan status is on

AND cooling is not active

The heating coil valve shall open for freeze protection whenever mixed air temperature drops from 40°F to 35°F (adj.) OR the freezestat (if present) is on.

5. Cooling Coil Valve: The controller shall measure the discharge air temperature and modulate the cooling coil

valve to maintain its cooling set point. The cooling coil valve shall be enabled whenever:

Outside air temperature is greater than 75°F (adj.)
 AND the economizer (if present) is disabled or fully open
 AND the supply fan status is on.
 AND the zone temperature is above the cooling set point.
 AND heating is not active

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

The discharge air temperature set point shall be reset using a trim and respond algorithm based on zone cooling requirements. If there is a demand for cooling then the set point shall be reset to a lower value (adj.). If the demand for cooling decreases then the set point shall reset to a higher value (adj.). Once the zone is satisfied then the set point shall gradually moderate over time to reduce cooling energy use.

The discharge air temperature set point shall be reset based on zone cooling requirements as follows:

The initial supply air temperature set point shall be 55°F (adj.).

As cooling demand increases, the set point shall incrementally reset down to a minimum of 53°F (adj.).

As cooling demand decreases, the set point shall incrementally reset up to a maximum of 75°F (adj.).

6. Filter: The controller shall monitor the filter status. Alarms shall be provided as follows: Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).
7. Discharge Air Temperature: The controller shall measure the discharge air temperature.

Alarms shall be provided as follows:

High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).

Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

8. Mixed and Return Air Temperature: The controller shall monitor the mixed air temperature and use as required for economizer control or preheating control.

Alarms shall be provided as follows:

High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).

Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

9. Freeze Protection: The unit shall be hard wired for a shut down from the freezestat and generate an alarm upon receiving a freezestat status from the auxiliary contact.
10. Monitoring: The controller shall monitor additional points not noted in the sequence as indicted on the points list and flow diagrams.

B. 24.KH.1.1-1.5, Kitchen Supply/Exhaust Hoods

1. Run Conditions: Each of the five kitchen exhaust hoods shall be controlled by their existing On/Off control switches. When an individual exhaust hood On/Off switch is placed in the On position, the respective exhaust fan and supply fan will be energized and the respective exhaust damper shall be powered open. When any of the exhaust hoods are energized, all kitchen hood outside air dampers shall be powered open.
2. Monitoring: The DDC system shall monitor the status of each kitchen hood exhaust and supply fans. The DDC system shall also use the number of active kitchen hoods as a basis for determining how much outside air is delivered by makeup air handling unit 24.MAU.M.1 as noted in the sequence of operation for that unit.

C. 24.MAU.M.1, Kitchen Makeup Air Unit

1. Run Conditions: The makeup air unit will operate whenever two or more kitchen hoods are in operation. If only one kitchen hood is in operation, air handling unit CVAHU.M.1 will provide the required makeup air.
2. Supply Fan Speed Control: If two or more kitchen fume hoods are in operation, the unit supply fan shall be energized at minimum 30% speed. When more than two kitchen hoods are on at the same time, the DDC system will adjust the speed of the makeup air unit supply fan based on the following schedule:

MAKE UP UNIT FAN SPEED AS FUNCTION OF KITCHEN HOODS ON					
KH-1	KH-2	KH-3	KH-4	KH-5	MAUSF SPEED
ANY TWO ON					30%
ANY ONE ON			ON		30%
ANY ONE ON				ON	30%
ON	ON	ON			60%
ANY TWO ON			ON		54%
ANY TWO ON				ON	44%
ANY ONE ON			ON	ON	38%
ON	ON	ON	ON		81%
ON	ON	ON		ON	70%
ANY TWO ON			ON	ON	64%
ON	ON	ON	ON	ON	91%

Unit outside air damper (normally closed) shall be powered open whenever supply fan is energized.

D. 24.CH.1.1, Packaged Chiller with Pumps

1. See control sequence C.CH.1 for control of packaged chiller with chilled water pump.

E. 24.GLY.B,1 Glycol System Pressure Monitoring

1. See control sequence C.GLY.1 for control of glycol system pressure monitoring.

F. 24.DXFCU.1.1, Retherm Room DX Fan Coil Unit

1. Run Conditions - Scheduled: The DDC system shall enable the operation of the DX condensing unit and indoor fan coil unit. The unit shall run according to a user definable time schedule in the following modes:

Occupied Mode: The unit shall maintain 74°F (adj.) cooling set point.

Unoccupied Mode (night setback): The unit shall maintain 85°F (adj.) cooling set point.

2. Monitoring: The DDC system shall monitor zone temperature and the status of the fan coil unit supply fan and outdoor condensing unit.

G. 24.AHU.B.1, Ventilation Air Handler (no coils) & Exhaust Fan

1. Ventilation air handling unit supply fan and remote exhaust fan shall run according to user definable time schedules in the following modes:

Occupied Mode: Air handling unit shall operate continuously to maintain a 68°F (adj.) supply air discharge temperature set point by adjusting position of outside air and return air dampers. If outside air temperature is 68°F or above, outside air damper/return air damper shall be positioned for 25% minimum outside air. Exhaust fan shall be energized.

Unoccupied Mode: (Night/weekend setback): Air handling unit supply fan and remote exhaust fan shall be off and air handling unit outdoor air damper shall be closed.

H. 24.UH.B.1-2 & 1.1-7, Steam Unit Heaters

1. See control sequence C.UH-STM.2 for control of steam unit heaters.

3.3.6 Building 30 Sequence of Operations

A. 30.CH.1.1, Packaged Glycol Chiller With Pumps

1. Run Conditions: The chiller shall be enabled to run by the DDC system whenever the outside air temperature is greater than 54°F (adj.).
 - a. The chiller shall be enabled a user adjustable time after pump statuses are proven on and water flow is proven via the flow switch, the chiller shall have a user adjustable delay on start.
 - b. The delay time shall be set appropriately to allow for orderly chilled water system start-up, shutdown and sequencing.
 - c. To prevent short cycling, the chiller shall run for and be off for minimum adjustable times (both user definable), unless shutdown on safeties or outside air conditions.
 - d. The chiller shall run subject to its own internal safeties and controls.
 - e. Alarms shall be provided as follows:
 - Chiller failure: Commanded on, but the status is off.
 - Chiller running in hand: Commanded off, but the status is on.

- Chiller runtime exceeded: Status runtime exceeds a user definable limit.
2. Chilled Glycol Supply Set Point: The chiller shall maintain a chilled glycol supply temperature set point as determined by its own internal controls.
 3. Chilled Glycol Temperature Monitoring: The following temperatures shall be monitored:
 - Chiller glycol supply
 - Chilled glycol return

Alarms shall be provided as follows:

- High Chilled Glycol Supply Temp: If the chilled glycol supply temperature is greater than 55°F (adj.).
 - Low Chilled Glycol Supply Temp: If the chilled glycol supply temperature is less than 38°F (adj.).
 - High Chilled Glycol Return Temp: If the chilled glycol supply temperature is greater than 68°F (adj.).
 - Low Chilled Glycol Return Temp: If the chilled glycol supply temperature is less than 47°F (adj.).
4. Chilled Glycol Primary Loop Operation (GWP.B.1): The primary chilled glycol pump shall run anytime a chiller is called to run.

The pump shall start prior to a chiller being enabled and shall stop only after the chiller is disabled. The pump shall therefore have:

- A user adjustable delay on start.
- And a user adjustable delay on stop.

The delay times shall be set appropriately to allow for orderly chilled glycol system start-up, shutdown and sequencing.

Alarms shall be provided as follows:

- Chilled water pump
- Failure: commanded on, but the status is off.
- Running in hand: Commanded off, but the status is on.
- Runtime exceeded: Status runtime exceeds a user definable limit.

5. Chilled Glycol Secondary Loop Operation (30.CGS.B.1): The secondary chilled glycol pump shall run anytime a chiller is called to run.

The pump shall start prior to a chiller being enabled and shall stop only after the chiller is disabled. The pump shall therefore have:

- A user adjustable delay on start.
- And a user adjustable delay on stop.

The delay times shall be set appropriately to allow for orderly chilled glycol system start-up, shutdown and sequencing.

Alarms shall be provided as follows:

- Chilled water pump
- Failure: commanded on, but the status is off.
- Running in hand: Commanded off, but the status is on.
- Runtime exceeded: Status runtime exceeds a user definable limit.

6. Glycol Fill (Make-Up) station:

Alarm whenever the glycol level in the storage tank drops below the low level sensor set point.

B. 30.HTNG-GLY.B.1, Glycol Loop With Two Steam Valves

1. Run Conditions: The hot water system shall be enabled to run from the DDC system whenever:

- A definable number of hot water coils need heating.

Hot water pump run conditions: The hot water pumps shall be enabled whenever:

- A definable number of hot water coils need heating.

To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable).

2. Hot Water Pump Lead/ Lag Operation:

The hot water pumps shall operate in a lead/Lag fashion.

- The lead pump shall run first.
- On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.

The designated lead pump shall rotate upon one of the following conditions (user selectable):

- Manually through a software switch
- If pump runtime (adj.) is exceeded
- Weekly
- Monthly

Alarms Shall Be Provided As Follows:

Hot Water Pump 1& 2:

- Failure: commanded on, but the status is off.
- Running in hand: Commanded off, but the status is on.
- Runtime exceeded: Status runtime exceeds a user definable limit.

3. Heat Exchangers (HX.B.1 & HX.B.2):

Steam flow to hot water convertors shall modulate using control valves to maintain hot water temperature of 180°F (adj.).

4. Glycol Fill (Make-Up) Station:

Alarm whenever the glycol level in the storage tank drops below the low level sensor

C. 30.RAD, Steam Radiators W/Valves

1. See control sequence C.RAD.3 for control of Steam Fin Tube W/Valve.

D. 30.AHU.A.1 & A.2, Attic Energy Recovery Air Handling Units

1. Run Conditions - Scheduled: The unit shall run based upon an operator adjustable schedule or a manual software switch.
2. Low Temperature Protection: The unit shall shut down and generate an alarm upon receiving a low supply air temperature of 40°F (adj.).
3. Supply Fan: The supply and return air fans shall run anytime the unit is commanded to run, unless shut down on safeties. To prevent short cycling, the fans shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Chilled water pump
- Failure: commanded on, but the status is off.
- Running in hand: Commanded off, but the status is on.
- Runtime exceeded: Status runtime exceeds a user definable limit.

4. Supply Air Temperature Set Point: The controller shall monitor the supply air temperature and shall maintain a supply air temperature set point reset based on zone cooling and heating requirements.

The supply air temperature set point shall be reset for cooling based on zone cooling requirements as follows:

The initial supply air temperature set point shall be 55°F (adj.).

- As cooling demand increases, the set point shall incrementally reset down to a minimum of 50°F (adj.).
- As cooling demand decreases, the set point shall incrementally reset up to a maximum of 60°F (adj.).

For 30.AHU.A.1 only, if more zones need heating than cooling, then the supply air temperature set point shall be reset for heating as follows:

- The supply air temperature set point shall be 60°F (adj.).
- The induction unit coils shall cool the supply air to each space to maintain space temperature set point as controlled by the space temperature sensor.

For 30.AHU.2 only, supply air temperature shall reset incrementally based on average of space temperature sensors as indicated on drawings (7 total).

5. Cooling Coil Valve: The controller shall measure the supply air temperature and modulate the air cooling coil valve to maintain its cooling set point.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- And the supply fan is on.

Alarms shall be provided as follows:

- High supply air temp: If the supply air temperature is 5°F (adj.) greater than set point.

The controller shall measure the supply air temperature and modulate the heating coil valve to maintain its heating set point.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- And the supply fan status is on.
- And the cooling (if present) is not active.

Alarms shall be provided as follows:

- Low supply air temp: If the supply air temperature is 5°F (adj.) less than set point.

6. Filter Status: The controller shall monitor the filter status.

Alarms shall be provided as follows:

- Filter change required: Filter differential pressure exceeds a user definable limit (adj.).

7. Supply air temperature: The controller shall monitor the supply air temperature.

8. Alarms: Alarms shall be provided as follows:

- High supply air temp: If the supply air temperature is greater than 120°F (adj.) unit shall shut down on activation of high temperature alarm.
- Low supply air temp: If the supply air temperature is less than 50°F (adj.).

9. System Stop:

- When the air-handling unit is indexed to shut down, the fans shall stop.
- Dampers and control valve shall be indexed to their system off conditions.

10. Smoke Control: Duct smoke detectors(s) shall stop the supply fan and annunciate alarm when products of combustion

are detected in the air stream. Dampers and control valve shall be indexed to the system off conditions.

The supply fan shall be interlocked to shut down upon a command from the building fire alarm system.

Upon a return to normal, the supply fan shall start after an adjustable delay to provide a staggered start of all building loads.

Filter Condition: Monitor differential pressure and annunciate alarm when differential pressure set point (adj.) is exceeded.

Annunciate off normal alarms whenever supply fan status does not equal command.

11. Desiccant Wheel Energy Recovery System (ERW):

Heating Mode:

- a. Exhaust air temperature is 5°F (adj.) or more above the outside air temperature.
- b. The zone temperature is below the heating set point.
- c. The supply and return fans are on.

Cooling Mode:

- a. Exhaust air temperature is 5°F (adj.) or more below the outside air temperature.
- b. The zone temperature is above the heating set point.
- c. The supply and return fans are on.

E. 30.DSFCU.1.1, 1.2 & 3.1, Ductless Split Fan Coil Unit

- 1. Units shall run intermittently to maintain maximum space set point temperatures.
- 2. Monitoring: The DDC system shall monitor the space temperature.
- 3. Alarms: The DDC system shall initiate an alarm whenever the space temperature exceeds space set point temperature by 5°F (adjustable).

F. 30.IU, 1st, 2nd, 3rd Floor, Induction Units

- 1. See Control Sequence C.IU.1 & .2 for control of induction units

G. 30.EF.1.1, 1.2 & 1.3, 1st Floor Exhaust Fans:

1. General: The exhaust fan shall be enabled by the DDC system and interlocked to operate whenever the room temperature exceeds 80°F (adj.).
 - The outside air damper shall open when the fan is energized and close when the fan is de-energized. Limit switches on damper shall confirm position of damper prior to fan operation.
 - Provide hand-off-auto (H-O-A) switch for manual control for 30.EF.1.3.

Safeties and alarms: alarm whenever the fan status or the air flow system status does not equal command.

H. 30.UH.B.1, Basement Hot Water Unit Heater

1. See control sequence C.UH-HW.2 for control of hot water unit heater.

3.3.7 Building 33 Sequence of Operations

A. 33.HTNG-HW.B.1, Basement Hot Water Heating System

1. Primary Pumps (HWP.B.1, HWP.B.2) Control: During the occupied mode and when the outside air temperature is below a heating enable set point of 60°F (adj.), as sensed by the outside air sensor, the lead hot water pump will be enabled to operate continuously, initially set for HWP.B.1. If the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but the status is on, an alarm will be generated. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

The lead pump will rotate upon one of the following conditions (user selectable):

- Manually through software switch
- Pump runtime (adj.) is exceeded
- Daily
- Weekly
- Monthly

2. Heat Exchanger HX.B.1&2: Upon a proof of lead pump run status, as sensed by its current switch, the lead set of valves, configured in a 1/3 and 2/3 configuration, will be enabled to operate to maintain a HW supply set point, as reset by the following schedule:

Outside Air Temperature

0°F

60°F

Hot Water Set point

180°F

120°F

If HW set point cannot be met, the second set of 1/3 - 2/3 valves shall be enabled to operate as required to maintain HW supply set point.

B. 33.AHU.B.1 & 33.ERU.B.1 , Basement Air Handling Unit with Hydronic Heating/Cooling

1. Building Automation System Interface: The Building DDC System will send the controller Occupied, Unoccupied, Optimal Start, Night Heat/ Cool, and Timed Override commands. The DDC may also send a Heat / Cool mode, space temperature and/or space temperature set point. If a DDC is not present, or communication is lost with the DDC, the controller will operate using its local schedule and set points.
2. Fan Control: During the occupied mode, the supply fan will be enabled. Before the fan starts, the remote OA damper will open fully. When the damper is open, its end switch will close and the fan will start at its low speed setting. Upon a proof of air flow, the return fan will be enabled. Before the fan starts, the remote EA dampers will open fully. When the dampers are open, the end switches will close and the fan will start at its low speed setting. If the supply or return fan fails to start when commanded to run, an alarm will be generated. If the fan is commanded off but the start is on, an alarm will be generated. Start runtime for each fan will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

The building DDC System shall continuously monitor the damper position of all VAV terminal units. The discharge dud static pressure shall be sensed directly at the discharge of the air handler. When any VAV damper is more than 75% (adj.) open, the supply fan discharge dud static

pressure set point shall be reset upward by 0.1 in W.C. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 75% open or the static pressure set point has reset upward to the system maximum duct static pressure set point or the AHU variable-frequency drive is at the maximum speed setting. When all VAV dampers are less than 65% (adj.) open, the supply fan discharge duct static pressure set point shall be reset downward by 0.1 in W.C. (adj.) at a frequency of 15 minutes (adj.), until at least one damper is more than 65% open or the static pressure set point has reset downward to the system minimum duct static pressure set point or the AHU variable-frequency drive is at the minimum speed setting.

3. B3.ERU.B.1 Control: During the occupied mode and when the outside air temperature is within the economizer set points of 20°F (adj.) and 55°F (adj.), the ERU will be disabled. During the occupied mode, upon a proof of supply fan run status and when the outside air temperature outside the economizer set points as described above the isolation dampers will open fully. When the damper is open, its end switch will close and both the fresh air and exhaust air fans will start. If the fresh air or exhaust fan fails to start when commanded to run, an alarm will be generated. Status runtime for each fan will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.
4. Occupied Mode (Temperature Control): During the occupied mode, upon a proof of supply fan airflow and during the economizer mode, the AH will be in the heating mode. During the heating mode the heating valve will modulate to maintain a discharge air set point (adj.). The initial set point will be 60°F (adj.). The DX cooling will be inactive. If the fan will off, the heating valve will modulate to maintain a mixed air temperature set point (adj.).

When the AH is no longer in the economizer mode (see -Mixed Air Damper Control- above the AH will be in the cooling mode. During the cooling mode the DX cooling will cycle to maintain discharge air set point (adj.). The initial set point will be 55°F (adj.). The heating valve will be inactive.

If the discharge air temperature falls below a low limit of 45°F (adj.), the heating valve will open and an alarm will be generated. If the discharge air temperature drifts 5°F (adj.) above or below the calculated set point, an alarm will be generated. If the discharge air temperature rises

above a high limit of 120°F (adj.), an alarm will be generated.

5. **Mixed Air Damper Control:** During the occupied mode and upon a proof of supply flow, the mixed air dampers will open to a minimum position (20% adj.). When the outside air temperature is below an economizer set point of 65°F (adj.) and when the outside air temperature is greater than the return air temperature, the AH will be in the economizer mode. During the economizer mode the mixed air dampers will modulate to maintain a mixed air set point. The mixed air set point will be the calculated discharge air set point minus 2°F (adj.). When the outside air temperature rises above the economizer set point the mixed air dampers will revert to the minimum position. During the unoccupied mode or when the supply fan is off or when the mixed air temperature falls below a low limit set point of 35°F (adj.), the outside air damper will close and the return air damper will open. If the mixed air temperature rises above a high limit of 90°F (adj.), an alarm will be generated. If the mixed air temperature falls below limit of 45°F (adj.), an alarm will be generated.
6. **Occupied Mode (Temperature Control):** During the occupied mode, upon a proof of supply fan airflow and during the economizer mode, the AH will be in the heating mode. During the heating mode the heating valve will modulate to maintain a discharge air set point (adj.). The initial set point will be 60°F (adj.). The DX cooling will be inactive. If the fan will off, the heating valve will modulate to maintain a mixed air temperature set point (adj.).

When the AH is no longer in the economizer mode (see -Mixed Air Damper Control- above the AH will be in the cooling mode. During the cooling mode the DX cooling will cycle to maintain discharge air set point (adj.). The initial set point will be 55°F (adj.). The heating valve will be inactive.

If the discharge air temperature falls below a low limit of 45°F (adj.), the heating valve will open and an alarm will be generated. If the discharge air temperature drifts 5°F (adj.) above or below the calculated set point, an alarm will be generated. If the discharge air temperature rises above a high limit of 120°F (adj.), an alarm will be generated.

7. **Unoccupied (Night Setback):** When the space temperature is below the unoccupied heating set point (adj.) the supply fan will start, the outside air damper will remain closed

and the hot water valve will open. When the minimum space temperature rises above the unoccupied heating set point plus the unoccupied differential (4°F adj.) the supply fan will stop and the hot water valve will modulate to maintain a mixed air set point of 50°F (adj.).

During the unoccupied mode and if the maximum space temperature is above the unoccupied cooling set point, a night cool down sequence will be activated. If not in the economizer mode, the supply fan will start, the DX will be cycled and the outside air damper will remain closed. If in the economizer mode, the supply fan will start, the DX cooling will be off and the mixed air dampers will modulate open. When the space temperature falls below the unoccupied cooling set point minus an unoccupied differential (4°F adj.) the supply fan will stop and the outside air damper will dose and/or DX cooling will be off.

8. Humidifier Control: During the unoccupied mode the humidifier will be off. During the occupied mode and upon a proof of supply fan status, the humidifier will be enabled to maintain a return air humidity set point (adj.). The humidifier will be subject to air flow switch interlock and discharge air humidity high limit of 85%.
9. Unoccupied (Night Setback): When the space temperature is below the unoccupied heating set point (adj.) the supply fan will start, the outside air damper will remain closed and the hot water valve will open. When the minimum space temperature rises above the unoccupied heating set point plus the unoccupied differential (4°F adj.) the supply fan will stop and the hot water valve will modulate to maintain a mixed air set point of 50°F (adj.).

During the unoccupied mode and if the maximum space temperature is above the unoccupied cooling set point, a night cool down sequence will be activated. If not in the economizer mode, the supply fan will start, the DX will be cycled and the outside air damper will remain closed. If in the economizer mode, the supply fan will start, the DX cooling will be off and the mixed air dampers will modulate open. When the space temperature falls below the unoccupied cooling set point minus an unoccupied differential (4°F adj.) the supply fan will stop and the outside air damper will dose and/or DX cooling will be off.

10. Morning Warm-up: During optimal start and based upon outside air temperature conditions and if the space temperature is below the occupied heating set point, a

morning warm-up sequence will be activated. The supply fan will start, the hot water valve will open and the outside air damper will remain dosed. Mode will terminate when the space temperature reaches the occupied heating set point or the occupied time period has started.

11. Morning Cool-down: During optimal Start, if the space temperature is above the occupied cooling set point, a morning cool down sequence will be activated. If not in the economizer mode, the supply fan will start, the DX cooling will cycle and the outside air damper will remain dosed. If in the economizer mode, the supply fan will start, the DX cooling will be off and the mixed air dampers will modulate open. Mode will terminate when the space temperature reaches the occupied cooling set point or the occupied time period has started.
12. Freeze Protection: The initial damper opening rate will be limited to 2% per minute until the damper has reached its minimum ventilation position. The outside air damper will modulate to a position less than the minimum damper position if the mixed air temperature drops below 45°F (adj.). If the mixed air temperature sensor fails the outside air damper will close and an alarm will be annunciated.

A hardwired, low limit temperature switch is electrically interlocked with the variable speed drive. If the low limit temperature switch is tripped (38°F adj.), the outside air damper will close, all valves will open to 100% and an alarm will be generated at the OWS. A manual reset of the low limit temperature switch will be required to restart the fan.

13. Temperature Alarms: If the return air temperature rises above a high limit set point (90°F adj.) or falls below a low limit set point (45°F adj.) an alarm will be generated at the OWS.
14. Fire Alarm: Upon a fire condition or if any supply air or return air smoke detectors indicate an alarm condition, the FACP will shutdown the fans and an alarm will be generated.

C. 33.VAV, 1st, 2nd, 3rd Floor VAV Boxes with Hot Water Reheat Coil

1. Hot Water Heat Building Automation System Interface: The building DDC System will send the controller occupied and unoccupied commands. The DDC may also send a Heat/Cool

mode, priority shutdown commands, space temperature and/or space temperature set point. If communication is lost with the DDC, the controller will operate using its local set points.

2. Heat/Cool Mode: The Heat/Cool mode will be set by a communicated value. In standalone or auto mode the VAV will compare the primary air temperature with the configured auto changeover set point to determine if the air is "hot" or "cold". Heating mode will command the VAV to heat only; It Implies the primary air temperature is hot. Cooling mode commands the VAV to cool only, it implies the primary air temperature is cold.

Heat/Cool Set point: The space temperature set point will be determined either by a local hardwired set point, the VAV default set point or a communicated value. The VAV uses the locally stored default set points when neither a local hardwired set point nor communicated set point is present if both a hardwired set point and communicated set point exist, the VAV will use the communicated value.

3. Occupancy Mode: The occupancy mode can be communicated or hard wired to the VAV via a binary input. Valid occupancy modes for the VAV will be:

Occupied: Normal operating mode for occupied spaces or daytime operation. When the unit is in the occupied mode the VAV will maintain the space temperature at the active occupied heating or cooling set point. Applicable ventilation and airflow set points will be enforced. The occupied mode will be the default mode of the VAV.

Unoccupied: Normal operating mode for unoccupied spaces or nighttime operation. When the unit is in unoccupied mode the VAV will maintain the space temperature at the stored unoccupied heating or cooling set point regardless of the presence of a hardwired or communicated set point. When the space temperature exceeds the active unoccupied set point the VAV will modulate fully closed.

Occupied Bypass: Mode used to temporarily place the unit into the occupied operation. Tenants will be able to override the unoccupied mode from the space sensor. The override will last for a maximum of 4 hours (configurable) the tenants will be able to cancel the override from the space sensor at any time. During the override the unit will run in occupied mode.

4. Cooling Mode: When the unit is in cooling mode, the VAV will maintain the space temperature at the active cooling set point by modulating the airflow between the active cooling minimum airflow set point to the maximum cooling airflow set point. Based on the VAV occupancy mode, the active cooling set point will be one of the following:

<u>Set point</u>	<u>Default Value</u>
Occupied Cooling Set point	74°F
Unoccupied Cooling Set point	85°F
Occupied standby Cooling Set point	78°F
Occupied Min Cooling Airflow Set point	See VAV Schedule
Occupied Max Cooling Airflow Set point	See VAV Schedule

The VAV will use the measured space temperature and the active cooling set point to determine the requested cooling capacity of the unit the outputs will be controlled based on the unit configuration and the requested cooling capacity.

5. Heating Mode: When the unit is in heating mode, the CONTROLLER will maintain the space temperature at the active heating set point by modulating the airflow between the active heating minimum airflow set point to the maximum heating airflow set point. Based on the CONTROLLER occupancy mode, the active heating set point will be one of the following:

<u>Set point</u>	<u>Default Value</u>
Occupied Cooling Set point	71°F
Unoccupied Cooling Set point	60°F
Occupied standby Cooling Set point	67°F
Occupied Min Cooling Airflow Set point	See VAV Schedule
Occupied Max Cooling Airflow Set point	See VAV Schedule

The controller will use the measured space temperature and the active heating set point to determine the requested heating capacity of the unit.

The outputs will be controlled based on the unit configuration and the requested heating capacity.

6. Reheat Control: Reheat will only be allowed when the primary air temperature is 5°F below the configured reheat enable set point, (70°F adjustable). The reheat will be enabled when the space temperature drops below the active cooling set point and the airflow is in the minimum cooling airflow set point. During reheat the VAV will operate at its minimum heating airflow set point and energize the heat as follows:
 7. Proportional Hot Water Reheat: If the space temperature is below the heating set point the hot water reheat valve will modulate as required to maintain the active heating set point.
 8. Space Sensor Failure: If there is a fault with the operation of the zone sensor, it will be feed back to the DDC. Zone sensor failure will cause the VAV to drive the damper to minimum air flow if the VAV is in the occupied mode, or drive it dosed if the VAV is in the unoccupied mode. If a series fan is available, it will be enabled, and the reheat will be disabled. If a parallel fan is available, it will be disabled along with the reheat.
- D. 33.FT, 1st, 2nd, 3rd Floor Fin Tube Radiation
1. During 33.AHU.1 occupied mode, each fin tube valve will be controlled to maintain an occupied space heating set point (adj.), as sensed by its space sensor, during the unoccupied mode, the fin tube valves will control to maintain an unoccupied space heating set point (adj.).
- E. 33.CUH.1.1, 1st Floor Hot Water Cabinet Unit Heater
1. Building Automation System Interface: The DDC will send occupied, unoccupied and night heat commands. If communication is lost with the DDC, or a DDC is not present, Morning Warm-up and Morning Cool-down will be disabled.

Unoccupied (Night Setback): When the space temperature is below the unoccupied heating set point (60°F adj.) the supply fan will start and the hot water valve will open when the space temperature rises above the unoccupied heating set point (60°F adj.) plus the unoccupied differential (2°F adj.) the supply fan will stop and the hot water valve will dose.

Occupied: During occupied periods the supply fan will run continuously. The hot water valve will open and close as necessary to maintain the active space temperature set point.

2. Space Temperature Control: The space temperature will be maintained between the occupied cooling set point (74°F adj.) and the occupied heating set point (71°F adj.). The unit will transition to the cooling mode when the space temperature rises one degree above the occupied cooling set point (74°F adj.). The unit will transition to the heating mode when the space temperature drops one degree below the occupied heating set point (71°F adj.).
3. Supply Fan Operation: The fan will be off in the unoccupied mode. When the controller is in the occupied mode, the supply fan will operate continuously at rated speed.

F. Fire Alarms

1. Upon a fire condition or if any supply air or return air smoke detectors indicate an alarm condition, the FACP will shutdown the fans and an alarm will be generated.

G. 33.DSFCU.B.1, Ductless Split Fan Coil Unit

1. Units shall run intermittently to maintain maximum space set point temperatures.
2. Monitoring: The DDC system shall monitor the space temperature.
3. Alarms: The DDC system shall initiate an alarm whenever the space temperature exceeds space set point temperature by 5°F (adjustable).

3.3.8 Building 34 Sequence of Operations

A. 34.FCUCW-CW, 1st, 2nd, 3rd Floor Heating/ Cooling Fan Coil Unit

1. Fan control: Fan start/stop and speed control is provided by a multispeed switch mounted in the room space thermostat.
2. Temperature control: Set point adjustment is provided at the room space thermostat. Factory mounted direct digital controller will read the space temperature set point and

space temperature and will cycle the factory mounted hot and chilled water three way valves to maintain the room temperature set point.

B. 34.ERV.B.1, Basement Energy Recovery Ventilation

1. Run Mode: Whenever 34.AHU.B.1 is enabled and the outside air temperature is below 55°F (adj.) the DDC System will start the exhaust fan and enable the energy recovery unit 34.ERV.1. The DDC System will modulate the 34.ERV.1 bypass damper to maintain a supply air temperature set point of at least 55°F (adj.) to 34.AHU.B.1 at all times. If the wheel exhaust air temperature drops to 40°F (adj.) or below the DDC System will modulate the bypass damper to decrease the exhaust air cooling to prevent frosting of the energy wheel.

Whenever 34.AHU.B.1 is off the DDC System will disable 34.ERV.1 and associated exhaust fan. Alarms the following points are available for monitoring, trending or alarming at the DDC system:

- Exhaust fan status
- 34.ERV.1 plugged wheel indication
- 34.ERV.1 plugged filter indication
- 34.ERV.1 outside air intake temperature
- 34.ERV.1 supply air to 34.AHU.B.1 temperature
- 34.ERV.1 return air temperature
- 34.ERV.1 return air humidity
- 34.ERV.1 exhaust air temperature

C. 34.CUH.1.1, Hot Water Cabinet Heater

1. Fan control: Fan speed control is provided by a multi-speed switch mounted in the cabinet unit heater cabinet.
2. Temperature control: Set point adjustment is provided at the room space thermostat. Factory mounted direct digital controller will read the space temperature set point and space temperature and will cycle the cabinet unit heater fan to maintain the room temperature set point.

D. 34.AHU.B.1, Air Handling Unit

1. General: 34.AHU.B.1 can be started and stopped through commands or time schedules provided by the operator through the engineering control center operator's work station (OWS). Initially the AHU will be programmed to run

continuously. The building automation system (DDC SYSTEM) will only modulate the AHU chilled water valve when chilled water is available and will only enable the glycol pumps and plate exchanger control when primary hot water is available.

2. Fan Control: When the AHU is commanded to run by the DDC System the outside air and discharge fire/smoke dampers open. End switches on these dampers enable the supply fan. When the DDC System senses that the supply fan is running the temperature control and humidification routines are enabled. The fan will run continuously unless shut down by the unit low limit or duct smoke detector. The DDC System will stop the AHU upon receiving a general fire alarm signal from the fire alarm system. When the supply fan stops the outside air and discharge fire/smoke dampers will close, the chilled water valve will close and the hot water coil valve will cycle to maintain discharge conditions in the unit.
3. Glycol Heat Exchanger Pump Control: Whenever the heating system is enabled, the primary hot water pump is running and 34.AHU.B.1 is enabled, the DDC System will start the lead glycol pump GWP.B.1. In the event that the lead glycol pump does not start, or if the lead glycol pump fails after being commanded to run, the lag, or backup pump, GWP.B.2, will be started and an alarm will be generated at the OWS. The lead glycol pump will run until the DDC System senses that the primary heating pump is no longer running.

In the event that both glycol pumps fail 34.AHU.B.1 will be stopped and an alarm message will be generated at the OWS. The lead glycol pump will be alternated every 240 hours of operation (adj.) to equalize run time on the pumps.

4. Temperature Control: Whenever 34.AHU.B.1 is running the DDC System will modulate the glycol hot water valve with the chilled water coil valve in sequence to maintain a discharge set point according to the following reset schedule (adj.):

<u>OA TEMP</u>	<u>Discharge Temp</u>
0°F	85°F
90°F	55°F

5. Humidification Control: Whenever the AHU is running & main steam is available the DDC SYSTEM will modulate the steam-to-steam humidifier to maintain a return air humidity (as sensed in the return air duct to ERV.1. See 34.ERV.1

control drawing) set point according to the following reset schedule:

<u>OA temp</u>	<u>Return % RH</u>
0°F or below	15%
10°F	25%
20°F or above	35%

At no time will the DDC System allow the discharge humidity to exceed 85% (adj.). Whenever 34.AHU.B.1 is off the humidifier is disabled.

6. Alarms: The following points are available for monitoring, trending or alarming at the OWS:

- Supply fan status
- Plugged filter status
- Low limit trip indication
- Heating coil discharge temperature
- Cooling coil discharge temperature
- AHU discharge humidity
- Return air humidity
- Glycol pump status (typical for pumps GWP.B.1 & GWP.B.2).
- Glycol supply and return water temperature

E. 34.HTNG-HW.B.1, Basement Hot Water Heating System

1. General: The heating hot water system consists of steam to hot water heat exchanger HX.B.1, primary pumps HWP.B.1 and HWP.B.2, secondary pumps HWP.B.3 and HWP.B.4, and a secondary reset hot water control valve.
2. Pump control: When the main steam pressure rises above 15 psi (adj.) the DDC system will start the lead primary pump, HWP.B.1. In the event that the lead primary pump does not start, or if the lead primary pump fails after being commanded to run, the lag, or backup pump, HWP.B.2, will be started and an alarm will be generated at the DDC system. The lead pump will run until the outside air temperature rises above 67°F (adj.).

In the event that both primary pumps fail 34.AHU.B.1 and all FCU's and CUH's will be stopped and an alarm message will be generated at the DDC system. Shutdown when both pumps fail.

The lead primary pump will be alternated weekly (adj.) to equalize run time on the pumps.

Once the DDC System senses that the primary pump has started the lead secondary pump, HWP.B.3, will be started. In the event that the lead secondary pump does not start, or if the lead secondary pump should fail after being commanded to run, the lag, or backup pump, HWP.B.4, will be started and an alarm will be generated at the OWS. The secondary pumps will run until the DDC System senses that the primary pumps have been shut down. In the event that both secondary pumps fail all FCU's and CUH's will be stopped and an alarm message will be generated at the DDC system.

The lead secondary pump will be alternated weekly (adj.) to equalize run time on the pumps.

3. Main Steam Valve: When the OA temperature drops below 65°F, the DDC System will give the main steam valve controller an open command. When the OA temperature rises above 65°F +3°F offset, the DDC System will give the main steam valve controller the close command.
4. Heat Exchanger HX.B.1 Control: When the main steam pressure rises above .5 psi (adj.) and the DDC SYSTEM senses that the primary hot water pump is running the heat exchanger will be enabled. The DDC SYSTEM will modulate the heat exchanger 1/3, 2/3 valves in sequence to maintain a primary hot water supply loop temperature of 180°F (adj.). The heat exchanger will remain enabled until main steam pressure falls below .5 psi and the primary pumps have stopped. When the heat exchanger is disabled the 1/3,2/3 valves will be closed.
5. Secondary Hot Water Loop Control: When the main steam pressure rises above .5 psi and the DDC System Senses that the secondary hot water pump is running the

Secondary reset hot water zone will be enabled. The DDC System will modulate the reset hot water valve to maintain a reset Hot water set point according to the following schedule:

<u>OA Temp.</u>	<u>HWS</u>
0°F	180°F
60°F	120°F

When the DDC System senses that the secondary pump has stopped the control valve.

6. Alarms: The following points are available for monitoring, trending and alarming at the OWS:
 - Pump run indication (typical for pumps HWP.B.1 through HWP.B.4)

- High and low loop temperature alarms (typical for both primary and secondary loops). Low system steam pressure (from steam pressure transmitter).

F. 34.CH.1.1: See C.CH. Control Sequence

3.3.9 Building 35 Sequence of Operations

A. 35.CVAHU.B.1 & 2, Basement Constant Volume Air Handling Units

1. Run Conditions - Scheduled: The unit shall run according to a user definable time schedule in the following modes:

Occupied Mode: The unit shall run continuously and maintain 74°F (adj.) cooling set point and 70°F (adj.) heating set point. Outside air damper and return air damper shall be positioned for minimum (20%) outside air. When unit is in cooling mode, secondary chilled water pump (normally off) shall be energized. Unit UV lamps (normally off) shall be energized.

Unoccupied Mode (night setback): The unit shall maintain 85°F (adj.) cooling set point and 55°F (adj.) heating set point. Outside air damper and return air damper shall be positioned for 100% return air. Secondary chilled water pump (normally off) shall be energized. Unit UV lamps shall be off.

Monitoring: The DDC system shall monitor the status of unit supply fan, secondary chilled water pump and food preparation area exhaust fan.

2. Zone Set point Adjust and Override: The occupant shall be able to adjust the zone temperature heating and cooling set points at the zone sensor. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period. At the expiration of this time, control of the unit shall automatically return to the schedule.
3. Supply Fan: The supply fan shall run continuously in occupied mode, unless shut down on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime, unless shutdown on safeties. Fan status to be monitored.

Alarms shall be provided as follows:

Supply Fan Failure: Commanded on, but the status is off.

Supply Fan in Hand: Commanded off, but the status is on.

Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.)

4. Heating Coil Valve: The controller shall measure the heated air temperature and modulate the heating coil steam valve(s) to maintain the heating set point.

The heating coil valve(s) shall be enabled whenever:
 Outside air temperature is less than 65°F (adj.)
 AND the supply fan status is on
 AND cooling is not active

The heating coil valve shall open for freeze protection whenever:

Mixed air temperature drops from 40°F to 35°F (adj.).
 OR the freezestat (if present) is on.

5. Cooling Coil Valve: The controller shall measure the discharge air temperature and modulate the cooling coil valve to maintain its cooling set point. The cooling coil valve shall be enabled whenever:

- a. Chilled water secondary circulator is on.
- b. Outside air temperature is greater than 75°F (adj.)
 AND the supply fan status is on.
 AND the zone temperature is above the cooling set point.
 AND heating is not active

The cooling coil valve shall open to 50% (adj.) whenever the freezestat is on.

The discharge air temperature set point shall be reset using a trim and respond algorithm based on zone cooling requirements. If there is a demand for cooling then the set point shall be reset to a lower value (adj.). If the demand for cooling decreases then the set point shall reset to a higher value (adj.). Once the zone is satisfied then the set point shall gradually moderate over time to reduce cooling energy use.

The discharge air temperature set point shall be reset based on zone cooling requirements as follows:

The initial supply air temperature set point shall be 55°F (adj.).

As cooling demand increases, the set point shall incrementally reset down to a minimum of 53°F (adj.).

As cooling demand decreases, the set point shall incrementally reset up to a maximum of 75°F (adj.).

6. Filter: The controller shall monitor the filter status. Alarms shall be provided as follows: Filter Change

Required: Filter differential pressure exceeds a user definable limit (adj.).

7. Discharge Air Temperature: The controller shall measure the discharge air temperature.

Alarms shall be provided as follows:

High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).

Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

8. Freeze Protection: The unit shall be hard wired for a shut down from the freezestat and generate an alarm upon receiving a freezestat status from the auxiliary contact.
9. Monitoring: The controller shall monitor additional points not noted in the sequence as indicted on the points list and flow diagrams.

B. 35.EF.1.1, 1st Floor Food Prep Area Exhaust Fan

1. Run Conditions: Exhaust fan shall be controlled by local On/Off controls.
2. Monitoring: The DDC system shall monitor the On/Off status of the exhaust fan.

C. 35.CH.1.1, Packaged Chiller with Pumps

1. See control sequence C.CH.1 for control of packaged chiller with chilled water pump.

D. 35.HFCU.2.1 & 35.EF.2.1, 2nd Floor Heating/Ventilating Fan Coil Unit & Exhaust Fan

1. Run Conditions - Scheduled: The DDC system shall control the operation of the ventilation fan coil unit and companion exhaust fan. The unit shall run according to a user definable time schedule in the following modes:

Occupied Mode: The unit shall operate continuously. When the outside air temperature is 65°F or below, the unit shall maintain 65°F (adj.) supply air discharge set point. At outside air temperatures above 65°F, the heating coil control valve shall be closed.

Unoccupied Mode (night setback): The unit shall be off, the exhaust fan shall be off and the heating coil control valve shall be in the closed position.

2. Discharge Air Temperature: The controller shall measure the discharge air temperature.

Alarms shall be provided as follows:

Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

3. Freeze Protection: The unit shall be hard wired for a shut down from the freezestat and generate an alarm upon receiving a freezestat status from the auxiliary contact.
4. Monitoring: The DDC system shall monitor zone temperature and the status of the fan coil unit supply fan and the exhaust fan.

E. 35.CFCU.2.1-7, 2nd Floor Cooling Only Fan Coil Units

1. Run Conditions - Scheduled: The DDC system shall control the operation of the cooling fan coil unit. The unit shall run according to a user definable time schedule in the following modes:

Occupied Mode: The unit shall operate continuously at the speed selected by the local three speed switch (existing). When the outside air temperature is over 65°F, the unit chilled water three way valve shall modulate to maintain a 74°F (adj.) zone set point temperature.

Unoccupied Mode (night setback): The unit shall cycle as need to maintain 85°F (adj.) zone cooling set point.

2. Monitoring and Set Point Override: The DDC system shall monitor the space temperature. Space temperature sensors shall be provided with an override pushbutton that will enable fan coil unit operation for 1 hour (adj.) period.

F. 35.DSFCU.1.1, 1st Floor Ductless Split Fan Coil Unit and Condensing Unit

1. See control sequence C.DSFCU.1.1 for control of ductless split fan coil unit.

G. 35.GLY.B.1, Glycol System Pressure Monitoring

1. See control sequence C.GLY.1 for control of glycol system pressure monitoring.

3.3.10 Building 41 Sequence of Operations

A. 41.VAVAHU.3.1, 3rd Floor VAV Air Handling Unit

1. When indexed for occupied operation by the DDC system, the supply and return fans start and run continuously. The supply duct smoke dampers (normally closed) will be powered open. The unit runs on return air and full heat until the return air temperature reaches the adjustable warm up set point.
2. After the warm up period, the outside air damper opens to its minimum position.
3. Heating: the preheat steam coil valve (normally closed) shall open and the face and bypass damper shall modulate to maintain the preheat discharge temperature as reset from outside air temperature.
4. When the outside air enthalpy is less than the return air enthalpy, the DDC system shall modulate the outside, return and exhaust air dampers to maintain the preheat coil discharge temperature setting. Above the mechanical cooling outside air lockout temperature setting, the DDC system shall cycle the DX cooling to maintain the representative space temperature at set point. When the outside air enthalpy is greater than that of the return air, the DDC will position the outside air dampers to maintain minimum outside air flow and will cycle the DX cooling to maintain the representative space set point temperature.
5. The DDC system shall modulate the supply fan VSD to maintain the downstream static pressure set point. The DDC system senses the supply and return fan cfm and modulates the return fan VSD to maintain the differential airflow set point between the supply and return fans. On startup, the DDC system ramps the supply and return variable speed drives to their respective control settings to prevent startup instability.
6. In order to maintain a minimum airflow through the DX coil, the DDC system shall monitor the supply airflow. If the downstream VAV boxes and volume dampers close to a point where the supply air to the spaces is less than the minimum airflow required for the DX coil, the supply air bypass damper shall modulate open to maintain the minimum airflow through the DX coil.
7. When indexed for unoccupied mode by the DDC, the unit cycles on full heat to maintain the reduced night temperature setting, or on free cooling to maintain the setback night temperature space setting as sensed by the representative space sensor.
8. When the low limit thermostat on the downstream side of the preheat coil is below its set point or when the supply

smoke detector is in an alarm condition, the unit will shut down.

9. Whenever the unit is off, the outside, exhaust and smoke dampers will be closed, the return air damper opens and the VSD's are at minimum setting.
- B. 41.VAV & 41.VD, 1st & 2nd Floor VAV Box W/O Reheat and Zone Volume Dampers
1. When the AHU discharge temperature is above the VAV box changeover setting, the respective space thermostat modulates its respective VAV box or duct volume damper for heating. When the discharge temperature is below the changeover setting, the thermostat modulates its respective VAV box or duct volume damper for cooling. Changeover is indexed by the DDC system.
- C. 41.RAD.3.1-2, Steam Radiator
1. See Control Sequence C.RAD.1
- D. 41.CUH.1.1 & 2, 1st Floor Stairwell Steam, Cabinet Unit Heaters
1. See Control Sequence C.CUH-STM.1
- E. 41.UH.3.1, 3rd Floor Mech Room Unit Heaters
1. See Control Sequence C.UH-STM.1
- F. 41.ZCV.B.1 & 2, Basement Steam Zone Dampers
1. Basement steam zone control valves shall be scheduled to open whenever the outside air temperature is 65°F (adj.) or below. The zone control valves shall close whenever air handling unit 41.VAVAHU.3.1 is in the cooling mode.

3.3.11 Building 76

3.3.11.1 Building 76, Ground Floor

- A. 76.MAU.G.1, 2nd Floor Lab Makeup Air Unit
1. Supply Make-Up Air and Exhaust Fan Control (76.MAU.G.1, 76.EF.6.4 & EF.6.5): Supply fan and exhaust fans will be scheduled to operate through the DDC system to correspond

with the operating hours of the 2nd Floor Chemistry and Hematology Lab and associated spaces. An "On/ Off/ Auto" selector switch is provided on the control panel.

- a. The units outdoor air damper will open.
 - b. Exhaust fan and runaround coil pump to start through interlocks.
 - c. Chilled water pump will be placed under control.
 - d. Humidifier to become activated from a closed position.
 - e. Well water coil valve to become activated from a closed position.
2. Reclaim Coil Control (ERC.6.1, air handling unit preheat coil)
 - a. When the make-up air unit is running, reclaim pump will run to transfer heat from the exhaust coil (ERC.6.1) to the preheat air coil subject to outdoor air temperature. Pump will not operate at temperature between 50°F and 80°F (adjustable)
 - b. 3-way valve shall be fully open to the outside air coil whenever the exhaust coil supply water temp is above 35°F.
 - c. 3-way valve shall modulate flow to the outside air coil to maintain 35°F supply water to the exhaust coil.
3. Preheat Coil Control
 - a. Control valve shall modulate the heating coil valve to maintain a temperature no lower than 45°F (adj.).
4. Chilled Water Control
 - a. An average control signal from three space thermostats (rooms 230, 242 and 239) will select, in conjunction with a humidistat (set at 50% R.H.) will on a call for cooling or dehumidifying start the chilled water pump (which in turn will allow a flow switch to start the refrigeration chiller) and gradually position three-way mixing valve to maintain supply air set point. (Note: Chiller to maintain the required chilled water supply temperature through its own self-contained controller which will also include a low ambient cutout.
5. Humidity Control

- a. The space humidistat set will gradually position a normally closed humidifier to maintain the required space humidity of no lower than 30% , subject to a discharge humidity high limit set at 85%.

6. Exhaust Fan Control

- a. Exhaust fans EF.6.4 and EF.6.5 shall be energized whenever the makeup air unit is energized. When exhaust fans EF.6.4 and EF.6.5 are running, normally closed dampers will open and when the exhaust fan is off, the dampers will close.

B. 76.DDAHU.G.1&2, Ground Floor Dual Duct Air Handling Units (formerly AC-1 and AC-2)

1. AC Unit supply fan starts through H-O-A switch. When the fan starts, minimum O.A damper will open. The return air fan will operate independently of the supply fan.

When the outside air temperature is above 57°F, cold deck sensor will modulate cooling valve to maintain its setting of 55°F.

When the outside air temperature drops below 55°F, the mixed air sensor will be allowed to modulate the O.A. and Relief Air dampers open and the R.A damper closed.
2. Hot deck sensor will modulate steam valve to maintain its setting of 100°F regardless of outside air temperature. The hot deck temperature will be reset directly according to hot deck airflow. As hot deck airflow increases, hot deck air temperatures will be increased.
3. Return air humidistat will modulate humidifier valve through high limit humidity sensor set at 60%, to maintain 30% relative humidity. Humidity valve will be inoperable when supply fan is off. Outdoor sensors will shut off steam supply to humidifier valve, by closing humidifier valve, when O.A. temperature rises above 60°F and open valve humidifier valve when outside air temperature drops below 60°F.
4. Duct static pressure will be maintained by fan discharge static pressure sensor controlling fan inlet vanes.

5. Freeze-stat shuts down S.F. & R.F. whenever temperature drops below 45°F and initiates alarm through DDC.
6. Room Control: Room thermostats to remain on pneumatic system. Sequence of Operation below for information only.

Room thermostat will control dampers IDVC box will modulate between full heating and full cooling. The control valve on the radiator will open should the hot deck of IDVC box be unable to supply sufficient heat to the room. As the room temperature rises the radiation valve will close and allow only the hot deck to heat the room. As room temperatures continues to rise the hot deck will close and the cold deck will modulate open. When AC unit is off, the room thermostats will continue to function as described above. When more than one box and/or more than one radiator valve is required dampers and/or valves shall sequence in parallel.

7. Smoke Detectors and Operation of Smoke Dampers

Smoke detectors (existing to remain) operate the smoke dampers (existing to remain) at duct penetration of smoke barriers. (AUX contacts of smoke detectors)

Supply fan, return fan and all interlocked fans stop when any smoke detector is activated.

- C. 76.GER.G.1: See sequence of operation C.GER.1.
- D. 76.UH.G.1 & 2: See sequence of operation C.UH.STM.2.
- E. 76.WCDXFCU.G.1, Ground Floor Water Cooled DX Fan Coil Unit
 1. Run Conditions - Scheduled: The DDC system shall enable the operation of the water cooled DX condensing unit and companion fan coil unit. The unit shall run according to a user definable time schedule in the following modes:

Occupied & Unoccupied Mode: The unit shall maintain 74°F (adj.) cooling set point.

2. Monitoring: The DDC system shall monitor zone temperature and the status of the fan coil unit supply fan and outdoor condensing unit.
 3. Flow of condenser water (i.e. campus well water) to the chillers will be controlled via the chiller's self-contained controls.
 4. Alarms: The DDC system shall monitor unit trouble alarms originating from unit controller.
- E. 76.HTNG-HW.G.1, Rm G114 Steam to Hot Water Converter, with One Pump and Single Steam Control Valve serving 1st Floor Fintubes units.

1. Main Hot Water Supply Temperature Set Point Reset: The hot water supply temperature set point during occupied periods shall reset based on outside air temperature. As outside air temperature, rises from 0°F (adj.) to 70°F (adj.) the hot water supply temperature set point shall reset downwards from 180°F (adj.) to 110°F (adj.).

The hot water supply temperature set point during building warm-up periods shall reset, as outside air temperature, rises from 0°F (adj.) to 70°F (adj.) the hot water supply temperature set point shall reset downwards from 195°F (adj.) to 125°F (adj.).

Alarms shall be provided as follows:

- High Hot Water Supply Temp: If greater than 200°F (adj.).
 - Low Hot Water Supply Temp: If less than 100°F (adj.).
2. Heat Exchanger Steam Valve - Hot Water Control(XN.G.3): The controller shall measure the hot water supply temperature and modulate the steam valve to maintain its set point. The steam valve shall be enabled whenever hot water supply temperature is below set point. The steam valve shall close whenever the hot water supply temperature rises from 180°F to 200°F (adj.).
 3. Hot Water Pump Run Conditions (HWP.G.5): The hot water pump shall be enabled whenever outside air temperature is less than 54°F. (adj.) To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable). Pump status and Hand-Off-Auto status to be monitored.

The hot water pump shall have a user adjustable delay on start and a user adjustable delay on stop. The delay times

shall be set appropriately to allow for orderly hot water system start-up, shutdown and sequencing.

Alarms shall be provided as follows:

- a. Hot Water Pump Failure: Commanded on, but the status is off
- b. Hot Water Pump Running in Hand: Commanded off, but the status is on
- c. Hot Water Pump Runtime Exceeded: Status runtime exceeds a user definable limit

5. Monitoring: Hot water supply and return temperature.

F. 76.HTNG-HW.G.2, Room C117 Hot Water Heating Loop with 1 Steam Valve serving MAU.G.1

1. Steam to Hot Water Converter, Hot Water Pumps and Single Steam Control Valve

a. Main Hot Water Supply Temperature Set Point Reset:

The hot water supply temperature set point during occupied periods shall reset based on outside air temperature. As outside air temperature, rises from 0°F (adj.) to 70°F (adj.) the hot water supply temperature set point shall reset downwards from 180°F (adj.) to 110°F (adj.).

The hot water supply temperature set point during building warm-up periods shall reset, as outside air temperature, rises from 0°F (adj.) to 70°F (adj.) the hot water supply temperature set point shall reset downwards from 195°F (adj.) to 125°F (adj.).

b. Alarms shall be provided as follows:

- High Hot Water Supply Temp: If greater than 200°F (adj.).
- Low Hot Water Supply Temp: If less than 100°F (adj.).

2. Heat Exchanger Steam Valve - Hot Water Control (XN.G.1):
The controller shall measure the hot water supply temperature and modulate the steam valve to maintain its set point. The steam valve shall be enabled whenever hot water supply temperature is below set point. The steam valve shall close whenever the hot water supply temperature rises from 180°F to 200°F (adj.).

3. Hot Water Pump Run Conditions (HWP.G.1 & 2):

The hot water pumps shall be enabled whenever outside air temperature is less than 54°F. (adj.) To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable). Pump status and Hand-Off-Auto status to be monitored.

Two pumps:

Shall operate in a lead/lag fashion. The lead pump shall run first. On failure of the lead pump, the lag pump shall run and the lead pump shall turn off. Lead/lag pump selection shall be automatically alternated weekly.

The hot water pumps shall have a user adjustable delay on start and a user adjustable delay on stop. The delay times shall be set appropriately to allow for orderly hot water system start-up, shutdown and sequencing.

4. Alarms shall be provided as follows:

- Hot Water Pump Failure: Commanded on, but the status is off
- Hot Water Pump Running in Hand: Commanded off, but the status is on
- Hot Water Pump Runtime Exceeded: Status runtime exceeds a user definable limit

5. Monitoring: Hot water supply and return temperature.

G. 76.HTNG-HW.G.3, 3BICU Steam to Hot Water Converter, with One Pump and Single Steam Control Valve serving 3rd Floor VAV Boxes

1. Pump Control (HWP.G.3 & 4):

On a drop in outdoor air temperature below 52°F HWP.G.3 shall be enabled and the pump shall be designated as the lead pump and pump HWP.G.4 shall be designated as the lag pump. Upon a start command, the pump shall run continuously. The run time of the lead and lag pumps shall be totalized. If the lead pump run time exceeds set point of 672 hours (adj.), the lag pump shall start and be designated as the lead pump. The system shall be off at an outdoor air temperature >52°F (adj.). Alarms shall be recorded at the dispatch center for pump failure.

2. The lead pumps variable frequency drive (VSD) shall vary the flow based on maintaining a differential of 5 psi (adj.) at the remote differential static pressure transducers. The worse case differential static pressure transducer shall be utilized for controlling the speed of the pump. The DDC system shall monitor VSD alarm and differential static pressure high and low limits. If a VSD

alarm is activated or limits exceeded, an alarm shall be recorded at the dispatch center.

3. Control valve:

The preheat hot water system shall be scheduled based on outside air temperature. The control valve shall modulate to maintain a heating hot water schedule as follows:

Heating Water Supply Temp (°F):	OA Temp (°F):
90	55
100	10

The DDC system shall monitor hot water supply and return temperatures. If temperatures exceed high or low limits, an alarm shall be recorded at the operator's workstation.

On a drop in outdoor air temperature below 52°F, the control valve shall modulate open to maintain the leaving water temperature as dictated by the reset schedule.

H. 76.HTNG-HW.G.4, Emergency Department Reheat Hot Water System for air handling unit 76.VAVAHU.1.1 (ED air handling unit VAV box reheat coils)

1. General: The system as provided is a steam to hot water heat exchanger with a parallel pump set to produce hot water for the volume box reheats.
2. Reheat pump controls (Pumps HWP.G.6 & 7)

When the outside air temperature (OA) drops below 52°F (adj.) for longer than 10 minutes (adj.) the lead heating water pump (GWP.G.6) will be enabled, in the event that the pump does not start, or if the pump should stop running when commanded to run, an alarm will be generated at the operator's work station (OWS) and the back up pump (HWP.G.7) will be started. The pump will run until the outside air temperature rises above 52°F (adj.) for longer than 10 minutes (adj.) or until commanded "off" from the OWS. The building automation system (DDC) will totalize the pump run time. If the pump run time exceeds 672 hours (adj.) the DDC system will stop the lead pump and start the LAG pump.

When the pump is running the DDC system will modulate the pump variable frequency drive (VSD) to maintain constant system differential pressure of 5 psi (adj.) as sensed by the differential pressure sensor mounted 2/3 of the distance into the reheat loop piping. In the event the pump

VSD's cannot maintain sufficient system differential an alarm will be generated at the OWS.

3. Heat Exchanger Control (HX.G.4)

When the DDC senses that the outside air is below 52°F (adj.) and there is a run indication from either one of the reheat pumps (HWP.G.6 or G.7) the steam to hot water heat exchanger will be enabled. When the heat exchanger is enabled the DDC system will modulate the 1/3, 2/3 valves as follows to maintain supply water temperature set point as outlined below. The DDC system will modulate the smaller valve to maintain the set point using a PID temperature control loop. The larger valve will control to the temperature offset using an integral only temperature control loop. This will serve to keep the smaller valve at mid-stroke and will provide better control resolution through the control range.

The reheat hot water set point will be based on outside air temperature according to the following reset schedule:

Outside air temperature:	Reheat water supply temp:
10°F (adj.)	180°F (adj.)
Outside air temperature:	Reheat water supply temp:
55°F (adj.)	90°F (adj.)

4. Monitoring and alarm points

The following points are available from monitoring and alarming the DDC system:

- a. Pump run indication (pump failure alarm) - typical for HWP.G.6 & 7
- b. Low system differential
- c. Pump VSD fault alarms-typical for HWP.G.6 & 7
- d. High and low reheat loop temperature alarms

I. 76.WCCH.G.1&2, Water Cooled Chillers for MAU.G.1 (76.WCCH.G.2) and 6th Floor FCUs and MAU.7.1 & 3 (76.WCCH.G.1)

1. Pump Control:

When the respective air handlers call for cooling and when the water temperature is below a cooling enable set point of 56°F (adj.) the chilled water pumps will be enabled to operate continuously. If the pump is commanded off but

status is on, an alarm will be generated. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

1. Chiller Control:

Upon proof of chilled water flow, as determined by the flow switch, the chiller will be commanded on. The chiller will maintain a chilled water supply temperature set point as determined by its own internal controls. If the chiller fails, an alarm will be displayed at the DDC system. The chiller's chilled water inlet and outlet temperatures will be continuously monitored and displayed at the OWS. The chiller will run and be off for minimum adjustable times (adj.). If the chiller fails to start when commanded to run, an alarm will be generated. If the chiller is commanded off but status is on, an alarm will be generated.

2. Temperature Monitoring:

If the chilled water supply temperature rises above 65°F (adj.) or falls below 38°F (adj.) the limit settings, an alarm will be generated. If the chilled water return temperature rises above 68°F (adj.) or falls below 47°F (adj.) the limit settings, an alarm will be generated.

3. Flow of condenser water (i.e. campus well water) to the chillers will be controlled via the chiller's self-contained controls.

4. Alarms: Chiller fault alarms shall be monitored by the DDC system.

3.3.11.2 Building 76, First Floor

A. 76.VAVAHU.1.1, Emergency Department Variable Air Volume Air Handling Unit

1. General

Air handling unit VAVAHU.1.1 can be enabled from the DDC system through either an automatic time-of-day schedule (adj.) Entered at the operator s work station (OWS) or manually from the OWS by the facility operator.

When enabled the equipment will control as described below according to the mode selected by the facility operator. When the equipment is disabled it remains off or closed and is unavailable to run.

When the VAVAHU is off all valves and dampers will be in their fail-safe positions.

If a fan should fail to start, or should a fan fail after being commanded to run, the VAVAHU will be shut down and an alarm message will be generated at the OWS.

2. Unoccupied Control

The supply and exhaust fans, the humidifier and the DX cooling are off, the outside and exhaust air dampers are closed, the mixing dampers are positioned to 100% return air and the heating coil valve is closed. If the outside air drops below 42 f (adj.) The bas will open the face and bypass coil steam valve and modulate the face and by pass dampers to maintain a minimum unit discharge temperature of 55°F (adj.).

If any of the space temperature sensors served by AHU-1 should drop below the unoccupied heating set point (initially set at 55°F (adj.)) The supply fan will start and its VSD will modulate to maintain a supply system static pressure of 2 WC (adj.). The return fan will start and will match the supply air flow. The unit will run on 100% return air with the heating coil valve at 100% until the coldest space temperature served is 4 f (adj.) Above the unoccupied heating temperature set point.

If any of the space temperature sensors served by AHU-1 should rise above the unoccupied cooling set point (initially set at 90 f (adj.)) The supply fan will start and its VSD will modulate to maintain a supply system static pressure of 2 WC (adj.). The return fan will start and will match the supply air flow. The unit will run on 100% return air, the heating coil valve will be 100% closed and the DX cooling will be enabled until the hottest space temperature served is 8°F(adj.) Below the unoccupied cooling temperature set point.

3. Occupied Control

76.VAVAHU.1.1 will be indexed to the occupied mode on a schedule entered at the OWS by the facility operator. The supply and exhaust fans will start and will run continuously. The supply fan VSD will modulate to maintain a supply system static pressure of 2 WC (adj.). The bas will monitor the supply and return fan flows and will modulate the exhaust fan VSD to maintain 98% (adj.) Of the supply air flow minus the exhaust air flow from exhaust fans. The exhaust flow will equal the flow from exhaust fans ef-1, 2, 3, and 4 as follows: ef-1 375 CFM; ef-2 310 CFM; ef-3 700 CFM; ef-4 350 CFM (total of 1,735 CFM). The DDC will monitor the run status of the exhaust fans and will reset the return air flow for 76.VAVAHU.1.1 as

required to compensate for the exhaust fans that are currently running.

The volume control damper will initially be set to a minimum outdoor air setting as directed by the air balancer at system start-up. The bas will modulate the mixing dampers, face and bypass dampers and cycle the DX cooling in sequence as required to maintain the unit discharge air temperature set point of 55°F (adj.). At no time will the cooling coil be enabled when the face and bypass damper and coil are in operation and at no time will the face and bypass system be enabled when the cooling coil is enabled.

At no time will the unit discharge air temperature be allowed to fall below 55°F (adj.).

4. Heating Mode

When the mixed air temperature is equal to or less than 45°F (adj.) and the mixing (economizer) dampers are 100% closed the unit will be in heating mode. The bas will open the face and bypass coil steam valve and modulate the face and bypass dampers as required to maintain a discharge set point of 55°F (adj.).

5. Cooling Mode

When the outside air temperature is below 55°F (adj.) The DX cooling will be disabled and the mixing dampers will modulate as required to maintain the discharge air temperature set point of 55°F (adj.).

When the outside air temperature is above 55°F (adj.) The mixing dampers will be at minimum position and the stages of DX cooling will cycle in sequence as required to maintain the unit discharge temperature.

6. Humidity Control

Once the DDC system has proof that the supply and return fan are running the humidifier control valve will modulate to maintain a return air humidity of 35% (adj.). The AHU discharge humidity will never be allowed to exceed 80% (adj.). When the unit is unoccupied, or if the DDC senses that either fan is not running, the humidifier will be disabled.

7. Unit Safety Control

Any of the following conditions will cause VAVAHU.1.1 to generate an alarm message at the OWS:

- A unit mixed air or discharge air temperature reading of 40°F (adj.) or less
- A unit discharge air temperature of 120°F (adj.) Or more
- A unit mixed air temperature greater than 90°F (adj.)
- VSD fault (typical for supply and return fans)
- Supply or exhaust fan failure
- Fire alarm system is activated
- High or low outside air flows
- Unit high static shutdown
- Unit low static shutdown
- Unit low mixed air static
- A unit discharge air temperature that is 8°F (adj.) Above or below set point for longer than 15 minutes (adj.)
- A unit discharge humidity that is higher than 85% (adj.) For longer than 15 minutes (adj.)

B. 76.VAV.1.1-20, Emergency Department VAV Boxes

The VAV units are individually controlled by factory mounted DDC controllers.

Through the operator's work station (OWS) the DDC can group the VAV units such that all units in a group can be commanded to operate in the same mode.

The DDC edits the zone space temperature set point of each VAV unit through the OWS. In the event of a communication loss the VAV unit will continue to control to its current set points.

The system operator has the ability to adjust the maximum and minimum CFM flow limits for all operating modes of each VAV unit through the OWS.

The DDC puts the VAV unit in either the occupied or unoccupied mode based on an operator adjustable time schedule entered at the OWS. The VAV units may also be placed in the full open, full closed, maximum flow or minimum flow modes through commands entered at the OWS.

The system automatically recalibrates its airflow sensing and air valve position measurement system at system start-up and on a scheduled basis.

When energized the VAV unit operates continuously on a rise in space temperature the unit modulates to provide maximum CFM (adj.) as the space temperature decreases the box modulates down to its minimum CFM (adj.) on a further decrease in temperature the controller modulates the reheat coil to maintain the room temperature set points (initially set at 72°F (adj.) occupied, 65°F (adj.) Unoccupied).

The following conditions will cause the VAV to generate an alarm at the DDC:

A space temperature reading the deviates from set point by more than 6°F (adj.) for longer than 30 minutes (adj.)

See 76.HTNG-HW.G.4 for sequence of operation for VAV box reheat hot water system.

C. 76.EF.1.3, 1st Floor Isolation Room Exhaust Fan

1. Sequence of Operation:

When energized the VAV unit operates continuously. On a rise in space temperature the unit modulates to provide maximum CFM (adj.) as the space temperature decreases the box modulates down to its minimum CFM (adj.). On a further decrease in temperature the controller modulates the reheat coil to maintain the room temperature set points (initially set at 72°F (adj.) occupied, 65°F (adj.) unoccupied).

Exhaust fan EF.1.3 runs continuously. If the fan should fail to start, or if the fan should fail after being commanded to run, the output will be de-energized and an alarm will be generated at the OWS.

The following conditions will generate an alarm at the OWS:

- A space temperature reading the deviates from set point by more than 6°F (adj.) for longer than 30 minutes (adj.)
- Exhaust fan- EF.1.3 failure
- Exhaust fan- EF.1.3 damper failure
- Low space pressure alarm
- High space pressure alarm
- Low exhaust air flow (less than 650 CFM (adj.)) for longer than 10 minutes (adj.)

D. 76.EF.1.1, 2, 4, Exhaust Fans

1. Sequence of Operations

The DDC can put the exhaust fans in either the occupied or unoccupied mode based on an operator adjustable time schedule entered at the OWS.

When commanded "on" the fans run continuously.

When the exhaust fans start the exhaust damper associated with the fan opens making the damper end switch interlock and enabling the fan. When the exhaust fan stops its corresponding damper goes closed.

If a fan should fail to start, or should a fan stop after being commanded to run, the control output will be turned off and an alarm message will be generated at the OWS.

The exhaust fans will operate continuously

The following conditions will generate an alarm message at the OWS:

- Exhaust fan damper failure
- Exhaust fan failure

E. 76.EF.1.5 & 6, Exhaust Fans

1. Exhaust fans 76.EF.1.5 and 1.6 shall be interlocked with the operation of air handling unit 76.DDAHU.G.1 such that the exhaust fans are energized whenever the air handling unit is in the occupied mode of operation.
2. 76.EF.1.6 shall also be controlled by a Hand-Off-Auto (HOA) switch. In the Auto mode, the exhaust fan shall be interlocked with the operation of the associated air handling unit.

F. 76.DSFCU.1.1-8: See sequence of operation C.DSFCU.1

G. 76.FCU-HW-CH.1: See sequence of operation C.FCU-HW-CW.1

H. 76.DXFCU.1.1 & 2, Room 152 DX Fan Coil Units

1. Run Conditions - Scheduled: The DDC system shall enable the operation of the DX condensing unit and indoor fan coil unit. The unit shall run according to a user definable time schedule in the following modes:

Occupied and Unoccupied Mode: The unit shall maintain 74°F (adj.) cooling set point.

2. Monitoring: The DDC system shall monitor zone temperature and the status of the fan coil unit supply fan and outdoor condensing unit.
3. Alarms: An alarm condition will be initiated whenever the space temperature is 5°F (adj.) greater than space set point.

3.3.10.3 Building 76, Second Floor

A. 76.HTNG-GLY.2.1, Sterile Storage Hot Water Heating System

Primary Pumps (76.HWP.2.1 & 2) Control: The lead hot water pump will be enabled to operate continuously, initially set for 76.HWP.1. If the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but the status is on, an alarm will be generated.

Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):

- Manually through software switch
- Pump runtime (adj.) is exceeded
- Daily
- Weekly
- Monthly

Glycol Tank Monitoring: The ultrasonic level sensor will measure the level of glycol in the glycol tank. When the level falls below the low limit set point (adj.) an alarm will be generated at the operator workstation.

HX Valve Control: Upon a proof of pump run status, the HX valve will modulate to maintain a hot water temperature set point, as sensed by a temperature sensor ____ and as reset by the following reset schedule:

OA Temperature	HWS Set point
0°F	180°F
60°F	120°F

B. 76.CH.2.2, 5TH Floor FCU Chiller with Pumps

1. When the outside air temperature rises above the cooling outside air temperature enable setpoint of 65°F (adj.) and one or more of the fifth floor fan coil units are in the occupied mode, the chilled glycol system will be enabled. Otherwise, the chilled glycol system will be disabled.
2. Chilled glycol pumps CWP.2.3 & 4 will operate in an automatic lead-lag sequence with the lead pump rotated weekly. When the chilled glycol system is enabled, the lead pump 76CWP.2.3 will run. The lead pump variable frequency drive will modulate to maintain the chilled glycol system differential. Pressure setpoint of 12 psi (adj.) while ensuring that the chilled glycol system flow does not drop below the minimum evaporator flow rate of 72 gpm for

chiller 76CH.2.2. If the lead pump fails, the DDC will generate an alarm and the LAG pump will take over.

3. When the chilled glycol system is enabled and flow through the lead chilled glycol pump has been proven, chiller 76.CH.2.2 will be enabled to run in the auto mode subject to its own internal safeties and controls. In the auto mode, chiller 76.CH.2.2 will sequence the available stages of cooling to maintain the chilled water supply temperature setpoint of 42°F (adj.). If the chiller fails, the DDC will generate an alarm.

C. 76.CH.2.3, Sterile Storage Chilled Water System (serves 76.DNAHU.2.1 & FCU.HW-CW.2

1. Primary Pumps (76.CWP.2.3 & 4) Control: When the outside air temperature is greater than a cooling enable set point of 54°F (adj.), lead chilled water pump will be enabled to operate continuously, initially set for 76.CWP.2.3. If the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but the status is on, an alarm will be generated. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):
 - Manually through software switch
 - Pump runtime (adj.) is exceeded
 - Daily
 - Weekly
 - Monthly
2. Chiller Control: Upon a proof of chilled water flow, as determined by the flow switch and a proof via aux contact at the pump starter, the chiller will be commanded on. The chiller will maintain a chilled water supply temperature set point as determined by its own internal controls. The chilled water set point will be adjustable from the head end. If the chiller fails, an alarm will be displayed at the OWS. The chiller's chilled water inlet and outlet temperatures will be continuously monitored and displayed at the OWS. The chiller will run for and be off for a minimum adjustable times (adj.). If the chiller fails to start when commanded to run, an alarm will be generated. If the chiller is commanded off but the status is on, an alarm will be generated. Status runtime for the chiller will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

If the chilled water supply temperature rises above a high limit set point of 55°F (adj.) or falls below a low limit set point of 38°F (adj.) an alarm will be generated at the OWS. If the chilled water return temperature rises above a high limit set point of 68°F (adj.) or falls below a low limit set point of 47°F (adj.) an alarm will be generated at the OWS.

D. 76.AHU.2.1 & 76.DHAHU.2.1 Sterile Storage Air Handling Unit & Dehumidification Unit with Energy Recovery Loop

1. Building Automation System Interface:

The Building Automation System (BAS) will send the controller Occupied, Unoccupied, Optimal Start, Night Heat/Cool, and Timed override commands. The DDC may also send a Heat/Cool mode, space temperature and/or space temperature set point. If a DDC is not present, or communication is lost with the DDC, the controller will operate using its local schedule and set points.

2. Occupied (Temperature Control):

During the occupied mode or upon an activation of the HOA switch on the starter to the "hand"- position, the outside air damper with a louver will open fully. When the damper is fully open, its end switch will close and the supply fan will run continuously. Whenever the fan shuts down, the outside air damper will close fully. If the supply fan fails to prove status for 30 seconds (adj.), the fan will be commanded off, the outside air damper and all valves will close and an alarm will be generated. A manual reset is required to restart the fan. If the supply fan is operating, as sensed by its air proving switch, but the commanded output is off, an alarm will be generated at the OWS. The fan will operate for a minimum on and off time to prevent short cycling.

During the occupied mode, upon a proof of supply fan status and when the outside air temperature is below the cooling enable set point of 65°F (adj.), the chilled water valve will close and the hot water valve will modulate to maintain a discharge air set point. The discharge air set point will be reset based on zone heating and cooling requirements. If the discharge air temperature is 5°F (adj.) or more below the set point for a pre-determined amount of time, an alarm will be generated.

When the outside air temperature is above the cooling enable set point, the hot water valve will close, the cooling coil valve will modulate to maintain an initial discharge air set point of 55°F (adj.). If the space temperatures of the reheat coils, as sensed by sensors in

Break Out 250A, Bulk Storage 250B and Clean sterile 250, continues to rise, the discharge air set point will be reset down to a minimum set point of 53°F (adj.). If the space temperature of the reheat coils begins to fall, the discharge air set point will be reset up to a maximum set point of 65°F (adj.) If the discharge air temperature is 5°F (adj.) or more above the set point for a pre-determined amount of time, an alarm will be generated.

If the discharge air temperature sensor fails during normal operation all associated valves will close and an alarm will be generated. If the discharge air temperature rises above a high limit set point of 120°F (adj.) or falls below a low limit. set point of 40°F (adj.) an alarm will be generated at the OWS.

3. Exhaust Fan 76.EF.2.1: During the occupied mode and upon a proof of the supply fan run status, the exhaust fan will operate continuously. If the exhaust fan fails to prove status for 30 seconds (adj.), the fan will be commanded off and an alarm will be generated. If the exhaust fan is operating, as sensed by its current switch, but the commanded output is off, an alarm will be generated at the OWS. The fan will operate for a minimum on and off time to prevent short cycling.
4. Energy Recovery Coil: When the outside air temperature is less than a heating recovery mode set point of 50°F (adj.), upon a call for heating and upon a proof of the supply fan run status, the energy recovery pump 76-P5 will operate. Upon a proof of the recovery loop pump run status, the 3-way valve will modulate to maintain an energy recovery heating mode discharge air set point. The energy recovery heating mode discharge air set point will be equal to the AHU discharge air set point plus an offset of 2°F (adj.).

When the outside air temperature is greater than a cooling recovery mode set point of 80°F (adj.), upon a call for cooling and upon a proof of the supply fan run status, the energy recovery pump 76.GWP.2.1 will operate. Upon a proof of the energy recovery loop pump run status, the 3-way valve will modulate to maintain an energy recovery cooling mode discharge air set point. The energy recovery cooling mode discharge air set point will be equal to the AHU discharge air set point minus an offset of 2°F (adj.).

If any of the run around loop water temperatures fall below a low limit. set point of 33°F (adj.) or if the energy recovery coil exhaust air temperature falls below a low limit. Set point of 30°F (adj.), the energy recovery coil pump will operate and the 3-way valve will be positioned to allow full flow through the AHU energy recovery coil.

If the energy recovery pump fails, as sensed by its current switch, an alarm will be generated at the DDC system. If the pump is operating, as sensed by its current switch, but the commanded output is off, an alarm will be generated at the OWS. If the pump run time is exceeded, as determined by a pre-defined hours limit. (adj.), an alarm will be generated at the DDC system.

5. Occupied (Humidity Control):

Upon a proof of supply air flow, as sensed by the airflow switch, and when the outside air dew point is below a humidifier enable set point of 55°F (adj.), the humidifier valve will modulate to maintain a space humidity set point of 35% (adj.), as sensed in Clean sterile 250.

If at anytime the fan is off or if the high humidistat rises above a high limit setting of 85%, the humidifier valve will dose fully. Mode will terminate when the space relative humidity falls below the relative humidity set point minus 3% (adj.). If the space relative humidity sensor fails the humidification sequence will be terminated and an alarm will be generated. If at any time the discharge air humidity, as sensed by TEH-2, rises above a high limit setting of 85%, an alarm will be generated and the humidifier will be off.

6. Unoccupied (Night Setback):

When any of the (3) reheat space temperatures are below the unoccupied heating set point (60°F adj.) the outside air Damper will open, the supply fan will start and the hot water valve will open. When all space temperatures are above the unoccupied heating set point plus an unoccupied differential (4°F adj.) the supply fan will stop, the outside air damper will close and the hot water valve will dose.

When any of the (3) reheat space temperatures are above the unoccupied cooling set point (55°F adj.) the outside air Damper will open, the supply fan will start and the chilled water coil will modulate open. When all space temperatures are below the unoccupied cooling set point minus the unoccupied differential (4°F adj.) the supply fan will

stop, the outside air damper will close and the cooling coil valve will close.

Low Temperature Protection:

If the discharge air temperature falls below a low limit set point of 40°F (adj.), the fan will shutdown, the hot water valve will open, the chilled water valve will close and an alarm will be generated.

7. Filter status: A differential pressure switch will monitor the differential pressure across the pre filter, final filter as well as the filters for each energy recovery coil, when the AHU fan and EF-1 fans are running. If any switch closes during normal operation a dirty filter alarm will be generated.
 8. Typical Reheat Coil Control (RHC.2.1-3): During the occupied mode the reheat valve will modulate to maintain an occupied heating set point (adj.). During the unoccupied mode the reheat valve will modulate in sequence with its associated air handler to maintain the unoccupied heating set point (adj.). The reheat coils serve Break Out 250A (76.RHC.2.1), Bulk Storage 250B (76.RHC.2.2) and Clean Sterile 250 (76.RHC.2.3).
 9. DHAHU.2.1 Dehumidification Unit:
During the occupied mode, upon a proof of AHU supply fan status and when the space humidity in Clean Sterile 250, rises above a dehumidification set point of 45% (adj.), the dehumidification unit 76.DHAHU.2.1 will be enabled. Before the unit operates, its outside air damper will open fully. When the damper is open, its end switch contact will close and the DH reactivation fan and supply fan will operate. Once the isolation damper is open and the DH unit is on, the AHU damper will close. When the humidity level falls below the set point minus a differential of 3% RH (adj.), the dehumidification unit will turn off, its isolation damper will close and the outside air damper will open.
- E. 76.RHC.2.1-3, Sterile Storage Reheat Coils: See sequence for operation C.RHC.1.
- F. 76.FCU-HW-CH.2.1 Sterile Storage Mech Room Heating/Cooling Fan Coil Unit
1. When the space temperature is below the heating set point (65°F adj.) the supply fan will cycle on and the hot water valve will open. When the space temperature rises above the

heating set point plus a differential (2°F adj.) the supply fan will stop and the hot water valve will close. If at anytime the hot water supply temperature falls below 100°F (adj.), the FCU will not operate in the heating mode.

When the space temperature is above the cooling set point (85°F adj.) the supply fan will cycle on and the chilled water valve will open. When the space temperature falls below the cooling set point minus a differential (2°F adj.) the supply fan will stop and the chilled water valve will close. If at anytime the chilled water supply temperature rises above 60°F (adj.) the FCU will not operate in the cooling mode.

If the supply fan fails to prove status when the space temperature is between 65°F and 85°F or is it fails after 30 seconds(adj.), the fan will be commanded off, all valves will close and an alarm will be generated.

G. 76.EF.2.2 Mech Rm 251 Exhaust Fan Control:

1. When the space temperature is above the cooling set point (see above), the exhaust fan EF.2.2 will be enabled to operate, its exhaust air damper will open fully and the outside air intake damper will open fully. When the space temperature falls below the cooling set point minus a differential (2°F adj.) the exhaust fan will stop and the exhaust air and outside air dampers will close fully. If at anytime the local override switch is positioned from "Auto" to "Closed", the exhaust fan will be overridden on and exhaust air damper will open fully and the outside air intake damper will open fully.

If the exhaust fan fails to prove status for 30 seconds (adj.), the fan will be commanded off, the exhaust air and outside air dampers will close and an alarm will be generated. A manual reset is required to restart the fan. If the exhaust fan is operating, as sensed by its current switch, but the commanded output is off, an alarm will be generated at the OWS. The fan will operate for a minimum on and off time to prevent short cycling.

H. 76.C.RAD.2.1-25: Hematology Lab Radiators: See sequence of operation C.RAD.3

- I. 76.CV.2.1-14: Hematology Lab Constant Volume Box with Reheat Control:
 - 1. The room thermostat will have separate D.A. outputs for heating and cooling. When the space temperature is above the cooling temperature set point, the reheat coil valve will be full closed and the box will deliver the scheduled air volume to the room.
 - 2. When the space temperature is between the cooling and heating set points, the system will operate in the free energy ban, the reheat valve will remain closed and the box will deliver the scheduled air volume to the room.
 - 3. When the space temperature is below the heating set point, the reheat coil valve will open and the box will deliver the scheduled air volume.

- J. 76.DSFCU.2.1 & 2, Ductless Split Fan Coil Units (rooms 256 & 221A): See sequence of operation C.DSFCU.1.

- K. 76.UH.2.1, West Annex Steam Unit Heater
 - 1. See C.UH-STM.1 control sequence.

- L. 76.DXFCU.2.1, DX Fan Coil Unit (room 212E)
 - 1. Run Conditions - Scheduled: The DDC system shall enable the operation of the DX condensing unit and indoor fan coil unit. The unit shall run according to a user definable time schedule in the following modes:
 - Occupied Mode: The unit shall maintain 74°F (adj.) cooling set point.
 - Unoccupied Mode: The unit shall maintain 85°F (adj.) cooling set point.
 - 2. Monitoring: The DDC system shall monitor zone temperature and the status of the fan coil unit supply fan and outdoor condensing unit.
 - 3. Alarms: An alarm condition will be initiated whenever the space temperature is 5°F (adj.) greater than space set point.

- M. 76.CH.2.1, Packaged Chiller with Pumps (serves DDAHU.G.1 & 2)

1. Run Conditions:

The chiller shall be enabled to run by the DDC system whenever the outside air temperature is greater than 54°F (adj.).

The chiller shall be enabled a user adjustable time after pump statuses are proven on and water flow is proven via the flow switch. The chiller shall therefore have a user adjustable delay on start.

- a. The delay time shall be set appropriately to allow for orderly chilled water system start -up, shutdown and sequencing.
- b. To prevent short cycling, the chiller shall run for and be off for minimum adjustable times (both user definable), unless shut down on safeties or outside air conditions.
- c. The chiller shall run subject to its own internal safeties and controls.
- d. Alarms:
 - Chiller failure: commanded on, but the status is off.
 - Chiller running in hand: commanded off, but the status is on.
 - Chiller runtime exceeded: status runtime exceeds a user definable limit.

2. Chiller Chilled Water Supply Set Point:

- a. The chiller shall maintain a chilled water supply temperature set point as determined by its own internal controls (provided by others).
- b. Chilled Water Temperature Monitoring: The following temperatures shall be monitored:
 - Chilled water supply.
 - Chilled water return.
- c. Alarms:
 - High chilled water supply temp: if the chilled water supply temperature is greater than 55°F (adj.).
 - Low chilled water supply temp: if the chilled water supply temperature is less than 38°F (adj.).
 - High chilled water return temp: if the chilled water return temperature is greater than 68°F (adj.).
 - Low chilled water return temp: if the chilled water return temperature is less than 47°F (adj.).

3. Chilled Water Primary Loop Pump Lead/Standby Operation:
 - a. The primary chilled water pump CWP.G.3 shall run anytime a chiller is called to run.
 - b. The lead pump shall start prior to a chiller being enabled and shall stop only after
 - c. The chiller is disabled. The pump(s) shall therefore have:
 - A user adjustable delay on start.
 - And a user adjustable delay on stop.

The delay times shall be set appropriately to allow for orderly chilled water system start -up, shutdown and sequencing. The two pumps shall operate in a lead/standby fashion.
 - d. The lead pump shall run first.
 - e. On failure of the lead pump, the standby pumps shall run and the lead pump shall turn off.
 - f. The designated lead pump shall rotate upon one of the following conditions (user Selectable):

Manually through a software switch

If pump runtime (adj.) is exceeded

 - Daily
 - Weekly
 - Monthly
 - g. Alarms shall be provided as follows:

Chilled Water Pump 1

 - Failure: commanded on, but the status is off.
 - Running in hand: commanded off, but the status is on.
 - Runtime exceeded: status runtime exceeds a user definable limit.

Chilled Water Pump 2

 - Failure: commanded on, but the status is off.
 - Running in hand: commanded off, but the status is on.
 - Runtime exceeded: status runtime exceeds a user definable limit.
- N. 76.PAHU.2.1, 1ST Floor Data Closet Packaged Air Handling Unit (Backup Unit)
1. Run Conditions: Back up air handling unit 76.PAHU.2.1 shall not be controlled by the DDC. Unit shall be controlled by existing local controls.

3.3.11.4 Building 76, Third Floor

A. 76.VAVAHU.3.1.VAV 3B/ICU VAV Air Handling Unit

1. Building Automation System Interface:

The Building Automation System (DDC) will send the programmable controller (M P580) Occupied, Unoccupied, Optimal Start, Night Heat / Cool and Timed Override commands, The DDC will also send a discharge air temperature set point and a duct static pressure set point. If communication is lost with the BAS, the controller will operate in the occupied cooling mode using its default set points.

2. Cooling Mode:

- a. Whenever the outdoor air temperature is above 50°F as sensed by the outdoor air temperature sensor, the unit will be in cooling mode.
- b. The air cooled condensing unit will be enabled through the Tracer Summit System. The air cooled condensing unit will operate through its factory packaged controls to maintain the discharge temperature set point of 55°F once the unit has been enabled.

3. Economizer Mode:

- a. Whenever the outdoor air temperature sensed by the outdoor air temperature sensor is 5°F below the return air temperature as sensed by the return air temperature sensor, the system will be in economizer mode.
- b. The return damper, both O.A. dampers and the exhaust damper will modulate to maintain a mixed air temperature set point of 55-60°F as sensed by the mixed air temperature sensor.

4. Heating Mode:

- a. If the mixed air temperature as sensed by the mixed air temperature sensor is below 55°F and the economizer damper is closed, the system will be in heating mode.
- b. The two position steam control valve open.
- c. The face and bypass dampers will modulate as required to maintain a discharge air temperature of 55°F.

5. Occupied (Temperature Control):

During Occupied periods the supply fan and return fan will run continuously and the minimum outside air damper will open to maintain minimum ventilation requirements. The DX cooling will start, the Economizer will operate if conditions permit or the steam heating valve will open along with the face-bypass dampers modulating to maintain the discharge air temperature cooling set point (55°F adj.). If the discharge air temperature sensor fails during normal operation, the DX cooling will de-energize, the steam heating valve will close and an alarm will be annunciated.

6. Occupied (Daytime Warm-up):

During Occupied periods, when the space temperature is 1.5°F (adj.) or more below the Occupied heating set point, a daytime warm-up sequence will be activated. The minimum outside air damper will open to maintain minimum ventilation requirements, and the steam valve will open/face-bypass dampers modulate to maintain the DDC heating set point (100°F adj.). Mode will terminate when the average space temperature reaches the Occupied heating set point.

7. Unoccupied (Night Setback):

When the space temperature is below the Unoccupied heating set point (60°F adj.), the supply fan and return fan will start, the outside air dampers will remain closed, and the steam valve will open/face-bypass dampers modulate. When the space temperature rises above the Unoccupied heating set point (60°F adj.) plus the Unoccupied differential (4°F adj.), the supply fan will stop and the hot water valve will close.

When the space temperature is above the Unoccupied cooling set point 85°F (adj.), the supply fan and return fan will start, the outside air damper will remain closed, and the DX Cooling will stage on. When the space temperature falls below the Unoccupied cooling set point (85°F adj.) min us the Unoccupied differential (4°F adj.), the supply fan will stop and the DX cooling stages will de-energize.

8. Morning Warm-up:

During optimal start, if the space temperature is 1.5°F (adj.) or more below the Occupied heating set point, a morning warm-up sequence will be activated. The supply fan and return fan will start, the outside air dampers will remain closed the steam valve will open and the face-bypass dampers will modulate to maintain the DDC heating set point (100°F adj.). Mode will terminate when the space temperature reaches the Occupied heating set point or the occupied time period has started.

9. Morning Cool-down:

During Optimal Start, if the space temperature is above the Occupied cooling set point, a morning cool-down sequence will be activated. The supply fan and return fan will start and the economizer will operate if conditions permit or the DX Cooling will stage on to maintain the DAT cooling set point (55°F adj.). The outside air dampers will remain closed. Mode will terminate when the space temperature reaches the Occupied cooling set point or the occupied time period has started.

10. VAV Supply Fan:

The fan will be off in the Unoccupied mode. When the controller is in the Occupied mode, the supply fan will operate continuously and its speed will be modulated to maintain the duct static pressure set point. The static pressure sensor will be installed as part of phase I. The sensor set point will be adjusted as required during each phase of the project to the minimum value required to make the system work properly. The duct static pressure set point is sent by the DDC and is reset between the minimum and maximum static pressure limits to maintain the "critical zone" VAV air damper in a position between 65 % and 75% open.

If the supply fan fails to prove status for 30 seconds (adj.), the fan will be commanded off, the outside air damper and steam valve will close and an alarm will be annunciated. If the status and the commanded value are equal but the airflow station reads 'ZERO' airflow, a belt failure alarm will be generated at the Tracer Summit System operator's workstation. A manual reset is required to restart the fan. A hardwired, high static pressure cut-off switch is electrically interlocked with the variable speed drive. If the high static pressure cut-off switch reaches its set point of 4.5' w.g. the fan will stop, the outside air damper and steam valve will close and an alarm will be annunciated. A manual reset of the high static pressure cut-off switch will be required to restart the fan.

11. VAV Return Fan:

The return fan will be off in the Unoccupied mode. When the controller is in the occupied mode, the return fan will operate continuously and modulate the VSD to maintain CFM set point as measured by the fan inlet p robes. The return fan CFM set point will be determined by 98% of the CFM of the supply (as measured by the fan inlet probes) minus the total exhaust for the area served.

If the return fan fails to prove status for 30 seconds (adj.), the fan will be commanded off, the outside air damper and all cooling and heating will be disabled and an

alarm will be annunciated. If the status and the commanded value are equal but the airflow station reads 'ZERO" airflow, a belt failure alarm will be generated at the Tracer Summit System operator's workstation. A manual reset is required to restart the fan. A hardwired, high static pressure cut-off switch is electrically interlocked with the variable speed drive. If the high static pressure cut-off switch reaches its' set point of 4.5" w.g., the fan will stop, the outside air damper will close and all heating and cooling will be disabled and an alarm will be annunciated. A manual reset of the high static pressure cut-off switch will be required to restart the fan. Supply and return fans are interlocked via software, a failure of either will disable both.

12. Safeties:

Freeze Protection: the initial damper opening rate will be limited to 2% per minute until the damper has reached its minimum ventilation position. The outside air damper will modulate to a position less than the minimum damper position if the mixed air temperature drops below 50°F (adj.). If the mixed air temperature sensor fails the outside air damper will close and an alarm will be annunciated.

A hardwired, low limit temperature switch is electrically interlocked with the variable speed drive. If the low limit temperature switch is tripped (38°F adj), the outside air damper will close, all valves will open to 100% (adjust per climate), all stages of DX cooling will be disabled and an alarm will be annunciated. A manual reset of the low limit temperature switch will be required to restart the fan.

13. Duct Smoke Detectors: duct smoke detectors on the supply and return air will, upon sensing the products of combustion, de-energize supply and return fans, via fire safety relay (by others), and an alarm will be annunciated.

14. Filter Status:

A differential pressure switch will monitor the differential pressure across the filters when the fan is running. If the switch closes during normal operation a dirty filter alarm will be annunciated.

B. 76.EF.3.1-9 & 12-14, 3B/ICU Exhaust Fans (Typ. Of 12)

1. The exhaust fans will be operated continuously. The exhaust fans will have the capability to be started and stopped through the Tracer Summit System.

2. If an exhaust fan has been indexed off by the Tracer Summit System, the respective backdraft damper will be closed.
3. If an exhaust fan has been indexed on by the Tracer Summit System, the respective backdraft damper will be open.
4. If an exhaust fan has been indexed to operate and the respective current sensor does not indicate a normal status, an exhaust fan failure alarm for that fan will be indicated at the Tracer Summit System Operator's Workstation.

C. 76.EF.3.10, 11, 15, 16, 3B/ICU Exhaust Fans with Air Flow Station (Typ. Of 4), Negative Pressure Isolation Room Sequence of Operation

1. The supply air terminal unit will be modulated and the exhaust fan Indexed "on" to maintain the constant airflow rate for the associated space. When space temperature exceeds set point d 74°F, the supply air terminal unit reheat control valve will modulate close to maintain set point. If space temperature drops below 70°F set point, the supply air terminal unit reheat control valve will modulate open to maintain set point. If space temperature exceeds high or low limits as sensed by the space temperature sensor, an alarm will be recorded at the DDC Operator's Workstation.
2. The alarm at the Isolation Room monitor will be monitored. If an alarm is activated, an alarm will be recorded at the DDC Operator's Workstation.
3. If an exhaust fan has been indexed off by the DDC, the respective isolation damper will be indexed closed.
4. If an exhaust fan has been indexed on by the DDC, the isolation damper will be opened and proven open by the end switch before the exhaust fan is energized.
5. An airflow station at the exhaust fan will monitor exhaust airflow. The exhaust airflow will be 150 cfm greater than the supply airflow.
6. If an exhaust fan has been indexed to operate, the respective current sensor indicates a normal status, but the airflow station indicates no airflow, an exhaust fan belt failure alarm for that fan will be indicated at the Tracer Summit System Operator's Workstation.

D. 76.VAV.3.1-33, 3B/ICU VAV Boxes

1. The Building Automation System Interface:

The Building Automation System (DDC) will send the controller Occupied and Unoccupied commands. The DDC may also send a Heat/cool mode, priority shutdown commands, space temperature and/ or space temperature set point. If a DDC is not present or communication is lost with the DDC, the controller will operate using its local set points.

2. Heat/Cool Mode:

The Heat/Cool mode will be set by a communicated value or automatically by the VAV. In standalone or auto mode the VAV will compare the primary air temperature with the configured auto changeover set point to determine if the air is "hot" or "cold". Heating mode will command the VAV to heat only; it implies the primary air temperature is hot. Cooling mode commands the VAV to cool only; it implies the primary air temperature is cold.

3. Heat/Cool Set point:

The space temperature set point will be determined either by a local hardwired set point, the VAV default set point or a communicated value. The VAV uses the locally stored default set points when neither a local hardwired set point nor communicated set point is present. If both a hardwired set point and communicated set point exist, the VAV will use the communicated value.

4. Occupancy Mode:

The occupancy mode can be communicated or hardwired to the VAV via a binary input. Valid Occupancy modes for the VAV will be:

- a. Normal operating mode for occupied spaces or daytime operation. When the unit is in the occupied mode the VAV will maintain the space temperature at the active occupied heating or cooling set point. Applicable ventilation and airflow set points will be enforced. The occupied mode will be the default mode of the VAV.
- b. Normal operating mode for unoccupied spaces or nighttime operation. When the unit is in unoccupied mode the VAV will maintain the space temperature at the stored mode the VAV will maintain the space temperature at the stored unoccupied heating or cooling set point regardless of the presence of a hardwired or communicated set point. When the space temperature exceeds the active unoccupied set point the VAV will modulate fully closed.

- c. Mode used to temporarily place the unit into occupied operation. Tenants will be able to override the unoccupied mode from the space sensor. The override will last for a maximum for 4 hours (configurable). The tenants will be able to cancel the override from the space sensor at any time. During the override the unit will run in occupied mode.

5. Cooling Mode:

When the unit is in cooling mode, the VAV will maintain the space temperature set point of 74°F by modulating the airflow between the active cooling minimum airflow set point to the maximum cooling airflow set point. Based on the VAV occupancy mode, the active cooling set point will be one of the following:

Set Point	Default Value
Occupied Cooling Set Point	74°F
Unoccupied Cooling Set Point	85°F
Set point	Default Value
Occupied Min Cooling Airflow Set Point	See VAV Schedule
Occupied Max Cooling Airflow Set Point	See VAV Schedule

The VAV will use the measured space temperature and the active cooling set point to determine the requested cooling capacity of the unit. The outputs will be controlled based on the unit and the requested cooling capacity.

6. Heating Mode:

When the unit is in heating mode, the CONTROLLER will maintain the space temperature set point of 70°F by modulating the airflow between the active heating minimum airflow set point to the maximum heating airflow set point. Based on the CONTROLLER occupancy mode, the active heating set point will be one of the following:

Set Point	Default Vale
Occupied Heating Set Point	70°F
Unoccupied Heating Set Point	60°F
Occupied Standby Heating Set Point	67°F
Occupied Min Heating Airflow Set point	See VAV Schedule

Occupied Max Heating Airflow Set point See VAV Schedule

The controller will use the measured space temperature and the active heating set point to determine the requested heating capacity of the unit.

7. Reheat Control:

Reheat will only be allowed when the primary air temperature is 5°F below the configured reheat enabled set point, (69°F adj.). The reheat will be enabled when the space temperature drops below the active cooling set point and the airflow is in the minimum cooling airflow set point. During reheat the VAV will operate at its minimum heating airflow set point and energize the heat as follows:

a. Proportional Hot Water Reheat:

If the space temperature is below the heating set point water reheat valve will modulate as required to maintain the active heating set point.

8. Space Sensor Failure:

If there is a fault with the operation of the zone sensor, it will be feed back to the DDC. Zone sensor failure will cause the VAV to drive the damper to minimum air flow if the VAV is in the occupied mode, or drive it closed if the VAV is in the occupied mode.

9. Reheat Valve Failure:

If the VAV box is in cooling mode and the discharge air temperature is 65°F or above as sensed by the discharge air temperature sensor, a reheat valve failure alarm will be generated at the Tracer Summit System operator's workstation.

E. 76.RAV.3.1-23, 3B/ICU Return Air VAV Box -Single Duct, Cooling Only

1. Building Automation System Interface:

The Building Automation System (DDC) to minimum airflow" if the VAV is in the occupied mode, or drive it closed The Building Automation System (DDC) will send the controller Occupied and Unoccupied commands. The DDC may also send a

Heat/Cool mode, priority shutdown commands, space temperature and/or space temperature set point. If a BAS is not present, a communication is lost with the DDC, the controller will operate using its local set points.

2. Hot/Cool Mode:

The Heat/Cool mode will be set by a communicated value or automatically by the VAV. In standalone or auto mode the VAV will compare the primary air temperature with the configured auto changeover set point to determine if the air is "hot" or "cold". Heating mode will command the VAV to heat only; It Implies the primary air temperature is hot. Cooling mode commands the VAV to cool only; it implies the primary air temperature is cold.

a. Hot/Cool Set Point:

A 10,000 ohm resistor takes the place of the typical space temperature sensor as the Return Air VAV box simply tracks its' associated Supply Air VAV box. See Cooling Mode operation below.

3. Occupancy Mode:

The occupancy mode can be communicated or hardwired to the VAV via a binary input. Valid occupancy modes for the VAV will be:

a. Occupied:

Normal operating mode for occupied spaces or daytime operation. When the unit is in the occupied mode the VAV will maintain the space temperature at the active occupied heating or cooling set point. Applicable ventilation and airflow set points will be enforced. The occupied mode will be the default mode of the VAV.

b. Unoccupied:

Normal operating mode for unoccupied spaces or nighttime operation. When the unit is in unoccupied mode the VAV will maintain the space temperature at the stored unoccupied heating or cooling set point regardless of the presence of a hardwired or a communicated set point. When the space temperature exceeds the active unoccupied set point the VAV will modulate fully closed.

c. Occupied Bypass:

Mode used to temporarily place the unit into the occupied operation. Tenants will be able to override the unoccupied mode from the space sensor. The override will last for a maximum of 4 hours (configurable). The tenants will be able

to cancel the override from the space sensor at any time. During the override the unit will run in occupied mode.

4. Cooling Mode:

When the unit is in cooling mode, the Return Ai-VAV box will track its' associated space Supply Air VAV box. The Return Air VAV box air valve % open position will be matched with the position of the Supply Air VAV box air valve % open position. While each boxes air-valve is operating within its' minimum and maximum cfm values, the pressure relationship as indicated on mechanical drawing H2.6 will be maintained.

5. Space Sensor Failure:

If there is a fault with the operation 10,000 ohm resistor, it will be feed back to the DDC. Resistor failure will cause the VAV to drive the damper to minimum airflow if the VAV is in the occupied mode, or drive it closed if the VAV is in the unoccupied mode.

F. 76.AHU.3.1 & 76.DHAHU.3.1, SPD Annex Air handling Unit, Dehumidification Unit and Heat Recovery System

1. Run conditions - Scheduled:

The unit shall run based upon an operator adjustable schedule or a manual software switch. The AHU shall be interlocked with the SPD suite exhaust fan to operate at the same time.

2. Low Temperature Protection:

- a. The unit shall shut down and generate an alarm upon receiving a low supply air temperature of 40°F (adj.).

3. Supply Fan:

- a. The supply and exhaust fans shall run anytime the unit is commanded to run, unless shut down on safeties. To prevent short cycling, the fans shall have a user definable (adj.) minimum runtime.
- b. Alarms shall be provided as follows:
 - Fan failure: commanded on, but the status is off.
 - Fan in hand: commanded off, but the status is on.

- Fan runtime exceeded: status runtime exceeds a user definable limit (adj.).

4. Supply Air Temperature Set Point:

- a. The controller shall monitor the supply air temperature and shall maintain a supply air temperature set point reset based on zone cooling and heating requirements.

The supply air temperature set point shall be reset for cooling based on zone cooling requirements as follows:

- The initial supply air temperature set point shall be 55°F (adj.).
 - As cooling demand increases, the set point shall incrementally reset down to a minimum of 53°F (adj.).
 - As cooling demand decreases, the set point shall incrementally reset up to a maximum of 55°F (adj.).
- b. If more zones need heating than cooling, then the supply air temperature set point shall be reset for heating as follows:
- The supply air temperature set point shall be 60°F (adj.).
 - The duct reheat coils shall heat the supply air to each space to maintain space temperature set point as controlled by the air flow system.

5. Cooling Coil Valve:

The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling set point.

- a. The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F(adj.).
 - And the supply fan status is on.
 - And the preheat system is not active.
- b. Alarms shall be provided as follows:
- High supply air temp: if the supply air temperature is 5°F (adj.) greater than set point.

6. Heating Coil Valve:

The controller shall measure the supply air temperature and modulate the heating coil Valve to maintain its heating set point.

- a. The heating shall be enabled whenever:
 - Outside air temperature is less than 65°F (adj.).
 - And the supply fan status is on.
 - And the cooling (if present) is not active.
 - b. The heating coil valve shall open whenever:
 - Supply air temperature drops below 40°F (adj.).
 - Alarms shall be provided as follows:
 - Low supply air temp: if the supply air temperature is 5°F (adj.) less than set point.
7. Filter Status: The controller shall monitor the filter status.
- a. Alarms shall be provided as follows:
 - Filter change required: filter differential pressure exceeds a user definable limit (adj.).
8. Supply Air Temperature:
- a. The controller shall monitor the supply air temperature.
 - b. Alarms shall be provided as follows:
 - High supply air temp: if the supply air temperature is greater than 120°F (adj.).
 - Low supply air temp: if the supply air temperature is less than 40°F (adj.).
9. Dehumidification Unit (76.DHAHU.3.1)
- The unit shall be controlled by factory installed packaged controls and enabled by the DDC.
- a. System Off:
 - The supply and reactivation fans shall be off.
 - The outside air dampers shall be closed.
 - The desiccant wheel shall remain stationary.
 - b. System Start:
 - The unit shall be enabled and disabled by the DDC system on a programmable time schedule.
 - c. System Run:

Occupied mode:

 - The occupied temperature is set to 68 to 73 °F (adj.). The occupied maximum relative humidity set point is 50% RH (adj.). The reactivation outside air and exhaust dampers are full open.
 - The supply fan and desiccant wheel reactivation fan run continuously. The regeneration system operates

to reactivate the desiccant wheel as controlled by the packaged controls.

- The desiccant wheel shall rotate when space humidity exceeds the humidity set point. The cooling coil control valve shall close and the wheel stop rotating when dehumidification is not required.
- d. System Stop:
- When the air-handling unit is indexed to shut down, the fans shall stop.
 - Dampers and control valve shall be indexed to their system off conditions.
- e. Safeties and Alarms:
- Low limit: manual reset low limit thermostat shall stop the supply fan, close the outdoor air dampers, and annunciate alarm should the discharge air temperature fall below 38°F.
 - High limit: manual reset high limit thermostat shall stop the supply fan and annunciate alarm should the air temperature rise above 125 °F. Dampers and control valve shall be indexed to their system off conditions.
- f. Smoke Control:
- Duct smoke detector(s) shall stop the supply fan and annunciate alarm when products of combustion are detected in the air stream. Dampers and control valve shall be indexed to their system off conditions.
 - The supply fan shall be interlocked to shut down upon a command from the building fire alarm system.
 - Upon a return to normal, the supply fan shall start after an adjustable delay to provide a staggered start of all building loads.
 - Filter condition: monitor differential pressure across filter and annunciate alarm when differential pressure set point (adj.) is exceeded.
 - Annunciate off normal alarms whenever supply fan status does not equal command.

10. Steam-to-Steam Humidifier (76.HU.3.1)

The humidifier system shall run subject to its own internal safeties and controls. The Controller shall monitor space humidity and enable the humidifier whenever space humidity drops below 50% RH (adj.). Upon proof of airflow, the humidifier shall modulate moisture addition to the supply airstream to maintain space humidity set point of 35% RH (adj.). The humidifier shall be interlocked so as not to humidify the air if the system is in the cooling mode. An

alarm shall be generated at the DDC whenever the humidifier is enabled and the relative humidity is above 55% (adj.) As sensed by the duct mounted high humidity sensor. An alarm shall also be generated at the doc if the humidifier fails to operate as commanded.

11. Run-Around Energy Recovery System

- a. Heating Mode: the circulating pump (GWP.3.1) shall operate for heat recovery whenever:
 - Exhaust air temperature is 5°F(adj.) Or more above the outside air temperature.
 - The zone temperature is below the heating set point.
 - The supply and return fans are on.

The DDC controller shall measure the return water temperature to the exhaust air recovery coil and modulate the energy recovery 3-way control valve to maintain the return water temperature above 32°F (adj.) to prevent frosting the coil.

- b. Cooling mode: the circulating pumps (2 ea.) shall operate for heat rejection when:
 - The exhaust air temperature is 5 °F (adj.) or more below the outside air temper
 - The zone temperature is above the cooling set point.
 - The supply and exhaust fans are on.
- c. The DDC controller shall position the 3-way control valve for 100% fluid flow through the outside air recovery coil.

12 76.EF.3.18 Exhaust Fan / Air Flow Terminals - SPD suite

General:

- a. The exhaust fan and air flow valve system shall be enabled by the DDC and interlocked to operate whenever the air handling unit is energized.
- b. The outside air damper shall open when the fan is energized and close when the fan is de-energized
- c. The air flow valve system shall be controlled by factory installed packaged controls to maintain positive and negative pressure conditions in the spaces and to control reheat coils to maintain space

temperature set point s. Space temperature in the decontamination room shall be 58 °F (adj.). Space temperature in all other rooms in the SPD suite shall be 73 °F (adj.).

13 Variable Volume Terminal Air Valve with Tracking Return and Heating

- a. Pressure independent control provides for both supply and exhaust valves while maintaining their flow set point s to within ±5% accuracy.
- b. The supply air valve modulates the reheat coil hot water control valve to maintain space set point.
- c. The return air valve modulates with the supply air valve to maintain the differential preset supply and return airflow rates (offset).
- d. The control system monitors zone temperature, hot water control valve and airflow.
- e. Zone set point s are capable of local or remote adjustment with the capability to lockout local adjustment.

14. BACnet Interface

- a. The airflow control system network will interface digitally with the DDC. The required Software drivers are being developed and housed in a dedicated interface device furnished by the airflow control system supplier.
- b. All room-level points will be available to the DDC system for monitoring or trending.

- Fail-safe condition for loss of building-level network communication upon loss of building-level network communication the controller will operate the valves and other connected equipment consistent with the current occupancy mode.

The controller may be configured to go to occupied mode upon persistent loss of building-level network communications.

- Fail-safe condition for loss of power (low-speed electric actuator)

Under loss of power, the supply valve, exhaust valve and return valve will all fail in place. There is no change in offset. Safeties and alarms: alarm whenever the fan status or the air flow system status does not equal command.

15. 76.UH.3.1 Unit Heater

- a. Constant fluid temperature: provide single-temperature room thermostat to maintain constant space temperature by automatically changing position of normally open

modulating hot water or steam valve and by cycling the fan motor.

- b. Provide strap-on aquastat on unit return piping, to de-energize fan motor when fluid temperature falls below adjustable setting of aquastat.

16. Glycol Fill (make-up) Station

- a. Alarm whenever the glycol level in the storage tank drops below the low level sensor.

G. 76.CH.3.1, SPD Annex Packaged Chiller with Pumps

1. Run Conditions:

The chiller shall be enabled to run by the DDC system whenever the outside air temperature is greater than 54°F (adj.).

The chiller shall be enabled a user adjustable time after pump statuses are proven on and water flow is proven via the flow switch. The chiller shall therefore have a user adjustable delay on start.

- a. The delay time shall be set appropriately to allow for orderly chilled water system start -up, shutdown and sequencing.
- b. To prevent short cycling, the chiller shall run for and be off for minimum adjustable times (both user definable), unless shut down on safeties or outside air conditions.
- c. The chiller shall run subject to its own internal safeties and controls.
- d. Alarms:
 - Chiller failure: commanded on, but the status is off.
 - Chiller running in hand: commanded off, but the status is on.
 - Chiller runtime exceeded: status runtime exceeds a user definable limit.

2. Chiller Chilled Water Supply Set Point:

- a. The chiller shall maintain a chilled water supply temperature set point as determined by its own internal controls (provided by others).
- b. Chilled Water Temperature Monitoring: The following temperatures shall be monitored:
 - Chilled water supply.

- Chilled water return.
- c. Alarms:
 - High chilled water supply temp: if the chilled water supply temperature is greater than 55°F (adj.).
 - Low chilled water supply temp: if the chilled water supply temperature is less than 38°F (adj.).
 - High chilled water return temp: if the chilled water return temperature is greater than 68°F (adj.).
 - Low chilled water return temp: if the chilled water return temperature is less than 47°F (adj.).

3. Chilled Water Primary Loop Pump Lead/Standby Operation:

- a. The primary chilled water pump 76.CWP.3.1 shall run anytime a chiller is called to run.
- b. The lead pump shall start prior to a chiller being enabled and shall stop only after
- c. The chiller is disabled. The pump(s) shall therefore have:
 - A user adjustable delay on start.
 - And a user adjustable delay on stop.

The delay times shall be set appropriately to allow for orderly chilled water system start -up, shutdown and sequencing. The two pumps shall operate in a lead/standby fashion.
- d. The lead pump shall run first.
- e. On failure of the lead pump, the standby pump shall run and the lead pump shall turn off.
- f. The designated lead pump shall rotate upon one of the following conditions (user Selectable):
 - Manually through a software switch
 - If pump runtime (adj.) Is exceeded
 - Daily
 - Weekly
 - Monthly
- g. Alarms shall be provided as follows:
 - Chilled Water Pump 76.CWP.3.1
 - Failure: commanded on, but the status is off.
 - Running in hand: commanded off, but the status is on.
 - Runtime exceeded: status runtime exceeds a user definable limit.
 - Chilled Water Pump 76.CWP.3.2

- Failure: commanded on, but the status is off.
- Running in hand: commanded off, but the status is on.
- Runtime exceeded: status runtime exceeds a user definable limit.

H. 76.HTNG-GLY.3.1, SPD Annex Glycol Heating System

1. Run Conditions:

- a. The hot water system shall be enabled to run from the DDC system whenever:
 - A definable number of hot water coils need heating
 - And the outside air temperature is less than 54°F (adj.).

2. Hot Water Pump Run Conditions:

- a. The hot water pumps shall be enabled whenever:
 - A definable number of hot water coils need heating.
 - And outside air temperature is less than 54°F (adj.).
- b. To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable).

3. Hot Water Pump Lead/Lag Operation:

- a. The hot water pumps shall operate in a lead/lag fashion.
 - The lead pump 76.HWP.3.1 shall run first.
 - On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
- b. The designated lead pump shall rotate upon one of the following conditions (user selectable):
 - Manually through a software switch
 - If pump runtime (adj.) Is exceeded
 - Daily
 - Weekly
 - Monthly
- c. Alarms shall be provided as follows:

Hot water pump 76.HWP.3.1

 - Failure: commanded on, but the status is off.
 - Running in hand: commanded off, but the status is on.

- Runtime exceeded: status runtime exceeds a user definable limit.

Hot water pump 76.HWP.3.2

- Failure: commanded on, but the status is off.
- Running in hand: commanded off, but the status is on.
- Runtime exceeded: status runtime exceeds a user definable limit.

- I. 76.EF.3.17, Thermostat Controlled Mech Room Exhaust Fan: See C.MREF.1 sequence of operation.
- J. 76.RHC.3.1& 2, 3RD Floor Retail Area Reheat Coils: See C.RHC.1 sequence of operation.
- K. 76.FT-HW.3.1-6, 3rd Floor Kitchen and Retail Area Hot Water Fin Tube Convectors: See C.FT-HW.2 sequence of operation.

3.3.11.5 Building 76, Fourth Floor

- A. 76.RHC.4.1-7, 4TH Floor Steam Reheat Coils
 - 1. See C.RHC.2 Control Sequence

3.3.11.6 Building 76, Fifth Floor

- A. 76.FCU-HW-CW.5.1,2,7,11,15,19,22,25,29, South Wing Heating/Cooling Fan Coil Units with 2-way Cooling Valve and 3-way Hot Water Valve with Outside Air Damper
 - 1. Building Automation System Interface:
The DDC will send Occupied, Unoccupied, Optimal Start, Night Heat/Cool and Timed Override commands. If communication is lost with the DDC, or a DDC is not present, Morning Warm-up and Morning Cool-down will be disabled.
 - 2. Unoccupied (Night Setback): When the space temperature is below the unoccupied heating set point (60°F adj.) the supply fan will start, the outside air damper will remain closed and the hot water valve will open. When the space temperature rises above the unoccupied heating set point

(60°F adj.) plus the unoccupied differential (2°F adj) the supply fan will stop and the hot water valve will close.

When the space temperature is above the unoccupied cooling set point (85°F adj.) the supply fan will start and the chilled water valve will open. The outside air damper will open if economizing is enabled and remain closed if economizing is disabled. When the space temperature falls below the unoccupied cooling set point (85°F adj.) minus the unoccupied differential (2°F adj.) the supply fan will stop and the chilled water valve and outside air damper will close.

Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours(adj.). The occupancy override will end after the time period expires or when the occupant presses the "cancel" button on the space temperature sensor.

3. Occupied: During unoccupied periods the supply fan will run continuously and the outside air damper will open to maintain minimum ventilation requirements. All valves will modulate to maintain the active space temperature set point. If economizing is enabled the outside air damper will also modulate to maintain the active space temperature set point.
4. Space Temperature Control: The space temperature shall be maintained between the occupied cooling set point (74°F) and the occupied heating set point (71°F adj.). The unit will transition to the cooling mode when the space temperature rises one degree above the occupied cooling set point (74°F adj.). The unit will transition to the heating mode when the space temperature drops one degree below the occupied heating set point (71°F adj.).
5. Supply Fan Operation: The fan will be off in the unoccupied mode. When the controller is in the occupied mode, the supply fan will operate continuously at rated speed. If the supply fan fails the fan will be commanded off and an alarm will be annunciated. A manual reset is required to restart the fan.
6. Economizer (Dry Bulb Temperature): Economizing will be disabled when the outdoor air temperature is greater than the economizer disable set point (65°F adj.). Economizing will be enabled when the outdoor air temperature is 5°F (adj.) below the economizing disable set point. When economizing is enabled the outside air damper will modulate between the minimum damper position and 100% open to maintain the occupied cooling set point. If the outdoor air

temperature sensor is failed economizing is not allowed and an alarm will be annunciated.

B. 76.FCU-CW-STM.5.33,36,48,56, Central Heating/Cooling Fan Coil Units with 2-way Steam Valve and 2-way Cooling Coil Valve and Outside Air Damper

1. Occupied Mode: The outside air damper will run continuously. The supply fan will cycle through its available speeds. The cooling coil chilled glycol valve will modulate, and the heating coil steam valve will modulate in sequence to maintain the occupied space temperature setpoint (adj.). The cooling coil chilled glycol valve and the heating coil steam valve will operate with a deadband between them.
2. Unoccupied Mode: The outside air damper will close. The supply fan will stop. The cooling coil chilled glycol valve will close and the heating coil steam valve will close. The supply fan will cycle on and the cooling coil chilled glycol valve or the heating coil steam valve will modulate to maintain the unoccupied space temperature setpoint (adj.). Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours (adj.) The occupancy override will end after the time period or when the occupant pressed the "cancel" button on the space temperature sensor.

C. 76.FCU-CW-STM.5.5,10,13,16,20,23,27, South Wing Heating/Cooling Fan Coil Units with 3-way Cooling and Hot Water Valves and Outside Air Damper

1. Building Automation System Interface: The DDC will send Occupied, Unoccupied and Timed Override commands. If communication is lost with the DDC, or a DDC is not present, Morning warm-up and Morning Cool-down will be disabled.
2. Unoccupied (Night Setback): When the space temperature is below the unoccupied heating setpoint (60°F adj.) the supply fan will start, the outside air damper will remain closed and the hot water valve will open. When the space temperature rises above the unoccupied heating setpoint (60°F adj.) plus the unoccupied differential (2°F adj.) the supply fan will stop and the hot water valve will close.

When the space temperature is above the unoccupied cooling setpoint (85°F adj.) the supply fan will start and the chilled water valve will open. The outside air damper will open if economizing is enabled and remain closed if economizing is disabled. When the space temperature falls below the unoccupied cooling setpoint (85°F adj.) minus the

unoccupied differential (2°F adj.) the supply fan will stop and the chilled water valve and outside air damper will close.

Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours (adj.). The occupancy override will end after the time period expires or when the occupant presses the "cancel" button on the space temperature sensor.

3. Occupied: During occupied periods the supply fan will run continuously and the outside air damper will open to maintain minimum ventilation requirements. All valves will modulate to maintain the active space temperature setpoint. If economizing is enabled the outside air damper will also modulate to maintain the active space temperature setpoint.
 4. Space Temperature Control: The space temperature shall be maintained between the occupied cooling setpoint (74°F adj.) and the occupied heating setpoint (71°F Adj.). The unit transition to the cooling mode when the space temperature rises one degree above the occupied cooling setpoint (74°F adj.). The unit will transition to the heating mode when the space temperature drops one degree below the occupied heating setpoint (71°F adj.).
 5. Supply Fan Operation: The fan will be off in the unoccupied mode. When the controller is in the occupied mode, the supply fan will operate continuously at rated speed. If the supply fan fails the fan will be commanded off and an alarm will be annunciated. A manual reset is required to restart the fan.
 6. Economizer (Dry Bulb Temperature): Economizing will be disabled when the air temperature is greater than the economizer disable setpoint (65°F adj.). Economizing will be enabled when the outdoor air temperature is 5°F (adj.) below the economizing disable setpoint. When economizing is enabled the outside air damper will modulate between the minimum damper position and 100% open to maintain the occupied cooling setpoint. If the outdoor air temperature sensor is failed economizing is not allowed and an alarm will be annunciated.
- D. 76.FCU-CW-STM.5.42,45, Corridor Cooling Only Fan Coil Units with 2-way Cooling Valve and Outside Air Damper
1. Building Automation System Interface: The DDC will send Occupied, Unoccupied Optimal Start, night Cool and Timed Override commands. If communication is lost with the BAS, or a BAS is not present Morning Cool-down will be disabled.

2. When the space temperature is above the unoccupied cooling setpoint (85°F adj.) the supply fan will start and the chilled water valve will open. The outside air damper will open if economizing is enabled and remain closed if economizing is disabled. When the space temperature falls below the unoccupied cooling setpoint (85°F adj.) minus the unoccupied differential (2°F adj.) the supply fan will stop and the chilled water valve and outside air damper will close.

Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours (adj.). The occupancy override will end after the time period expires or when the occupant presses the "cancel" button on the space temperature sensor.

3. Occupied: During occupied periods the supply fan will run continuously and the outside air damper will open to maintain minimum ventilation requirements. All valves will modulate to maintain the active space temperature setpoint. If economizing is enabled the outside air damper will also modulate to maintain the active space temperature setpoint.
4. Space Temperature Control: The space temperature shall be maintained between the occupied cooling setpoint (74°F adj.). The unit transition to the cooling mode when the space temperature rises one degree above the occupied cooling setpoint (74°F adj.).
5. Supply Fan Operation: The fan will be off in the unoccupied mode. When the controller is in the occupied mode, the supply fan will operate continuously at rated speed. If the supply fan fails the fan will be commanded off and an alarm will be annunciated. A manual reset is required to restart the fan.
6. Economizer (Dry Bulb Temperature): Economizing will be disabled when the air temperature is greater than the economizer disable setpoint (65°F adj.). Economizing will be enabled when the outdoor air temperature is 5°F (adj.) below the economizing disable setpoint. When economizing is enabled the outside air damper will modulate between the minimum damper position and 100% open to maintain the occupied cooling setpoint. If the outdoor air temperature sensor is failed economizing is not allowed and an alarm will be annunciated.

- E. 76.FCU-CW-STM.5.34,35,37,38,44,46,47,50,52,55,57, Central Heating/Cooling Fan Coil Units with 2-way Cooling and Steam Valves

1. Occupied Mode: The supply fan will run continuously. The supply fan will cycle through its available speeds. The cooling coil chilled glycol valve will close and the heating coil steam valve will modulate in sequence to maintain the occupied space temperature setpoint (adj.). The cooling coil chilled glycol valve and the heating coil steam valve will operate with a deadband between them.
 2. Unoccupied Mode: The supply fan will stop. The cooling coil chilled glycol valve will close and the heating coil will close. The supply fan will cycle on and the cooling coil chilled glycol valve or the heating coil steam valve will modulate to maintain the unoccupied space temperature setpoint (adj.). Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours (adj.) The occupancy override will end after the time period or when the occupant pressed the "cancel" button on the space temperature sensor.
- F. 76.FCU-CW-STM.5.30,31,39,40,41,43,49,53, Central Heating/Cooling Fan Coil Units with 2-way Steam Valves and 2-way Cooling Coil Valve
1. Occupied Mode: The supply fan will run continuously. The supply fan will cycle through its available speeds. The cooling coil chilled glycol valve will modulate and the heating coil steam valve will modulate in sequence to maintain the occupied space temperature setpoint (adj.). The cooling coil chilled glycol valve and the heating coil steam valve will operate with a deadband between them.
 2. Unoccupied Mode: The supply fan will stop. The cooling coil chilled glycol valve will close, and the heating coil will close. The supply fan will cycle on and the cooling coil chilled glycol valve or the heating coil steam valve will modulate to maintain the unoccupied space temperature setpoint (adj.). Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours (adj.) The occupancy override will end after the time period or when the occupant pressed the "cancel" button on the space temperature sensor.
- G. 76.FCU-CW-STM.5.6,17,32,51, Corridor Cooling Only Fan Coil Units with 2-way Cooling Valve
1. Building Automation System Interface: The DDC will send Occupied, Unoccupied Optimal Start, Night Heat/Cool and Timed Override commands. If communication is lost with the

DDC, or a DDC is not present Morning Cool-down will be disabled.

2. Unoccupied (Night Setback): When the space temperature is above the unoccupied heating set point (85°F adj.) the supply fan will start and the chilled water valve will open. When the space temperature falls below the unoccupied heating set point (85°F adj.) minus the unoccupied differential (2°F adj.) the supply fan will stop and the chilled water valve will close.
 3. Occupied: During occupied periods the supply fan will run continuously. The cooling will be enabled to maintain the active space temperature setpoint.
 4. Space Temperature Control: The space temperature will be maintained between the occupied cooling setpoint (74°F adj.) and the occupied heating setpoint (71°F adj.). The unit will transition to the cooling mode when the space temperature rises one degree above the occupied cooling set point (74°F adj.).
 5. Morning Cool-down: During optimal start, if the space temperature is 3°F or more above the occupied cooling setpoint, a morning cool-down sequence will be activated. The supply fan will start and the chilled water valve will open to lower the space temperature to the occupied cooling setpoint. Mode will terminate when the space temperature reaches the occupied cooling setpoint.
 6. Supply Fan Operation: The fan will be off in the unoccupied mode. When the controller is in the occupied mode, the supply fan will operate continuously at rated speed.
- H. 76.FCU-STM.5.58,59,60, Corridor Heating Only Fan Coil Units with Steam Valve
1. Occupied Mode: The supply fan will run continuously. The supply fan will cycle through its available speeds. The heating coil steam valve will modulate in sequence to maintain the occupied space temperature setpoint (adj.). The cooling coil chilled glycol valve and the heating coil steam valve will operate with a deadband between them.
 2. Unoccupied Mode: The supply fan will stop. The heating coil will close. The supply fan will cycle on and the heating coil steam valve will modulate to maintain the unoccupied space temperature setpoint (adj.). Occupants may press the "on" button on the space temperature sensor to override the unit to the occupied mode for a period of two hours (adj.) The occupancy override will end after the time period or

when the occupant pressed the "cancel" button on the space temperature sensor.

3.3.11.7 Building 76, Sixth Floor

A. 76.AHU.6.1, 3RD Floor Retail Air Handling Unit and Exhaust Fan

1. Building Automation System Interface:

The Building DDC System will send the controller Occupied, Unoccupied, Optimal Start, Night Heat/ Cool, and Timed Override commands. The DDC may also send a Heat / Cool mode, space temperature and/or space temperature set point. If a DDC is not present, or communication is lost with the DDC, the controller will operate using its local schedule and set points.

2. Occupied Mode (Temperature Control): During the occupied mode and during the economizer mode, the AHU will be in the heating mode. During the heating mode the steam valve will modulate to maintain a discharge air set point (adj.). The initial set point will be 60°F (adj.). The DX cooling will be inactive.

When the AHU is no longer in the economizer mode the AHU will be in cooling mode. During the cooling mode, the DX cooling will cycle to maintain a discharge air set point (adj.). The initial set point will be 55°F (adj.). The heating valve will be inactive.

If the discharge air temperature falls below a low limit of 45°F (adj.), the heating valve will open and an alarm will be generated. If the discharge air temperature drifts 5°F (adj.) above or below the calculated set point, an alarm will be generated. If the discharge air temperature rises above a high limit of 120°F (adj.), an alarm will be generated.

3. Unoccupied (Night Setback): When the space temperature is below the unoccupied heating set point (adj.) the supply fan will be energized, the outside air damper will remain closed and the steam valve will open. When the minimum space temperature rises above the unoccupied heating set point plus the unoccupied differential 6°F (adj.), the supply fan will stop and the steam valve, outside and return air air dampers will modulate to maintain a supply air set point of 50°F (adj.).

During the unoccupied mode and if the maximum space temperature is above the unoccupied cooling set point, a night cool down sequence will be activated. If not in the economizer mode, the supply fan will energize, the DX will

be cycled and the outside air damper will remain closed. If in the economizer mode, the supply fan will start, the DX cooling will be off and the outside air damper will modulate. When the space temperature falls below the unoccupied cooling set point minus an unoccupied differential 6°F (adj.), the supply fan will stop and the outside air damper will close and/or DX cooling will turn off.

4. Morning Warm-up:

During optimal start and based upon outside air temperature conditions and if the space temperature is below the occupied heating set point, a morning warm-up sequence will be activated. The supply fan will start, the steam valve will open and the outside air damper will remain closed. The mode will terminate when the space temperature reaches the occupied heating set point or the occupied time period has started.

5. Morning Cool Down:

During optimal start, if the space temperature is above the occupied cooling set point, a morning cool down sequence will be activated. If not in the economizer mode, the supply fan will start, the DX cooling will cycle and the outside air damper will remain closed. If in the economizer mode, the supply fan will start, the DX cooling will be off and the outside air damper will modulate open. The mode will terminate when the space temperature reaches the occupied cooling set point or the occupied time period has begun.

6. Supply Fan Control:

During the occupied mode, the supply fan will be enabled and the outside air damper normally closed will open. If the supply fan fails to start when commanded to run, an alarm will be generated. If the fan is commanded off but the status is on, an alarm will be generated. Status runtime will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

7. Exhaust Fan Control:

Exhaust fan EF.6.1 shall be energized whenever the AHU is energized. When exhaust fans EF.6.4 and EF.6.5 are running, normally closed dampers will open and when the exhaust fan is off, the dampers will close. If the exhaust fan fails to start when commanded to run, an alarm will be generated. If the fan is commanded off but the status is on, an alarm will be generated. Status runtime will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

8. Temperature Alarms:

If the return air temperature rises above a high limit set point (90°F adj.) or falls below a low limit set point (45°F adj.) an alarm will be generated at the OWS.

9. Filter Status:

The controller shall monitor the filter status.

Alarms shall be provided as follows:

- Filter change required: filter differential pressure exceeds a user definable limit (adj.).

10. Freeze protection:

The initial damper opening rate will be limited to 2% per minute until the damper has reached its minimum damper position if the mixed air temperature drops below 45°F (adj.), if the mixed air temperature sensor fails the outside air damper will close and an alarm will be annunciated.

B. 76.MAU.6.1, 3rd Floor Kitchen Make-Up Air Unit, Heat Recovery Unit 76.HRU.6.1 and Exhaust Fan EF.6.2

1. Run Conditions: The makeup air unit, heat recovery unit 76.HRU.6.1 and exhaust fan EF.6.2 will operate together whenever the kitchen exhaust hood is in operation as energized by a local On/Off switch.

Outside air and exhaust air dampers (normally closed) shall be powered open whenever the system is energized.

2. Alarms shall be provided as follows:
Supply Fan Failure: Commanded on, but the status is off.
Exhaust Fan Failure: Commanded on, but the status is off.
3. Heating Coil Valve: The controller shall measure the heated air temperature and modulate the heating coil steam valve(s) to maintain the heating set point.

The heating coil valve(s) shall be enabled whenever:
Outside air temperature is less than 65°F (adj.)

- AND the supply fan status is on
- AND cooling is not active

The discharge temperature sensor shall initiate a low limit temperature alarm if a discharge temperature of 45°F or below is sensed.

4. Cooling Coil: The DDC system shall enable the units associated water cooled DX condensing unit whenever the outside air temperature is 65°F or greater (adj.). The

condensing unit will operate through its factory packaged controls to maintain the discharge temperature set point of 55°F once the unit has been enabled.

5. Filter: The controller shall monitor the filter status. Alarms shall be provided as follows: Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).
6. Discharge Air Temperature: The controller shall measure the discharge air temperature.

Alarms shall be provided as follows:

High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).

Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

7. Freeze Protection: The unit shall be hard wired for a shut down from the freezestat and generate an alarm upon receiving a freezestat status from the auxiliary contact..
8. Monitoring: The controller shall monitor additional points not noted in the sequence as indicted on the points list and flow diagrams.

C. 76.HRU.6.1, Z-Duct Heat Recovery Unit

1. Run Mode: The heat recovery unit shall be in heat recovery mode whenever makeup air unit 76.MAU.6.1 and 76.EF.2 are energized and the outside air temperature is below 55°F (adj.) the DDC system will modulate the HRU bypass damper to maintain a supply air temperature set point of at least 55°F (adj.) to 76.MAU.6.1 at all times. If the exhaust air temperature drops to 40°F (adj.) or below the DDC System will modulate the bypass damper to decrease the exhaust air cooling to prevent frosting of the heat exchanger.

Whenever 76.MAU.6.1 is off the DDC System will disable 76.HRU.6.1 and EF.6.2. Alarms the following points are available for monitoring, trending or alarming at the OWS:

- HRU excessive pressure drop indication
- outside air intake temperature
- supply air to 76.MAU.6.1 temperature
- HRU return air temperature
- HRU exhaust air temperature

2. Heat Exchanger Cleaning Cycle: The heat exchanger wash cycle shall be provided with both automatic and manual controls to open and close the wash-down supply and drain solenoid valves. In the automatic mode, the DDC system shall cycle the cleaning cycle during the unoccupied evening period as scheduled by the DDC system if the pressure drop across the heat exchanger during the most recent operation exceeds a user defined setpoint of 0.5" w.g. (adj.). The wash cycle duration (nominal 5 minutes, adjustable) shall be monitored and adjusted at the DDC system. Manual controls will also be provided to manually initiate the wash-down cycle.

D. 76.WCCU.6.1 & 2, Water Cooled Condensing Units for 6th Floor Air Handling Units

1. Water-cooled DX condensing units 76.WCCU.6.1 (serves MAU.6.1) and 76.WCCU.6.2 (serves 76.AHU.6.1) are enabled by the DDC system whenever there is a demand from cooling from their respective air handling unit.
2. Flow of condenser water (i.e. campus well water) to the chillers will be controlled via the chiller's self-contained controls.
3. The DDC system shall monitor the status of each condensing unit as well as the alarm status of each condensing unit.

E. 76.CFCU.6.1-16, Cooling Only Fan Coil Units

1. Run Conditions - Scheduled: The DDC system shall control the operation of the cooling fan coil unit. The unit shall run according to a user definable time schedule in the following modes:

Occupied Mode: The unit shall cycle as required to maintain space cooling set point temperature. When the outside air temperature is over 65°F, the unit chilled water three way valve shall modulate to maintain a 74°F (adj.) zone set point temperature.

Unoccupied Mode (night setback): The unit shall cycle as need to maintain 78°F (adj.) zone cooling set point.

2. Monitoring and Set Point Override: The DDC system shall monitor the space temperature. Space temperature sensors shall be provided with an override pushbutton that will enable fan coil unit operation for 1 hour (adj.) period.

- F. 76.RHC.6.1&2, 6TH Floor Steam Reheat Coils: See C.RHC.2 Control Sequence
- G. 76.ERU.6.1&2, 5th Floor Renewaire Air to Air Energy Recovery Units
 - 1. Control:

During the occupied mode and when the outside air temperature is within the economizer set points of 20°F (adj.) and 55°F (adj.), the ERU will be disabled. During the occupied mode, upon a proof of supply fan run status and when the outside air temperature outside the economizer set points as described above the isolation dampers will open fully. When the damper is open the supply air and exhaust air fans will energize. If the fresh air or exhaust fan fails to start when commanded to run, an alarm will be generated. Status runtime for each fan will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.
- H. 76.HTNG-HW.6.1, 5th Floor Fan Coil Unit Heating Hot Water System
 - 1. Pump Control:

Hot water pumps P-1 & P-2 serve the FCU loop and shall work on a lead/lag/failure basis. The lead pump shall rotate once a week to help equalize runtime. If the lead pump fails the lag shall start and an alarm shall be sent to the operator workstation (OWS).
 - 2. Steam Valve Control:

The steam valve will modulate to maintain a leaving water temperature of 180°F (adj.). Valves shall remain closed until a pump has proven status.
- I. 76.EF.6.5, 2nd Floor Rm. 240 Hematology Lab Hood Exhaust Fan
 - 1. Run Conditions - Manual Operation:

Exhaust fan will be energized upon receiving the command to run from local on/off switch. Once the fan is energized the DDC system will open the duct exhaust air damper (normally closed) and shall monitor the status of the exhaust fan.
- J. 76.EF.6.6, 2nd Floor Rm. 242 Hematology Lab Hood Exhaust Fan

1. Run Conditions - Manual Operation:

Exhaust fan will be energized upon receiving the command to run from local on/off switch. Once the fan is energized the DDC system will open the duct exhaust air damper (normally closed) and shall monitor the status of the exhaust fan.

3.3.11.8 Building 76, Seventh Floor

A. 76.MAU.7.1 & EF.7.3, 4th Floor ICU Make Up Air Unit and Exhaust Fan

1. Supply Make-Up Air and Exhaust Fan Control (76.MAU.7.1 & 76.EF.7.3):

Supply fan and exhaust fans will be scheduled to operate through the DDC system to correspond with the operating hours of the 4th Floor ICU and associated spaces. An "On/Off/ Auto" selector switch is provided on the control panel.

- a. The unit's outdoor air damper will open.
- b. Exhaust fan and runaround coil pump to start through interlocks.
- c. Chilled water pump and chiller will be placed under control.
- d. Humidifier to become activated from a closed position.
- e. Well water coil valve to become activated from a closed position.

2. Reclaim Coil Control (ERC, MAU preheat coil)

- a. When the make-up air unit is running, reclaim pump will run to transfer heat from the exhaust coil (ERC.7.1) to the preheat air coil subject to outdoor air temperature. Pump will not operate at temperature between 50°F and 80°F (adjustable)
- b. 3-way valve shall be fully open to the outside air coil whenever the exhaust coil supply water temp is above 35°F.
- c. 3-way valve shall modulate flow to the outside air coil to maintain 35°F supply water to the exhaust coil.

3. Preheat Coil Control

- a. Control valve shall modulate the heating coil valve to maintain a temperature no lower than 45°F (adj.).

4. Chilled Water Control

- a. An average control signal from three space thermostats (rooms 230, 242 and 239) will select, in conjunction with a humidistat (set at 50% R.H.) will on a call for cooling or dehumidifying start the chilled water pump (which in turn will allow a flow switch to start the refrigeration chiller) and gradually position three-way mixing valve to maintain supply air set point. (Note: Chiller to maintain the required chilled water supply temperature through its own self-contained controller which will also include a low ambient cutout.

5. Humidity Control:

- a. The space humidistat set will gradually position a normally closed humidifier to maintain the required space humidity of no lower than 30%, subject to a discharge humidity high limit set at 85%.

6. Exhaust Fan Control:

- a. Exhaust fan EF.7.3 shall be energized whenever the makeup air unit is energized. When exhaust fan EF.7.3 is running, normally closed dampers will open and when the exhaust fan is off, the dampers will close.

B. 76.MAU.7.3, 6th Floor Make Up Air Unit

C. 76.GER.7.1, MAU.7.1 Energy Recovery Loop with One Pump

- 1. Heating mode: the circulating pump(s) shall operate for heat recovery whenever:
 - a. Exhaust air temperature is 5°F (adj.) or more above the outside air temperature.
 - b. The zone temperature is above the cooling set point.
 - c. The supply and return fans are on.

The DDC controller shall measure the return water temperature to the exhaust air recovery coil and modulate the energy recovery 3-way control valve to maintain the

return water temperature above 35°F (adj.) To prevent frosting the coil.

2. Cooling mode: the circulating pump(s) shall operate for heat rejection whenever:
 - a. Exhaust air temperature is 5°F (adj.) or more below the outside air temperature.
 - b. The zone temperature is above the cooling set point.
 - c. The supply and return fans are on.

The DDC controller shall position the 3-way control for 100% fluid flow through the outside air recovery coil.

3. Pump Control:

If the pump GWP.7.1 is commanded off but the status is on, an alarm will be generated. Status runtime for the pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.

- D. 76.EF.7.2, Exhaust Fan Serving 5th Floor: See C.EF.1 Sequence of Operation.
- E. 76.EF.7.4, Exhaust Fan Serving 4th & 5th Floors: See C.EF.1 Sequence of Operation.
- F. 76.EF.7.5, Exhaust Fan Serving 3rd Floor: See C.EF.1 Sequence of Operation.
- G. 76.EF.7.6, Exhaust Fan Serving Center Exhaust: See C.EF.1 Sequence of Operation.

3.3.12 Building 78 Sequence of Operations

- A. 78.VAVAHU.1.1 & 1.3 Sequence of Operation (new units, formerly AH-3 & AH-5)
 1. Units are variable volume air handling units, consisting of a mixed air section with an outdoor air damper with airflow monitoring station and a return air damper with an airflow monitoring station. The unit has a supply fan with VFD and inline return air fan. The unit has an integral face and bypass steam coil and chilled water coil. The unit also has a humidifier manifold for humidity control. The unit is DDC controlled using electric actuators.

2. The air handling unit is scheduled for automatic operation on a time of day basis for occupied and unoccupied modes. There will be night setback/morning warm-up control, as well as optimal start/stop control. All set points will be adjustable at the operator workstation.
3. Safeties
 - a. A low limit thermostat, located after the heating coil, will shutdown the air handling unit supply fan when the temperature drops below its set point, 38°F adjustable at sensor.
 - b. A static pressure high limit, located immediately after the supply fan, will shutdown the supply fan variable speed drive if the duct static pressure exceeds it's set point, 3. "WG.
4. Occupied/Unoccupied Control
 - a. During the occupied mode the air handling fan will be enabled and will run continuously.

In the unoccupied mode the unit will be off and the terminal heating units shall operate to maintain the spaces at their unoccupied heating set point of 60°F.
 - c. An optimal start process will calculate a time at which the air handling unit will start prior to occupancy to allow the spaces to reach their occupied set point at the occupied time.
5. Start/Stop Control
 - a. When an occupied command is given the air handling unit supply fan will be started. Proof of supply fan status must be obtained. If the status of the supply fan does not match the command state, a supply fan failure alarm will be generated and sent to the operator workstation. Upon a condition of supply fan failure, the outdoor air dampers and cooling valve will close and the heating valve will remain in the control of the mixed air temperature sensor.
 - b. The return air fan will be interlocked with the supply air fan and its status will be monitored. If the return air fan status does not match the command state, a return fan failure alarm will be generated and sent to the operator workstation.
6. Discharge Air Control
 - a. Upon proof of supply fan status the economizer dampers will be opened to their minimum position. The economizer dampers, chilled water valve, face and bypass dampers and heating valve will be sequenced to maintain the discharge air temperature at its set point. The discharge air set point will be reset by

the enthalpy and reheat coil valve position. The supply air temperature set point shall be 55°F during the cooling season and be reset up to a maximum of 60°F during the heating season.

- b. There will be a global economizer set point, which will allow the controller to use the economizer dampers for free cooling when chilled water is not available.
- c. The heating valve will be closed when steam is not available.

7. Static Pressure Control

- a. A static pressure transmitter will be located 2/3 of the way down the duct, to modulate the control, signal to the supply fan variable speed drive to maintain the duct pressure at its set point.
- b. The return fan variable speed drive will be modulated to maintain the supply/return air flow differential to maintain a minimum outside air flow rate.

B. 78.AHU.1.2 (exist. unit, formerly AH-4)

- 1. Occupied/Unoccupied operation of unit will be determined by the DDC panel. During unoccupied operation the supply fan will cycle on 100% return air to maintain the night temperature set point. The chilled water valve will be closed between the hours of 06:00 PM and 06:00 AM during unoccupied operation.
- 2. When unit operates in occupied mode, the relief damper will be two positioned open. When the relief damper is full open, the damper and switch will energize the relief fan.
- 3. The DDC panel will modulate the outside and return dampers to maintain 55°F (adj.) mixed air temperature. The DDC will modulate the supply and relief fan inlet vanes to maintain .75" (w.g.) S.P.
- 4. When the outside temperature is above 70°F (adj.) and chilled water is available, the chilled water valve will modulate to maintain the discharge air schedule. If no chilled water is available the O.A. damper will open full.
- 5. When the outside temperature is below 55°F, the space sensor will reset to discharge air temperature between 55°F and 65°F by modulating the heating coil valve.
- 6. When the outside temperature is above 70°F, the space sensor will reset the discharge air temperature between 55°F and 65°F by modulating the cooling valve. When the outside temperature is between 55°F and 70°F, the space sensor will reset the discharge air temperature by modulating the heating and cooling valves in sequence.

7. The DDC panel will modulate the humidifier valve to maintain 30% RH (adj.) as sensed by the return air humidity transmitter. A humidity high limit thermostat will be provided in the air supply fan ductwork.
 8. Whenever the freeze stat or smoke detector indicates an alarm, unit will shut off. The outside dampers will close, return dampers will open, exhaust dampers will close and the preheat coil valve will remain under DDC control.
- C. 78.MAU.A.1 & 78.EF.A.1, Makeup Air Handling Unit (exist to remain, formerly AH-1)
1. Unit and associated exhaust fan will operate continuously. The supply fan will be interlocked with the O.A. damper end switch. The O.A. damper must be full open for fan to operate.
 2. The heat recovery pump will run at outdoor air temperature less than 50°F and greater than 80°F. Between these temperatures the pump will be off.
 3. The DDC panel will modulate the heat recovery 3-way valve to maintain the supply water temperature to the exhaust fan heat recovery coil at a minimum for 30°F (adj.). Below 30°F supply water temperature, the valve will modulate to bypass the supply fan heat recovery coil and open to the coil above 30°F.
 4. When the O.A. temperature is below 55°F (adj.) the DDC panel will modulate the heat recovery 3-way valve, preheat coil #1 valve and preheat coil #2 valve in sequence to maintain the discharge air schedule and demand of space temperature sensors. The cooling coil valve will remain closed. The discharge low limit temperature will be 55°F.
 5. When the outside air temperature is above 70°F, the DDC panel will modulate the cooling coil 3-way valve to maintain the discharge air schedule as calculated by the DDC panel using humidity transmitter in the exhaust fan ductwork. The preheat valves will remain closed.
 6. At outside temperatures between 55°F and 70°F, the preheat coil valves will be opened in sequence if the temperature sensed by any of the space sensors is less than 72°F. The preheat coil valves will be closed when the temperature sensed by all the space sensors is above 72°F and before the cooling valve opens. The cooling coil valve will modulate open as required to maintain the dew point set point of the exhaust air.
 7. The DDC panel will modulate the humidifier valve to maintain 30% RH (adj.) as sensed by the exhaust humidity transmitter. A humidity high limit thermostat will be mounted in the supply fan ductwork.

8. Whenever the freezestat or smoke detector indicates an alarm, AHU-1 will shut off. The outside damper will close, return dampers will open and the preheat valves will remain under DDC control.
 9. Exhaust fan EF-A.1 will be interlocked to operate whenever MAU.A.1 or AHU.A.1 is on.
- D. 78.VAVAHU.A.1, Variable Air Volume Air Handling Units (formerly AH-2)
1. Units will operate continuously. The outside air and return dampers will position to allow 3890 CFM (78.AHU.A.1) or of return air to enter mixing box.
 2. The DDC panel will modulate the outside and return dampers to maintain 55°F (adj.) mixed air temperature. During economizer operation the relief damper will be two positioned open. When the relief damper is full open, the damper switch will energize the relief fan. The DDC panel will modulate the supply and relief fan inlet vanes to maintain 0.75" (w.g.) S.P.
 3. When the outside temperature is above 70°F (adj.) and chilled water is available, the chilled water valve will modulate to maintain the discharge air schedule. If no chilled water is available the O.A. damper will open full.
 4. The space sensor located in room 347 will reset the discharge air temperature. When the space temperature falls below 72°F (adj.) the heating valve will modulate to maintain the discharge air schedule. When the space temperature rises above 76°F (adj.) the cooling coil valve will modulate to maintain the discharge air schedule.
 5. The DDC panel will modulate the humidifier valve to maintain 30% RH (adj.) as sensed by return air humidity transmitter. A humidity high limit thermostat will be provided in the supply fan ductwork.
 6. Whenever the freezestat or smoke detector indicates an alarm, unit will shut off. The outside dampers will close, return dampers will open, exhaust dampers will close and the preheat coil valve will remain under DDC control.
- E. 78.VAV.1, Variable Volume Box with Reheat Coil Control:
1. Cooling: The reheat coil will be closed. Room temperature sensor, with override push button, will modulate the primary air damper from the maximum position during occupied periods and to the minimum position during unoccupied periods. If the room sub cools below the set point, the hot water control valve will modulate open to maintain room temperature.

2. Heating: The hot water valve will be modulated open to maintain the room heating set point.
- F. 78.VAV.2, Variable Volume Box without Reheat Coil Control:
1. Existing Pneumatic units: The pneumatic room thermostat will modulate the VAV damper actuator to maintain the cooling space temperature set point.
- G. 78.CV.1, Constant Volume Box with Reheat Control:
1. The room thermostat will have separate D.A. outputs for heating and cooling. When the space temperature is above the cooling temperature set point, the reheat coil valve will be full closed and the box will deliver the scheduled air volume to the room.
 2. When the space temperature is between the cooling and heating set points, the system will operate in the free energy band, the reheat valve will remain closed and the box will deliver the scheduled air volume to the room.
 3. When the space temperature is below the heating set point, the reheat coil valve will open and the box will deliver the scheduled air volume.
- H. 78.HCP.1, Heating/Cooling Radiant Ceiling Panel Control
1. The room thermostat will have separate outputs for heating and cooling. The heating supply and return valve will modulate to maintain the heating temperature set point of 70°F (adj.). The cooling supply and return valve will modulate to maintain the cooling temperature set point of 74°F (adj.). Both the heating and cooling supply and return valves will be closed when the space temperature is between the heating and cooling temperature set points.
- I. 78.HRP.1, Radiant Ceiling Panel Control
1. The room thermostat will modulate the heating supply valve to maintain the temperature set point of 70°F (adj.).
- J. 78.GER.A.1, Energy Recovery Loop Control: see sequence of operation C.GER.1P.
- K. Duct Mounted and Elevator Hoistway Smoke Dampers:
1. The local smoke detector will de-energize the EP to cause the smoke damper to close.
- L. 78.EF.1, First Floor Exhaust Fans:
1. Exhaust fans shall be started when in occupied mode. Exhaust fans shall be stopped when in unoccupied mode.
 2. Exhaust fan status will be monitored by the DDC system..
- M. 78.HTNG-HW.1, Hot Water System
1. The hot water heating system shall be enabled whenever the outdoor air temperature is below 60°F.

2. There are two heat exchangers, HX.1.1 & 1.2. One heat exchanger shall be designated lead, one heat exchanger shall be designated lag. The lead heat exchanger shall operate to maintain the hot water supply set point. The lag heat exchanger shall be enabled if the lead heat exchanger cannot maintain the hot water supply set point. If the lead heat exchanger fails the lag heat exchanger will be enabled, and an alarm will be issued.
3. When the heating system is enabled, the lead system pump shall start. Upon proof of pump status, the isolation valve associated with the lead heat exchanger shall be opened. Once the valve is confirmed open, the heat exchanger will be enabled. The hot water supply set point shall be reset from the outdoor air temperature. The hot water supply temperature set point will be 180°F (adjustable) when the outdoor air temperature is 0°F. The set point will be reset to 120°F (adjustable) when the outdoor air temperature is 60°F.
4. There are two pumps, HWP.1.10 and HWP.1.11. One pump shall be designated lead pump, one pump will be designated lag pump. The lag pump shall be used as an automatically stand-by. The lead and lag pumps shall be alternated once a week.
5. If the lead pump fails, the lag pump shall be automatically started, and an alarm shall be issued. The same shall occur if the second pump fails. In addition, any unit that uses this water in its heating coil shall be stopped and an alarm issued for each unit.

N. 78.CWS.1, Packaged Chillers and Chilled Water Pump System

1. Primary Pumps (CWP.1.11 & CWP.1.2) Control: When the outside air temperature is greater than a cooling enable set point of 54°F (adj.), lead chilled water pump will be enabled to operate continuously. If the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but the status is on, an alarm will be generated. For systems with a single chilled water pump, the DDC system shall operate as above with the exception of pump alternation. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):
 - Manually through software switch
 - Pump runtime (adj.) is exceeded
 - Daily
 - Weekly
 - Monthly

2. Chiller Control: Individual chillers shall be enabled by the DDC system as required to maintain primary loop chilled water set point. Upon proof of chilled water flow, as determined by the flow switch and a proof via aux contact at the secondary circulator starter (CWP.1.3 or CWP.1.4), the chiller will be commanded on. The chiller will maintain a chilled water supply temperature set point as determined by its own internal controls. The chilled water set point will be adjustable from the head end. If the chiller fails, an alarm will be generated. The chiller's common chilled water inlet and outlet temperatures will be continuously monitored. The chillers will run for and be off for a minimum adjustable times (adj.). If a chiller fails to start when commanded to run, an alarm will be generated. If a chiller is commanded off but the status is on, an alarm will be generated. Status runtime for each chiller will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.
 3. If the chilled water supply temperature rises above a high limit set point of 55°F (adj.) or falls below a low limit set point of 38°F (adj.) an alarm will be generated. If the chilled water return temperature rises above a high limit set point of 68°F (adj.) or falls below a low limit set point of 47°F (adj.) an alarm will be generated.
 4. Radiant Panel Chilled Water 3-Way Valve and Secondary Circulator Control: The secondary circulators (CWP.1.6 & CWP.1.7) shall be controlled by the DDC system and shall be energized whenever the outside air temperature is 60°F (adj.) or greater or when there is a demand for cooling from the second and third floor spaces that have heating/cooling radiant panels.
 5. The 3-way control valve in the chilled water supply to the radiant ceiling panels shall be controlled from the DDC panel. The temperature of the chilled water supply to the radiant panels shall always be greater than the discharge air temperature of the air handling unit serving the spaces with heating/cooling panels (i.e., AHU.A.1). The differential pressure sensor that measures the differential pressure between the chilled water supply and return to the heating/cooling panels will provide an output differential pressure signal to the DDC system.
 6. Monitoring: The DDC system shall monitor the status of all six chilled water pumps in the system, the two packaged chillers and all associated chilled water temperatures and pressures.
- O. 78.CUH.1, Cabinet Unit Heaters: see sequence of operation C.CUH-HW.1
- P. 78.UH.1, Hot Water Unit Heaters: see sequence of operation C.UH-HW.1

Q. Recent Controls Integration with Existing DDC System (by Siemens)

1. Siemens will integrate to the existing Barber-Colman network 8000 building automation system.
2. Siemens will replace the existing Barber-Colman global control module with a Barber-Colman network 8000 enhanced driver. This driver consists of' a Siemens PXC-modular controller, loaded with the Barber-Colman network 8000 driver.
3. All existing Microzone controllers will remain. These controllers contain all of' the current point data and programming. They currently communicate to the Barber-Colman network 8000 global control module via the ASO bus, which is a two wire communication link.
4. The ASO bus will be connected to the Siemens Barber-Colman network 8000 enhanced driver. This will allow Siemens to view all current points in the system.
5. The network 8000 enhanced driver will be connected to an insight computer workstation. This workstation will include all new Siemens equipment, as well as all existing equipment. Custom graphics will be created for all existing systems as well as the new Siemens equipment. This will allow the customer to have full access to the new Siemens equipment being installed as well as the existing equipment in the building.
6. This integration plan was demonstrated to Bath VA representatives on 7/6/11 and accepted.

3.3.13 Building 92 Sequence of Operations

A. 92.VRV

1. The variable refrigerant volume (VRV) system serving all floor spaces is controlled by the VRV system manufacturer's packaged control system to provide heating and cooling to each space that has a VRV ductless split system. The packaged control system shall control the operation of the various system components including heat recovery VRV units (ACCU's) and branch selector boxes and ductless split systems to meet the heating and cooling set points as scheduled by the DDC system.
2. Run Conditions - Scheduled: The systems shall run according to a user definable time schedule in the following modes:
Occupied Mode: Ductless split units shall maintain a cooling set point of 74°F (adj.) and a heating set point of 70°F (adj.).

Unoccupied Mode (Night Setback): Ductless split units shall maintain a cooling set point of 85°F (adj.) and a heating set point of 60°F (adj.). If the space temperature rises above the cooling set point by a user definable amount (adj.), an alarm will be generated. If the space temperature falls below the heating set point by a user definable amount (adj.), an alarm will be generated.

B. 92.HP.3.1, Heat Pump Damper Control

1. Run Conditions: Whenever one air condenser is on, as determined by its current switch, AH-4 relief air damper, the outside air damper, return air dampers and exhaust relief damper will open to a 50% (adj.) position.
2. When both air condensers and air handler AHU.3.2 are on, the AHU.3.2 relief air damper, the outside air damper and exhaust relief damper will open fully and the two return air dampers will fully close.
3. When both air condensers and air handler AHU.3.2 are off, the AHU.3.2 relief air damper , the outside air damper and exhaust relief damper will dose fully and the two return air dampers will fully open.

C. 92.HTNG-GLY.3.1, Glycol Hot Water Heating System

1. Primary Pumps (GWP1, GWP2) Control: When a definable number of hot water coils are calling for heat and when air temperature is below a heating enable set point of 54°F (adj.), as sensed by the outside air sensor, the lead hot water pump will be enabled to operate continuously, initially set for GWP1, if the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but status is on, an alarm will be generated. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):
 - Manually through software switch
 - Pump runtime (adj.) is exceeded
 - Daily
 - Weekly
 - Monthly
2. Glycol Tank Monitoring: The ultrasonic level sensor will measure the level of glycol in the glycol tank. When the level falls below the low limit set point (adj.), an alarm will be generated at the operator workstation.

D. 92.CH.1.1, Packaged Glycol Chilled Water Heating System

1. Primary Pumps (GWP1, GWP2) Control: When a definable number of hot water coils are calling for heat and when air temperature is below a heating enable set point of 54°F (adj.), as sensed by the outside air sensor, the lead hot water pump will be enabled to operate continuously, initially set for GWP1, if the pump fails to start when commanded to run, an alarm will be generated. If the pump is commanded off but status is on, an alarm will be generated. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated. The lead pump will rotate upon one of the following conditions (user selectable):
 - Manually through software switch
 - Pump runtime (adj.) is exceeded
 - Daily
 - Weekly
 - Monthly
 2. Chiller Control: Upon proof of chilled water flow, as determined by the flow switch, the chiller will be commanded on. The chiller will maintain a chilled water supply temperature set point as determined by its own internal controls. If the chiller fails, an alarm will be displayed as the OWS. The chiller's chilled water inlet and outlet temperatures will be continuously monitored and displayed at the OWS. The chiller will run and be off for minimum adjustable times (adj.). If the chiller fails to start when commanded to run, an alarm will be generated. If the chiller is commanded off but status is on, an alarm will be generated. Status runtime for each pump will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.
 3. Temperature Monitoring: If the chilled water supply temperature rises above (56°F adj.) or falls below (38°F adj.) the limit settings, an alarm will be generated. If the chilled water return temperature rises above (68°F adj.) or falls below (47°F adj.) the limit settings, an alarm will be generated.
 4. Glycol Tank Monitoring: The ultrasonic level sensor will measure the level of glycol in the glycol tank. When the level falls below the low limit set point (adj.), an alarm will be generated at the operator workstation.
- E. 92.AHU.1.1 & 3.1-4, Air Handling Units
1. Building Automation System Interface: The Building Automation System (BAS) will send the controller Occupied, Unoccupied, Optimal Start, Night Heat / Cool, and Timed Override commands. The BAS may also send a Heat/Cool mode, space temperature and/or space temperature set point. If

communication is lost with the BAS, the controller will operate using its local schedule and set points.

2. Run Conditions- Scheduled: Units shall run according to a user definable time schedule in the following modes:
 - a. Occupied Mode (Temperature Control): During the occupied mode, upon a proof of supply fan air flow and during the economizer mode, the AHU will be in the heating mode. During the heating mode the heating valve will modulate to maintain a discharge air set point, as reset by the space temperature. The initial set point will be 82°F (adj.), with a maximum of 85°F (adj.) on an increase in demand and a minimum of 72°F (adj.) on a decrease in demand. The cooling valve will be inactive.
 - b. When the AHU is no longer in the economizer mode (see "Mixed Air Damper Control" above), the AHU will be in the cooling mode. During the cooling mode the cooling valve will modulate to maintain a discharge air set point, as reset by the space temperature. The initial set point will be 55°F (adj.), with a maximum of 72°F (adj.) on a decrease in demand and a minimum of 53°F (adj.) on an increase in demand. The heating valve will be inactive.
 - c. If the discharge air temperature falls below a low limit of 45°F (adj.), the heating valve will open and an alarm will be generated. If the discharge air temperature drifts 5°F (adj.) above or below the calculated set point, an alarm will be generated. If the discharge air temperature rises above a high limit of 120°F (adj.), an alarm will be generated.
 - d. Unoccupied (Night Setback): When the space temperature is below the unoccupied heating set point (adj.) the supply fan will start, the outside air damper will remain closed and the hot water valve will open. When the space temperature rises above the unoccupied heating set point plus the unoccupied differential (4°F adj.) the supply fan will stop and the hot water valve will close.
 - e. During the unoccupied mode and if the space temperature is above the unoccupied cooling set point, a night cool down sequence will be activated. If not in the economizer mode and chilled water is available, the supply fan will start, the chilled water valve will open and the outside air damper will remain closed. If in the economizer mode, the supply fan will start, the chilled water valve will dose and the mixed air dampers will modulate open. When the space temperature falls below the unoccupied cooling set point minus an unoccupied differential 4°F(adj.) the

supply fan will stop and the outside air damper and/or chilled water valve will close.

- f. Morning Warm-up: During optimal start and based upon outside air temperature conditions and if the space temperature is below the occupied heating setpoint, a morning warm-up sequence will be activated. The supply fan will start, the hot water valve will open and the outside air damper will remain closed. Mode will terminate when the space temperature reaches the occupied heating setpoint or the occupied time period has started.
 - g. Morning Cool-down: During optimal Start, if the space temperature is above the occupied cooling set point, a morning cool down sequence will be activated. If not in the economizer mode and chilled water is available, the supply fan will start, the chilled water valve will open and the outside air damper will remain closed. If in the economizer mode, the supply fan will start, the chilled water valve will close and the mixed air dampers will modulate open. Mode will terminate when the space temperature reaches the occupied cooling set point or the occupied time period has started.
3. Energy Recovery Loop (AHU-1 and AHU-3 Only): When the space temperature is below the heating set point, during the occupied mode, upon a proof of supply fan air now and when the return air temperature, as sensed by DTS2, is 5°F (adj.) or more above the outside air temperature, the circulating pump (P5 for AHU-1, P6 for AHU-3) will be enabled. The 3-way valve will modulate to maintain a return water temperature, as sensed, of 32°F (adj.) to prevent frosting of the coil.

When the space temperature is above the cooling set point, during the occupied mode, upon a proof of supply fan air now and when the room air temperature, as sensed, is 5°F (adj.) or more below the outside air temperature, the circulating pump (P5 for AHU-1, P6 for AHU-3) will be enabled. The 3-way valve will be positioned 100% to allow full flow through the outside air recovery coil.

If the pump fails, as determined by its current switch, an alarm will be generated at the OWS.

4. Humidifier Control, (AHU.3.1): During the occupied mode, upon a proof of supply fan air flow and when the space humidity, as sensed, falls below a space relative humidity set point of 50% (adj.), the humidifier will be enabled to operate. The humidifier will modulate to maintain the space humidity set point. The humidifier will be locked out, via

hardwire interlocks from the air flow switch and the humidity high limit (85%RH) humidistat. During the cooling mode the humidifier will not operate.

5. Fan Control: During the occupied mode, the supply fan will start. Upon a proof of airflow, the return fan will start. If the supply or return fan fails to start when commanded to run, an alarm will be generated. If the fan is commanded off but the status is on, an alarm will be generated. Status runtime for each fan will be monitored. If the runtime exceeds a user definable limit (adj.), an alarm will be generated.
6. Mixed Air Damper Control: During the occupied mode and upon a proof of supply flow, the mixed air dampers will open to a minimum position (see below). When the outside air temperature is below an economizer set point of 65°F (adj.) and when the outside air temperature is greater than the return air temperature, the AHU will be in the economizer mode. During the economizer mode the mixed air dampers will modulate to maintain a mixed air set point. The mixed air set point will be the calculated discharge air set point minus 2°F (adj.). When the outside air temperature rises above the economizer set point the mixed air dampers will revert to the minimum position. During the unoccupied mode or when the e supply fan is off or when the mixed air temperature falls below a low limit set point of 35°F (adj.), the outside and exhaust air dampers will close and the return air damper will open. If the mixed air temperature rises above a high limit of 90°F (adj.), an alarm will be generated. If the mixed air temperature falls below a low limit of 45°F (adj.), an alarm will be generated.

<u>AHU-#</u>	<u>Min OA %</u>
AHU.3.4	42%
AHU.3.1	22%
AHU.3.3	42%
AHU.3.2	100%
AHU.3.5	29%
AHU.3.6	28%
AHU.1.1	47%

7. Filter Status: A differential pressure switch will monitor the differential pressure across the filter when the fan is running. If the switch closes during normal operation a

dirty filter alarm will be annunciated. The OA, pre-filter and return air filter will be continuously monitored.

8. Temperature Alarms: If the return air temperature rises above a high limit set point (90°F adj.) or falls below a low limit set point (45°F adj.) an alarm will be generated at the CMIS.
9. Freeze Protection: The initial damper opening rate will be limited to 2% per minute until the damper has reached its minimum ventilation position. The outside air damper will modulate to a position less than the minimum damper position if the mixed air temperature drops below 45°F (adj.), if the mixed air temperature sensor fails the outside air damper will close and an alarm will be annunciated.
10. Fire Alarm / Fire-Smoke Damper: During normal conditions, the FACP will open all fire-smoke dampers. Upon a fire condition or if any supply air or return air smoke detectors indicate an alarm condition, the FACP will shutdown the fans, close all fire-smoke dampers and an alarm will be generated.

F. 92.EF.3.1 & 92.PRE.1, Exhaust Fan

1. Typical Exhaust Fan Control: During the occupied mode and upon a proof of its associated air handler, the exhaust fan will be enabled to operate. During the occupied mode the fan will be off. If the fan fails, as sensed by its current switch, an alarm will be generated at the OWS.

<u>EF-#</u>	<u>AHU-#</u>
PRE.1	AHU.1.1
PRE.2	AHU.3.5
PRE.3	AHU.3.6
EF.3.1	AHU.3.6
PRE.4	AHU.3.6

2. Damper Control (EF.3.1): Whenever the fan operates, its damper will open fully. When the fan is off, the damper will close.

3.3.14 Buildings 103/14 Sequence of Operations

A. 103/14.HTNG-HW.A.1, Bldg 14 Heating Hot Water System With Pumps

This system serves building 103 hydronic heating system but is located in attic of building 14. See Control Sequence C.HTNG-HW.1

- B. 103.UH.1.1-11, HW Unit Heaters: See Control Sequence C.UH-HW.2
- C. 103.FT.1.1-3, Fin Tube Convectors: See Control Sequence C.FT-HW.2
- D. 103.CUH.1.1, HW CHU: See Control Sequence C.CUH-HW.1
- E. 103.DXFCU.1.1, Liebert Cooling and Dehumidifying DX Fan Coil Unit

- 1. Run Conditions: The system shall operate continuously to maintain constant space temperature and humidity:

The system shall be controlled by its own self-contained controls and remote temperature and humidity controller. The system shall maintain a cooling set point of 70°F (adj.) and relative humidity set point of 50% (adj.).

- 2. Monitoring: The DDC system shall monitor space temperature and relative humidity and the operating status of the system. An alarm condition will be initiated by the DDC system if zone temperature increases 5°F or more above set point and if zone relative humidity increases 10% or more from set point.

- F. 103.DHAHU.1.1, Munters Cooling and Dehumidifying Unit

- 1. Run Conditions: The system shall operate continuously to maintain constant zone temperature and humidity:

The system shall be controlled by its own self-contained controls and remote temperature and humidity controller. The system shall maintain a cooling set point of 70°F (adj.) and relative humidity set point of 50% (adj.).

- 2. Monitoring: The DDC system shall monitor zone temperature and relative humidity and the operating status of the system. An alarm condition will be initiated by the DDC system if zone temperature increases 5°F or more above set point and if zone relative humidity increases 10% or more from set point.

The DDC system shall also monitor the supply air and return air temperature and the operating status of the unit.

- 3. Heating System Controls Integration: The DDC system shall lockout the operation of the zone unit heaters whenever the Munters unit is in cooling mode. If the building heating hot water system is active, the DDC system shall enable the

unit heaters prior to enabling any electric resistance heating associated with the Munters unit.

G. 103.EF.1.1 & 2, Exhaust Fans With Inlet Dampers

1. Run Conditions:

- a. EF.1.2 shall be controlled by existing manual On/Off switch. Whenever the exhaust fan is energized the associated inlet air dampers (normally closed) shall be powered open.
- b. EF.1.1 shall be controlled by a new Hand-Off-Auto (HOA) switch.
- c. Hand Mode: Exhaust fan shall be energized and associated inlet air dampers (normally closed) shall be powered open.
- d. Auto Mode: In the occupied or unoccupied periods, if the zone temperature exceeds the zone cooling set point of 74°F (adj.), and the outside air temperature is 2°F or more below the zone temperature, the exhaust fan shall be energized and the associated outside air inlet dampers shall be powered open. The exhaust fan shall continue to run until the space temperature is 2°F below the space cooling set point temperature.

3.3.15 Building 104 Sequence of Operations

A. 104.VAVAHU.1.1, 1.2 & 1.3, VAV Air Handling Units

1. The supply fan, return fan and interlocked exhaust fans shall start thru respective H-O-A switches, when the exhaust fans start their respective motorized back draft dampers shall open and when the exhaust fans stop reverse shall occur. Provide end switches for O.A. intake dampers and return air dampers to open these dampers first before the units are started.
2. A duct static pressure sensor located in the supply duct shall reset the supply fan speed to maintain a minimum duct static pressure. A high limit static pressure sensor located at the supply fan discharge shall prevent supply fan from developing over three inches of static pressure. A velocity pressure signal from the velocity pressure sensor for the return fan shall reset return fan speed to maintain a constant CFM difference between the CFM for the supply fan and the CFM for the return fan.
3. Dampers: When the outside air temperature is above 56°F and the supply fan and return fan are operating at maximum CFM

and the return air temperature is lower than the outside air temperature, OA, RA and EA dampers shall be balanced by DDC system to provide scheduled exhaust air, return air and outside air. When the outside air temperature is above 56°F and the return air temperature is higher than the outside air temperature EA and OA (max) dampers shall be fully open and damper RA damper shall be fully closed.

4. When the outside air duct temperature sensor drops to 56°F duct temperature sensor shall modulate dampers as required to maintain 56°F.
5. When the supply fan discharge temperature drops to 52°F duct temperature sensor shall modulate steam heating coil valve for preheat coil to maintain 55°F.
6. When the supply fan discharge temperature rises to 58°F duct temperature sensor shall modulate cooling coil valve for cooling coil to maintain 58°F.
7. Room thermostats shall control for variable constant volume reheat box and reheat coil valve. On a drop in room temperature below 78°F room thermostat T5 thru pneumatic operator shall reduce air flow to the room to the boxes minimum setting. Air flow shall remain at its minimum between 72°F and 77°F. On a further drop in room temperature below 72°F room thermostat shall increase the air flow and modulate valve in parallel to maintain 72°F.
8. Humidity Control: Duct humidistat shall modulate humidifier valve to maintain 30 % relative humidity to its modulating type high limit duct humidistat set at 80 % relative humidity. Humidifier valve shall close whenever supply fan is off. Valve shall be interlocked with temperature switch to keep humidifier off until condensate approached steam temperature. Duct thermostat shall close on-off two-way control valve when outside air temperature rises above 58°F and open valve when outside air temperature drops below 56°F.
9. Freeze-stat shall automatically stop supply fan and return fan to prevent freezing whenever air temperature drops below 45°F. An alarm signal shall be initiated.
10. Smoke detectors and operation of smoke dampers:
 - a. Individual duct mounted smoke detectors in the return air and exhaust air ducts shall operate smoke dampers in the duct penetration of the smoke barrier. When smoke is detected in the return air or exhaust air the return air, exhaust air and supply air fans shall stop and respective smoke dampers shall close.
 - b. The smoke dampers in the supply air duct shall be interlocked with the respective supply fan. When smoke

is detected by the supply air smoke detector the supply fan shall stop.

- c. Smoke dampers shall close on loss of power.
- d. Use smoke detector auxiliary contracts for interlocking of HVAC functions.

B. 104.CH.1, Chilled Water System:

- 1. The chilled water pumps shall start and stop thru H-O-A switch.
- 2. See sequence of operation C.CH.1

C. 104.HTNG-HW.1, Hot Water System:

- 1. The hot water pumps shall start and stop thru H-O-A switches
- 2. When either or both pumps are in operation, steam control valves for the hot water convectors shall modulate in parallel to maintain the supply temperature at the control point.
- 3. The supply temperature shall be reset inversely with the outdoor air temperature as scheduled.

D. 104.GLY.1, Glycol System Monitoring: See sequence of operation C.GLY.1

E. 104.WFM.1.1-4, Water Flow Meters: The DDC system shall monitor and display the flow through venturi flow meters WFM.1.1 through 1.4.

F. 104.VAV, VAV and CV Boxes with Reheat Coils: See sequence of operation C.VAV.1

G. 104.CUH.1.1-9, Hot Water Cabinet Heaters: See sequence of operation C.CUH-HW.1

H. 104.UH.A.1-12 & UH.3.1, Hot Water Unit Heaters: See sequence of operation C.CUH-HW.1

I. 104.UH.1.1-3, Steam Unit Heaters: See sequence of operation C.CUH-HW.1

J. 104.EF.A.1 & 2 & 1.1: Exhaust fans EF.1.1, EF.A.1 and EF.A.2 shall be energized whenever the air handling units are energized.

K. 104.EF.A.3-6: Attic exhaust fans shall be energized when space temperature reaches 90°F set point.

L. 104.UH.A.1-14: Unit heaters shall cycle whenever space temperature is 50°F or below.

----- END -----

SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Water piping to connect HVAC equipment, and necessary to complete any work in this project including the following:
 - 1. Chilled water and heating hot water piping.
 - 2. Modifications to domestic water make-up piping.
 - 3. Glycol-water piping.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 31 20 00, EARTH MOVING: Excavation and backfill.
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION: General mechanical requirements and items, which are common to more than one section of Division 23.
- F. Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION: Piping insulation.
- G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, which includes welding qualifications.
- B. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.
- C. For mechanical pressed sealed fittings, only tools of fitting manufacturer shall be used.
- D. Mechanical pressed fittings shall be installed by factory trained workers.
- E. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be the same manufacturer as the grooved components.
 - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers.
 - 2. Pipe and tubing, with specification, class or type, and schedule.
 - 3. Pipe fittings, including miscellaneous adapters and special fittings.
 - 4. Flanges, gaskets and bolting.
 - 5. Grooved joint couplings and fittings.
 - 6. Valves of all types.
 - 7. All specified hydronic system components.
 - 8. Water flow measuring devices.
 - 9. Gages.
 - 10. Thermometers and test wells.
 - 11. Electric heat tracing systems.
- C. Submit the welder's qualifications in the form of a current (less than one year old) and formal certificate.
- D. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

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. American National Standards Institute, Inc.
- B. American Society of Mechanical Engineers/American National Standards Institute, Inc. (ASME/ANSI):
 - B1.20.1-83(R2006).....Pipe Threads, General Purpose (Inch)
 - B16.4-06.....Gray Iron Threaded FittingsB16.18-01 Cast
Copper Alloy Solder joint Pressure fittings
 - B16.23-02.....Cast Copper Alloy Solder joint Drainage
fittings
 - B40.100-05.....Pressure Gauges and Gauge Attachments
- C. American National Standards Institute, Inc./Fluid Controls Institute (ANSI/FCI):
 - 70-2-2006.....Control Valve Seat Leakage
- D. American Society of Mechanical Engineers (ASME):
 - B16.1-98.....Cast Iron Pipe Flanges and Flanged Fittings

- B16.3-2006.....Malleable Iron Threaded Fittings: Class 150 and
300
- B16.4-2006.....Gray Iron Threaded Fittings: (Class 125 and
250)
- B16.5-2003.....Pipe Flanges and Flanged Fittings: NPS ½
through NPS 24 Metric/Inch Standard
- B16.9-07.....Factory Made Wrought Butt Welding Fittings
- B16.11-05.....Forged Fittings, Socket Welding and Threaded
- B16.18-01.....Cast Copper Alloy Solder Joint Pressure
Fittings
- B16.22-01.....Wrought Copper and Bronze Solder Joint Pressure
Fittings.
- B16.24-06.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings
- B16.39-06.....Malleable Iron Threaded Pipe Unions
- B16.42-06.....Ductile Iron Pipe Flanges and Flanged Fittings
- B31.1-08.....Power Piping
- E. American Society for Testing and Materials (ASTM):
- A47/A47M-99 (2004).....Ferritic Malleable Iron Castings
- A53/A53M-07.....Standard Specification for Pipe, Steel, Black
and Hot-Dipped, Zinc-Coated, Welded and
Seamless
- A106/A106M-08.....Standard Specification for Seamless Carbon
Steel Pipe for High-Temperature Service
- A126-04.....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings
- A183-03 Standard Specification for Carbon Steel Track
Bolts and Nuts
- A216/A216M-08 Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service
- A234/A234M-07 Piping Fittings of Wrought Carbon Steel and
Alloy Steel for Moderate and High Temperature
Service
- A307-07 Standard Specification for Carbon Steel Bolts
and Studs, 60,000 PSI Tensile Strength
- A536-84 (2004) Standard Specification for Ductile Iron Castings

A615/A615M-08	Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
A653/A 653M-08	Steel Sheet, Zinc-Coated (Galvanized) or Zinc- Iron Alloy Coated (Galvannealed) By the Hot-Dip Process
B32-08	Standard Specification for Solder Metal
B62-02	Standard Specification for Composition Bronze or Ounce Metal Castings
B88-03	Standard Specification for Seamless Copper Water Tube
B209-07	Aluminum and Aluminum Alloy Sheet and Plate
C177-04	Standard Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
C478-09	Precast Reinforced Concrete Manhole Sections
C533-07	Calcium Silicate Block and Pipe Thermal Insulation
C552-07	Cellular Glass Thermal Insulation
D3350-08	Polyethylene Plastics Pipe and Fittings Materials
C591-08	Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
D1784-08	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compound
D1785-06	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
D2241-05	Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
F439-06	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
F441/F441M-02	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
F477-08	Elastomeric Seals Gaskets) for Joining Plastic Pipe

- F. American Water Works Association (AWWA):
- C110-08.....Ductile Iron and Grey Iron Fittings for Water
- C203-02.....Coal Tar Protective Coatings and Linings for
Steel Water Pipe Lines Enamel and Tape Hot
Applied
- G. American Welding Society (AWS):
- B2.1-02.....Standard Welding Procedure Specification
- H. Copper Development Association, Inc. (CDA):
- CDA A4015-06.....Copper Tube Handbook
- I. Expansion Joint Manufacturer's Association, Inc. (EJMA):
- EMJA-2003.....Expansion Joint Manufacturer's Association
Standards, Ninth Edition
- J. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-67-02a.....Butterfly Valves
- SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded
Ends
- SP-71-05.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-80-08.....Bronze Gate, Globe, Angle and Check Valves
- SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends
- SP-110-96.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends
- SP-125-00.....Gray Iron and Ductile Iron In-line, Spring
Loaded, Center-Guided Check Valves
- K. National Sanitation Foundation/American National Standards Institute,
Inc. (NSF/ANSI):
- 14-06.....Plastic Piping System Components and Related
Materials
- 50-2009a.....Equipment for Swimming Pools, Spas, Hot Tubs
and other Recreational Water Facilities -
Evaluation criteria for materials, components,
products, equipment and systems for use at
recreational water facilities
- 61-2008.....Drinking Water System Components - Health
Effects

L. Tubular Exchanger Manufacturers Association: TEMA 9th Edition, 2007

1.6 SPARE PARTS

- A. For mechanical pressed sealed fittings provide tools required for each pipe size used at the facility.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

- A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

2.2 PIPE AND TUBING

- A. Chilled Water, Condenser Water, Heating Hot Water, and Glycol-Water:
 - 1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
 - 2. Copper water tube option: ASTM B88, Type K or L, hard drawn. Soft drawn tubing, 20 mm (3/4 inch) and larger, may be used for runouts routed under slab to floor mounted fan coil units.
- B. Extension of Domestic Water Make-up Piping: ASTM B88, Type K or L, hard drawn copper tubing.
- C. Pipe supports, including insulation shields, for above ground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

2.3 FITTINGS FOR STEEL PIPE

- A. 50 mm (2 inches) and Smaller: Screwed or welded joints.
 - 1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
 - 2. Forged steel, socket welding or threaded: ASME B16.11.
 - 3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 - 4. Unions: ASME B16.39.
 - 5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.
- B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Contractor's option: Grooved mechanical couplings and fittings are optional.
 - 1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
 - 2. Welding flanges and bolting: ASME B16.5:
 - a. Water service: Weld neck or slip-on, plain face, with 6 mm (1/8 inch) thick full face neoprene gasket suitable for 104 degrees C (220 degrees F).

- 1) Contractor's option: Convoluted, cold formed 150 pound steel flanges, with teflon gaskets, may be used for water service.
- b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.
- D. Grooved Mechanical Pipe Couplings and Fittings (Contractor's Option): Grooved Mechanical Pipe Couplings and Fittings may be used, with cut or roll grooved pipe, in water service up to 110 degrees C (230 degrees F) in lieu of welded, screwed or flanged connections. All joints must be rigid type.
 1. Grooved mechanical couplings: Malleable iron, ASTM A47 or ductile iron, ASTM A536, fabricated in two or more parts, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A449 and A183.
 2. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service.
 3. Grooved end fittings: Malleable iron, ASTM A47; ductile iron, ASTM A536; or steel, ASTM A53 or A106, designed to accept grooved mechanical couplings. Tap-in type branch connections are acceptable.

2.4 FITTINGS FOR COPPER TUBING

- A. Joints:
 1. Solder Joints: Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
 2. Contractor's Option: Mechanical press sealed fittings, double pressed type, NSF 50/61 approved, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements for up to 65 mm (2-1/2 inch) and below are optional for above ground water piping only.
 3. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch

tube in a single process to provide free flow where the branch tube penetrates the fitting.

- B. Bronze Flanges and Flanged Fittings: ASME B16.24.
- C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 99 degrees C (210 degrees F).
- E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass ball valves or dielectric nipples may be used in lieu of dielectric unions.

2.6 SCREWED JOINTS

- A. Pipe Thread: ANSI B1.20.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer.
- C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Shut-Off Valves
 - 1. Ball Valves (Pipe sizes 2" and smaller): MSS-SP 110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 2760 kPa (400 psig) working pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.
 - 2. Butterfly Valves (Pipe Sizes 2-1/2" and larger): Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation. MSS-SP 67, flange lug type or grooved end rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F). Valves shall be ANSI Leakage Class VI and rated for bubble tight shut-off to full valve pressure rating. Valve shall be rated for dead end service and bi-directional flow

capability to full rated pressure. Not permitted for direct buried pipe applications.

- a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
- b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
- c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 150 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
 - 2) Valves 200 mm (8 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.
 - 3) 3. Gate Valves (Contractor's Option in lieu of Ball or Butterfly Valves):
 - a) 50 mm (2 inches) and smaller: MSS-SP 80, Bronze, 1034 kPa (150 psig), wedge disc, rising stem, union bonnet.
 - b) 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke. MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.

E. Globe and Angle Valves

1. Globe Valves

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.

2. Angle Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.

- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for angle.
- 3. A dual purpose flow balancing valve and adjustable flow meter, with bronze or cast iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure.
- 4. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.
- F. Automatic Balancing Control Valves: Factory calibrated to maintain constant flow (plus or minus five percent) over system pressure fluctuations of at least 10 times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:
 - 1. Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
 - 2. Brass or ferrous body designed for 2067 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
 - 3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.
 - 4. Provide a readout kit including flow meter, probes, hoses, flow charts and carrying case.
- G. Manual Radiator/Convactor Valves: Brass, packless, with position indicator.

2.8 WATER FLOW MEASURING DEVICES

- A. Minimum overall accuracy plus or minus three percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.
- B. Venturi Type: Bronze, steel, or cast iron with bronze throat, with valved pressure sensing taps upstream and at the throat.
- C. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.

- D. Self-Averaging Annular Sensor Type: Brass or stainless steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.
- E. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- F. Flow Measuring Device Identification:
 - 1. Metal tag attached by chain to the device.
 - 2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in l/m (gpm).
- G. Portable Water Flow Indicating Meters:
 - 1. Minimum 150 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows, designed for 1205 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
 - 2. Bleed and equalizing valves.
 - 3. Vent and drain hose and two 3000 mm (10 feet) lengths of hose with quick disconnect connections.
 - 4. Factory fabricated carrying case with hose compartment and a bound set of capacity curves showing flow rate versus pressure differential.
 - 5. Provide one portable meter for each range of differential pressure required for the installed flow devices.
- H. Permanently Mounted Water Flow Indicating Meters: Minimum 150 mm (6 inch) diameter, or 450 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in lps (gpm), with three valve manifold and two shut-off valves.

2.9 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.
- B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gages in water service.
- C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.

1. For condenser water suction (compound): Minus 100 kPa (30 inches Hg) to plus 700 kPa (100 psig).

2.10 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.
- B. Provide one each of the following test items to the Resident Engineer:
 1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, -- 100 kPa (30 inches) Hg to 700 kPa (100 psig) range.
 3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.11 THERMOMETERS

- A. Mercury or organic liquid filled type, red or blue column, clear plastic window, with 150 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading.
- B. Case: Chrome plated brass or aluminum with enamel finish.
- C. Scale: Not less than 225 mm (9 inches), range as described below, two degree graduations.
- D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.
- E. Scale ranges:
 1. Chilled Water and Glycol-Water: 0-38 degrees C (32-100 degrees F).
 2. Hot Water and Glycol-Water: -1 - 116 degrees C (30-240 degrees F).

2.12 FIRESTOPPING MATERIAL

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

2.13 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. Provide tracing for outdoor piping subject to freezing temperatures (Below 38 degrees F) as follows:
 1. Make-up water

2. Chilled water, hot water piping at units and all other areas exposed to the weather.
 3. Domestic water lines exposed to weather.
- C. Heat tracing shall be provided to the extent shown on the drawings (Floor plans and Elevations). Heat tracing shall extend below grade to below the defined frost line.
- D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
1. Provide end seals at ends of circuits. Wire at the ends of the circuits is not to be tied together.
 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm (4 inch) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per feet of pipe.
- E. Electrical Heating Tracing Accessories:
1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
 2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
 3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 13 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
 4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION**3.1 GENERAL**

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Install heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.

- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Water treatment pot feeders and condenser water treatment systems.
 - 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.
- K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- L. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. Mechanical Joint: Pipe grooving shall be in accordance with joint manufacturer's specifications. Lubricate gasket exterior including lips, pipe ends and housing interiors to prevent pinching the gasket during installation. Lubricant shall be as recommended by coupling manufacturer.
- D. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.
- E. Solvent Welded Joints: As recommended by the manufacturer.

3.3 LEAK TESTING ABOVEGROUND PIPING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer. Tests may be either of those below, or a combination, as approved by the Resident Engineer.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

3.4 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
 - 1. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/S (6 feet per second), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the Resident Engineer.
 - 2. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any

system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 1.8 m/S (6 feet per second). Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.

3. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.5 WATER TREATMENT

- A. Install water treatment equipment and provide water treatment system piping.
- B. Close and fill system as soon as possible after final flushing to minimize corrosion.
- C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
- D. Utilize this activity, by arrangement with the Resident Engineer, for instructing VA operating personnel.

3.6 ELECTRIC HEAT TRACING

- A. Install tracing as recommended by the manufacturer.
- B. Coordinate electrical connections.

3.7 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Adjust red set hand on pressure gages to normal working pressure.

- - - E N D - - -

SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam, condensate and vent piping inside buildings. Associated with piping modifications in this project.

1.2 RELATED WORK

- A. Excavation and backfill: Section 31 20 00, EARTH MOVING.
- B. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- C. Piping insulation: Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
- D. Temperature and pressure sensors and valve operators: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, which includes welding qualifications.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and equipment supports.
 - 2. Pipe and tubing, with specification, class or type, and schedule.
 - 3. Pipe fittings, including miscellaneous adapters and special fittings.
 - 4. Flanges, gaskets and bolting.
 - 5. Valves of all types.
 - 6. All specified steam system components.
 - 7. Gages.
 - 8. Thermometers and test wells.
 - 9. Electric heat tracing systems.
- C. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- D. As-Built Piping Diagrams: Provide drawing as follows for steam and steam condensate piping and other central plant equipment.
 - 1. One wall-mounted stick file for prints. Mount stick file in the chiller plant or adjacent control room along with control diagram stick file.
 - 2. One set of reproducible drawings.

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. American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI):
 - B1.20.1-83(R2006).....Pipe Threads, General Purpose (Inch)
 - B16.4-2006.....Gray Iron Threaded Fittings
- C. American Society of Mechanical Engineers (ASME):
 - B16.1-2005.....Gray Iron Pipe Flanges and Flanged Fittings
 - B16.3-2006.....Malleable Iron Threaded Fittings
 - B16.9-2007.....Factory-Made Wrought Buttwelding Fittings
 - B16.11-2005.....Forged Fittings, Socket-Welding and Threaded
 - B16.14-91.....Ferrous Pipe Plugs, Bushings, and Locknuts with
Pipe Threads
 - B16.22-2001.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
 - B16.23-2002.....Cast Copper Alloy Solder Joint Drainage Fittings
 - B16.24-2006.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings, Class 150, 300, 400, 600, 900, 1500
and 2500
 - B16.39-98.....Malleable Iron Threaded Pipe Unions, Classes
150, 250, and 300
 - B31.1-2007.....Power Piping
 - B31.9-2008.....Building Services Piping
 - B40.100-2005.....Pressure Gauges and Gauge Attachments
 - Boiler and Pressure Vessel Code: SEC VIII D1-2001, Pressure Vessels,
Division 1
- D. American Society for Testing and Materials (ASTM):
 - A47-99.....Ferritic Malleable Iron Castings
 - A53-2007.....Pipe, Steel, Black and Hot-Dipped, Zinc-Coated,
Welded and Seamless
 - A106-2008.....Seamless Carbon Steel Pipe for High-Temperature
Service
 - A126-2004.....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings
 - A181-2006.....Carbon Steel Forgings, for General-Purpose
Piping
 - A183-2003 Carbon Steel Track Bolts and Nuts

- A216-2008 Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service
- A285-01 Pressure Vessel Plates, Carbon Steel, Low-and-
Intermediate-Tensile Strength
- A307-2007 Carbon Steel Bolts and Studs, 60,000 PSI Tensile
Strength
- A516-2006 Pressure Vessel Plates, Carbon Steel, for
Moderate-and- Lower Temperature Service
- A536-84(2004)e1 Standard Specification for Ductile Iron Castings
- B32-2008 Solder Metal
- B61-2008 Steam or Valve Bronze Castings
- B62-2009 Composition Bronze or Ounce Metal Castings
- B88-2003 Seamless Copper Water Tube
- F439-06 Socket-Type Chlorinated Poly (Vinyl Chloride)
(CPVC) Plastic Pipe Fittings, Schedule 80
- F441-02(2008) Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic
Pipe, Schedules 40 and 80
- E. American Welding Society (AWS):
- A5.8-2004.....Filler Metals for Brazing and Braze Welding
- B2.1-00.....Welding Procedure and Performance Qualifications
- F. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-67-95.....Butterfly Valves
- SP-70-98.....Cast Iron Gate Valves, Flanged and Threaded Ends
- SP-71-97.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-72-99.....Ball Valves with Flanged or Butt-Welding Ends
for General Service
- SP-78-98.....Cast Iron Plug Valves, Flanged and Threaded Ends
- SP-80-97.....Bronze Gate, Globe, Angle and Check Valves
- SP-85-94.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends
- G. Military Specifications (Mil. Spec.):
- MIL-S-901D-1989.....Shock Tests, H.I. (High Impact) Shipboard
Machinery, Equipment, and Systems

H. National Board of Boiler and Pressure Vessel Inspectors (NB): Relieving Capacities of Safety Valves and Relief Valves

I. Tubular Exchanger Manufacturers Association: TEMA 18th Edition, 2000

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.2 PIPE AND TUBING

A. Steam Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40.

B. Steam Condensate and Pumped Condensate Piping:

1. Concealed above ceiling, in wall or chase: Copper water tube ASTM B88, Type K, hard drawn.
2. All other locations: Copper water tube ASTM B88, Type K, hard drawn; or steel, ASTM A53, Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80.

C. Vent Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40, galvanized.

2.3 FITTINGS FOR STEEL PIPE

A. 50 mm (2 inches) and Smaller: Screwed or welded.

1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
2. Forged steel, socket welding or threaded: ASME B16.11.
3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron, except for steam and steam condensate piping. Provide 300 pound malleable iron, ASME B16.3 for steam and steam condensate piping. Cast iron fittings or piping is not acceptable for steam and steam condensate piping. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
4. Unions: ASME B16.39.
5. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 15 mm (1/2 inch) ID hose. No integral shut-off is required.

B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints.

1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
2. Welding flanges and bolting: ASME B16.5:

- a. Steam service: Weld neck or slip-on, raised face, with non-asbestos gasket. Non-asbestos gasket shall either be stainless steel spiral wound strip with flexible graphite filler or compressed inorganic fiber with nitrile binder rated for saturated and superheated steam service 750 degrees F and 1500 psi.
- b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

2.4 FITTINGS FOR COPPER TUBING

- A. Solder Joint:
 - 1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
- B. Bronze Flanges and Flanged Fittings: ASME B16.24.
- C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 121 degrees C (250 degrees F) for steam condensate and as required for steam service.
- E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass gate valves // or dielectric nipples // may be used in lieu of dielectric unions.

2.6 SCREWED JOINTS

- A. Pipe Thread: ANSI B1.20.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer.
- C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2100 mm (7 feet) or more above the floor or operating platform.
- D. Shut-Off Valves

1. Gate Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.
- b. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.
 - 1) High pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide 25 mm (1 inch) factory installed bypass with globe valve on valves 100 mm (4 inches) and larger.
 - 2) All other services: MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.

E. Globe and Angle Valves:

1. Globe Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger:
 - 1) Globe valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.

2. Angle Valves

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger:
 - 1) Angle valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for angle valves.

F. Swing Check Valves

- 1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 psig), 45 degree swing disc.
- 2. 65 mm (2-1/2 inches) and Larger:
 - a Check valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system: Cast steel body, ASTM A216 grade WCB, flanged,

OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.

- b. All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-71 for check valves.

G. Manual Radiator/Convactor Valves: Brass, packless, with position indicator.

2.8 STEAM SYSTEM COMPONENTS

A. Steam Trap: Each type of trap shall be the product of a single manufacturer. Provide trap sets at all low points and at 61 m (200 feet) intervals on the horizontal main lines.

1. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated on the drawings, traps shall be sized for capacities indicated at minimum pressure drop as follows:

- a. For equipment with modulating control valve: 1.7 kPa (1/4 psig), based on a condensate leg of 300 mm (12 inches) at the trap inlet and gravity flow to the receiver.
- b. For main line drip trap sets and other trap sets at steam pressure: Up to 70 percent of design differential pressure. Condensate may be lifted to the return line.

2. Trap bodies: Bronze, cast iron, or semi-steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping. For systems without relief valve traps shall be 5.

Mechanism: Brass, stainless steel or corrosion resistant alloy. rated for the pressure upstream of the PRV supplying the system.

3. Balanced pressure thermostatic elements: Phosphor bronze, stainless steel or monel metal.
4. Valves and seats: Suitable hardened corrosion resistant alloy.
5. Floats: Stainless steel.
6. Inverted bucket traps: Provide bi-metallic thermostatic element for rapid release of non-condensables.

B. Thermostatic Air Vent (Steam): Brass or iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 861 kPa (125 psig) working pressure, 20 mm (3/4 inch) screwed connections. Air vents shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure.

C. Steam Humidifiers:

1. Steam separator type that discharges steam into the air stream through a steam jacketed distribution manifold or dispersion tube.

Humidifiers shall be complete with Y-type steam supply strainer; modulating, normally closed steam control valve; normally closed condensate temperature switch; and manufacturer's standard steam trap.

2. Steam separator: Stainless steel or cast iron.
3. Distribution manifold: Stainless steel, composed of dispersion pipe and surrounding steam jacket, manifold shall span the width of duct or air handler, and shall be multiple manifold type under any of the following conditions:
 - a. Duct section height exceeds 900 mm (36 inches).
 - b. Duct air velocity exceeds 5.1 m/s (1000 feet per minute).
 - b. If within 900 mm (3 feet) upstream of fan, damper or pre-filter.
 - d. If within 3000 mm (10 feet) upstream of after-filter.

2.9 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.1, Accuracy Grade 1A, (pressure, vacuum, or compound), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.
- B. Provide brass, lever handle union cock. Provide brass/bronze pressure snubber for gages in water service. Provide brass pigtail syphon for steam gages.
- C. Range of Gages: For services not listed provide range equal to at least 130 percent of normal operating range:

Low pressure steam and steam condensate to 103 kPa(15 psig)	0 to 207 kPa (30 psig).
Medium pressure steam and steam condensate nominal 413 kPa (60 psig)	0 to 689 kPa (100 psig).
High pressure steam and steam condensate nominal 620 kPa to 861 kPa (90 to 125 psig)	0 to 1378 kPa (200 psig).
Pumped condensate, steam condensate, gravity or vacuum (30" HG to 30 psig)	0 to 415 kPa (60 psig)

2.10 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Provide one each of the following test items to the Resident Engineer:
 1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.

2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, 762 mm (30 inches) Hg to 689 kPa (100 psig) range.
3. 0 - 104 degrees C (32-220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.11 FIRESTOPPING MATERIAL

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.12 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. Provide tracing for outdoor piping subject to freezing temperatures (Below 38 degrees F) as follows:
 1. Steam piping exposed to weather.
 2. Steam condensate exposed to weather.
 3. Pumped condensate piping exposed to weather.
- C. Heat tracing shall be provided to the extent shown on the drawings (Floor Plans and Elevations). Heat tracing shall extend below grade to below the defined frost line.
- D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
 1. Provide end seals at ends of circuits. Wires at the ends of the circuits are not to be tied together.
 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm (4 inch) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per feet of pipe.
- E. Electrical Heating Tracing Accessories:
 1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
 2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.

3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 13 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope steam, condensate and drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.

- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- I. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- J. Where copper piping is connected to steel piping, provide dielectric connections.
- K. Pipe vents to the exterior. Where a combined vent is provided, the cross sectional area of the combined vent shall be equal to sum of individual vent areas. Slope vent piping one inch in 40 feet (0.25 percent) in direction of flow. Provide a drip trap elbow on relief valve outlets if the vent rises to prevent backpressure. Terminate vent minimum 0.3 M (12 inches) above the roof or through the wall minimum 2.5 M (8 feet) above grade with down turned elbow.

3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

3.3 STEAM TRAP PIPING

- A. Install to permit gravity flow to the trap. Provide gravity flow (avoid lifting condensate) from the trap where modulating control valves are used. Support traps weighing over 11 kg (25 pounds) independently of connecting piping.

3.4 LEAK TESTING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer in accordance with the specified requirements. Testing shall be performed in accordance with the specification requirements.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.

3.5 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Steam, Condensate and Vent Piping: No flushing or chemical cleaning required. Accomplish cleaning by pulling all strainer screens and cleaning all scale/dirt legs during start-up operation.

3.6 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Adjust red set hand on pressure gages to normal working pressure.

- - - E N D - - -

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 wiring, systems, equipment and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on drawings.
- C. Electrical service entrance equipment and arrangements for temporary and permanent connections to the utility's system shall conform to the utility's requirements. Coordinate fuses, circuit breakers and relays with the utility's system, and obtain utility approval for sizes and settings of these devices.
- D. Wiring ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways accordingly sized. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

- A. References to the International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL) and National Fire Protection Association (NFPA) are minimum installation requirement standards.
- B. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.

1.3 TEST STANDARDS

- A. All materials and equipment shall be listed, labeled or certified by a nationally recognized testing laboratory to meet Underwriters Laboratories, Inc., standards where test standards have been established. Equipment and materials which are not covered by UL Standards will be accepted provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed; Equipment, materials, or services 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 equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
2. Labeled; Equipment or materials 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 equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. Certified; equipment or product which:
 - a. Has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
 - b. Production of equipment or product is periodically inspected by a nationally recognized testing laboratory.
 - c. Bears a label, tag, or other record of certification.
4. Nationally recognized testing laboratory; laboratory which is approved, in accordance with OSHA regulations, by the Secretary of Labor.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

- A. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.
- B. Product Qualification:
 1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
 2. The Government reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.
- C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory

service to this installation within eight hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

Applicable publications listed in all Sections of Division are the latest issue, unless otherwise noted.

1.6 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts shall be available.
- B. When more than one unit of the same class or type of 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 shall be identified on the equipment being furnished and on all wiring diagrams.
- E. When Factory Testing Is Specified:
 - 1. The Government shall have the option of witnessing factory tests. The contractor shall notify the VA through the Resident Engineer a minimum of 15 working days prior to the manufacturers making the factory tests.
 - 2. Four copies of certified test reports containing all test data shall be furnished to the Resident Engineer prior to final inspection and not more than 90 days after completion of the tests.
 - 3. When equipment fails to meet factory test and re-inspection is required, the contractor shall be liable for all additional expenses, including expenses of the Government.

1.7 EQUIPMENT REQUIREMENTS

Where variations from the contract requirements are requested in accordance with Section 00 72 00, GENERAL CONDITIONS and Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, 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.

1.8 EQUIPMENT PROTECTION

- A. Equipment and materials shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.
 - 1. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Equipment shall include but not be limited to switchgear, switchboards, panelboards, transformers, motor control centers, motor controllers, uninterruptible power systems, enclosures, controllers, circuit protective devices, cables, wire, light fixtures, electronic equipment, and accessories.
 - 2. 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.
 - 3. Damaged equipment shall be, as determined by the Resident Engineer, placed in first class operating condition or be returned to the source of supply for repair or replacement.
 - 4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
 - 5. Damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

- A. All electrical work must comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J, OSHA Part 1910 subpart S and OSHA Part 1910 subpart K 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. When an electrical outage cannot be accomplished in this manner for the required work, the following requirements are mandatory:
 - 1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.

2. Electricians must wear personal protective equipment while working on energized systems in accordance with NFPA 70E.
3. Before initiating any work, a job specific work plan must be developed by the contractor with a peer review conducted and documented by the Resident Engineer and Medical Center staff. The work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used and exit pathways.
4. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the Resident Engineer.
- D. For work on existing stations, arrange, phase and perform work to assure electrical service for other buildings at all times. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.
- E. 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.
- F. Coordinate location of equipment and conduit with other trades to minimize interferences.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

- A. Equipment location shall be as close as practical to locations shown on the drawings.
- B. Working spaces shall not be less than specified in the NEC for all voltages specified.
- C. Inaccessible Equipment:
 1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
 2. "Conveniently 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.

1.11 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 (starters), fused and unfused safety switches, 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. Nameplates for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Nameplates 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 1/2 inch [12mm] high. Nameplates 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.

1.12 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.
- C. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary for the Government to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.
- D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
 - 1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
 - 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 - 3. Submit each section separately.

E. 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, pictures, nameplate data and test reports as required.
2. Elementary and interconnection wiring diagrams for communication and signal systems, control systems and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
3. Parts list which shall include those replacement parts recommended by the equipment manufacturer.

F. Manuals: Submit in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1. Maintenance and Operation Manuals: Submit as required for systems and equipment specified in the technical sections. Furnish four copies, bound in hardback binders, (manufacturer's standard binders) or an approved equivalent. Furnish one complete manual as specified in the technical section but in no case later than prior to performance of systems or equipment test, and furnish the remaining manuals prior to contract completion.
2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, equipment, building, name of Contractor, and contract 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 system 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 and replacement frequencies.
 - 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 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.
- G. Approvals will be based on complete submission of manuals together with shop drawings.
- H. After approval and prior to installation, furnish the Resident Engineer with one sample of each of the following:
- 1. A 300 mm (12 inch) length of each type and size of wire and cable along with the tag from the coils of reels from which the samples were taken.
 - 2. Each type of conduit coupling, bushing and termination fitting.
 - 3. Conduit hangers, clamps and supports.
 - 4. Duct sealing compound.
 - 5. Each type of receptacle, toggle switch, occupancy sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.14 ACCEPTANCE CHECKS AND TESTS

The contractor shall furnish the instruments, materials and labor for field tests.

1.15 TRAINING

- A. Training shall be provided in accordance with Article 1.25, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.
- B. Training shall be provided for the particular equipment or system as required in each associated specification.
- C. A training schedule shall be developed and submitted by the contractor and approved by the Resident Engineer at least 30 days prior to the planned training.

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SECTION 26 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies the furnishing, installation and connection of motors for HVAC equipment.

1.2 RELATED WORK:

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements common to more than one Section of Division 26.
- B. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Starters, control and protection for motors.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. 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.

- 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.
- F. Number of phases shall be as follows:
 - 1. Motors, less than 373 W (1/2 HP): Single phase.
 - 2. Motors, 373 W (1/2 HP) and larger: 3 phase.
 - 3. Exceptions:
 - a. Hermetically sealed motors.
 - b. Motors for equipment assemblies, less than 746 W (one HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- G. Motors shall be designed for operating the connected loads continuously in a 40°C (104°F) environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 40°C (104°F), the motors shall be rated for the actual ambient temperatures.
- H. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.
- I. 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.
- J. 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.
- K. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.
- L. 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%

M. 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 26 05 21
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW)

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of the low voltage power and lighting wiring.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-rated construction.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for cables and wiring.
- E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Installation of low-voltage conductors and cables in manholes and ducts.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

Low voltage cables shall be thoroughly tested at the factory per NEMA WC-70 to ensure that there are no electrical defects. Factory tests shall be certified.

1.5 SUBMITTALS

In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

- 1. Manufacturer's Literature and Data: Showing each cable type and rating.
- 2. Certifications: Two weeks prior to the final inspection, submit four copies of the following certifications to the COTR:
 - 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.

1.6 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):
 - D2301-04.....Standard Specification for Vinyl Chloride
Plastic Pressure-Sensitive Electrical Insulating
Tape
- C. National Fire Protection Association (NFPA):
 - 70-08.....National Electrical Code (NEC)
- D. National Electrical Manufacturers Association (NEMA):
 - WC 70-09.....Power Cables Rated 2000 Volts or Less for the
Distribution of Electrical Energy
- E. Underwriters Laboratories, Inc. (UL):
 - 44-05.....Thermoset-Insulated Wires and Cables
 - 83-08.....Thermoplastic-Insulated Wires and Cables
 - 467-071.....Electrical Grounding and Bonding Equipment
 - 486A-486B-03.....Wire Connectors
 - 486C-04.....Splicing Wire Connectors
 - 486D-05.....Sealed Wire Connector Systems
 - 486E-94.....Equipment Wiring Terminals for Use with Aluminum
and/or Copper Conductors
 - 493-07.....Thermoplastic-Insulated Underground Feeder and
Branch Circuit Cable
 - 514B-04.....Conduit, Tubing, and Cable Fittings
 - 1479-03.....Fire Tests of Through-Penetration Fire Stops

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Conductors and cables shall be in accordance with NEMA WC-70 and as specified herein.
- B. Single Conductor:
 - 1. Shall be annealed copper.
 - 2. Shall be stranded for sizes No. 8 AWG and larger, solid for sizes No. 10 AWG and smaller.
 - 3. Shall be minimum size No. 12 AWG, except where smaller sizes are allowed herein.
- C. Insulation:
 - 1. XHHW-2 or THHN-THWN shall be in accordance with NEMA WC-70, UL 44, and UL 83.

D. Color Code:

1. Secondary service feeder and branch circuit conductors shall be color-coded as follows:

208/120 volt	Phase	480/277 volt
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

- a. Lighting circuit "switch legs" and 3-way switch "traveling wires" shall have color coding that is unique and distinct (e.g., pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC.
Coordinate color coding in the field with the COTR.
2. Use solid color insulation or solid color coating for No. 12 AWG and No. 10 AWG branch circuit phase, neutral, and ground conductors.
3. Conductors No. 8 AWG and larger shall be 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 above.
 - c. Color as specified using 0.75 in [19 mm] wide tape. Apply tape in half-overlapping turns for a minimum of 3 in [75 mm] for terminal points, and in junction boxes, pull-boxes, troughs, 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.
4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.

2.2 SPLICES AND JOINTS

- A. In accordance with UL 486A, C, D, E, and NEC.
- B. Aboveground Circuits (No. 10 AWG and smaller):
 1. Connectors: Solderless, screw-on, reusable pressure cable type, rated 600 V, 220° F [105° C], with integral insulation, approved for copper and aluminum conductors.
 2. The integral insulator shall have a skirt to completely cover the stripped wires.
 3. The number, size, and combination of conductors, as listed on the manufacturer's packaging, shall be strictly followed.

C. Aboveground Circuits (No. 8 AWG and larger):

1. Connectors shall be indent, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
2. Field-installed compression connectors for cable sizes 250 kcmil and larger shall have not fewer than two clamping elements or compression indents per wire.
3. Insulate splices and joints with materials approved for the particular use, location, voltage, and temperature. Splice and joint insulation level shall be not less than the insulation level of the conductors being joined.
4. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.

D. Underground Branch Circuits and Feeders:

1. Submersible connectors in accordance with UL 486D, rated 600 V, 190° F [90° C], with integral insulation.

2.3 CONTROL WIRING

- A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified for power and lighting wiring, except that the minimum size shall be not less than No. 14 AWG.
- B. Control wiring shall be large enough such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.4 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 in accordance with the NEC, and as specified.
- B. Install all wiring in raceway systems.
- C. Splice cables and wires only in outlet boxes, junction boxes, pull-boxes, manholes, or handholes.
- D. Wires of different systems (e.g., 120 V, 277 V) shall not be installed in the same conduit or junction box system.
- 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. For panel boards, cabinets, wireways, switches, and equipment assemblies, neatly form, train, and tie the cables in individual circuits.

- G. Seal cable and wire entering a building from underground between the wire and conduit where the cable exits the conduit, with a non-hardening approved compound.
- H. Wire Pulling:
 - 1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables. Use lubricants approved for the cable.
 - 2. Use nonmetallic ropes for pulling feeders.
 - 3. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors, as approved by the COTR.
 - 4. All cables in a single conduit shall be pulled simultaneously.
 - 5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- I. No more than three single-phase branch circuits shall be installed in any one conduit.

3.2 INSTALLATION IN MANHOLES

- A. Install and support cables in manholes on the steel racks with porcelain or equivalent insulators. Train the cables around the manhole walls, but do not bend to a radius less than six times the overall cable diameter.

3.3 SPLICE INSTALLATION

- A. Splices and terminations shall be mechanically and electrically secure.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque values.
- C. Where the Government determines that unsatisfactory splices or terminations have been installed, remove the devices and install approved devices at no additional cost to the Government.

3.4 FEEDER IDENTIFICATION

- A. In each interior pull-box and junction box, install metal tags on all circuit cables and wires to clearly designate their circuit identification and voltage. The tags shall be the embossed brass type, 1.5 in [40 mm] in diameter and 40 mils thick. Attach tags with plastic ties.
- B. In each manhole and handhole, provide tags of the embossed brass type, showing the circuit identification and voltage. The tags shall be the embossed brass type, 1.5 in [40 mm] in diameter and 40 mils thick. Attach tags with plastic ties.

3.5 EXISTING WIRING

Unless specifically indicated on the plans, existing wiring shall not be reused for a new installation.

3.6 CONTROL AND SIGNAL WIRING INSTALLATION

- A. Unless otherwise specified in other sections, install wiring and connect to equipment/devices to perform the required functions as shown and specified.
- B. Except where otherwise required, install a separate power supply circuit for each system so that malfunctions in any system will not affect other systems.
- C. Where separate power supply circuits are not shown, connect the systems to the nearest panel boards of suitable voltages, which are intended to supply such systems and have suitable spare circuit breakers or space for installation.

3.7 CONTROL AND SIGNAL SYSTEM WIRING 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.
- D. In each manhole and handhole, install embossed brass tags to identify the system served and function.

3.8 ACCEPTANCE CHECKS AND TESTS

- A. Feeders and branch circuits shall have their insulation tested after installation and before connection to utilization devices, such as fixtures, motors, or appliances. Test each conductor with respect to adjacent conductors and to ground. Existing conductors to be reused shall also be tested.
- B. Applied voltage shall be 500VDC for 300-volt rated cable, and 1000VDC for 600-volt rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300-volt rated cable and 100 megohms for 600-volt rated cable.
- C. Perform phase rotation test on all three-phase circuits.
- D. The contractor shall furnish the instruments, materials, and labor for all tests.

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SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the general grounding and bonding requirements for electrical equipment and operations to provide a low impedance path for possible ground fault currents.
- B. "Grounding electrode system" refers to all electrodes required by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low Voltage power and lighting wiring.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present enough information to determine compliance with drawings and specifications.
 - 2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.
- C. Test Reports: Provide certified test reports of ground resistance.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR:
 - 1. Certification that the materials and installation are in accordance with the drawings and specifications.
 - 2. Certification by the contractor that the complete installation has been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

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.

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

B1-07.....Standard Specification for Hard-Drawn Copper Wire

B3-07.....Standard Specification for Soft or Annealed Copper Wire

B8-04.....Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B. 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

C2-07.....National Electrical Safety Code

C. National Fire Protection Association (NFPA):

70-08.....National Electrical Code (NEC)

99-2005.....Health Care Facilities

D. Underwriters Laboratories, Inc. (UL):

44-05Thermoset-Insulated Wires and Cables

83-08Thermoplastic-Insulated Wires and Cables

467-07Grounding and Bonding Equipment

486A-486B-03Wire Connectors

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment grounding conductors shall be UL 44 or UL 83 insulated stranded copper, except that sizes No. 10 AWG [6 mm²] and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG [25 mm²] and larger shall be identified per NEC.

B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes No. 10 AWG [6 mm²] and smaller shall be ASTM B1 solid bare copper wire.

C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.

2.2 GROUND RODS

- A. Steel or copper clad steel, 0.75 in [19 mm] diameter by 10 ft [30 M] long, conforming to UL 467.
- B. Quantity of rods shall be as required to obtain the specified ground resistance, as shown on the drawings.

2.3 CONCRETE ENCASED ELECTRODE

Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

2.4 MEDIUM VOLTAGE SPLICES AND TERMINATIONS

Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.5 GROUND CONNECTIONS

- A. Below Grade: Exothermic-welded type connectors.
- B. Above Grade:
 - 1. Bonding Jumpers: Compression-type connectors, using zinc-plated fasteners and external tooth lockwashers.
 - 2. Connection to Building Steel: Exothermic-welded type connectors.
 - 3. Ground Busbars: Two-hole compression type lugs, using tin-plated copper or copper alloy bolts and nuts.
 - 4. Rack and Cabinet Ground Bars: One-hole compression-type lugs, using zinc-plated or copper alloy fasteners.

2.6 EQUIPMENT RACK AND CABINET GROUND BARS

Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks with minimum dimensions of 0.375 in [4 mm] thick x 0.75 in [19 mm] wide.

2.7 GROUND TERMINAL BLOCKS

At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

2.8 GROUNDING BUS

Pre-drilled rectangular copper bar with stand-off insulators, minimum 0.25 in [6.3 mm] thick x 4 in [100 mm] high in cross-section, length as shown on drawings, with 0.281 in [7.1 mm] holes spaced 1.125 in [28 mm] apart.

PART 3 - EXECUTION**3.1 GENERAL**

- A. Ground in accordance with the NEC, as shown on drawings, and as specified herein.

B. System Grounding:

1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

C. Equipment Grounding: Metallic structures, including ductwork and building steel, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.

D. Special Grounding: For patient care area electrical power system grounding, conform to NFPA 99 and NEC.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

Make grounding connections, which are normally buried or otherwise inaccessible (except connections for which access for periodic testing is required), by exothermic weld.

3.3 MEDIUM VOLTAGE EQUIPMENT AND CIRCUITS

- A. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing medium voltage conductors, sized per NEC except that minimum size shall be 2 AWG [25 mm²]. Bond the equipment grounding conductors to the switchgear ground bus, to all manhole hardware and ground rods, to the cable shielding grounding provisions of medium-voltage cable splices and terminations, and to equipment enclosures.
- B. Lightning Arresters: Connect lightning arresters to the equipment ground bus or ground rods as applicable.

3.4 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
- B. Metallic Piping, Building Steel, and Supplemental Electrode(s):
 1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water pipe systems, building steel, and supplemental or made electrodes. Provide jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to UL 467.
 2. Provide a supplemental ground electrode and bond to the grounding electrode system.
- C. Panelboards, Motor Control Centers and Panelboards:

1. Connect the various feeder equipment grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
2. For service entrance equipment, connect the grounding electrode conductor to the ground bus.
3. Provide ground bars, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.
4. Connect metallic conduits that terminate without mechanical connection to the housing, by grounding bushings and grounding conductor to the equipment ground bus.

3.5 RACEWAY

A. Conduit Systems:

1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.
3. Conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.
4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a bare grounding conductor to the equipment ground bus.

B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders and power and lighting branch circuits.

C. Boxes, Cabinets, Enclosures, and Panelboards:

1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).
2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

D. Wireway Systems:

1. Bond the metallic structures of wireway to provide 100% electrical continuity throughout the wireway system, by connecting a No. 6 AWG

- [16 mm²] bonding jumper at all intermediate metallic enclosures and across all section junctions.
2. Install insulated No. 6 AWG [16 mm²] bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 50 ft [16 M].
 3. Use insulated No. 6 AWG [16 mm²] bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.
 4. Use insulated No. 6 AWG [16 mm²] bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 49 ft [15 M].
- E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.
- F. Ground lighting fixtures to the equipment grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.
- H. Raised Floors: Provide bonding of all raised floor components. //See details on the drawings. //
- I. Panelboard Bonding in Patient Care Areas: The equipment grounding terminal buses of the normal and essential branch circuit panel boards serving the same individual patient vicinity shall be bonded together with an insulated continuous copper conductor not less than No. 10 AWG [16 mm²]. These conductors shall be installed in rigid metal conduit.

3.6 CORROSION INHIBITORS

When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.7 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

- B. In operating rooms and at intensive care and coronary care type beds, bond the gases and suction piping at the outlets directly to the room or patient ground bus.

3.8 LIGHTNING PROTECTION SYSTEM

Bond the lightning protection system to the electrical grounding electrode system.

3.9 ELECTRICAL ROOM GROUNDING

Building Earth Ground Busbars: Provide ground busbar and mounting hardware at each electrical room and connect to pigtail extensions of the building grounding ring.

3.10 EXTERIOR LIGHT POLES

Provide 20 ft [6.1 M] of No. 4 bare copper coiled at bottom of pole base excavation prior to pour, plus additional unspliced length in and above foundation as required to reach pole ground stud.

3.11 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Services at power company interface points shall comply with the power company ground resistance requirements.
- D. Below-grade connections shall be visually inspected by the COTR prior to backfilling. The contractor shall notify the COTR 24 hours before the connections are ready for inspection.

3.12 GROUND ROD INSTALLATION

- A. For outdoor installations, drive each rod vertically in the earth, until top of rod is 24 in [609 mm] below final grade.
- B. For indoor installations, leave 4 in [100 mm] of rod exposed.

- C. Where permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.
- D. Where rock prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified resistance.

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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 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- C. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground conduits.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

- A. Manufacturer's Literature and Data: Showing each cable type and rating. The specific item proposed and its area of application shall be identified on the catalog cuts.
- B. Shop Drawings:
 - 1. Size and location of main feeders.
 - 2. Size and location of panels and pull-boxes.
 - 3. Layout of required conduit penetrations through structural elements.
- C. Certifications:
 - 1. Two weeks prior to the final inspection, submit four copies of the following certifications to the COTR:
 - a. Certification by the manufacturer that the material conforms to the requirements of the drawings and specifications.
 - b. Certification by the contractor that the material has 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):
 - 70-08.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
 - 1-05.....Flexible Metal Conduit
 - 5-04.....Surface Metal Raceway and Fittings
 - 6-07.....Electrical Rigid Metal Conduit - Steel
 - 50-95.....Enclosures for Electrical Equipment
 - 360-093.....Liquid-Tight Flexible Steel Conduit
 - 467-07.....Grounding and Bonding Equipment
 - 514A-04.....Metallic Outlet Boxes
 - 514B-04.....Conduit, Tubing, and Cable Fittings
 - 514C-96.....Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers
 - 651-05.....Schedule 40 and 80 Rigid PVC Conduit and Fittings
 - 651A-00.....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-2-03.....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
 - TC-3-04.....PVC Fittings for Use with Rigid PVC Conduit and Tubing
 - FB1-07.....Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

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. Rigid steel: Shall conform to UL 6 and ANSI C80.1.
2. Rigid intermediate steel conduit (IMC): Shall conform to UL 1242 and ANSI C80.6.
3. 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.
4. Flexible galvanized steel conduit: Shall conform to UL 1.
5. Liquid-tight flexible metal conduit: Shall conform to UL 360.
6. Direct burial plastic conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high density polyethylene (PE).
7. Surface metal raceway: Shall conform to UL 5.

C. Conduit Fittings:

1. Rigid steel and IMC conduit fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
 - c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
 - d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - e. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
 - f. Sealing fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
2. 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.
- 3. Flexible steel conduit fittings:
 - a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
 - b. Clamp-type, with insulated throat.
- 4. 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.
- 5. Direct burial plastic conduit fittings:
 - Fittings shall meet the requirements of UL 514C and NEMA TC3.
- 6. 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.
- 7. 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. Cutting or Holes:
1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of the COTR prior to drilling through structural elements.
 2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except where permitted by the COTR as required by limited working space.
- B. 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.
- C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal clearances around the conduit and make watertight.

3.2 INSTALLATION, GENERAL

- A. In accordance with UL, NEC, as shown, and as specified herein.
- B. Essential (Emergency) raceway systems shall be entirely independent of other raceway systems, except where shown on drawings.
- 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. Support within 12 in [300 mm] of changes of direction, and within 12 in [300 mm] of each enclosure to which connected.
8. Close ends of empty conduit with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
9. Conduit installations under fume and vent hoods are prohibited.
10. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.
11. 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.

E. Layout and Homeruns:

1. Install conduit with wiring, including homeruns, as shown on drawings.
2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted approved by the COTR.

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.
2. Align and run conduit in direct lines.
3. Install conduit through concrete beams only:
 - a. Where shown on the structural drawings.

- b. As approved by the COTR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
- 4. Installation of conduit in concrete that is less than 3 in [75 mm] thick is prohibited.
 - a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.
 - b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.
 - c. Install conduits approximately in the center of the slab so that there will be a minimum of 0.75 in [19 mm] of concrete around the conduits.
- 5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.
- B. Above Furred or Suspended Ceilings and in Walls:
 - 1. Conduit for conductors above 600 V: Rigid steel. Mixing different types of conduits indiscriminately in the same system is prohibited.
 - 2. Conduit for conductors 600 V and below: Rigid steel, IMC, or EMT. Mixing different types of conduits indiscriminately in the same system is prohibited.
 - 3. Align and run conduit parallel or perpendicular to the building lines.
 - 4. Connect recessed lighting fixtures to conduit runs with maximum 6 ft [1.8 M] of flexible metal conduit extending from a junction box to the fixture.
 - 5. Tightening setscrews with pliers is prohibited.

3.4 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on the drawings, exposed conduit is only permitted in mechanical and electrical rooms.
- B. Conduit for Conductors above 600 V: Rigid steel. Mixing different types of conduits indiscriminately in the system is prohibited.
- C. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or 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.

H. Painting:

1. Paint exposed conduit to match adjacent surfaces as selected by COTR.
2. Paint all conduits containing cables rated over 600 V safety orange.
In addition, paint legends, using 2 in [50 mm] high black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 20 ft [6 M] intervals in between.

3.5 DIRECT BURIAL INSTALLATION

Refer to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.6 HAZARDOUS LOCATIONS

- A. Use rigid steel conduit only, notwithstanding requirements otherwise specified in this or other sections of these specifications.
- B. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.7 WET OR DAMP LOCATIONS

- A. Unless otherwise shown, use conduits of rigid steel or IMC.
- 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. Unless otherwise shown, use rigid steel or IMC conduit within 5 ft [1.5 M] of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

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.

3.9 EXPANSION JOINTS

- A. Conduits 3 in [75 mm] 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 3 in [75 mm] with junction boxes on both sides of the expansion joint. Connect conduits to junction boxes with sufficient slack of flexible conduit to produce 5 in [125 mm] vertical drop midway between the ends. Flexible conduit shall have a bonding jumper installed. In lieu of this flexible conduit, expansion and deflection couplings as specified above for conduits 15 in [375 mm] and larger 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.
- F. Hollow Masonry: Toggle bolts.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. 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.
- C. 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.
- D. 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.
- E. 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.
- F. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."
- G. On all branch circuit junction box covers, identify the circuits with black marker.

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SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of precast manholes and pullboxes with ducts to form a complete underground raceway system.
- B. "Duct" and "conduit," and "rigid metal conduit" and "rigid steel conduit" are used interchangeably in this specification.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings and boxes for raceway systems.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Coordinate layout and installation of ducts, manholes and pull-boxes with final arrangement of other utilities, site grading, and surface features, as determined in the field.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include manholes, pullboxes, duct materials, and hardware. Submit plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories and details.
 - 3. Proposed deviations from details on the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes or pullboxes at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit four copies to the COTR for approval prior to construction.

- C. Certifications: Two weeks prior to the final inspection, submit four copies of the following certifications to the COTR:
1. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 2. 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
318/318M-05.....Building Code Requirements for Structural
Concrete & Commentary
SP-66-04.....ACI Detailing Manual
- C. American National Standards Institute (ANSI):
- 77-07.....Underground Enclosure Integrity
- D. American Society for Testing and Materials (ASTM):
- C478-09.....Standard Specification for Precast Reinforced
Concrete Manhole Sections
C858-09.....Underground Precast Concrete Utility Structures
C990-09.....Standard Specification for Joints for Concrete
Pipe, Manholes and Precast Box Sections Using
Preformed Flexible Joint Sealants.
- E. Institute of Electrical and Electronic Engineers (IEEE):
- C2-07National Electrical Safety Code
- F. National Electrical Manufacturers Association (NEMA):
- TC 2-03.....Electrical Polyvinyl Chloride (PVC) Tubing And
Conduit
TC 3-2004.....PVC Fittings for Use With Rigid PVC Conduit And
Tubing
TC 6 & 8 2003.....PVC Plastic Utilities Duct For Underground
Installations
TC 9-2004.....Fittings For PVC Plastic Utilities Duct For
Underground Installation
- G. National Fire Protection Association (NFPA):
- 70-08.....National Electrical Code (NEC)

H. Underwriters Laboratories, Inc. (UL):

- 6-07.....Electrical Rigid Metal Conduit-Steel
- 467-07.....Grounding and Bonding Equipment
- 651-05.....Schedule 40 and 80 Rigid PVC Conduit and
Fittings
- 651A-00.....Type EB and A Rigid PVC Conduit and HDPE
Conduit
- 651B-07.....Continuous Length HDPE Conduit

I. U.S. General Services Administration (GSA):

- A-A-60005-1998.....Frames, Covers, Gratings, Steps, Sump and Catch
Basin, Manhole

1.6 STORAGE

Lift and support pre-cast concrete structures only at designated lifting or supporting points.

PART 2 - PRODUCTS

2.1 PRE-CAST CONCRETE MANHOLES AND HARDWARE

- A. Structure: Factory-fabricated, reinforced-concrete, monolithically-poured walls and bottom. Frame and cover shall form top of manhole. Comply with ASTM C 858.
- B. Cable Supports:
 - 1. Cable stanchions shall be hot-rolled, heavy duty, hot-dipped galvanized "T" section steel, 2.25 in [56 mm] x 0.25 in [6 mm] in size, and punched with 14 holes on 1.5 in [38 mm] centers for attaching cable arms.
 - 2. Cable arms shall be 0.1875 in [5 mm] gauge, hot-rolled, hot-dipped galvanized sheet steel, pressed to channel shape. Arms shall be approximately 2.5 in [63 mm] wide x 14 in [350 mm] long.
 - 3. Insulators for cable supports shall be high-glazed, wet process porcelain, and shall completely encircle the cable.
 - 4. Equip each cable stanchion with two spare cable arms and six spare insulators for future use.
- C. Ladder: Fiberglass with 16 in [400 mm] rung spacing. Provide securely-mounted ladder for every manhole over 4 ft [1.2 M] deep.
- D. Ground Rod Sleeve: Provide a 3 in [75 mm] PVC sleeve in manhole floors so that a driven ground rod may be installed.
- E. Sump: Provide 12 in x 12 in [305 mm x 305 mm] covered sump frame and cover.

2.2 PULLBOXES

- A. General: Size as indicated on 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/SCTE 77 Tier 22 loading. Provide pulling irons, 0.875 in [22 mm] 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 drawings.
- B. Ducts (concrete-encased):
 - 1. Plastic Duct:
 - a. UL 651 and 651A Schedule 40 PVC.
 - b. Duct shall be suitable for use with 194° F [90° C] rated conductors.
 - 2. Conduit Spacers: Prefabricated plastic.
- C. Ducts (direct-burial):
 - 1. Plastic duct:
 - a. NEMA TC2 and TC3
 - b. UL 651, 651A, and 651B, Schedule 80 PVC or HDPE.
 - c. Duct shall be suitable for use with 167° F [75° C] rated conductors.
 - 2. Rigid metal conduit: UL6 and NEMA RN1 galvanized rigid steel, threaded type, half-lapped with 10 mil PVC tape.

2.4 GROUNDING

- A. Rods: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- B. Ground Wire: Stranded bare copper 6 AWG [16 mm²] minimum.

2.5 WARNING TAPE

Standard 4-mil polyethylene 3 in [76 mm] wide detectable tape, red with black letters, imprinted with "CAUTION - BURIED ELECTRIC CABLE BELOW" or similar.

2.6 PULL ROPE FOR SPARE DUCTS

Plastic with 200 lb [890 N] minimum tensile strength.

PART 3 - EXECUTION**3.1 MANHOLE AND PULLBOX INSTALLATION**

- A. Assembly and installation shall follow the printed instructions and recommendations of the manufacturer. Install manholes and pullboxes level and plumb.
 - 1. Units shall be installed on a 12 in [300 mm] level bed of 90% compacted granular fill, well-graded from the 1 in [25 mm] sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.
 - 2. Seal duct terminations so they are watertight.
- B. Access: Ensure the top of frames and covers are flush with finished grade.
- C. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 4 in [100 mm] above the manhole floor.
- D. Grounding in Manholes:
 - 1. Install a No. 3/0 AWG [95 mm²] bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
 - 2. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
 - 3. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG [16 mm²] bare copper jumper.

3.2 TRENCHING

- A. Before performing trenching work at existing facilities, the Ground Penetrating Radar Survey shall be carefully performed by certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.
- B. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.
- D. Cut the trenches neatly and uniformly.
- E. For Concrete-Encased Ducts:
 - 1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 4 ft [1.2 M] 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 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.

F. Conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place. Conduits shall be heavy wall rigid steel.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC and IEEE C2, as shown on the drawings, and as specified.
2. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 4 in [100 mm] in 100 ft [30 M].
3. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be taped galvanized rigid steel, and shall extend a minimum of 5 ft [1.5 M] outside the building foundation. Tops of conduits below building slab shall be minimum 24 in [610 mm] below bottom of slab.
4. Stub-ups, sweeps, and risers to equipment mounted on outdoor concrete slabs shall be taped galvanized rigid steel, and shall extend a minimum of 5 ft [1.5 M] away from the edge of slab.
5. Install insulated grounding bushings on the terminations.
6. Radius for turns of direction shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter. Use manufactured long sweep bends.
7. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 3 in [75 mm] above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 5 ft [1.5 M]. Secure

spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during pouring of concrete. Tie wires shall not act as substitute for spacers.

9. Duct lines shall be installed no less than 12 in [300 mm] from other utility systems, such as water, sewer, and chilled water.
 10. Clearances between individual ducts:
 - a. For like services, not less than 3 in [75 mm].
 - b. For power and signal services, not less than 6 in [150 mm].
 11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
 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. Seal conduits, including spare conduits, at building entrances and at outdoor equipment terminations with a suitable compound to prevent entrance of moisture and gases.
- B. Concrete-Encased Ducts and Conduits:
1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
 2. Duct lines shall consist of 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 24 in [600 mm] and not less than shown on the drawings, below finished grade.
 - b. Not less than 30 in [750 mm] and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Conduits crossing under grade slab construction joints shall be installed a minimum of 4 ft [1.2 M] below slab.
 4. Extend the concrete envelope encasing the ducts not less than 3 in [75 mm] beyond the outside walls of the outer ducts and conduits.
 5. Within 10 ft [3 M] of building manhole and pullbox 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, conduits, and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, conduits, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Conduit joints in concrete may be placed side by side horizontally, but shall be staggered at least 6 in [150 mm] 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 0.75 in [19 mm] reinforcing rod dowels extending 18 in [450 mm] 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 COTR.

C. Direct-Burial Duct and Conduits:

1. Install direct-burial ducts and conduits only where shown on the drawings. Provide direct-burial ducts only for low-voltage systems.
2. Join and terminate ducts and conduits with fittings recommended by the conduit manufacturer.
3. Tops of ducts and conduits shall be:
 - a. Not less than 24 in [600 mm] and not less than shown on the drawings, below finished grade.
 - b. Not less than 30 in [750 mm] and not less than shown on the drawings, below roads and other paved surfaces.
4. Do not kink the ducts or conduits. Compaction shall not deform the ducts.

D. Concrete-Encased and Direct-Burial Duct and Conduit Identification:

Place continuous strip of warning tape approximately 12 in [300 mm] above ducts or conduits before backfilling trenches. Warning tape shall be preprinted with proper identification.

E. Spare Ducts and Conduits: 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.

F. Duct and Conduit 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. The mandrel shall be not less than 12 in [3600 mm] long, and shall have a diameter not less than 0.5 in [13 mm] 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.

2. Mandrel pulls shall be witnessed by the COTR.

- G. Duct and Conduit Sealing: Seal the ducts and conduits at building entrances, and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.
- H. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 12 in [300 mm] in each direction. Perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.
- I. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.
- J. Connections to Existing Ducts: Where connections to existing duct banks are indicated, excavate around the duct banks 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.
- K. Partially-Completed Duct Banks: 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 conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 ft [0.6 M] back into the envelope and a minimum of 2 ft [0.6 M] beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 in [75 mm] from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately

12 in [300 mm] apart. Restrain reinforcing assembly from moving during pouring of concrete.

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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 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 electrical 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.

~~SPEC WRITER NOTE: Paragraph C is for LEED projects. Delete paragraph or subparagraphs as necessary for specific projects.~~

- ~~C. The commissioning activities have been developed to support the United States Green Building Council (USGBC) LEED™ rating program and to support delivery of project performance in accordance with the Contract Documents developed with the approval of the VA.~~
 - ~~1. Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" prerequisite of "Fundamental Building Systems Commissioning".~~
 - ~~2. Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" requirements for the "Enhanced Building System Commissioning" credit.~~

~~3. Activities and documentation for the LEED™ section on "Measurement and Verification" requirements for the Measurement and Verification credit.~~

- ~~DC.~~ 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.

~~SPEC WRITER NOTE: Paragraph B should list the specific systems that will be commissioned. Edit the list as necessary for specific projects. The list below should match the list included in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. It is recommended that the list included in Section 01 91 00 be developed first and then copied/pasted into the list below. Both lists should be identical to prevent confusion.~~

- B. The following Electrical systems will be commissioned:

- ~~1. Utility Service Entrance Switchgear (Fuses and circuit breaker settings, metering, mimic diagram, gages, and controls).~~
- ~~2. Standby Generator Systems (Automatic transfer switches, fuel delivery pumps and motors, battery charging and instrumentation, muffler and exhaust system, and vibration isolation).~~
- ~~3. Generator Paralleling Switchboards (Automatic transfer switches, instrumentation, metering and gages, and controls).~~
- ~~4. Generator Power Distribution Systems (Fuses and circuit breaker settings, metering, gages, and controls).~~
- ~~5. Utility Power Unit Substations (Transformers and tap settings, fuses and circuit breaker settings, metering, gages, and controls).~~
- ~~6. Generator Power Unit Substations (Transformers and tap settings, fuses and circuit breaker settings, metering, gages, and controls).~~
- ~~7. Automatic Transfer Switches (Test with associated generator).~~

- ~~8. Normal Power Distribution Systems (Grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls).~~
- ~~91. Life Safety Power Distribution Systems (Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls Mechanical equipment and shutdown).~~
- ~~10. Critical Power Distribution Systems (Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls).~~
- ~~11. Essential Equipment Power Distribution Systems (Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls).~~
- ~~122. Lighting Controls (Control system hardware and software, scene settings, zone settings, occupancy sensor interface, and unoccupied cycle control).~~
- ~~13. Uninterruptible Power Supply Systems and UPS Power Distribution Systems (Battery chargers, static and dynamic power generators i.e. inverters, MG sets, metering and controls, system power displays, and distribution panel circuit breakers).~~

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 Resident Engineer 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 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.

3.2 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. The Commissioning Agent will witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.3 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.

3.4 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 26 Sections for additional Contractor training requirements.

----- END -----

SECTION 26 09 23
LIGHTING CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of the lighting controls.

1.2 RELATED WORK

- A. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Interface of lighting controls with HVAC control systems.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Product Data: For each type of lighting control, submit the following information.
 - 1. Manufacturer's catalog data.
 - 2. Wiring schematic and connection diagram.
 - 3. Installation details.
- C. Manuals:
 - 1. Submit, simultaneously with the shop drawings companion copies of complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.
 - 2. Two weeks prior to the final inspection, submit four copies of the final updated maintenance and operating manuals, including any changes, to the Resident Engineer.
- D. Certifications:
 - 1. Two weeks prior to final inspection, submit four copies of the following certifications to the Resident Engineer:
 - a. Certification by the Contractor that the equipment has 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 designation only.
- B. Green Seal (GS):
 - GC-12.....Occupancy Sensors
- C. Illuminating Engineering Society of North America (IESNA):
 - IESNA LM-48.....Guide for Calibration of Photoelectric Control Devices
- D. National Electrical Manufacturer's Association (NEMA)
 - C136.10.....American National Standard for Roadway Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing
 - ICS-1.....Standard for Industrial Control and Systems General Requirements
 - ICS-2.....Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
 - ICS-6.....Standard for Industrial Controls and Systems Enclosures
- E. Underwriters Laboratories, Inc. (UL):
 - 20.....Standard for General-Use Snap Switches
 - 773.....Standard for Plug-In Locking Type Photocontrols for Use with Area Lighting
 - 773ANonindustrial Photoelectric Switches for Lighting Control
 - 98.....Enclosed and Dead-Front Switches
 - 917.....Clock Operated Switches

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY SENSORS

- A. General: Provide factory fabricated motion sensor controls consisting of passive infrared, ultrasonic, and dual technology motion detecting systems which scans an area in search of changes in temperature and motion caused by the presence, or absence, of people within the desired viewing area. When no presence is detected for a period of up to 15 minutes, the lights are switched off.
- B. Ultrasonic/Dual Technology Ceiling Mounted Sensors (180 and 360 degree coverage):

1. Unit shall feature 360 degree viewing angle, with square feet of viewing area as noted below.
2. Unit shall utilize adaptive technology to automatically adjust detection threshold dynamically to compensate for constantly changing levels of activity and air flow through controlled space.
3. Capable of switching all types of fluorescent ballasts, both solid state electronic and magnetic ballasts, and incandescent loads, UL listed.
4. Load capacity as required per individual room arrangement; provide "Additional relays" when wattage to be controlled exceeds that specified for control unit.
5. Finish shall be white.
6. Equip with all necessary control units, relays, backboxes, mounting plates, etc. for complete operation.
7. Acceptable technologies consist of combination of passive infrared and ultrasonic detection (dual technology) or straight ultrasonic, as indicated.
8. Minimum 1000 square foot coverage for 180 degree units, and 2000 square foot coverage for 360 degree units, ceiling mounted. Rated 120/277 volts.
 - a. Type P Passive Infrared Sensor, 360 degree coverage: Hubbell "H-MOSS ATP1000C" series, Leviton "OSC15-IOW" series, or accepted equal.
 - b. Type D Dual Technology Sensor, 360 degree coverage (2000 square feet of coverage): Hubbell "H-MOSS ATD2000C" series, Leviton "USC20-MOW" series, or accepted equal.
 - c. Type U Ultrasonic Sensor, 360 degree coverage (1000 square foot of coverage): Hubbell "H-MOSS ATU1000C" series, Leviton "USC10-UOW" series, The Watt Stopper "WT-1105" series.
 - d. Type UH Ultrasonic Hallway Sensor, 360 degree coverage (2000 square foot of coverage, 16' x 64' coverage pattern): Hubbell "H-MOSS ATU2000C Hallway Application" series, or accepted equal.

C. Fluorescent High Bay Sensor (Warehouse Application):

1. Passive infrared sensor, white finish, relay type switch compatible with all types of fluorescent (electronic and magnetic ballasts) and incandescent lighting loads. Designed to remain on in the event of a failure. Provide sensor with ceiling bracket.
2. Provide unit with 3 relay outputs to control multiple fluorescent lighting fixtures (each relay output will control 480 watts).
3. Aisle coverage lense.

4. Temperature and humidity resistant receivers.
 5. User adjustable timeout delay, adjustable from 2 minutes to 30 minutes (Primary), and 1 hour to 4 hour (Secondary).
 6. Provide all power pack and slave packs as required for additional load capacity. Unit shall be used alone or to operate zones of lighting as shown on drawings. Unit shall operate multiple lighting circuits as indicated.
 7. Type PW: Hubbell Building Automation "LO-FLHB" series with LO-Lens-07 Aisle Lens, or accepted equal.
- D. Dual Technology Wall/Switch Mounted Sensors (Type W):
1. Unit shall have minimum 180 degree viewing angle, minimum 1000 square foot nominal viewing range; positive detector indication. Unit shall utilize adaptive technology to atomically adjust detection threshold dynamically to compensate for constantly changing levels of activity and air flow throughout controlled space.
 2. Capable of switching all types of fluorescent ballasts, both solid-state electronic and magnetic ballasts, and incandescent lighting loads.
 3. Dual element detection with time-out delay adjustable from 4 to 32 minutes.
 4. Ambient light override adjustable from full daylight to less than 40 footcandles.
 5. Equipped with manual off override, UL listed.
 6. Acceptable technologies consist of combination of passive infrared and ultrasonic detection (dual technology) or straight ultrasonic, as indicated.
 7. White color protruding less than 1" from wall plate, mounts in single gang outlet box and utilizes decorator style rectangular opening wall plate, stainless steel, satin finish.
 8. Type "W" shall be rated for minimum 600 watts at 120 VAC, or 1200 watts at 277 VAC as required; Hubbell "H-MOSS AD1277" series, Levitton "OSMT-MD" series, or accepted equal.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Installation shall be in accordance with the NEC, manufacturer's instructions and as shown on the drawings or specified.
- B. Aiming for wall-mounted and ceiling-mounted motion sensor switches shall be per manufacturer's recommendations.

- C. Set occupancy sensor "on" duration to 10 minute minimum for Bathrooms and Storage Rooms, and 15 minute minimum for Offices, Conference Rooms, and Hallways.
- D. Locate light level sensors as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for the scheduled light level at the typical work plane for that area.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations.
- B. Upon completion of installation, conduct an operating test to show that equipment operates in accordance with requirements of this section.
- C. Test for full range of dimming ballast and dimming controls capability. Observe for visually detectable flicker over full dimming range.
- D. Test occupancy sensors for proper operation. Observe for light control over entire area being covered.
- E. Program lighting control panels per schedule on drawings.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting control devices are in good operating condition and properly performing the intended function.

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SECTION 26 29 11
MOTOR STARTERS

PART 1 - GENERAL

1.1 DESCRIPTION

All motor starters and variable speed motor controllers, including installation and connection (whether furnished with the equipment specified in other Divisions or otherwise), shall meet these specifications.

1.2 RELATED WORK

- A. Other sections which specify motor driven equipment, except elevator motor controllers.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one Section of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, weights, mounting details, materials, running over current protection, size of enclosure, over current protection, wiring diagrams, starting characteristics, interlocking and accessories.
- C. Manuals:
 - 1. 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.
 - a. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance and operation.
 - b. Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.

- c. Elementary schematic diagrams shall be provided for clarity of operation.
- 2. Two weeks prior to the project final inspection, submit four copies of the final updated maintenance and operating manual to the Resident Engineer.
- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certifications to the Resident Engineer:
 - 1. Certification that the equipment has been properly installed, adjusted, and tested.
 - 2. Certification by the manufacturer that medium voltage motor controller(s) conforms to the requirements of the drawings and specifications. This certification must be furnished to the Resident Engineer prior to shipping the controller(s) to the job site.

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.....Recommended Practices and Requirements for
Harmonic Control in Electrical Power Systems
 - C37.90.1.....Standard Surge Withstand Capability (SWC) Tests
for Protective Relays and Relay Systems
- C. National Electrical Manufacturers Association (NEMA):
 - ICS 1.....Industrial Control and Systems General
Requirements
 - ICS 1.1.....Safety Guidelines for the Application,
Installation and Maintenance of Solid State
Control
 - ICS 2.....Industrial Control and Systems, Controllers,
Contactors and Overload Relays Rated 600 Volts
DC
 - ICS 6.....Industrial Control and Systems Enclosures
 - ICS 7.....Industrial Control and Systems Adjustable-Speed
Drives
 - ICS 7.1.....Safety Standards for Construction and Guide for
Selection, Installation and Operation of
Adjustable-Speed Drive Systems
- D. National Fire Protection Association (NFPA):
 - 70.....National Electrical Code (NEC)

E. Underwriters Laboratories Inc. (UL):

508.....Industrial Control Equipment

PART 2 - PRODUCTS

2.1 MOTOR STARTERS, GENERAL

- A. Shall be in accordance with the requirements of the IEEE, NEC, NEMA (ICS 1, ICS 1.1, ICS 2, ICS 6, ICS 7 and ICS 7.1) and UL.
- B. Shall have the following features:
 1. Separately enclosed unless part of another assembly.
 2. Circuit breakers and safety switches within the motor controller enclosures shall have external operating handles with lock-open padlocking provisions and shall indicate the ON and OFF positions.
 3. Motor control circuits:
 - a. Shall operate at not more than 120 volts.
 - b. Shall be grounded except as follows:
 - 1) Where isolated control circuits are shown.
 - 2) Where manufacturers of equipment assemblies recommend that the control circuits be isolated.
 - c. Incorporate a separate, heavy duty, control transformer within each motor controller enclosure to provide the control voltage for each motor operating over 120 volts.
 - d. Incorporate over current protection for both primary and secondary windings of the control power transformers in accordance with the NEC.
 4. Overload current protective devices:
 - a. Overload relay (thermal or induction type).
 - b. One for each pole.
 - c. Manual reset on the door of each motor controller enclosure.
 - d. Correctly sized for the associated motor's rated full load current.
 - e. Check every motor controller after installation and verify that correct sizes of protective devices have been installed.
 - f. Deliver four copies of a summarized list to the Resident Engineer, which indicates and adequately identifies every motor controller installed. Include the catalog numbers for the correct sizes of protective devices for the motor controllers.
 5. Hand-Off-Automatic (H-O-A) switch is required unless specifically stated on the drawings as not required for a particular starter. H-O-A switch is not required for manual motor starters.
 6. Incorporate into each control circuit a 120-volt, solid state 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.
7. Unless noted otherwise, equip with not less than two normally open and two normally closed auxiliary contacts. Provide green run pilot lights and H-O-A control devices as indicated, operable at front of enclosure without opening enclosure. Push buttons, selector switches, pilot lights, etc., shall be interchangeable.
 8. Enclosures:
 - a. Shall be the NEMA types shown on the drawings for the motor controllers and shall be the NEMA types which are the most suitable for the environmental conditions where the motor controllers are being installed.
 - b. Doors mechanically interlocked to prevent opening unless the breaker or switch within the enclosure is open. Provision for padlock must be provided.
 - c. Enclosures shall be primed and finish coated at the factory with the manufacturer's prime coat and standard finish.
 - C. Motor controllers incorporated with equipment assemblies shall also be designed for the specific requirements of the assemblies.
 - D. For motor controllers being installed in existing motor control centers or panelboards, coordinate with the existing centers or panelboards.
 - E. Additional requirements for specific motor controllers, as indicated in other sections, shall also apply.
 - F. Provide a disconnecting means or safety switch near and within sight of each motor. Provide all wiring and conduit required to facilitate a complete installation.

2.2 MANUAL MOTOR STARTERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Manual motor starters.
 1. Starters shall be general-purpose Class A, manually operated type with full voltage controller for induction motors, rated in horsepower.
 2. Units shall include overload protection, red pilot light, NO auxiliary contact, toggle operator and lock-out tabs.
- C. Fractional horsepower manual motor starters.
 1. Starters shall be general-purpose Class A, manually operated with full voltage controller for fractional horsepower induction motors.
 2. Units shall include thermal overload protection, red pilot light, toggle operator and lock-out tabs.
- D. Motor starting switches.

1. Switches shall be general-purpose Class A, manually operated type with full voltage controller for fractional horsepower induction motors.
2. Units shall include thermal overload protection, red pilot light, low NO auxiliary contact, toggle operator and lock-out tabs.

2.3 MAGNETIC MOTOR STARTERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Starters shall be general-purpose, Class A magnetic controllers for induction motors rated in horsepower. Minimum size 0.
- C. Where combination motor starters are used, combine starter with protective or disconnect device in a common enclosure.
- D. Provide phase loss protection for each starter, with contacts to de-energize the starter upon loss of any phase.
- E. Unless otherwise indicated, provide full voltage non-reversing across-the-line mechanisms for motors less than 75 HP, closed by coil action and opened by gravity. For motors 75 HP and larger, provide reduced voltage starters. Equip starters with 120V AC coils and individual control transformer unless otherwise noted. Locate "reset" button to be accessible without opening the enclosure.

2.4 REDUCED VOLTAGE MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above.
- B. Shall be installed as shown for motors on the contract drawings.
- C. Shall have closed circuit transition for the types which can incorporate such transition.
- D. Shall limit inrush currents to not more than 70 percent of the locked rotor currents.
- E. Provide phase loss protection for each starter, with contacts to de-energize the starter upon loss of any phase.

2.5 VARIABLE SPEED MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above.
- B. Shall be solid state, micro processor-based with adjustable frequency and voltage, three phase output capable of driving standard NEMA B design, three phase alternating current induction motors at full rated speed. The drives shall utilize a full wave bridge design incorporating diode rectifier circuitry with pulse width modulation (PWM). Other control techniques are not acceptable. Silicon controlled rectifiers (SCR) shall not be used in the rectifying circuitry. The drives shall be designed to be used on 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.

C. Unit shall be capable of operating within voltage parameters of plus 10 to minus 10 percent of line voltage, and be suitably rated for the full load amps of the maximum watts (HP) within its class.

D. Operating and Design Conditions:

Elevation: 500 feet AMSL

Temperatures: Maximum +90°F, Minimum -10°F

Relative Humidity: 95%

E. Controllers shall have the following features:

1. Isolated power for control circuits.
2. Manually re-settable motor 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 30 seconds. (Set timers to the equipment manufacturer's recommended time in the above range.)
5. Provide 4 to 20 ma current follower circuitry for interface with mechanical sensor devices.
6. Automatic frequency adjustment from 20 Hz to 60 Hz.
7. Provide circuitry to initiate an orderly shutdown when any of the conditions listed below occur. The controller shall not be damaged by any of these electrical disturbances and shall automatically restart when the conditions are corrected. The drive 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. Over voltage in excess of 10 percent.
 - d. Under voltage in excess of 10 percent.
 - e. Running over current above 110 percent (shall not automatically reset for this condition.)
 - f. Instantaneous overcurrent above 150 percent (shall not automatically reset for this condition).
 - g. Surge voltage in excess of 1000 volts.
 - h. Short duration power outages of 12 cycles or less (i.e., distribution line switching, generator testing, and automatic transfer switch operations.)
8. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for

- manual reset or fault correction; adjustable delay time between restart attempts.
9. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
 10. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- F. Minimum efficiency shall be 95 percent at 100 percent speed and 85percent at 50 percent speed.
 - G. The displacement power factor of the controller shall not be less than 95 percent under any speed or load condition.
 - H. Controllers shall include a door interlocked fused safety disconnect switch or door interlocked circuit breaker switch which will disconnect all input power.
 - I. Controller shall include a 3% line reactor, and RFI/EMI filter.
 - J. The following accessories are to be door mounted:
 1. AC Power on light.
 2. Ammeter (RMS motor current).
 3. HAND-OFF-AUTOMATIC switch.
 4. Manual speed control in HAND mode.
 5. System protection lights indicating that the system has shutdown and will not automatically restart.
 6. System protection light indicating that the system has shutdown but will restart when conditions return to normal.
 7. Manual variable speed controller by-pass switch.
 8. Diagnostic shutdown indicator lights for each shutdown condition.
 9. Provide two N.O. and two N.C. dry contacts rated 120 volts, 10 amperes, 60 HZ for remote indication of the following:
 - a. System shutdown with auto restart.
 - b. System shutdown without auto restart.
 - c. System running.
 10. Incorporate into each control circuit a 120-volt, time delay relay (ON delay), adjustable from 0.3-10 minutes, with transient protection. Provide transformer/s for the control circuit/s.
 11. Controller shall not add any current or voltage transients to the input AC power distribution system nor shall transients from other devices on the AC power distribution system affect the controller. Controllers shall be protected to comply with IEEE C37.90.1 and

- UL-508. Line noise and harmonic voltage distortion shall not exceed the values allowed by IEEE 519.
- K. Hardware and software to enable the BAS to monitor, control, and display controller status and alarms.
 - L. Network Communications Ports: Ethernet and RS-422/485.
 - M. Embedded BAS Protocols for Network Communications: As specified in Division 22.
 - N. Bypass Operation: Manually transfers motor between power converter output and bypass circuit, manually, automatically, or both. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.
 - O. Bypass Controller: Provide contactor-style bypass, arranged to isolate the power converter input and output and permit safe testing of the power converter, both energized and de-energized, while motor is operating in bypass mode. Motor overload protection shall be provided.
 - 1. Bypass Contactor: Load-break NEMA-rated contactor.
 - 2. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.
 - 3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor control equipment in accordance with manufacturer's recommendations, the NEC, NEMA and as shown on the drawings.
- B. Furnish and install heater elements in motor starters and to match the installed motor characteristics. Submit a list of all motors listing motor nameplate rating and heater element installed.
- C. Motor Data: Provide neatly-typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating and heater element installed.
- D. Connect hand-off auto selector switches so that automatic control only is by-passed in "manual" position and any safety controls are not by-passed.
- E. Install manual motor starters in flush enclosures in finished areas.
- F. Examine control diagrams indicated before ordering motor controllers. Should conflicting data exist in specifications, drawings and diagrams, request corrected data prior to placing orders.

3.2 ADJUSTING

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
- C. Adjust trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust at six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Resident Engineer before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers at 65 percent.
- E. In reduced-voltage solid-state controllers, set field-adjustable switches and program microprocessors for required start and stop sequences.

3.3 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
 - 1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Inspect contactors.
 - d. Clean motor starters and variable speed motor controllers.
 - e. Verify overload element ratings are correct for their applications.
 - f. If motor-running protection is provided by fuses, verify correct fuse rating.
 - g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - 2. Variable speed motor controllers:
 - a. Final programming and connections to variable speed motor controllers 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.

- b. Test all control and safety features of the variable frequency drive.

3.4 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the motor starters and variable speed motor controllers are in good operating condition and properly performing the intended functions.

3.5 SPARE PARTS

Two weeks prior to the final inspection, provide one complete set of spare fuses (including heater elements) for each starter/controller installed on this project.

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SECTION 26 29 21
DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of low voltage disconnect switches.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES 600 VOLTS AND BELOW: Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground faults.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for cables and wiring.
- E. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Motor rated toggle switches.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, enclosure types, and fuse types and classes.
 - 3. Show the specific switch and fuse proposed for each specific piece of equipment or circuit.
- C. Manuals:
 - 1. Provide complete maintenance and operating manuals for disconnect switches, including technical data sheets, wiring diagrams, and information for ordering replacement parts. Deliver four copies to the COR two weeks prior to final inspection.
 - 2. Terminals on wiring diagrams shall be identified to facilitate maintenance and operation.
 - 3. Wiring diagrams shall indicate internal wiring and any interlocking.

- D. Certifications: Two weeks prior to the final inspection, submit four copies of the following certifications to the COR:
1. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 2. 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. National Electrical Manufacturers Association (NEMA):
- FU 1-07.....Low Voltage Cartridge Fuses
- KS 1-06.....Enclosed and Miscellaneous Distribution
Equipment Switches (600 Volts Maximum)
- C. National Fire Protection Association (NFPA):
- 70-08.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
- 98-04.....Enclosed and Dead-Front Switches
- 248-00.....Low Voltage Fuses
- 977-94.....Fused Power-Circuit Devices

PART 2 - PRODUCTS

2.1 LOW VOLTAGE FUSIBLE SWITCHES RATED 600 AMPERES AND LESS

- A. In accordance with UL 98, NEMA KS1, and NEC.
- B. Shall have NEMA classification General Duty (GD) for 240 V switches and NEMA classification Heavy Duty (HD) for 480 V switches.
- C. Shall be HP rated.
- D. Shall have the following features:
1. Switch mechanism shall be the quick-make, quick-break type.
 2. Copper blades, visible in the OFF position.
 3. An arc chute for each pole.
 4. External operating handle shall indicate ON and OFF position and have lock-open padlocking provisions.
 5. Mechanical interlock shall permit opening of the door only when the switch is in the OFF position, defeatable to permit inspection.
 6. Fuse holders for the sizes and types of fuses specified.
 7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
 8. Ground lugs for each ground conductor.
 9. Enclosures:
 - a. Shall be the NEMA types shown on the drawings for the switches.

b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions. Unless otherwise indicated on the plans, all outdoor switches shall be NEMA 3R.

c. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel (for the type of enclosure required).

2.2 LOW VOLTAGE UNFUSED SWITCHES RATED 600 AMPERES AND LESS

Shall be the same as Low Voltage Fusible Switches Rated 600 Amperes and Less, but without provisions for fuses.

2.3 LOW VOLTAGE FUSIBLE SWITCHES RATED OVER 600 AMPERES TO 1200 AMPERES

Shall be the same as Low Voltage Fusible Switches Rated 600 Amperes and Less, except for the minimum duty rating which shall be NEMA classification Heavy Duty (HD). These switches shall also be HP rated.

2.4 MOTOR RATED TOGGLE SWITCHES

Refer to Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

2.5 LOW VOLTAGE CARTRIDGE FUSES

A. In accordance with NEMA FU1.

B. Motor Branch Circuits: Class RK1, time delay.

C. Control Circuits: Class CC, time delay.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches in accordance with the NEC and as shown on the drawings.

B. Fusible disconnect switches shall be furnished complete with fuses.

Arrange fuses such that rating information is readable without removing the fuse.

3.2 SPARE PARTS

Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fusible disconnect switch installed on the project. Deliver the spare fuses to the COR.

- - - E N D - - -

**SECTION 26 51 00
INTERIOR LIGHTING**

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies the furnishing, installation and connection of the interior lighting systems.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Product Data: For each type of lighting fixture (luminaire) designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of fixture designation, submit the following information.
 - 1. Material and construction details include information on housing, optics system and lens/diffuser.
 - 2. Physical dimensions and description.
 - 3. Wiring schematic and connection diagram.
 - 4. Installation details.
 - 5. Energy efficiency data.
 - 6. Photometric data based on laboratory tests complying with IESNA Lighting Measurements, testing and calculation guides.
 - 7. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours) and color temperature (degrees Kelvin).
 - 8. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts and total harmonic distortion (THD).
- C. Manuals:

1. Submit, simultaneously with the shop drawings companion copies of complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.
2. Two weeks prior to the final inspection, submit four copies of the final updated maintenance and operating manuals, including any changes, to the Resident Engineer.

D. Certifications:

1. Two weeks prior to final inspection, submit four copies of the following certifications to the Resident Engineer:
 - a. Certification by the Contractor that the equipment has 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 designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - C62.41-91.....Guide on the Surge Environment in Low Voltage
(1000V and less) AC Power Circuits
- C. National Fire Protection Association (NFPA):
 - 70.....National Electrical Code (NEC)
 - 101.....Life Safety Code
- D. National Electrical Manufacturer's Association (NEMA):
 - C82.1-97.....Ballasts for Fluorescent Lamps - Specifications
 - C82.2-02.....Method of Measurement of Fluorescent Lamp
Ballasts
 - C82.4-02.....Ballasts for High-Intensity-Discharge and Low-
Pressure Sodium Lamps
 - C82.11-02.....High Frequency Fluorescent Lamp Ballasts
- E. Underwriters Laboratories, Inc. (UL):
 - 496-96.....Edison-Base Lampholders
 - 542-99.....Lampholders, Starters, and Starter Holders for
Fluorescent Lamps
 - 844-95.....Electric Lighting Fixtures for Use in Hazardous
(Classified) Locations
 - 924-95.....Emergency Lighting and Power Equipment
 - 935-01.....Fluorescent-Lamp Ballasts
 - 1029-94.....High-Intensity-Discharge Lamp Ballasts
 - 1029A-06.....Ignitors and Related Auxiliaries for HID Lamp
Ballasts
 - 1598-00.....Luminaires
 - 1574-04.....Standard for Track Lighting Systems

2108-04.....Standard for Low-Voltage Lighting Systems

8750-08.....Light Emitting Diode (LED) Light Sources for Use
in Lighting Products

F. Federal Communications Commission (FCC):

Code of Federal Regulations (CFR), Title 47, Part 18

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES (LUMINAIRES)

- A. Shall be in accordance with NFPA 70 and UL 1598, as shown on drawings, and as specified.
- B. Sheet Metal:
 - 1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved) and parallel to each other as designed.
 - 2. Wireways and fittings shall be free of burrs and sharp edges and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 3. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
 - 4. Hinged door closure frames shall operate smoothly without binding when the fixture is in the installed position, latches shall function easily by finger action without the use of tools.
- C. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.
- D. Lamp Sockets:
 - 1. Fluorescent: Lampholder contacts shall be the biting edge type or phosphorous-bronze with silver flash contact surface type and shall conform to the applicable requirements of UL 542. Lamp holders for bi-pin lamps shall be of the telescoping compression type, or of the single slot entry type requiring a one-quarter turn of the lamp after insertion.
 - 2. High Intensity Discharge (H.I.D.): Shall have porcelain enclosures.
- E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.
- F. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- G. Metal Finishes:

1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
 2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
 3. Exterior finishes shall be as shown on the drawings.
- H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
- I. Light Transmitting Components for Fluorescent Fixtures:
1. Shall be 100 percent virgin acrylic.
 2. Flat lens panels shall have not less than 1/8 inch [3.2mm] of average thickness. The average thickness shall be determined by adding the maximum thickness to the minimum unpenetrated thickness and dividing the sum by 2.
 3. Unless otherwise specified, lenses, diffusers and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction of the lens without distortion or cracking.
- J. Lighting fixtures in hazardous areas shall be suitable for installation in Class and Group areas as defined in NFPA 70, and shall comply with UL 844.
- K. Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballast integral to the fixture. Assemblies designed to retrofit incandescent fixtures are prohibited except when specifically indicated for renovation of existing fixtures (not the lamp). Fixtures shall be designed for lamps as specified.

2.2 BALLASTS

- A. Linear Fluorescent Lamp Ballasts: Multi-voltage (120 - 277V) electronic programmed-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated; including the following features:
1. Lamp end-of-life detection and shutdown circuit (T5 lamps only).
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: Class A.
 4. Total Harmonic Distortion Rating: 10 percent or less.

5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. Ballast Factor: 0.87 or higher unless otherwise indicated.
 9. Power Factor: 0.98 or higher.
 10. Interference: Comply with 47 CFT 18, Ch.1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 11. To facilitate multi-level lamp switching, lamps within fixture shall be wired with the outermost lamp at both sides of the fixture on the same ballast, the next inward pair on another ballast and so on to the innermost lamp (or pair of lamps). Within a given room, each switch shall uniformly control the same corresponding lamp (or lamp pairs) in all fixture units that are being controlled.
 12. Where three-lamp fixtures are indicated, unless switching arrangements dictate otherwise, utilize a common two-lamp ballast to operate the center lamp in pairs of adjacent units that are mounted in a continuous row. The ballast fixture and slave-lamp fixture shall be factory wired with leads or plug devices to facilitate this circuiting. Individually mounted fixtures and the odd fixture in a row shall utilize a single-lamp ballast for operation of the center lamp.
 13. Dimming ballasts shall be as per above, except dimmable from 100% to 5% of rated lamp lumens.
- B. Low-Frequency Linear T8 Fluorescent Lamp Ballasts (allowed for Surgery Suites, Critical Care Units and Animal Labs): multi-voltage (120-277v) hybrid electronic-electromagnetic rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output; including the following features:
1. Automatic lamp starting after lamp replacement.
 2. Sound Rating: Class A.
 3. Total Harmonic Distortion Rating: 20 percent or less.
 4. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 5. Operating Frequency: 60 Hz.
 6. Lamp Current Crest Factor: 1.7 or less.
 7. Ballast Factor: 0.85 or higher unless otherwise indicated.
 8. Power Factor: 0.90 or higher.

9. Interference: Comply with 47 CFT 18, Ch.1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 10. To facilitate multi-level lamp switching, lamps within fixture shall be wired with the outermost lamp at both sides of the fixture on the same ballast, the next inward pair on another ballast and so on to the innermost lamp (or pair of lamps). Within a given room, each switch shall uniformly control the same corresponding lamp (or lamp pairs) in all fixture units that are being controlled.
 11. Where three-lamp fixtures are indicated, unless switching arrangements dictate otherwise, utilize a common two-lamp ballast to operate the center lamp in pairs of adjacent units that are mounted in a continuous row. The ballast fixture and slave-lamp fixture shall be factory wired with leads or plug devices to facilitate this circuiting. Individually mounted fixtures and the odd fixture in a row shall utilize a single-lamp ballast for operation of the center lamp.
- C. Compact Fluorescent Lamp Ballasts: Multi-voltage (120 - 277V), electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated; including the following features:
1. Lamp end-of-life detection and shutdown circuit.
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: Class A.
 4. Total Harmonic Distortion Rating: 10 percent or less.
 5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. Ballast Factor: 0.95 or higher unless otherwise indicated.
 9. Power Factor: 0.98 or higher.
 10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 11. Dimming ballasts shall be as per above, except dimmable from 100% to 5% of rated lamp lumens.

- D. Ballasts for high intensity discharge fixtures: Multi-tap voltage (120-480v) electromagnetic ballast for high intensity discharge lamps. Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:
1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
 3. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
 4. Open-circuit operation that will not reduce average life.
 5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- E. Electronic ballast for high intensity discharge metal-halide lamps shall include the following features unless otherwise indicated:
1. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
 2. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
 3. Lamp end-of-life detection and shutdown circuit.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: 20 percent or less.
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Lamp Current Crest Factor: 1.5 or less.
 8. Power Factor: 0.90 or higher.
 9. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 10. Protection: Class P thermal cut.

2.3 FLUORESCENT EMERGENCY BALLAST

- A. Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 2. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

- a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
- b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
- 3. Battery: Sealed, maintenance-free, nickel-cadmium type.
- 4. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
- 5. Integral Self-Test: Automatically initiates test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing LED.

2.4 LAMPS

A. Linear and U-shaped T5 and T8 Fluorescent Lamps:

- 1. Rapid start fluorescent lamps shall comply with ANSI C78.1; and instant-start lamps shall comply with ANSI C78.3.
- 2. Chromacity of fluorescent lamps shall comply with ANSI C78.376.
- 3. Except as indicated below, lamps shall be low-mercury energy saving type, have a color temperature between 3500° and 4100°K, a Color Rendering Index (CRI) of greater than 70, average rated life of 20,000 hours, and be suitable for use with dimming ballasts, unless otherwise indicated. Low mercury lamps shall have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.
- a. Over the beds in Intensive Care, Coronary Care, Recovery, Life Support, and Observation and Treatment areas; Electromyographic, Autopsy (Necropsy), Surgery, and certain dental rooms (Examination, Oral Hygiene, Oral Surgery, Recovery, Labs, Treatment, and X-Ray) use color corrected lamps having a CRI of 85 or above and a correlated color temperature between 5000 and 6000°K.

b. Other areas as indicated on the drawings.

B. Compact Fluorescent Lamps:

- 1. T4, CRI 80 (minimum), color temperature 3500 K, and suitable for use with dimming ballasts, unless otherwise indicated.

C. Long Twin-Tube Fluorescent Lamps:

- 1. T5, CRI 80 (minimum), color temperature between 3500° and 4100°K, 20,000 hours average rated life.

D. High Intensity Discharge Lamps:

1. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000°K.
2. Ceramic, Pulse-Start, Metal-Halide Lamps: CRI 80 (minimum), and color temperature 4000°K.
3. Low-Pressure Sodium Lamps: ANSI 78.41, CRI 0, and color temperature 1800°K.

2.5 RADIO-INTERFERENCE-FREE FLUORESCENT FIXTURES

- A. Shall be specially designed for suppressing radio-frequency energy produced within the fixtures. The Rules and Regulations of FCC (CFR 47, Part 18) shall apply.
- B. Lenses shall have a light-transparent layer of metal permanently bonded to them, and in positive contact with the steel housing or equal to prevent the radio-frequency interferences from passing through the lenses. The effective light transmittance of the lenses shall be not less than 75 percent.
- C. Install line filters within the body of the fixtures and wired in series with the supply circuit conductors to eliminate the transmission of radio frequency energy into the supply circuit.
- D. Ballasts shall be as specified herein.

2.6 FLUORESCENT BEDLIGHT FIXTURES

- A. Requirements:
 1. Fixed or movable arms are not acceptable.
 2. Exposed surfaces shall remain cool to the touch.
 3. Fixtures shall be lensed.
- B. Provide 4-position, pull cord switch to control the upward and downward portion of the light separately and simultaneously. Include an off position, except in single bed rooms where the switch shall energize and de-energize the downward light only. In the single bed rooms, provide a 2-position pull cord switch for "on-off" control of the downward lamps.
- C. Bedlight fixtures shall be rated for 120 volt operation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions and as shown on the drawings or specified.
- B. Align, mount and level the lighting fixtures uniformly.
- C. Fluorescent bed light fixtures shall be attached to the studs in the walls. Attachment to gypsum board only is not acceptable.
- D. Lighting Fixture Supports:
 1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural

- slab or to structural members within a partition, or above a suspended ceiling.
2. Shall maintain the fixture positions after cleaning and relamping.
 3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
 4. Hardware for recessed fluorescent fixtures:
 - a. Where the suspended ceiling system is supported at the four corners of the fixture opening, hardware devices shall clamp the fixture to the ceiling system structural members, or plaster frame at not less than four points in such a manner as to resist spreading of the support members and safely lock the fixture into the ceiling system.
 - b. Where the suspended ceiling system is not supported at the four corners of the fixture opening, hardware devices shall independently support the fixture from the building structure at four points.
 5. Hardware for surface mounting fluorescent fixtures to suspended ceilings:
 - a. In addition to being secured to any required outlet box, fixtures shall be bolted to a grid ceiling system at four points spaced near the corners of each fixture. The bolts shall be not less than 1/4 inch [6mm] secured to channel members attached to and spanning the tops of the ceiling structural grid members. Non-turning studs may be attached to the ceiling structural grid members or spanning channels by special clips designed for the purpose, provided they lock into place and require simple tools for removal.
 - b. In addition to being secured to any required outlet box, fixtures shall be bolted to ceiling structural members at four points spaced near the corners of each fixture. Pre-positioned 1/4 inch [6mm] studs or threaded plaster inserts secured to ceiling structural members shall be used to bolt the fixtures to the ceiling. In lieu of the above, 1/4 inch [6mm] toggle bolts may be used on new or existing ceiling provided the plaster and lath can safely support the fixtures without sagging or cracking.//
 - E. Furnish and install the specified lamps for all lighting fixtures installed and all existing lighting fixtures reinstalled under this project.
 - F. Coordinate between the electrical and ceiling trades to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.

- G. Bond lighting fixtures and metal accessories to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- H. Exercise electronic dimming ballasts over full range of dimming capability by operating the control devices(s) in the presence of the Resident Engineer. Observe for visually detectable flicker over full dimming range.
- I. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless a lesser period is specifically recommended by lamp manufacturer. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage. Replace any lamps and ballasts which fail during burn-in.
- J. At completion of project, relamp/reballast fixtures which have failed lamps/ballasts. Clean fixtures, lenses, diffusers and louvers that have accumulated dust/dirt/fingerprints during construction. Replace damaged lenses, diffusers and louvers with new.
- K. Dispose of lamps per requirements of Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.

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SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of exterior luminaires, poles, and supports.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
- E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground handholes and conduits.
- F. Section 26 09 23, LIGHTING CONTROLS: Controls for exterior lighting.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting, details, materials, required clearances, terminations, wiring and connection diagrams, photometric data, ballasts, poles, luminaires, lamps, and accessories. Include electronic photometric files in IES format, or provide link (URL) to manufacturer's website that contains photometric data for each specific fixture used, excluding wallpack fixtures.
- C. Manuals: Two weeks prior to final inspection, submit four copies of operating and maintenance manuals to the COTR. Include technical data

sheets, wiring and connection diagrams, and information for ordering replacement lamps, ballasts, and parts.

- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR:
1. Certification by the manufacturer that the materials are in accordance with the drawings and specifications.
 2. Certification by the contractor that the complete installation has been properly installed 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. Aluminum Association Inc. (AA):
AAH35.1-06.....Alloy and Temper Designation Systems for
Aluminum
- C. American Association of State Highway and Transportation Officials (AASHTO):
LTS-5-09Structural Supports for Highway Signs,
Luminaires and Traffic Signals
- D. American Concrete Institute (ACI):
318-05Building Code Requirements for Structural
Concrete
- E. American National Standards Institute (ANSI):
C81.61-09Electrical Lamp Bases - Specifications for
Bases (Caps) for Electric Lamps
- F. American Society for Testing and Materials (ASTM):
A123/A123M-09Zinc (Hot-Dip Galvanized) Coatings on Iron and
Steel Products
A153/A153M-09.....Zinc Coating (Hot-Dip) on Iron and Steel
Hardware
B108-03a-08Aluminum-Alloy Permanent Mold Castings
C1089-06Spun Cast Prestressed Concrete Poles
- G. Federal Aviation Administration (FAA):
AC 70/7460-IK-07.....Obstruction Lighting and Marking
AC 150/5345-43F-06.....Obstruction Lighting Equipment
- H. Illuminating Engineering Society of North America (IESNA)
HB-9-00.....Lighting Handbook

- RP-8-05.....Roadway Lighting
- RP-20-98.....Lighting for Parking Facilities
- RP-33-99.....Lighting for Exterior Environments
- LM-5-96.....Photometric Measurements of Area and Sports
Lighting Installations
- LM-50-99.....Photometric Measurements of Roadway Lighting
Installations
- LM-52-99.....Photometric Measurements of Roadway Sign
Installations
- LM-64-01.....Photometric Measurements of Parking Areas
- LM-72-97.....Directional Positioning of Photometric Data
- LM-79-08.....Approved Method for the Electrical and
Photometric Measurements of Solid-State Lighting
Products
- LM-80-08.....Approved Method for Measuring Lumen Maintenance
of LED Light Sources
- I. National Electrical Manufacturers Association (NEMA):
- C78.41-06.....Electric Lamps - Guidelines for Low-Pressure
Sodium Lamps
- C78.42-07Electric Lamps - Guidelines for High-Pressure
Sodium Lamps
- C78.43-07Electric Lamps - Single-Ended Metal-Halide
Lamps
- C78.1381-98.....Electric Lamps - 70-Watt M85 Double-Ended
Metal-Halide Lamps
- C82.4-02Ballasts for High-Intensity-Discharge and Low-
Pressure Sodium Lamps (Multiple-Supply Type)
- C136.3-05For Roadway and Area Lighting Equipment -
Luminaire Attachments
- C136.17-05Roadway and Area Lighting Equipment - Enclosed
Side-Mounted Luminaires for Horizontal-Burning
High-Intensity-Discharge Lamps - Mechanical
Interchangeability of Refractors
- ICS 2-00 (R2005)Controllers, Contactors and Overload Relays
Rated 600 Volts
- ICS 6-93 (R2006)Enclosures
- J. National Fire Protection Association (NFPA):
- 70-08National Electrical Code (NEC)

K. Underwriters Laboratories, Inc. (UL):

- 496-08Lampholders
- 773-95.....Plug-In, Locking Type Photocontrols for Use
with Area Lighting
- 773A-06Nonindustrial Photoelectric Switches for
Lighting Control
- 1029-94.....High-Intensity-Discharge Lamp Ballasts
- 1598-08Luminaires
- 8750-08.....Light Emitting Diode (LED) Light Sources for
Use in Lighting Products

1.6 DELIVERY, STORAGE, AND HANDLING

Provide manufacturer's standard provisions for protecting pole finishes during transport, storage, and installation. Do not store poles on ground. Store poles so they are at least 12 in [305 mm] above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

PART 2 - PRODUCTS**2.1 MATERIALS AND EQUIPMENT**

Materials and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.

2.2 LUMINAIRES

- A. Per UL 1598 and NEMA C136.17. Luminaires shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat, and safe cleaning and relamping.
- B. Light distribution pattern types shall be as shown on the drawings.
- C. Incorporate ballasts in the luminaire housing, except where otherwise shown on the drawings.
- D. Lenses shall be frame-mounted, heat-resistant, borosilicate glass, with prismatic refractors, unless otherwise shown on the drawings. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging-resistant, resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- E. Pre-wire internal components to terminal strips at the factory.
- F. Bracket-mounted luminaires shall have leveling provisions and clamp-type adjustable slip-fitters with locking screws.
- G. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.

- H. Provide manufacturer's standard finish, as scheduled on the drawings.
Where indicated on drawings, match finish process and color of pole or support materials.
- I. Luminaires shall carry factory labels, showing complete, specific lamp and ballast information.

2.3 LAMPS

- A. Install the proper lamps in every luminaire installed //and every existing luminaire relocated or reinstalled//.
- B. Lamps shall be general-service, outdoor lighting types.
- C. LED sources shall meet the following requirements:
 - 1. Operating temperature rating shall be between -40° F [-40° C] and 120° F [50° C].
 - 2. Correlated Color Temperature (CCT): 5000K.
 - 3. Color Rendering Index (CRI): ≥ 65.
 - 4. The manufacturer shall have performed JEDEC (Joint Electron Devices Engineering Council) reliability tests on the LEDs as follows: High Temperature Operating Life (HTOL), Room Temperature Operating Life (RTOL), Low Temperature Operating Life (LTOL), Powered Temperature Cycle (PTMCL), Non-Operating Thermal Shock (TMSK), Mechanical Shock Variable Vibration Frequency, and Solder Heat Resistance (SHR).
- G. Mercury vapor lamps shall not be used.

2.4 LED DRIVERS

- A. LED drivers shall meet the following requirements:
 - 1. Drivers shall have a minimum efficiency of 85%.
 - 2. Starting Temperature: -40° F [-40° C].
 - 3. Input Voltage: 120 to 480 (±10%) V.
 - 4. Power Supplies: Class I or II output.
 - 5. Surge Protection: The system must survive 250 repetitive strikes of "C Low" (C Low: 6kV/1.2 x 50 µs, 10kA/8 x 20 µs) waveforms at 1-minute intervals with less than 10% degradation in clamping voltage. "C Low" waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C.
 - 6. Power Factor (PF): ≥ 0.90.
 - 7. Total Harmonic Distortion (THD): ≤ 20%.
 - 8. Comply with FCC Title 47 CFR Part 18 Non-consumer RFI/EMI Standards.
 - 9. Drivers shall be reduction of hazardous substances (ROHS)-compliant.

2.5 EXISTING LIGHTING SYSTEMS

- A. For modifications or additions to existing lighting systems, the new components shall be compatible with the existing systems.
- B. New poles and luminaires shall have approximately the same configurations and dimensions as the existing poles and luminaires, except where otherwise shown on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lighting in accordance with the NEC, as shown on the drawings, and in accordance with manufacturer's recommendations.
- B. Pole Foundations:
 - 1. Excavate only as necessary to provide sufficient working clearance for installation of forms and proper use of tamper to the full depth of the excavation. Prevent surface water from flowing into the excavation. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath, and the end of conduit.
 - 2. Set anchor bolts according to anchor-bolt templates furnished by the pole manufacturer.
 - 3. Install poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
 - 4. After the poles have been installed, shimmed, and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 0.375 in [9 mm] inside diameter through the grout, tight to the top of the concrete base to prevent moisture weeping from the interior of the pole.
- C. Install lamps in each luminaire.
- D. Adjust luminaires that require field adjustment or aiming.

3.2 GROUNDING

Ground noncurrent-carrying parts of equipment, including metal poles, luminaires, mounting arms, brackets, and metallic enclosures, as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially-treated or lined connectors suitable and listed for this purpose.

3.3 ACCEPTANCE CHECKS AND TESTS

Verify operation after installing luminaires and energizing circuits.

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SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section specifies the furnishing, installing, certification, testing, and guaranty of a complete and operating Voice and Digital Cable Distribution System (here-in-after referred to as "*the System*"), and associated equipment and hardware to be installed in the VA Medical Center here-in-after referred to as "*the Facility*". The System shall include, but not be limited to: equipment cabinets, interface enclosures, and relay racks; necessary combiners, traps, and filters; and necessary passive devices such as: splitters, couplers, cable "patch", "punch down", and cross-connector blocks or devices, voice and data distribution sub-systems, and associated hardware. The System shall additionally include, but not be limited to: telecommunication closets (TC); telecommunications outlets (TCO); copper and fiber optic distribution cables, connectors, "patch" cables, and/or "break out" devices.
- B. The System shall be delivered free of engineering, manufacturing, installation, and functional defects. It shall be designed, engineered and installed for ease of operation, maintenance, and testing.
- C. The term "provide", as used herein, shall be defined as: designed, engineered, furnished, installed, certified, and tested, by the Contractor.
- D. The Voice and Digital Telecommunication Distribution Cable Equipment and System provides the media which voice and data information travels over and connects to the Telephone System which is defined as an Emergency Critical Care Communication System by the National Fire Protection Association (NFPA). Therefore, since the System connects to or extends the telephone system, the System's installation and operation shall adhere to all appropriate National, Government, and/or Local Life Safety and/or Support Codes, which ever are the more stringent for this Facility. At a minimum , the System shall be installed according to NFPA, Section 70, National Electrical Code (NEC), Article 517 and Chapter 7; NFPA, Section 99, Health Care Facilities, Chapter 3-4; NFPA, Section 101, Life Safety Code, Chapters 7, 12, and/or 13; Joint Commission on Accreditation of Health Care

Organization (JCAHCO), Manual for Health Care Facilities, all necessary Life Safety and/or Support guidelines; this specification; and the original equipment manufacturer's (OEM) suggested installation design, recommendations, and instructions. The OEM and Contractor shall ensure that all management, sales, engineering, and installation personnel have read and understand the requirements of this specification before the System is designed, engineered, delivered, and provided.

- E. The VA Project Manager (PM) and/or if delegated, Resident Engineer (RE) are the approving authorities for all contractual and mechanical changes to the System. The Contractor is cautioned to obtain in writing, all approvals for system changes relating to the published contract specifications and drawings, from the PM and/or the RE before proceeding with the change.

F. System Performance:

1. At a minimum, the System shall be able to support the following voice and data operations for Category 6 Certified Telecommunication Service:
 - a. Provide the following interchange (or interface) capabilities:
 - 1) Basic Rate (BRI).
 - 2) Primary Rate (PRI).
 - b. ISDN measured at system head end:
 - 1) Narrow Band BRI:
 - a) B Channel: 64 kilo-Bits per second (kBps), minimum.
 - b) D Channel: 16 kBps, minimum.
 - c) H Channel: 384 kBps, minimum.
 - 2) Narrow Band PRI:
 - a) B Channel: 64 kBps, minimum.
 - b) D Channel: 64 kBps, minimum.
 - c) H Channel: 1,920 kBps, minimum.
 - 3) Wide (or Broad) Band: All channels: 140 mega(m)-Bps, minimum, capable to 565 mBps at "T" reference.
 - c. Frame Relay: All stated compliance's measured at system head end.
 - d. Integrated Data Communications Utility (IDCU) operation and interface: Measured at system head end.
 - e. Government Open Systems Interconnection Profile (GOSSIP) compliant: Measured at system head end.
 - f. Fiberoptic Distributed Data Interface (FDDI): A minimum 100 mBps to a maximum of 1.8 giga(g)-Bps data bit stream speed measured at

system head end (shall be Synchronous Optical Network [SONET] compliant).

- g. System Sensitivity: Satisfactory service shall be provided for at least 3,000 feet for all voice and data locations.
- 2. At a minimum the System shall support the following operating parameters:
 - a. EPBX connection:
 - 1) System speed: 1.0 gBps per second, minimum.
 - 2) Impedance: 600 Ohms.
 - 3) Cross Modulation: -60 deci-Bel (dB).
 - 4) Hum Modulation: -55 dB.
 - 5) System data error: 10 to the -10 Bps, minimum.
 - 6) Loss: Measured at the frame output with reference Zero (0) deciBel measured (dBm) at 1,000 Hertz (Hz) applied to the frame input.
 - a) Trunk to station: 1.5 dB, maximum.
 - b) Station to station: 3.0 dB, maximum.
 - c) Internal switch crosstalk: -60 dB when a signal of ± 10 deciBel measured (dBm), 500-2,500 Hz range is applied to the primary path.
 - d) Idle channel noise: 25 dBm "C" or 3.0 dBm "O" above reference (terminated) ground noise, whichever is greater.
 - e) Traffic Grade of Service for Voice and Data:
 - (1) A minimum grade of service of P-01 with an average traffic load of 7.0 CCS per station per hour and a traffic overload in the data circuits will not interfere with, or degrade, the voice service.
 - (2) Average CCS per voice station: The average CCS capacity per voice station shall be maintained at 7.0 CCS when the EPBX is expanded up to the projected maximum growth as stated herein.
 - b. Telecommunications Outlet (TCO):
 - 1) Voice:
 - a) Isolation (outlet-outlet): 24 dB.
 - b) Impedance: 600 Ohms, balanced (BAL).
 - c) Signal Level: 0 deciBel per mili-Volt (dBmV) ± 0.1 dBmV.
 - d) System speed: 100 mBps, minimum.
 - e) System data error: 10 to the -6 Bps, minimum.

2) Data:

- a) Isolation (outlet-outlet): 24 dB.
- b) Impedance: 600 Ohms, BAL.
- c) Signal Level: 0 dBmV \pm 0.1 dBmV.
- d) System speed: 120 mBps, minimum.
- e) System data error: 10 to the -8 Bps, minimum.

3) Fiber optic:

- a) Isolation (outlet-outlet): 36 dB.
- b) Signal Level: 0 dBmV \pm 0.1 dBmV.
- c) System speed: 540 mBps, minimum.
- d) System data error: 10 to the -6 bps, minimum.

1.2 RELATED WORK

- A. Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Specification Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- C. Specification Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS.
- E. Specification Section 26 27 26, WIRING DEVICES.
- F. Specification Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in text by basic designation only. Except for a specific date given the issue in effect (including amendments, addenda, revisions, supplements, and errata) on the date the system's submittal is technically approved by VA, shall be enforced.
- B. National Fire Protection Association (NFPA):

70	NATIONAL ELECTRICAL CODE (NEC)
75	Protection of Electronic Computer/Data Processing Equipment
77	Recommended Practice on Static Electricity
	Standard for Health Care Facilities
101	Life Safety Code
1221	Emergency Services Communication Systems

C. Underwriters Laboratories, Inc. (UL):

65	Wired Cabinets
96	Lightning Protection Components
96A	INSTALLATION REQUIREMENTS FOR LIGHTNING PROTECTION SYSTEMS
467	Grounding and Bonding Equipment
497/497A/497B	PROTECTORS FOR PAIRED CONDUCTORS/ COMMUNICATIONS CIRCUITS/DATA COMMUNICATIONS AND FIRE ALARM CIRCUITS
884	Underfloor Raceways and Fittings

D. ANSI/EIA/TIA Publications:

568B	Commercial Building Telecommunications Wiring Standard
569B	Commercial Building Standard for Telecommunications Pathways and Spaces
606A	ADMINISTRATION STANDARD FOR THE TELECOMMUNICATIONS INFRASTRUCTURE OF COMMERCIAL BUILDINGS
607A	Grounding and Bonding Requirements for Telecommunications in Commercial Buildings
758	Grounding and Bonding Requirements for Telecommunications in Commercial Buildings

E. Lucent Technologies: Document 900-200-318 "Outside Plant Engineering Handbook".

F. International Telecommunication Union - Telecommunication Standardization Sector (ITU-T).

G. Federal Information Processing Standards (FIPS) Publications.

H. Federal Communications Commission (FCC) Publications: Standards for telephone equipment and systems.

I. United States Air Force: Technical Order 33K-1-100 Test Measurement and Diagnostic Equipment (TMDE) Interval Reference Guide.

J. Joint Commission on Accreditation of Health Care Organization (JCAHO): Comprehensive Accreditation Manual for Hospitals.

K. National and/or Government Life Safety Code(s): The more stringent of each listed code.

1.4 QUALITY ASSURANCE

- A. The authorized representative of the OEM, shall be responsible for the design, satisfactory total operation of the System, and its certification.
- B. The OEM shall meet the minimum requirements identified in Paragraph 2.1.A. Additionally, the Contractor shall have had experience with three or more installations of systems of comparable size and complexity with regards to coordinating, engineering, testing, certifying, supervising, training, and documentation. Identification of these installations shall be provided as a part of the submittal as identified in Paragraph 1.5.
- C. The System Contractor shall submit certified documentation that they have been an authorized distributor and service organization for the OEM for a minimum of three (3) years. The System Contractor shall be authorized by the OEM to certify and warranty the installed equipment. In addition, the OEM and System Contractor shall accept complete responsibility for the design, installation, certification, operation, and physical support for the System. This documentation, along with the System Contractor and OEM certification must be provided in writing as part of the Contractor's Technical Submittal.
- D. All equipment, cabling, terminating hardware, TCOs, and patch cords shall be sourced from the certifying OEM or at the OEM's direction, and support the System design, the OEM's quality control and validity of the OEM's warranty.
- E. The Contractor's Telecommunications Technicians assigned to the System shall be fully trained, qualified, and certified by the OEM on the engineering, installation, and testing of the System. The Contractor shall provide formal written evidence of current OEM certification(s) for the installer(s) as a part of the submittal or to the RE before being allowed to commence work on the System.

1.5 SUBMITTALS

- A. Provide submittals in accordance with Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. The RE shall retain one copy for review and approval.
 - 1. If the submittal is approved the RE shall retain one copy for Official Records and return three (3) copies to the Contractor.
 - 2. If the submittal is disapproved, three (3) copies will be returned to the Contractor with a written explanation attached that indicates

the areas the submittal deviated from the System specifications. The RE shall retain one copy for Official Records.

- B. Environmental Requirements: Technical submittals shall confirm the environmental specifications for physical TC areas occupied by the System. These environmental specifications shall identify the requirements for initial and expanded system configurations for:
1. Floor loading for batteries and cabinets.
 2. Minimum floor space and ceiling heights.
 3. Minimum size of doors for equipment passage.
 4. Power requirements: The Contractor shall provide the specific voltage, amperage, phases, and quantities of circuits required.
 5. Air conditioning, heating, and humidity requirements. The Contractor shall identify the ambient temperature and relative humidity operating ranges required preventing equipment damage.
 6. Air conditioning requirements (expressed in BTU per hour, based on adequate dissipation of generated heat to maintain required room and equipment standards).
 7. Proposed floor plan, based on the expanded system configuration of the bidder's proposed EPBX for this FACILITY.
 8. Conduit size requirement (between main TC, computer, and console rooms).
 9. Main backbone, trunk line, riser, and horizontal cable pathways, cable duct, and conduit requirements between each MTC, TC, and TCO.
- C. Documents: The submittal shall be separated into sections for each subsystem and shall contain the following:
1. Title page to include:
 - a. VA Medical Center.
 - b. Contractor's name, address, and telephone (including FAX) numbers.
 - c. Date of Submittal.
 - d. VA Project No.
 2. List containing a minimum of three locations of installations of similar size and complexity as identified herein. These locations shall contain the following:
 - a. Installation Location and Name.
 - b. Owner's or User's name, address, and telephone (including FAX) numbers.
 - c. Date of Project Start and Date of Final Acceptance by Owner.

- d. System Project Number.
 - e. Brief (three paragraphs minimum) description of each system's function, operation, and installation.
3. Narrative Description of the system.
 4. A List of the equipment to be furnished. The quantity, make, and model number of each item is required. The following is the minimum equipment required by the system:

QUANTITY	UNIT
As required	Cabinet Assembly(s)
As required	Distribution/Interface Cabinet
As required	Equipment (Radio Relay) Rack
As required	Cross Connection (CCS) Systems
As required	Wire Management System/Equipment
As required	Telecommunications Outlets (TCO)
As Required	Distribution Cables
As required	TCO Connection Cables
As required	System Connectors
As required	Terminators
As required	Distribution Frames
1 ea.	Installation Kit
As-required	Separate List Containing Each Equipment Spare(s)

5. Pictorial layouts of each MTC, IMTC, and RTCs; MCCS, IMCCS, VCCS, and HCCS termination cabinet(s), each distribution cabinet layout drawing, and TCO as each is expected to be installed and configured.
6. Equipment technical literature detailing the electrical and technical characteristics of each item of equipment to be furnished.
7. Engineering drawings of the System, showing calculated signal levels at the EPBX output, each input and output distribution point, proposed TCO values, and signal level at each TCO multipin and fiber optic jack.
8. List of test equipment as per paragraph 1.5.D. below.
9. Letter certifying that the Contractor understands the requirements of the SAMPLES Paragraph 1.5.E.
10. Letter certifying that the Contractor understands the requirements of Section 3.2 concerning acceptance tests.

D. Test Equipment List:

1. The Contractor is responsible for furnishing all test equipment required to test the system in accordance with the parameters specified. Unless otherwise stated, the test equipment shall not be considered part of the system. The Contractor shall furnish test equipment of accuracy better than the parameters to be tested.
2. The test equipment furnished by the Contractor shall have a calibration tag of an acceptable calibration service dated not more than 12 months prior to the test. As part of the submittal, a test equipment list shall be furnished that includes the make and model number of the following type of equipment as a minimum:
 - a. Spectrum Analyzer.
 - b. Signal Level Meter.
 - c. Volt-Ohm Meter.
 - d. Time Domain Reflectometer (TDR) with strip chart recorder (Data and Optical Measuring).
 - e. Bit Error Test Set (BERT).
 - f. Camera with a minimum of 60 pictures to that will develop immediately to include appropriate test equipment adapters. A video camera in digital format is an acceptable alternate.

E. Samples: A sample of each of the following items shall be furnished to the RE for approval prior to installation.

1. TCO Wall Outlet Box 4" x 4"x 2.5" with:
 - a. One each telephone (or voice) rj45 jack installed.
 - b. Two each multi pin data rj45 jacks installed.
 - c. Cover Plate installed.
 - d. Fiber optic ST jack(s) installed.
2. Data CCS patch panel, punch block or connection device with RJ45 connectors installed.
3. Telephone CCS system with IDC and/or RJ45 connectors and cable terminal equipment installed.
4. Fiber optic CCS patch panel or breakout box with cable management equipment and "ST" connectors installed.
5. 610 mm (2 ft.) section of each copper cable to be used with cable sweep tags as specified in paragraph 2.4.H and connectors installed.
6. 610 mm (2 ft.) section of each fiber optic cable to be used with cable sweep tags as specified in paragraph 2.4.H and connectors installed.

F. Certifications:

1. Submit written certification from the OEM indicating that the proposed supervisor of the installation and the proposed provider of the contract maintenance are authorized representatives of the OEM. Include the individual's exact name and address and OEM credentials in the certification.
2. Submit written certification from the OEM that the wiring and connection diagrams meet National and/or Government Life Safety Guidelines, NFPA, NEC, UL, this specification, and JCAHCO requirements and instructions, requirements, recommendations, and guidance set forth by the OEM for the proper performance of the System as described herein. The VA will not approve any submittal without this certification.
3. Preacceptance Certification: This certification shall be made in accordance with the test procedure outlined in paragraph 3.2.B.

G. Equipment Manuals: Fifteen (15) working days prior to the scheduled acceptance test, the Contractor shall deliver four complete sets of commercial operation and maintenance manuals for each item of equipment furnished as part of the System to the RE. The manuals shall detail the theory of operation and shall include narrative descriptions, pictorial illustrations, block and schematic diagrams, and parts list.

H. Record Wiring Diagrams:

1. Fifteen (15) working days prior to the acceptance test, the Contractor shall deliver four complete sets of the Record Wiring Diagrams of the System to the RE. The diagrams shall show all inputs and outputs of electronic and passive equipment correctly identified according to the markers installed on the interconnecting cables, Equipment and room/area locations.
2. The Record Wiring Diagrams shall be in hard copy and two compact disk (CD) copies properly formatted to match the Facility's current operating version of Computer Aided Drafting (AutoCAD) system. The RE shall verify and inform the Contractor of the version of AutoCAD being used by the Facility.

I. Surveys Required As A Part Of The Technical Submittal: The Contractor shall provide the following surveys that depict various system features and capacities are required in addition to the on site survey requirements described herein. Each survey shall be in writing and contain the following information (the formats are suggestions and may

be used for the initial Technical Submittal survey requirements), as a minimum:

1. Cable Distribution System Design Plan: A design plan for the entire cable distribution systems requirements shall be provided with this document. A specific cable count shall coincide with the total growth items as described herein. It is the Contractor's responsibility to provide the Systems entire cable requirements and engineer a distribution system requirement plan using the format of the following paragraph(s), at a minimum:

- a. UTP (and/or STP) Requirements/Column Explanation:

Column	Explanation
FROM BUILDING	Identifies the building by number, title, or location, and main signal closet or intermediate signal closet cabling is provided from
BUILDING	Identifies the building by number, title, or location cabling is to be provided in
TO BUILDING IMC	Identifies building main terminal signal closet, by room number or location, to which cabling is provided too, in, and from
FLOOR	Identifies the floor by number (i.e. 1st, 2nd, etc.) cabling and TCOs are to be provided
TC ROOM NUMBER	Identifies the floor signal closet room, by room number, which cabling shall be provided
ROOM NUMBER	Identifies the room, by number, from which cabling and TCOs shall be provided
NUMBER OF CABLE PAIR	Identifies the number of cable pair required to be provided on each floor designated OR the number of cable pair (VA Owned) to be retained
NUMBER OF STRANDS USED/SPARE	Identifies the number of strands provided in each run

b. Fiber Optic Cabling Requirements/Column Explanation:

Column	Explanation
FROM BUILDING	Identifies the building by number, title, or location, and main signal closet or intermediate signal closet cabling is provided from
TO BUILDING IMC	Identifies building, by number, title, or location, to which cabling is provided
FLOOR	Identifies the floor by number (i.e. 1st, 2nd, etc.)
TC ROOM NUMBER	Identifies the room, by number, from which cabling shall be installed
NUMBER OF STRANDS	Identifies the number of strands in each run of fiber optic cable
INSTALLED METHOD	Identifies the method of installation in accordance with as designated herein
NOTES	Identifies a note number for a special feature or equipment
BUILDING MTC	Identifies the building by number or title

PART 2 - PRODUCTS**2.1 EQUIPMENT AND MATERIALS**

A. System Requirements:

1. The System shall provide the following minimum services that are designed in accordance with and supported by an Original Equipment Manufacturer (OEM), and as specified herein. The System shall provide continuous inter and/or intra-Facility data service. The System shall be capacity sized so that loss of connectivity to external telephone systems shall not affect the Facilities operation in specific designated locations. The System shall:
 - a. Be capable of inter-connecting and functioning fully with the existing Local Telephone Exchange (LEC) Network(s), Federal Telephone System (FTS) Inter-city Network(s), Inter-exchange Carriers, Integrated Services Digital Network (ISDN), Electronic Private Branch Exchange (EPBX) switches, asynchronous/synchronous data terminals and circuits including Automatic Transfer Mode (ATM), Frame Relay, and local area networks (LAN), at a minimum.
 - b. Be a voice and data cable distribution system that is based on a physical "Star" and/or "Ring" Topology.

- c. Be compatible with and able to provide direct digital connection to trunk level equipment including, but, not limited to: directly accessing trunk level equipment including the telephone system, audio paging, Industry Standard "T" and/or "DS" carrier services and external protocol converters. Additionally, connections to "T" and/or "DS" access/equipment or Customer Service Units (CSU) that are used in FTS and other trunk applications shall be included in the System design. Provide T-1 access/equipment (or CSU), as required for use, in FTS and other trunk applications by system design if this equipment is not provided by the existing telephone system and/or will be deactivated by the installation of the System. The Contractor shall provide all T-1 equipment necessary to terminate and make operational the quantity of circuits designated. The CSU's shall be connected to the System's emergency battery power supply. The System shall be fully capable of operating in the Industry Standard "DS" protocol and provide that service when required.
2. Cable Systems - Twisted Pair and Fiber optic:
- a. General:
 - 1) The Contractor shall be responsible for providing a new system conforming to current and accepted telephone and digital industrial/commercial cable distribution standards. The distribution cable installation shall be fully coordinated with the Facility, the PM, the COR and the Contractor prior to the start of installation.
 - 2) The Contractor is responsible for complete knowledge of the space and cable pathways (i.e. equipment rooms, TCs, conduits, wireways, etc.) of the Facility. The Contractor shall at a minimum design and install the System using the Pathway Design Handbook H-088C3, TIA/EIA Telecommunications Building Wiring Standards, and Facility Chief of Information Resource Management's (IRM) instructions, as approved in writing by the PM and/or RE.
 - 3) The System cables shall be fully protected by cable duct, trays, wireways, conduit (rigid, thin wall, or flex), and when specifically approved, flexible innerduct. It is the responsibility of the Contractor to confirm all contract drawings and the Facility's physical layout to determine the

necessary cable protective devices to be provided. If flexible innerduct is used, it shall be installed in the same manner as conduit.

- 4) Cable provided in the system (i.e. backbone, outside plant, inside plant, and station cabling) shall conform to accepted industry and OEM standards with regards to size, color code, and insulation. The pair twists of any pair shall not be exactly the same as any other pair within any unit or sub-unit of cables that are bundled in twenty-five (25) pairs or less. The absence of specifications regarding details shall imply that best general industry practices shall prevail and that first quality material and workmanship shall be provided. Certification Standards, (i.e., EIA, CCITT, FIPPS, and NFPA) shall prevail.
- 5) Some areas of this Facility may be considered "plenum". All wire and cable used in support of the installation in those areas (if any) shall be in compliance with national and local codes pertaining to plenum environments. It is the responsibility of the Contractor to review the VA's cable and wire requirements with the RE and the IRM prior to installation to confirm the type of environment present at each location.
- 6) The Contractor shall provide outside and inside plant cables that furnishes the number of cable pairs required in accordance with the System requirements described herein. The Contractor shall fully coordinate and obtain approval of the design with the OEM, RE and the IRM prior to installation.
- 7) All metallic cable sheaths, etc. shall be grounded by the Contractor (i.e.: risers, underground, station wiring, etc.) as described herein.
- 8) If temporary cable and wire pairs are used, they shall be installed so as to not present a pedestrian safety hazard and the Contractor shall be responsible for all work associated with the temporary installation and for their removal when no longer necessary. Temporary cable installations are not required to meet Industry Standards; but, must be reviewed and approved by the RE and the IRM prior to installation.

- 9) Conductors shall be cabled to provide protection against induction in voice and data circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.
- 10) Measures shall be employed by the Contractor to 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.
- 11) The System's cables shall be labeled on each end and been fully tested and certified in writing by the Contractor to the RE before proof of performance testing can be conducted. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs. Minimum 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 tests required for data cable must be made to guarantee 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. All cable installation and test records shall be made available at acceptance testing by the RE or Contractor and thereafter maintained in the Facility's Telephone Switch Room. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.
- 12) The Contractor shall coordinate with the LEC to install the telephone entrance cable to the nearest point of entry into the Facility and as shown on the drawings. The Contractor shall coordinate with the COR and the LEC 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.
- 13) The Contractor shall coordinate with the COR and the IRM to install the computer interface cable to the Facility Telephone Switch Room from the Facility's Computer Room for all data,

DHCP, FTS, ATM, Frame Relay, and telephone circuits and as shown on the drawings.

- 14) The Contractor shall coordinate with the COR and the IRM to provide all cable pairs/circuits from the Facility Telephone Switch Room and establish circuits throughout the Facility for all voice, data, computer alarm (except fire alarm), private maintenance line, Radio Paging, PA, LAN, DHCP, and any low voltage circuits as described herein.

- 15) The Contractor shall provide proper test equipment to guarantee 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. Telecommunications Closets (TC): In TC's that are served with both a UTP backbone cable and a fiber optic backbone cable, the UTP cable shall be terminated on separate RJ-45, 8-pin connectors with 110A or equivalent type punch down blocks located on the back or front of a 48-port modular patch panel dedicated to data applications. Only the UTP backbone cable pairs, identified as being connected to the fiber optic backbone, shall be extended to the fiber optic interface device. All connecting cables required to extend these cables (i.e. patch cords, twenty-five pair connectors, etc.), to the fiber optic interface device, in the TC's shall also be provided by the Contractor to insure a complete and operational fiber optic distribution system:

- 1) In TC's, which are only served by a UTP backbone cable, the cable shall be terminated on separate modular connecting devices (110A or equivalent) that are dedicated to data applications. In order to provide full service to all data cable pairs as identified in each TC/cabinet including spare capacity noted herein, the size of all vertical (riser) cables and/or outside cables serving these TC's shall be increased as required.

c. Backbone and Trunk Cables:

- 1) The Contractor shall identify, in the technical submittal, the voice and data connecting arrangements required by the LEC for interconnection of the System to the commercial telephone and

FTS networks. The Contractor shall provide all required voice and data connecting arrangements.

- 2) The Contractor shall be responsible for compatibility of the proposed TCs (to be compliant with the EPBX and CSU equipment) numbering scheme with the numbering plan for the FTS, DID, local stations, and the North American Numbering Plan. The Contractor shall consult with the VA and the LEC regarding the FTS and North American Numbering plan to be implemented for the Facility to ensure system compatibility.
- 3) All submitted equipment shall meet or exceed standards, rules, and regulations of the Federal Communications Commission (FCC) and shall be capable of operating without outboard or "extra" devices. The Contractor shall identify the FCC registration number of the System equipment, EPBX, and proposed CSU (if known) in the technical submittal.

d. Riser Cable:

- 1) All communication riser cables shall be listed as being suitable for the purpose and marked accordingly per Articles 517, 700, and 800 of the NEC.
- 2) All voice and data communication riser cables shall be STP or Unshielded Twisted Pair (UTP), minimum 24 American Wire Gauge (AWG) solid, thermoplastic insulated conductors. They shall be enclosed with a thermoplastic outer jacket.
- 3) The Contractor shall provide and install inside riser cables to insure full service to all voice cable pairs identified in each TC terminating enclosure plus not less than 50% additional spare capacity.
- 4) The complete riser cabling system shall be labeled and tested as described herein.

e. Horizontal and Station Cable:

- 1) A Four (4) UTP 24 AWG station wiring cable shall be installed from the top TCO jack to the TC and shall be of a type designed to support Category 6 communications (250 MHz or above). At the jack location, terminate all four pair on the RJ-45/11 jack. At the signal closet, all four pair shall be terminated on the modular punch down blocks dedicated to telephone applications.

- 2) A Four (4) UTP 24 AWG (in thermoplastic jacket unless otherwise specified by RE) station wiring cable shall be installed from each of the two (2) bottom TCO RJ-45 jacks (shall conform to EIA/TIA 568 Standard "T568A" and NFPA) to the TC and shall be of a type designed to support Category 6 communications (250 mHz or above).
- f. Telecommunication Outlets (TCO), Jacks: All TCO's shall have a minimum of three (3) RJ-45 type jacks. The top jack shall be an eight pin RJ-45/11 compatible jack, labeled, and designated for telephone applications only. The bottom two jacks shall be eight pin RJ-45 type unkeyed (sometimes called center keyed) jacks, labeled, and designated for data.
- g. Fiber Optics:
- 1) A complete fiber optic cable distribution system shall be provided as a part of the System. The Contractor shall provide a fiber optic cable that meets the minimum bandwidth requirements for FDDI, ATM, and Frame Relay services. This fiber optic cable shall be a 62.5/125 micron multi-mode, containing a minimum of 18 strands of fiber, unless otherwise specified, and shall not exceed a distance of 2,000 Meters (M), or 6,560 feet (ft.) in a single run. Loose tube cable, which separates the individual fibers from the environment, shall be installed for all outdoor runs or for any area which includes an outdoor run. Tight buffered fiber cable shall be used for indoor runs. The multimode fibers shall be terminated and secured at both ends in "ST" type female stainless steel connectors installed in an appropriate patch or breakout panel with a cable management system. A 610 mm (2 ft.) cable loop (minimum) shall be provided at each end to allow for future movement.
 - 2) In addition, a 12 strand (minimum), 8.3 mm single mode fiber optic cable shall be provided. Single mode fibers shall be terminated and secured at both ends with "ST" type female stainless steel connectors installed in an appropriate patch or breakout panel. The panel shall be provided with a cable management system. A 610 mm (2 ft.) cable loop (minimum) shall be provided at each end to allow for future movement.

- 3) The fiber optic backbone shall use a conventional hierarchical "star" design where each TC is wired to the primary hub (main cross-connect system) or a secondary hub (intermediate cross-connect system) and then to the primary hub. There shall be no more than two hierarchical levels of cross-connects in the backbone wiring. Each primary hub shall be connected and terminated to a CCS in the Telephone Switch Room. Additionally, a parallel separate fiber optic interconnection shall be provided between the Telephone Switch Room CCS and the MDF in the Main Computer Room.
 - 4) In the TC's, Telephone Switch Room, and Main Computer Room, all fiber optic cables shall be installed in a CCS and/or MDF rack mounted fiber optic cable distribution component/splice case (Contractor provided and installed rack), patch, or breakout panel in accordance with industry standards. Female "ST" connectors shall be provided and installed on the appropriate panel for termination of each strand.
 - 5) The Contractor shall test each fiber optic strand. Cable transmission performance specifications shall be in accordance with EIA/TIA standards. Attenuation shall be measured in accordance with EIA fiber optic test procedures EIA/TIA-455-46, -61, or -53 and NFPA. Information transmission capacity shall be measured in accordance with EIA/TIA-455-51 or -30 and NFPA. The written results shall be provided to the RE for review and approval.
3. Specific Subsystem Requirements: The System shall consist, as a minimum, of the following independent sub-systems to comprise a complete and functional voice and digital telecommunications cabling system: "Main" (MTC), "intermediate" (IMTC), and "riser" (RTC) TC's; "backbone" cabling (BC) system; "vertical" (or "riser") trunk cabling system; "horizontal" (or "lateral") sub-trunk cabling system, vertical and horizontal cross-connection (VCC and HCC respectively) cabling systems, and TCO's with a minimum of three (3) RJ-45 jacks for the appropriate telephone, Data connections, and additional jacks, connectors, drop and patch cords, terminators, and adapters provided.

a. Cross-connect Systems (CCS):

- 1) The CCS shall be selected based on the following criteria:
requires the use of a single tool, has the fewest amount of parts, and requires the least amount of assembly or projected trouble shooting time during the life of the system.
- 2) The CCS system used at the MTC, each IMTC, and each TC shall force cross-connect cable slack management through adherence to the OEM's installation methods, provided cable management systems, and as described herein, so that moves, adds, and changes can be administered easily and cost effectively.
- 3) Copper Cables: The MTC, each IMTC, and TC shall contain a copper CCS sized to support the System TCO's and connections served by each individual TC and as shown on the drawings. The System layout shall allow for a minimum of 50% anticipated growth. Additionally, each CCS must provide maximum flexibility, while maintaining performance, in order to meet system-changing requirements that are likely to occur throughout its useful life.
- 4) Fiber Optic Cables:
 - a) The MTC and each TC shall contain a fiber CCS sized to support the System TCO's and connections served by each individual TC and as shown on the drawings. The System layout shall allow for a minimum of 50% anticipated growth.
 - b) Each fiber CCS must provide maximum flexibility and cable management while maintaining performance in order to meet changing requirements that are likely to occur throughout the expected life of the system. All fiber optic cable slack shall be stored in protective enclosures.
 - c) If it is determined that a fiber optic distribution system is not necessary for the immediate system needs. Each TC shall be provided with fiber optic cable(s) that contain a minimum of 12 strands "dark" multimode fiber and 12 strands "dark" single mode fiber, each fiber properly terminated on its respective female stainless steel connector mounted in an appropriate fiber termination enclosure provided in each TC.

- 5) The Contractor shall not "cross-connect" the copper or fiber optic cabling systems and subsystems even though appropriate "patch" cords are to be provided for each "patch", "punch", or "breakout" panel. In addition, the Contractor shall not provide active electronic distribution or interface equipment as a part of the System.
- 6) Grounding: Proper grounding and bonding shall be provided for each TC and all internal equipment. Reference shall be made to proper codes and standards, such that all grounding systems must comply with all applicable National, Regional, and Local Building and Electrical codes. The most stringent code of these governing bodies shall apply.
 - a) If local grounding codes do not exist for the System location, then at a minimum, a #6 American Wire Gauge (AWG) stranded copper wire, or equivalent copper braid, shall be connected to a separate earth grounding system for each TC (the looping of TC's in a general location is allowed as long as the specifications contained herein are met). Under no circumstance shall the AC neutral be used for this ground. See PART 3 - EXECUTION for specific grounding instructions.
 - b) Each copper UTP or STP cable that enters a TC from the outside of a building (regardless if the cable is installed underground or aerial) shall be provided with a surge protector and grounded an to earth ground at each cable's entry point in and out of the MTC and each IMTC.
- b. Main Cross-connection Subsystem (MCCS): The MCCS shall be located in the MTC and it shall be the common point of appearance for inter and intra-building copper and fiber optic "backbone" system cables, and connections to the telephone and data cable systems. The MTC usually houses telephone EPBX, public address, radio paging interface, routers, and main hierarchical data LAN concentrating equipment. Additionally, it shall provide a single administration and management point for the entire System.
- c. Data Cross-Connection Subsystems:
 - 1) The MCCS shall be a Main Distribution Terminating (MDT) data unit and shall be provided in the MTC. The MDT shall consist of a "patch" panel(s) provided with modular RJ45 female

connectors for cross-connection of all copper data cable terminations. The panels shall provide for system grounding (where no dielectric cables are used) and be provided with a cable management system.

- 2) Each panel shall conform to EIA dimensions and be suitable for mounting in standard equipment racks, have the RJ45 jacks aligned in two horizontal rows (up to a maximum of 48 jacks per panel), and shall not exceed the OEM's recommendations. Each RJ45 jack shall be of modular design and capable of accepting and functioning with other modular (i.e. RJ11) plugs without damaging the jack. It is not necessary to provide a jack for unused positions that are not part of the 50% expansion requirement.
 - a) All data system inputs from the server(s), data LAN, bridge, or interface distribution systems shall appear on the "top" row of jacks of the appropriate patch panel.
 - b) All System outputs or backbone cable connections shall appear on the "bottom" row of jacks of the same patch panel.
 - c) The splitting of pairs within cables between different jacks shall not be allowed. In the case of ISDN and/or ATM and/or Frame Relay applications, terminating resistors shall be provided externally to the patch panel connector or jack.
- 3) A patch cord shall be provided for each system "pair" of connection jacks. Each patch cord shall have modular RJ45 connectors provided on each end to match the panel's modular RJ45 female jack's being provided.
- d. Fiber optic Cross-Connection Subsystems: The MTC shall be provided with a separate fiber MCCC. Each TC shall be provided with a rack mounted patch or distribution panel that is installed inside a lockable cabinet or "breakout enclosure" that accommodates a minimum of 12 strands multimode fiber and 12 strand single mode fiber (these counts shall not be included the 50% spare requirement). Two of the single mode fibers shall be designated for educational analog video applications. A cable management system shall be provided for each panel.

- 1) The panel(s) shall contain a minimum of 24 female "ST" connectors, be able to accommodate splices and field mountable connectors and have capacity for additional connectors to be added up to the OEM's maximum standard panel size for this type of use. All patch panel sides, including the front and back, shall be protected by a cabinet or enclosure.
 - 2) The panel(s) shall conform to EIA dimensions and be suitable for installation in standard racks, cabinets, and enclosures. The panels shall provide for system grounding (where no dielectric cables are used).
 - 3) The patch panel with the highest OEM approved density of fiber "ST" termination's (maximum of 72 each), while maintaining a high level of manageability, shall be selected. Patch cables, with proper "ST" connectors installed on each end shall be provided for each pair of fiber optic cable "ST" connectors.
 - a) All System "inputs" from interface equipment or distribution systems shall appear on the "top" row of connectors of the appropriate patch panel.
 - b) All System "outputs" or backbone cable connections shall appear on the "bottom" row of connectors of the same patch panel.
 - 4) In order to achieve a high level of reliability that approximates that of an OEM connector, field installable connectors shall have an OEM specified physical contact polish. Every fiber cable shall be terminated with the appropriate connector, and tested to ensure compliance to OEM and specifications outlines herein. Where a local fiber optic system connector standard, Industry Standard fiber optic "ST" female connector terminated with a fiber optic cable, shall be used. But, if the fiber optic cable is not used (or "dark"), a "ST" male terminating "cap" shall be provided for each unused "ST" female connector.
- e. Intermediate Cross-connection Subsystems (IMCCS): The MTC and each IMTC shall be provided with an IMCCS that shall be the connection point between the MCCS system and the distribution backbone cable and the IMCCS, that is located in one or more buildings on a campus, where each IMCCS is placed by system

design. For a technical explanation of internal equipment and system requirements, refer to the above MTC and MCCA paragraphs.

- f. Distribution Cable Systems / Backbone Cable System (Common to Inter-buildings): The backbone cable system extends from the MCCA to each IMCCA to establish service between buildings on a campus. The media (copper and fiber optic) used in the BC system shall be designed according to the system requirements, OEM standards and guidelines, and as described herein. A multi-pair copper for voice and data, and separate multiple fiber optic backbone system shall be provided as a part of the BC distribution system.
- 1) All outside cable shall be minimum of STP or UTP, 22 AWG solid conductors, solid PVC insulation, and filled core (flexgel - waterproof Rural Electric Association (REA) LISTED PE 39 CODE) between the outer armor or jacket and inner conductors protective lining.
 - 2) The copper cable system shall be configured as a "Star" Topology with separate dedicated cables between the MCCA and each IMCCA.
 - 3) UTP and STP copper cables shall consist of thermoplastic insulated conductors formed into binder groups. The groups are to be identified by distinctly colored binders and assembled to form a single compact core covered by a protective sheath. Each cable shall be rated for Category 6 Telecommunications System Service. A minimum of eight pairs per circuit, plus an additional 50% spare for growth shall be provided.
 - 4) Where the distance limitations of UTP or STP may be exceeded, multimode (or single mode) fiber optic cable(s) shall be used to augment the voice and/or data backbone cable system(s). The total loss of each fiber shall not exceed 12 decibel (dB) at 850 nano-Meter (nM), 11 dB at 1,300 nM, or 10 dB at 1,500 nM.
 - 5) All voice system "inputs" from the MCCA via the BC distribution system shall appear on the "left" side of IDC (minimum 110 blocks) punch terminals of the IMCCA.
 - 6) All voice system "outputs" or trunk line connections shall appear on the "right" side of the same IDC (minimum 110 blocks) of the IMCCA.

- 7) All data system "inputs" from the MCCS via the BC distribution system shall appear on the "top" row of jacks of the appropriate patch panel of the IMCCS.
 - 8) All data system "outputs" or trunk line connections shall appear on the "bottom" row of jacks in the same patch panel of the IMCCS.
 - 9) The splitting of pairs within cables between different jacks shall not be allowed. In the case of ISDN and/or ATM and /or Frame Relay applications, terminating resistors shall be provided externally to the patch panel connector or jack.
 - 10) A patch cord shall be provided for each system "pair" of connection jacks. Each patch cord shall have modular connectors provided on each end to match the panel's modular female jack.
 - 11) The fiber optic BC system shall be configured as a "Buss" or Star Topology with separate dedicated fibers between the MCCS and each IMCCS. The System shall be sized to meet the system requirements plus an expansion capability of 50%. Fiber optic cable(s) having a minimum of 12 strands multimode fiber and 12 strands single mode fiber shall be provided. Two of the single mode fibers shall be designated for analog video service.
 - 12) All BC shall be identified with permanent labels at both ends. Labels will indicate system, floor, closet, and zone. The label designations shall match those used for cross-connect terminals and patch panels.
- g. Distribution (Common to Intra-Building) Cabling Systems: The intra-building trunk cabling system provides for connection between the IMCCS and each Riser TC's provided vertical cross-connecting system (VCCS) within a building. The media (copper, fiber optic) used in the intra-building backbone cabling system shall be designed according to the system requirements, OEM standards and guidelines, and as described herein. A multi-pair copper for voice and data, and separate multiple fiber optic trunk system shall be provided as a part of the System.
- 1) Category 6 UTP or STP multi-pair trunk cable(s) shall be used in the voice and data trunk-line-cabling systems. A minimum of

eight pairs per circuit, plus an additional 50% spare for growth shall be provided.

- 2) Where the distance limitations of UTP and/or STP will be exceeded, multimode (or single mode) fiber optic cable shall be used in the voice and/or trunk cabling systems. The total loss of the fiber trunks shall not exceed 12 dB at 850 nM , 11 dB at 1,300 nM, or 10 dB at 1,500 nM.
 - a) All voice system "outputs" from the IMCCS to the trunk-line distribution system shall appear on the "right" side of IDC (minimum 110A blocks) punch terminals of the IMCCS.
 - b) All data system "outputs" from the IMCCS to the trunk-line distribution system shall appear on the "bottom" row of jacks of the same IDC (minimum 110A blocks) of the IMCCS.
 - c) The splitting of pairs within cables between different jacks shall not be allowed. In the case of ISDN and/or ATM and/or Frame Relay applications, terminating resistors shall be provided externally to the patch panel connector or jack.
 - d) A patch cord shall be provided for each system "pair" of connection jacks. Each patch cord shall have modular connectors provided on each end to match the panel's modular female jack.
- 3) The fiber optic trunk line system shall be configured as a "Buss" or Star Topology with separate dedicated fibers between the IMCCS and each RCS. The System shall be sized to meet the System requirements with a expansion capability of 50% provided. Separate individual fiber optic cable(s) with a minimum of 18 strands multimode fiber and/or 12 strands single mode fiber shall be provided. Two of the single mode fibers shall be designated for analog video service.
- 4) All trunk lines shall be identified with permanent labels at both ends. Labels will indicate system, floor, closet, and zone. The label designations shall match those used for cross-connects and patch panels.
 - a) All System outputs from the IMCCS to the trunk-line distribution system shall appear on the "bottom" row of "ST" connectors in the appropriate patch panel.

- b) A patch cord shall be provided for each system "pair" of connection "ST" connectors. As a minimum, each patch cord shall have "ST" male connectors provided on each end to match the panel's female "ST" connector provided.
- h. VCCS and Horizontal Cross-connecting (HCCS) Systems: Each TC shall be provided with a separate VCCS and HCCS located within the TC. The VCCS and HCCS shall interconnect and interface the riser (vertical) trunk line cables with the horizontal (or station) sub-trunk line cables. The media (copper, fiber optic) used in the CCS system shall be designed according to the System requirements, OEM standards and guidelines, and as described herein. A multi-pair copper for voice and data, and separate multiple fiber optic CCS system shall be provided as a part of the System.
 - 1) The UTP, STP, and fiber optic trunk-line cabling systems are that connected between the trunk-lines and Riser VCCS, shall be terminated:
 - a) On the "left" or "top" IDC (or 110A blocks) for each UTP or STP voice cable.
 - b) On the "top" row of RJ45 jacks on the appropriate patch panel for each UTP or STP data cable.
 - c) On the "top" row of "ST" connectors on the appropriate patch panel for each fiber.
 - 2) The UTP, STP, and fiber optic sub-trunk (lateral) floor distribution cabling systems that are connected between each RTC and each TCO or secondary system distribution or connection point, shall terminate on an appropriate HCCS, at the:
 - a) On the "right" IDC (or 110A block) used as the VCCS input for each UTP or STP voice cable.
 - b) On the "bottom row of RJ45 jacks on the appropriate patch panel used as the VCCS input for each UTP or STP data cable.
 - c) On the "bottom" row of "ST" connectors on the appropriate patch panel used as the VCCS input for each fiber.
 - d) The technical requirements of the VCCS and HCCS "patch", "terminating", or "breakout" panels and cable management assemblies for voice, data and fiber optic (and RF

coaxial) cables shall be as described in the above M CCS, IM CCS, and TC technical paragraphs.

- 3) The Contractor shall not "cross-connect" the V CCS or H CCS cabling systems even though appropriate patch cords are provided for each "patch", "punch", or "breakout" panel. Also, the Contractor shall not provide active interface or distribution electronic equipment as a part of the System.
- i. Horizontal (or Station) Cabling (HC): The HC distribution cabling systems connects the distribution field of the voice and data H CCS, in a "Star" Topology, to each TCO or connector and as shown on the drawings via the sub-trunk system.
 - 1) Horizontal cables shall consist of insulated, UTP conductors that are rated for Category 6 telecommunications service for voice and data systems.
 - 2) The number of UTP distribution pairs dedicated to each floor from the HC shall be sufficient to accommodate all the horizontal voice and data circuits served by the distribution cable to each TCO.
 - a) A minimum of four pairs for voice shall be connected to the "right" side of the IDC (or 110A block) that the V CCS "input" connections appear in the RTC.
 - b) A minimum of two separate sets of four pairs each for data shall be connected to the "bottom" row of RJ45 jacks that the V CCS "input" connections appear in the RTC.
 - 3) The horizontal cable length to the farthest system outlet shall be limited to a maximum of 90M (or 295 ft). These maximum lengths must be derated, adjusted and reduced to include cross-connection and distribution system losses. Additional TC(s) shall be provided on large floor areas of buildings to limit the horizontal distribution to a maximum of 90M (or 295 ft).
 - 4) The splitting of pairs within a cable between different jacks shall not be permitted.
 - 5) The installation of the HC shall conform to appropriate OEM recommendations and standards outlined herein. This requirement will insure adequate protection for Electro-Magnetic Interference (EMI) sources.

- 6) A system design where "looping" the HC distribution cables from room to room shall not be permitted.
 - 7) The number of fiber optic cables dedicated from the "bottom" row of "ST" connectors of the appropriate patch panel that the VCCS "input" connections were made, to each floor shall be sufficient to accommodate all the horizontal TCO's served by the distribution cable system in a "home run" configuration minimum of two cables (one multimode and one single mode) per each TCO and as shown on the drawings.
- j. System Telecommunication Outlets (TCO): The System shall be capable of receiving the specified telephone (or voice) and data signals acquired from the LEC, FTS contracted carrier and computer system, one each fiber optic single mode and multimode cables, and shall process and distribute them to the designated TCO's and as shown on the drawings. At a minimum, one TCO shall be provided on each room wall, associated with an active 120 VAC shall be provided and as shown on the drawings. The only exception to the general rule, of one outlet per wall, shall be those "special" locations (e.g., surgical suites, radiology MRI rooms, labs, patient bed rooms, warehouse, loading docks, storage rooms, etc.) where there is usually only one TCO provided as designated on the drawings.
- 1) Each TCO shall consist of three multipin modular RJ45 jacks, one designated for telephone and two for data service, and two fiber optic "ST" connectors, one designated for multimode fiber optic cable and the other for single mode fiber optic cable connection(s). Each TCO with appropriate jacks installed shall be provided by the Contractor in each designated location and as shown on the drawings.
 - 2) The Contractor shall connect each telephone multipin modular RJ45 jack to a separate "right side as you look at it" telephone HC distribution system HCCS "punch down" 110A block or approved IDC terminating device in each associated RTC. The modular RJ45 jack shall be able to accept and operate with smaller modular RJ11 plugs while providing proper connection and not damaging the modular jack. The OEM shall warrant all modular RJ45/11 jacks in such a manner to be usable for modular RJ11 plugs.

- 3) The Contractor shall connect each TCO data multipin modular RJ45 jack to a separate lower row jack on the HCCS "patch panel" in each associated RTC. The Contractor is not to "cross-connect" VCCS and HCCS data distribution cables or provides active electronic data distribution equipment as a part of the System.
- 4) A non-impact termination method, using either a stuffer cap with installation tool or full-cycle terminating tool having both tactile and audible feedback to indicate proper termination shall be used. High impact installation tools shall not be used.
- 5) Each terminated conductor end shall be properly trimmed to assure a minimum clearance of 6.35 mm (0.250 in) clearance between the conductors of adjacent modules.
- 6) The multipin RJ45 jack shall be modular in construction that will accept and operate with a modular UTP and STP RJ45 connector and its pin assignments.
- 7) The Contractor shall connect each fiber optic TCO "ST" connector to a separate fiber optic "bottom" row "ST" connector HCCS "patch panel" or "breakout" terminating device in each associated TC. The Contractor is not to "interconnect" VCCS and HCCS fiber optic distributions cables or provide active fiber optic electronic distribution equipment as a part of the system.

B. System Performance:

1. At a minimum, the System shall be able to support the following voice and data operations for Category 6 Certified Telecommunication Service:
 - a. Provide the following interchange (or interface) capabilities:
 - 1) Basic Rate (BRI).
 - 2) Primary Rate (PRI).
 - b. ISDN measured at head end equipment:
 - 1) Narrow Band BRI.
 - a) B Channel: 64 kilo-Bits per second (kBps), minimum.
 - b) D Channel: 16 kBps, minimum.
 - c) H Channel: 384 kBps, minimum.
 - 2) Narrow Band PRI:
 - a) B Channel: 64 kBps, minimum.

- b) D Channel: 64 kbps, minimum.
 - c) H Channel: 1,920 kbps, minimum.
 - 3) Wide (or Broad) Band:
 - a) All channels: 140 mega(m)-Bps, minimum, capable to 565 Mbps at "T" reference.
 - c. Frame Relay: All stated compliance's measured at head end equipment.
 - d. Integrated Data Communications Utility (IDCU) operation and interface: Measured at head end equipment.
 - e. Fiberoptic Distributed Data Interface (FDDI): A minimum 100 Mbps to a maximum of 1.8 giga(g)-Bps data bit stream speed measured at head end equipment (shall be Synchronous Optical Network [Sonet] compliant).
 - f. System Sensitivity: Satisfactory service shall be provided for at least 3,000 feet for all voice and data // and analog RF // locations.
2. At a minimum the System shall support the following operating parameters:
- a. EPBX connection:
 - 1) System speed: 1.0 gbps per second, minimum.
 - 2) Impedance: 600 Ohms.
 - 3) Cross Modulation: -60 deci-Bel (dB).
 - 4) Hum Modulation: -55 Db.
 - 5) System data error: 10 to the -10 Bps, minimum loss measured at the frame output with reference Zero (0) deciBel measured (dBm) at 1,000 Hertz (Hz) applied to the frame input.
 - a) Trunk to station: 1.5 dB, maximum.
 - b) Station to station: 3.0 dB, maximum.
 - c) Internal switch crosstalk: -60 dB when a signal of ± 10 deciBel measured (dBm), 500-2,500 Hz range is applied to the primary path.
 - d) Idle channel noise: 25 dBm "C" or 3.0 dBm "O" above reference (terminated) ground noise, whichever is greater.
 - e) Traffic Grade of Service for Voice and Data:
 - (1) A minimum grade of service of P-01 with an average traffic load of 7.0 CCS per station per hour and a traffic overload in the data circuits will not interfere with, or degrade, the voice service.

(2) Average CCS per voice station: The average CCS capacity per voice station shall be maintained at 7.0 CCS when the EPBX is expanded up to the projected maximum growth as stated herein.

b. Telecommunications Outlet (TCO):

1) Voice:

- a) Isolation (outlet-outlet): 24 dB.
- b) Impedance: 600 Ohms, balanced (BAL).
- c) Signal Level: 0 deciBel per mili-Volt (dBmV) \pm 0.1 dBmV.
- d) System speed: 100 mBps, minimum.
- e) System data error: 10 to the -6 Bps, minimum.

2) Data:

- a) Isolation (outlet-outlet): 24 dB.
- b) Impedance: 600 Ohms, BAL.
- c) Signal Level: 0 dBmV \pm 0.1 dBmV.
- d) System speed: 120 mBps, minimum.
- e) System data error: 10 to the -8 Bps, minimum.

3) Fiber optic:

- a) Isolation (outlet-outlet): 36 dB.
- b) Signal Level: 0 dBmV \pm 0.1 dBmV.
- c) System speed: 540 mBps, minimum.
- d) System data error: 10 to the -6 BPS, minimum.

C. General:

1. All equipment to be supplied under this specification shall be new and the current model of a standard product of an OEM or record. An OEM of record shall be defined as a company whose main occupation is the manufacture for sale of the items of equipment supplied and which:
 - a. Maintains a stock of replacement parts for the item submitted.
 - b. Maintains engineering drawings, specifications, and operating manuals for the items submitted.
 - c. Has published and distributed descriptive literature and equipment specifications on the items of equipment submitted at least 30 days prior to the Invitation for Bid.
2. Specifications of equipment as set forth in this document are minimum requirements, unless otherwise stated, and shall not be construed as limiting the overall quality, quantity, or performance characteristics of items furnished in the System. When the

Contractor furnishes an item of equipment for which there is a specification contained herein, the item of equipment shall meet or exceed the specification for that item of equipment.

3. The Contractor shall provide written verification, in writing to the RE at time of installation, that the type of wire/cable being provided is recommended and approved by the OEM. The Contractor is responsible for providing the proper size and type of cable duct and/or conduit and wiring even though the actual installation may be by another subcontractor.
4. Active electronic component equipment shall consist of solid state components, be rated for continuous duty service, comply with the requirements of FCC standards for telephone equipment, systems, and service.
5. All passive distribution equipment shall meet or exceed -80 dB radiation shielding specifications.
6. All interconnecting twisted pair, fiber-optic cables shall be terminated on equipment terminal boards, punch blocks, breakout boxes, splice blocks, and unused equipment ports/taps shall be terminated according to the OEM's instructions for telephone cable systems without adapters. The Contractor shall not leave unused or spare twisted pair wire, fiber-optic cable unterminated, unconnected, loose or unsecured.
7. Color code all distribution wiring to conform to the Telephone Industry standard, EIA/TIA, and this document, which ever is the more stringent. At a minimum, all equipment, cable duct and/or conduit, enclosures, wiring, terminals, and cables shall be clearly and permanently labeled according to and using the provided record drawings, to facilitate installation and maintenance.
8. Connect the System's primary input AC power to the Facility' Critical Branch of the Emergency AC power distribution system as shown on the plans or if not shown on the plans consult with RE regarding a suitable circuit location prior to bidding.
9. Plug-in connectors shall be provided to connect all equipment, except coaxial cables and interface points. Coaxial cable distribution points and RF transmission lines shall use coaxial cable connections recommended by the cable OEM and approved by the System OEM. Base- band cable systems shall utilize barrier terminal screw type connectors, at a minimum. Crimp type connectors installed

- with a ratchet type installation tool are and acceptable alternate as long as the cable dress, pairs, shielding, grounding, and connections and labeling are provided the same as the barrier terminal strip connectors. Tape of any type, wire nuts, or solder type connections are unacceptable and will not be approved.
10. All equipment faceplates utilized in the System shall be stainless steel, anodized aluminum, or UL approved cycolac plastic for the areas where provided.
 11. Noise filters and surge protectors shall be provided for each equipment interface cabinet, switch equipment cabinet, control console, local, and remote active equipment locations to ensure protection from input primary AC power surges and noise glitches are not induced into low Voltage data circuits.
 12. Underground warning tape shall be standard, 4-Mil polyethylene 76 mm (3 inch) wide tape, detectable type, red with black letters imprinted with "CAUTION BURIED ELECTRIC LINE BELOW", orange with black letters imprinted with "CAUTION BURIED TELEPHONE LINE BELOW" or orange with black letters imprinted with "CAUTION BURIED FIBER OPTIC LINE BELOW", as applicable.

D. Equipment Functional Characteristics:

FUNCTIONS	CHARACTERISTICS
Input Voltage	105 to 130 VAC
POWER LINE FREQUENCY	60 HZ \pm 2.0 HZ
Operating Temperature	0 to 50 degrees (°) Centigrade (C)
Humidity	80 percent (%) minimum rating

E. Equipment Standards and Testing:

1. The System has been defined herein as connected to systems identified as Critical Care performing Life Support Functions. Therefore, at a minimum, the system shall conform to all aforementioned National and/or Local Life Safety Codes (which ever are the more stringent), NFPA, NEC, this specification, JCAHCO Life Safety Accreditation requirements, and the OEM recommendations, instructions, and guidelines.
2. All supplies and materials shall be listed, labeled or certified by UL or a nationally recognized testing laboratory where such

standards have been established for the supplies, materials or equipment.

3. The provided active and passive equipment required by the System design and approved technical submittal must conform with each UL standard in effect for the equipment, as of the date of the technical submittal (or the date when the RE approved system equipment necessary to be replaced) was technically reviewed and approved by VA. Where a UL standard is in existence for equipment to be used in completion of this contract, the equipment must bear the approved UL seal.
4. Each item of electronic equipment to be provided under this contract must bear the approved UL seal or the seal of the testing laboratory that warrants the equipment has been tested in accordance with, and conforms to the specified standards.

2.2 DISTRIBUTION EQUIPMENT AND SYSTEMS

A. Telecommunication Outlet (TCO):

1. The TCO shall consist of one telephone multipin jack and two data multipin jacks, one single mode fiber optic, and one multimode fiber optic jacks mounted in a steel outlet box. A separate 100mm (4in.) x 100mm (4in.) x 63mm (2.5in.) steel outlet box with a labeled stainless steel faceplate will be used. A second 100mm (4in.) x 100mm (4in.) x 63mm (2.5in.) steel outlet box with a labeled faceplate shall be provided as required adjacent to the first box to ensure system connections and expandability requirements are met.
2. All telephone multipin connections shall be RJ-45/11 compatible female types. All data multipin connections shall be RJ-45 female types. All fiber optic (single mode and multimode) connections shall be "ST" stainless steel female types.
3. The TCO shall be fed from the appropriate CCS located in the respective RTC in a manner to provide a uniform and balanced distribution system.
4. Interface of the data multipin jacks to appropriate patch panels (or approved "punch down" blocks) in the associated RTC, is the responsibility of the Contractor. The Contractor shall not extend data cables from the RTCs to data terminal equipment or install data terminal equipment.
5. The wall outlet shall be provided with a stainless steel or approve alternate cover plate to fit the telephone multipin jack, data

multi-pin jacks, fiber optic jacks and the outlet box provided (100mm (4in.) x 100mm (4in.) for single and 100mm (4in.) x 200mm (8in.) for dual outlet box applications). For PBPU installations, the cover plate shall be stainless steel.

- B. Distribution Cables: Each cable shall meet or exceed the following specifications for the specific type of cable. Each cable reel shall be sweep tested and certified by the OEM by tags affixed to each reel. The Contractor shall turn over all sweep tags to the RE or PM. Additionally, the Contractor shall provide a 610 mm (2 ft.) sample of each provided cable, to the RE and receive approval before installation. Cables installed in any outside location (i.e. above ground, under ground in conduit, ducts, pathways, etc.) shall be filled with a waterproofing compound between outside jacket (not immediately touching any provided armor) and inter conductors to seal punctures in the jacket and protect the conductors from moisture.

1. Remote Control:

- a. The remote control cable shall be multi-conductor with stranded (solid is permissible) conductors. The cable shall be able to handle the power and voltage necessary to control specified system equipment from a remote location. The cable shall be UL listed and pass the FR-1 vertical flame test, at a minimum. Each conductor shall be color-coded. Combined multi-conductor and coaxial cables are acceptable for this installation, as long as all system performance standards are met.
- b. Technical Characteristics:

Length	As required, in 1K (3,000 ft.) reels minimum
Connectors	As required by system design
Size	18 AWG, minimum, Outside 20 AWG, minimum, Inside
Color coding	Required, EIA industry standard
Bend radius	10X the cable outside diameter
Impedance	As required
Shield coverage	As required by OEM specification
Attenuation	
Frequency in MHz	dB per 305 M (1,000ft.), maximum

0.7	5.2
1.0	6.5
4.0	14.0
8.0	19.0
16.0	26.0
20.0	29.0
25.0	33.0
31.0	36.0
50.0	52.0

2. Data Multi-Conductor:

- a. The cable shall be multi-conductor, shielded or unshielded cable with stranded conductors. The cable shall be able to handle the power and voltage used over the distance required. It shall meet Category Six service at a minimum.

b. Technical Characteristics:

Wire size	22 AWG, minimum
Working shield	350 V
Bend radius	10X the cable outside diameter
Impedance	100 Ohms \pm 15%, BAL
Bandwidth	100 mHz, minimum
DC RESISTANCE	10.0 Ohms/100M, maximum
Shield coverage	
Overall Outside (if OEM specified)	100%
Individual Pairs (if OEM specified)	100%
Attenuation	
Frequency in mHz	dB per 305 M (1,000ft.), maximum
0.7	5.2
1.0	6.5
4.0	14.0
8.0	19.0
16.0	26.0
20.0	29.0
25.0	33.0

31.0	36.0
62.0	52.0
100.0	68.0

3. Fiber Optic:

a. Multimode Fiber:

- 1) The general purpose multimode fiber optic cable shall be a dual window type installed in conduit for all system locations. A load-bearing support braid shall surround the inner tube for strength during cable installation.
- 2) Technical Characteristics:

Bend radius	6.0", minimum Outer jacket, As required
FIBER DIAMETER	62.5 MICRONS
Cladding	125 microns
Attenuation	
850 nM	4.0 dB per kM, maximum
1,300 nM	2.0 dB per kM, maximum
Bandwidth	
850 nM	160 MHz, minimum
1,300 nM	500 MHz, minimum
Connectors	Stainless steel

b. Single mode Fiber:

- 1) The general purpose single mode fiber optic cable shall be a dual window type installed in conduit for all system locations. A load-bearing support braid shall surround the inner tube for strength during cable installation.
- 2) Technical Characteristics:

Bend radius	100 mm (4 in.) minimum
Outer jacket	PVC
Fiber diameter	8.7 microns
Cladding	125 microns
Attenuation at 850 nM	1.0 dBm per km
Connectors	Stainless Steel

4. AC Power Cable: AC power cable(s) shall be 3-conductor, no. 12 AWG minimum, and rated for 13A-125V and 1,625W. Master AC power, installation specification and requirements, are given in the NEC and herein.

C. Outlet Connection Cables:

1. Data:

- a. The Contractor shall provide a connection cable for each TCO data jack in the system with 10% spares. The data connection cable shall connect a data instrument to the TCO data jack. The Contractor shall not provide data terminal(s)/equipment.
- b. Technical Characteristics:

Length	1.8M (6 ft.), minimum
Cable	Data grade Category Six
Connector	RJ-45 male on each end
Color coding	Required, data industry standard
Size	24 AWG, minimum

2. Fiber Optic:

- a. The Contractor shall provide a connection cable for each TCO fiber optic connector in the System with 10% spares. The data connection cable shall connect a fiber optic instrument to the TCO fiber optic jack. The Contractor shall not provide fiber optic instrument(s)/equipment.
- b. Technical Characteristics:

Length	1.8M (6 ft.), minimum
Cable	Flexible single conductor with jacket
Connector	ST male on each end
Size	To fit single mode or multimode cable//

D. System Connectors:

1. Solderless (Forked Connector):

- a. The connector shall have a crimp-on coupling for quick connect/disconnect of wires or cables. The crimp-on connector

shall be designed to fit the wire or cable furnished. The connector barrel shall be insulated and color-coded.

b. Technical Characteristics:

Impedance	As required
Working Voltage	500 V

2. Multipin:

- a. The connector shall have a crimp-on coupling for quick connect/disconnect of wires or cables. The crimp-on connector shall be designed to fit the wire or cable furnished. The connector housing shall be fully enclosed and shielded. It shall be secured to the cable group by screw type compression sleeves.

b. Technical Characteristics:

Impedance	As required
Working Voltage	500 V
Number of pins	As requires, usually 25 pairs minimum

3. Modular (RJ-45/11 and RJ-45): The connectors shall be commercial types for voice and high speed data transmission applications. The connector shall be compatible with telephone instruments, computer terminals, and other type devices requiring linking through the modular telecommunications outlet to the System. The connector shall be compatible with UTP and STP cables.

a. Technical Characteristics:

Type	Number of Pins
RJ-11/45	Compatible with RJ45
RJ-45	Eight
Dielectric	Surge
Voltage	1,000V RMS, 60 Hz @ one minute, minimum
Current	2.2A RMS @ 30 Minutes or 7.0A RMS @ 5.0 seconds
Leakage	100 μ A, maximum
Connectability	

Initial contact resistance	20 mili-Ohms, maximum
Insulation displacement	10 mili-Ohms, maximum
Interface	Must interface with modular jacks from a variety of OEMs. RJ-11/45 plugs shall provide connection when used in RJ-45 jacks.
Durability	200 insertions/withdrawals, minimum

4. Fiber Optic: The connectors shall be commercial types for voice and high speed data transmission applications. The connector shall be compatible with telephone instruments, computer terminals, and other type devices requiring linking through the modular telecommunications outlet to the system. The connector shall be compatible with UTP and STP cables.

E. Terminators:

1. Fiber Optic:

- a. These units shall be metal-housed precision types in the frequency ranges selected. They shall be the screw-on type that has low VSWR when installed and the proper impedance to terminate the required system unit or fiber optic cable.
- b. Technical Characteristics:

Frequency	Lightwave
Power blocking	As required
Return loss	25 dB
Connectors	"ST", minimum
Construction	Stainless steel
Impedance	As required

F. Distribution Frames:

1. A new stand-alone (i.e., self supporting, free standing) MDF shall be provided to interconnect the EPBX and computer room. The MDF shall be modular and equipped with modular terminating mini blocks (i.e. Ericsson, 3M, etc.), and patch panels that are as small as possible and provide all the requirements of this specifications as described herein.
2. All cable distribution closets and MDFs shall be wired in accordance with industry standards and shall employ "latest state-of-the-art"

modular cross-connect devices. The MDF/telephone closet riser cable shall be sized to satisfy all voice requirements plus not less than 50% spare (growth) capacity in each telephone closet which includes a fiber optic backbone. The MDF/telephone closet riser cable shall be sized to satisfy all voice and data requirements plus not less than 50% spare (growth) capacity in each telephone closet which does not include a fiber optic backbone.

3. The MDF and all intermediate distribution frames shall be connected to the EPBX system ground.
4. Technical Characteristics:

Telephone	
IDC type unit	As described in Part 2
Contact wires	50 micron of Gold over Nickel
Contact pressure	100 Grams, MIN
110A Punch blocks	Acceptable alternate to IDC
Data	110A blocks as described in Part 2
Fiber optic	Patch panel as described in Part 2
Analog Video	Patch panel as described in Part 2

2.3 TELECOMMUNICATIONS CLOSET REQUIREMENTS

Refer to VA Handbook H-088C3, Telephone System Requirements, for specific TC guidelines for size, power input, security, and backboard mounting requirements. It is the Contractors responsibility to ensure TC compliance with the System Requirements.

2.4 ENVIRONMENTAL REQUIREMENTS

Technical submittals shall identify the environmental specifications for housing the system. These environmental specifications shall identify the requirements for initial and expanded system configurations for:

- A. Floor loading for batteries and cabinets.
- B. Minimum floor space and ceiling heights.
- C. Minimum size of doors for equipment passage.
- D. Power requirements: The bidders shall provide the specific voltage, amperage, phases, and quantities of circuits required.
- E. Air conditioning, heating, and humidity requirements. The bidder shall identify the ambient temperature and relative humidity operating ranges required preventing equipment damage.

- F. Air conditioning requirements (expressed in BTU per hour, based on adequate dissipation of generated heat to maintain required room and equipment standards).
- G. Proposed floor plan based on the expanded system configuration of the bidder's proposed EPBX for this Facility.
- H. Conduit size requirement (between equipment room and console room).

2.5 INSTALLATION KIT

The kit shall be provided that, at a minimum, includes all connectors and terminals, labeling systems, audio spade lugs, barrier strips, punch blocks or wire wrap terminals, heat shrink tubing, cable ties, solder, hangers, clamps, bolts, conduit, cable duct, and/or cable tray, etc., required to accomplish a neat and secure installation. All wires shall terminate in a spade lug and barrier strip, wire wrap terminal or punch block. Unfinished or unlabeled wire connections shall not be allowed. Turn over to the RE all unused and partially opened installation kit boxes, coaxial, fiberoptic, and twisted pair cable reels, conduit, cable tray, and/or cable duct bundles, wire rolls, physical installation hardware. The following are the minimum required installation sub-kits:

- A. System Grounding:
 - 1. The grounding kit shall include all cable and installation hardware required. All radio equipment shall be connected to earth ground via internal building wiring, according to the NEC.
 - 2. This includes, but is not limited to:
 - a. Coaxial Cable Shields.
 - b. Control Cable Shields.
 - c. Data Cable Shields.
 - d. Equipment Racks.
 - e. Equipment Cabinets.
 - f. Conduits.
 - g. Duct.
 - h. Cable Trays.
 - i. Power Panels.
 - j. Connector Panels.
 - k. Grounding Blocks.

- B. Wire and Cable: The wire and cable kit shall include all connectors and terminals, audio spade lugs, barrier straps, punch blocks, wire wrap strips, heat shrink tubing, tie wraps, solder, hangers, clamps, labels etc., required to accomplish a neat and orderly installation.
- C. Conduit, Cable Duct, and Cable Tray: The kit shall include all conduit, duct, trays, junction boxes, back boxes, cover plates, feed through nipples, hangers, clamps, other hardware required to accomplish a neat and secure conduit, cable duct, and/or cable tray installation in accordance with the NEC and this document.
- D. Equipment Interface: The equipment kit shall include any item or quantity of equipment, cable, mounting hardware and materials needed to interface the systems with the identified sub-system(s) according to the OEM requirements and this document.
- E. Labels: The labeling kit shall include any item or quantity of labels, tools, stencils, and materials needed to completely and correctly label each subsystem according to the OEM requirements, as-installed drawings, and this document.
- F. Documentation: The documentation kit shall include any item or quantity of items, computer discs, as installed drawings, equipment, maintenance, and operation manuals, and OEM materials needed to completely and correctly provide the system documentation as required by this document and explained herein.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Product Delivery, Storage and Handling:
 - 1. Delivery: Deliver materials to the job site in OEM's original unopened containers, clearly labeled with the OEM's name and equipment catalog numbers, model and serial identification numbers. The RE may inventory the cable, patch panels, and related equipment.
 - 2. Storage and Handling: Store and protect equipment in a manner, which will preclude damage as directed by the RE.
- B. System Installation:
 - 1. After the contract's been awarded, and within the time period specified in the contract, the Contractor shall deliver the total system in a manner that fully complies with the requirements of this specification. The Contractor shall make no substitutions or changes in the System without written approval from the RE and PM.

2. The Contractor shall install all equipment and systems in a manner that complies with accepted industry standards of good practice, OEM instructions, the requirements of this specification, and in a manner which does not constitute a safety hazard. The Contractor shall insure that all installation personnel understands and complies with all the requirements of this specification.
3. The Contractor shall install suitable filters, traps, directional couplers, splitters, TC's, and pads for minimizing interference and for balancing the System. Items used for balancing and minimizing interference shall be able to pass telephone and data, and lightwave signals in the frequency bands selected, in the direction specified, with low loss, and high isolation, and with minimal delay of specified frequencies and signals. The Contractor shall provide all equipment necessary to meet the requirements of Paragraph 2.1.C and the System performance standards.
4. All passive equipment shall be connected according to the OEM's specifications to insure future correct termination, isolation, impedance match, and signal level balance at each telephone/data outlet.
5. Where TCOs are installed adjacent to each other, install one outlet for each instrument.
6. All lines shall be terminated in a suitable manner to facilitate future expansion of the System. There shall be a minimum of one spare 25 pair cable at each distribution point on each floor.
7. All vertical and horizontal copper and fiber optic cables shall be terminated so any future changes only requires modifications of the existing EPBX or signal closet equipment only.
8. Terminating resistors or devices shall be used to terminate all unused branches, outlets, equipment ports of the System, and shall be devices designed for the purpose of terminating fiber optic or twisted pair cables carrying telephone and data signals in telephone and data systems.
9. Equipment installed outdoors shall be weatherproof or installed in weatherproof enclosures with hinged doors and locks with two keys.
10. Equipment installed indoors shall be installed in metal cabinets with hinged doors and locks with two keys.

C. Conduit and Signal Ducts:

1. Conduit:

- a. The Contractor shall employ the latest installation practices and materials. The Contractor shall provide conduit, junction boxes, connectors, sleeves, weatherheads, pitch pockets, and associated sealing materials not specifically identified in this document as GFE. Conduit penetrations of walls, ceilings, floors, interstitial space, fire barriers, etc., shall be sleeved and sealed. The minimum conduit size shall be 19 mm (3/4 in.).
- b. All cables shall be installed in separate conduit and/or signal ducts (exception from the separate conduit requirement to allow telephone cables to be installed in partitioned cable tray with data cables may be granted in writing by the RE if requested.) Conduits shall be provided in accordance with Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS, and NEC Articles 517 for Critical Care and 800 for Communications systems, at a minimum.
- c. When metal, plastic covered, etc., flexible cable protective armor or systems are specifically authorized to be provided for use in the System, their installation guidelines and standards shall be as specified herein, Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS, and the NEC.
- d. When "innerduct" flexible cable protective systems is specifically authorized to be provided for use in the System, it's installation guidelines and standards shall be as the specified herein, Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS, and the NEC.
- e. Conduit (including GFE) fill shall not exceed 40%. Each conduit end shall be equipped with a protective insulator or sleeve to cover the conduit end, connection nut or clamp, to protect the wire or cable during installation and remaining in the conduit. Electrical power conduit shall be installed in accordance with the NEC. AC power conduit shall be run separate from signal conduit.
- f. When metal, plastic covered, etc., flexible cable protective armor or systems are specifically authorized to be provided for use in the System, their installation guidelines and standards

shall be as specified herein, Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS, and the NEC.

2. Signal Duct, Cable Duct, or Cable Tray:

- a. The Contractor shall use existing signal duct, cable duct, and/or cable tray, when identified and approved by the COR.
- b. Approved signal and/or cable duct shall be a minimum size of 100 mm x 100 mm (4 in. X 4 in.) inside diameter with removable tops or sides, as appropriate. Protective sleeves, guides or barriers are required on all sharp corners, openings, anchors, bolts or screw ends, junction, interface and connection points.
- c. Approved cable tray shall be fully covered, mechanically and physically partitioned for multiple electronic circuit use, and be UL certified and labeled for use with telecommunication circuits and/or systems. The RE shall approve width and height dimensions.

D. Distribution System Signal Wires and Cables:

1. Wires and cables shall be provided in the same manner and use like construction practices as Fire Protective and other Emergency Systems that are identified and outlined in NFPA 101, Life Safety Code, Chapters 7, 12, and/or 13, NFPA 70, National Electrical Code, Chapter 7, Special Conditions. The wires and cables shall be able to withstand adverse environmental conditions in their respective location without deterioration. Wires and cables shall enter each equipment enclosure, console, cabinet or rack in such a manner that all doors or access panels can be opened and closed without removal or disruption of the cables.
 - a. Each wire and cable shall terminate on an item of equipment by direct connection. Spare or unused wire and cable shall be provided with appropriate connectors (female types) that are installed in appropriate punch blocks, barrier strips, patch, or bulkhead connector panels.
 - b. Fiber optic cables that are spare, unused or dark shall be provided with Industry Standard "ST" type female connectors installed in appropriate break out, patch, or bulkhead connector panels provided in enclosure(s) and shall be protected from the environment.
 - c. Coaxial cables that are spare, unused or dark shall be provided with the cable OEM specified type female connectors installed in

appropriate break out, patch, or bulkhead connector panels provided in enclosure(s) and shall be protected from the environment.

- d. All cable junctions and taps shall be accessible. Provide an 8" X 8" X 4" (minimum) junction box attached to the cable duct or raceway for installation of distribution system passive equipment. Ensure all equipment and tap junctions are accessible.

2. Routing and Interconnection:

- a. Wires or cables between consoles, cabinets, racks and other equipment shall be in an approved conduit, signal duct, cable duct, or cable tray that is secured to building structure.
- b. Wires and cables shall be insulated to prevent contact with signal or current carrying conductors. Wires or cables used in assembling consoles, panels, equipment cabinets and racks shall be formed into harnesses that are bundled and tied. Harnessed wires or cables shall be combed straight, formed and dressed in either a vertical or horizontal relationship to equipment, controls, components or terminations.
- c. Harnesses with intertwined members are not acceptable. Each wire or cable that breaks out from a harness for connection or termination shall have been tied off at that harness or bundle point, and be provided with a neatly formed service loop.
- d. Wires and cables shall be grouped according to service (i.e.: AC, grounds, signal, DC, control, etc.). DC, control and signal cables may be included with any group. Wires and cables shall be neatly formed and shall not change position in the group throughout the conduit run. Wires and cables in approved signal duct, conduit, cable ducts, or cable trays shall be neatly formed, bundled, tied off in 600 mm to 900 mm (24 in. to 36 in.) lengths and shall not change position in the group throughout the run. Concealed splices are not allowed.
- e. Separate, organize, bundle, and route wires or cables to restrict EMI, channel crosstalk, or feedback oscillation inside any enclosure. Looking at any enclosure from the rear (wall mounted enclosures, junction, pull or interface boxes from the front), locate AC power, DC and speaker wires or cables on the left; coaxial, control, microphone and line level audio and data wires or cables, on the right. This installation shall be accomplished

with ties and/or fasteners that will not damage or distort the wires or cables. Limit spacing between tied off points to a maximum of 150 mm (6 inches).

- f. Do not pull wire or cable through any box, fitting or enclosure where change of cable tray or signal or cable duct alignment or direction occurs. Ensure the proper bend radius is maintained for each wire or cable as specified by it's OEM.
- g. Employ temporary guides, sheaves, rollers, and other necessary items to protect the wire or cable from excess tension or damage from bending during installation. Abrasion to wire or cable jackets is not acceptable and will not be allowed. Replace all cables whose jacket has been abraded. The discovery of any abraded and/or damaged cables during the proof of performance test shall be grounds for declaring the entire system unacceptable and the termination of the proof of performance test. Completely cover edges of wire or cable passing through holes in chassis, cabinets or racks, enclosures, pull or junction boxes, conduit, etc., with plastic or nylon grommets.
- h. Cable runs shall be splice free between conduit junction and interface boxes and equipment locations.
- i. Cables shall be installed and fastened without causing sharp bends or rubbing of the cables against sharp edges. Cables shall be fastened with hardware that will not damage or distort them.
- j. Cables shall be labeled with permanent markers at the terminals of the electronic and passive equipment and at each junction point in the System. The lettering on the cables shall correspond with the lettering on the record diagrams.
- k. Completely test all of the cables after installation and replace any defective cables.
- l. Wires or cables that are installed outside of buildings shall be in conduit, secured to solid building structures. If specifically approved, on a case by case basis, to be run outside of conduit, the wires or cables shall be installed, as described herein. The bundled wires or cables must: Be tied at not less than 460 mm (18 in.) intervals to a solid building structure; have ultra violet protection and be totally waterproof (including all connections). The laying of wires or cables directly on roof tops, ladders,

drooping down walls, walkways, floors, etc. is not allowed and will not be approved.

- m. Wires or cables installed outside of conduit, cable trays, wireways, cable duct, etc.
 - 1) Only when specifically authorized as described herein, will wires or cables be identified and approved to be installed outside of conduit. The wire or cable runs shall be UL rated plenum and OEM certified for use in air plenums.
 - 2) Wires and cables shall be hidden, protected, fastened and tied at 600 mm (24 in.) intervals, maximum, as described herein to building structure.
 - 3) Closer wire or cable fastening intervals may be required to prevent sagging, maintain clearance above suspended ceilings, remove unsightly wiring and cabling from view and discourage tampering and vandalism. Wire or cable runs, not provided in conduit, that penetrate outside building walls, supporting walls, and two hour fire barriers shall be sleeved and sealed with an approved fire retardant sealant.
 - 4) Wire or cable runs to system components installed in walls (i.e.: volume attenuators, circuit controllers, signal, or data outlets, etc.) may, when specifically authorized by the RE, be fished through hollow spaces in walls and shall be certified for use in air plenum areas.
- n. Wires or cables installed in underground conduit, duct, etc.
 - 1) Wires or cables installed in underground installations shall be waterproofed by the inclusion of a water protective barrier (i.e. gel, magma, etc.) or flooding compound between the outside jacket and first shield. Each underground connection shall be accessible in a manhole, recessed ground level junction box, above ground pedestal, etc., and shall be provided with appropriate waterproof connectors to match the cable being installed. Once the System has been tested and found to meet the System performance standards and accepted by VA, the Contractor shall provide waterproof shrink tubing or approved mastic to fully encompass each wire or cable connection and overlay at least 150 mm (6 inches) above each wire or cable jacket trim point.

- 2) It is not acceptable to connect waterproofed cable directly to an inside CCS punch block or directly to an equipment connection port. When an under ground cable enters a building, it shall be routed directly to the closest TC that has been designated as the building's IMTC. The Contractor shall provide a "transition" splice in this TC where the "water proofed" cable enters on one side and "dry" cable exits on the other side. The "transition" splice shall be fully waterproof and be capable of reentry for system servicing. Additionally, the transition splice shall not allow the waterproofing compound to migrate from the water proof cable to the dry cable.
- 3) Warning tape shall be continuously placed 300 mm (12 inches) above buried conduit, cable, etc.

E. Outlet Boxes, Back Boxes, and Faceplates:

1. Outlet Boxes: Signal, power, interface, connection, distribution, and junction boxes shall be provided as required by the system design, on-site inspection, and review of the contract drawings.
2. Back Boxes: Back boxes shall be provided as directed by the OEM as required by the approved system design, on-site inspection, and review of the contract drawings.
3. Face Plates (or Cover Plates): Faceplates shall be of a standard type, stainless steel, anodized aluminum or UL approved cyclac plastic construction and provided by the Contractor for each identified system outlet location. Connectors and jacks appearing on the faceplate shall be clearly and permanently marked.

F. Connectors: Circuits, transmission lines, and signal extensions shall have continuity, correct connection and polarity. A uniform polarity shall be maintained between all points in the system.

1. Wires:

- a. Wire ends shall be neatly formed and where insulation has been cut, heat shrink tubing shall be employed to secure the insulation on each wire. Tape of any type is not acceptable.
- b. Audio spade lugs shall be installed on each wire (including spare or unused) end and connect to screw terminals of appropriate size barrier strips. AC barrier strips shall be provided with a protective cover to prevent accidental contact with wires carrying live AC current. Punch blocks are approved for signal,

not AC wires. Wire Nut or "Scotch Lock" connectors are not acceptable for signal wire installation.

2. Cables: Each connector shall be designed for the specific size cable being used and installed with the OEM's approved installation tool. Typical system cable connectors include; but, are not limited to: Audio spade lug, punch block, wirewrap, etc.

G. AC Power: AC power wiring shall be run separately from signal cable.

H. Grounding:

1. General: The Contractor shall ground all Contractor Installed Equipment and identified Government Furnished Equipment to eliminate all shock hazards and to minimize, to the maximum extent possible, all ground loops, common mode returns, noise pickup, crosstalk, etc. The total ground resistance shall be 0.1 Ohm or less.
 - a. The Contractor shall install lightning arrestors and grounding in accordance with the NFPA and this specification.
 - b. Gas protection devices shall be provided on all circuits and cable pairs serving building distribution frames located in buildings other than the building in which the head end equipment is located or in any area served by an unprotected distribution system (manhole, aerial, etc.). The Contractor shall install the gas protection devices at the nearest point of entrance in buildings where protection is required and on the same circuits on the MDF in the telephone switch room.
 - c. Under no conditions shall the AC neutral, either in a power panel or in a receptacle outlet, be used for system control, subcarrier or audio reference ground.
 - d. The use of conduit, signal duct or cable trays as system or electrical ground is not acceptable and will not be permitted. These items may be used only for the dissipation of internally generated static charges (not to be confused with externally generated lightning) that may be applied or generated outside the mechanical and/or physical confines of the System to earth ground. The discovery of improper system grounding shall be grounds to declare the System unacceptable and the termination of all system acceptance testing.
2. Cabinet Buss: A common ground buss of at least #10 AWG solid copper wire shall extend throughout each equipment cabinet and be connected to the system ground. Provide a separate isolated ground connection

- from each equipment cabinet ground buss to the system ground. Do not tie equipment ground busses together.
3. Equipment: Equipment shall be bonded to the cabinet bus with copper braid equivalent to at least #12 AWG. Self grounding equipment enclosures, racks or cabinets, that provide OEM certified functional ground connections through physical contact with installed equipment, are acceptable alternates.
 4. Cable Shields: Cable shields shall be bonded to the cabinet ground buss with #12 AWG minimum stranded copper wire at only one end of the cable run. Cable shields shall be insulated from each other, faceplates, equipment racks, consoles, enclosures or cabinets; except, at the system common ground point. Coaxial and audio cables, shall have one ground connection at the source; in all cases, cable shield ground connections shall be kept to a minimum.
- I. Labeling: Provide labeling in accordance with ANSI/EIA/TIA-606-A. All lettering for voice and data circuits shall be stenciled using thermal ink transfer process. Handwritten labels are not acceptable.
1. Cable and Wires (Hereinafter referred to as "Cable"): Cables shall be labeled at both ends in accordance with ANSI/EIA/TIA-606-A. Labels shall be permanent in contrasting colors. Cables shall be identified according to the System "Record Wiring Diagrams".
 2. Equipment: System equipment shall be permanently labeled with contrasting plastic laminate or bakelite material. System equipment shall be labeled on the face of the unit corresponding to its source.
 3. Conduit, Cable Duct, and/or Cable Tray: The Contractor shall label all conduit, duct and tray, including utilized GFE, with permanent marking devices or spray painted stenciling a minimum of 3 meters (10 ft.) identifying it as the System. In addition, each enclosure shall be labeled according to this standard.
 4. Termination Hardware: The Contractor shall label workstation outlets and patch panel connections using color coded labels with identifiers in accordance with ANSI/EIA/TIA-606-A and the "Record Wiring Diagrams".

3.2 TESTS

A. Interim Inspection:

1. This inspection shall verify that the equipment provided adheres to the installation requirements of this document. The interim

- inspection will be conducted by a factory-certified representative and witnessed by a Government Representative. Each item of installed equipment shall be checked to insure appropriate UL certification markings. This inspection shall verify cabling terminations in telecommunications rooms and at workstations adhere to color code for T568B pin assignments and cabling connections are in compliance with ANSI/EIA/TIA standards. Visually confirm Category 6 marking of outlets, faceplates, outlet/connectors and patch cords.
2. Perform fiber optical field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.
 3. The Contractor shall notify the COR, in writing, of the estimated date the Contractor expects to be ready for the interim inspection, at least 20 working days before the requested inspection date.
 4. Results of the interim inspection shall be provided to the COR and PM. If major or multiple deficiencies are discovered, a second interim inspection may be required before permitting the Contractor to continue with the system installation.
 5. The COR and/or the PM shall determine if an additional inspection is required, or if the Contractor will be allowed to proceed with the installation. In either case, re-inspection of the deficiencies noted during the interim inspection(s), will be part of the proof of performance test. The interim inspection shall not affect the Systems' completion date. The Contracting Officer shall ensure all test documents will become a part of the Systems record documentation.
- B. Pretesting:
1. Upon completing the installation of the System, the Contractor shall align and balance the system. The Contractor shall pretest the entire system.
 2. Pretesting Procedure:
 - a. During the system pretest, the Contractor shall verify (utilizing the approved spectrum analyzer and test equipment) that the System is fully operational and meets all the system performance requirements of this standard.

- b. The Contractor shall pretest and verify that all System functions and specification requirements are met and operational, no unwanted aural effects, such as signal distortion, noise pulses, glitches, audio hum, poling noise, etc. are present. The Contractor shall measure and record the aural carrier levels of each system telephone and data channel, at each of the following points in the system:
 - 1) EPBX interfaces or inputs and outputs.
 - 2) MDF interfaces or inputs and outputs.
 - 3) EPBX output S/NR for each telephone and data channel.
 - 4) Signal Level at each interface point to the distribution system, the last outlet on each trunk line plus all outlets installed as part of this contract.
3. The Contractor shall provide four (4) copies of the recorded system pretest measurements and the written certification that the System is ready for the formal acceptance test shall be submitted to the COR.
- C. Acceptance Test: After the System has been pretested and the Contractor has submitted the pretest results and certification to the COR, then the Contractor shall schedule an acceptance test date and give the RE 30 days written notice prior to the date the acceptance test is expected to begin. The System shall be tested in the presence of a Government Representative and an OEM certified representative. The System shall be tested utilizing the approved test equipment to certify proof of performance and Life Safety compliance. The test shall verify that the total System meets the requirements of this specification. The notification of the acceptance test shall include the expected length (in time) of the test.
- D. Verification Tests:
 1. Test the UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has an overall shield. Test the operation of shorting bars in connection blocks. Test cables after termination and prior to cross-connection.
 2. Multimode Fiber Optic Cable: Perform end-to-end attenuation tests in accordance with ANSI/EIA/TIA-568-B.3 and ANSI/EIA/TIA-526-14A using Method A, Optical Power Meter and Light Source. Perform verification acceptance test.

3. Single mode Fiber Optic Cable: Perform end-to-end attenuation tests in accordance with ANSI/EIA/TIA-568-B.3 and ANSI/EIA/TIA-526-7 using Method A, Optical Power Meter and Light Source. Perform verification acceptance test.

E. Performance Testing:

1. Perform Category 6 tests in accordance with ANSI/EIA/TIA-568-B.1 and ANSI/EIA/TIA-568-B.2. Test shall include the following: wire map, length, insertion loss, return loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, propagation delay and delay skew.
2. Fiber Optic Links: Perform end-to-end fiber optic cable link tests in accordance with ANSI/EIA/TIA-568-B.3.

F. Total System Acceptance Test: The Contractor shall perform verification tests for UTP copper cabling system(s), and the multimode and single mode fiber optic cabling system(s) after the complete telecommunication distribution system and workstation outlet are installed.

1. Data Testing: Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network is achieved.

3.3 TRAINING

- A. Furnish the services of a factory-trained engineer or technician for a total of two four hour classes to instruct designated Facility IRM personnel. Instruction shall include cross connection, corrective, and preventive maintenance of the System and equipment.
- B. Before the System can be accepted by the VA, this training must be accomplished. Training will be scheduled at the convenience of the Facilities Contracting Officer and Chief of Engineering Service.

3.4 GUARANTEE PERIOD OF SERVICE

A. Contractor's Responsibilities:

1. The Contractor shall guarantee that all installed material and equipment will be free from defects, workmanship, and will remain so for a period of one year from date of final acceptance of the System by the VA. The Contractor shall provide OEM's equipment warranty documents, to the COR (or Facility Contracting Officer if the Facility has taken possession of the building(s)), that certifies each item of equipment installed conforms to OEM published specifications.
2. The Contractor's maintenance personnel shall have the ability to contact the Contractor and OEM for emergency maintenance and

logistic assistance, remote diagnostic testing, and assistance in resolving technical problems at any time. The Contractor and OEM shall provide this contact capability at no additional cost to the VA.

3. All Contractor installation, maintenance, and supervisor personnel shall be fully qualified by the OEM and must provide two (2) copies of current and qualified OEM training certificates and OEM certification upon request.
4. Additionally, the Contractor shall accomplish the following minimum requirements during the one year guarantee period:
 - a. Response Time:
 - 1) The COR (or facility Contracting Officer if the facility has taken possession of the building[s]) are the Contractor's reporting and contact officials for the System trouble calls, during the guarantee period.
 - 2) A standard workweek is considered 8:00 A.M. to 5:00 P.M., Monday through Friday exclusive of Federal Holidays.
 - 3) The Contractor shall respond and correct on-site trouble calls, during the standard work week to:
 - a) A routine trouble call within one working days of its report. A routine trouble is considered a trouble which causes a system outlet, station, or patch cord to be inoperable.
 - b) An emergency trouble call within 6 hours of its report. An emergency trouble is considered a trouble which causes a subsystem or distribution point to be inoperable at anytime. Additionally, the loss of a minimum of 50 station or system lines shall be deemed as this type of a trouble call.
 - 4) The Contractor shall respond on-site to a catastrophic trouble call within 4 hours of its report. A catastrophic trouble call is considered total system failure.
 - a) If a system failure cannot be corrected within four hours (exclusive of the standard work time limits), the Contractor shall be responsible for providing alternate system CSS or TCO equipment, or cables. The alternate equipment and/or cables shall be operational within four hours after the four hour trouble shooting time.

- b) Routine or emergency trouble calls in critical emergency health care facilities (i.e., cardiac arrest, intensive care units, etc.) shall also be deemed as a catastrophic trouble call if so determined by the RE or Facility Director. The RE or Facility Contracting Officer shall notify the Contractor of this type of trouble call at the direction of the Facilities Director.
- b. Required on-site visits during the one year guarantee period
 - 1) The Contractor shall visit, on-site, for a minimum of eight hours, once every 12 weeks, during the guarantee period, to perform system preventive maintenance, equipment cleaning, and operational adjustments to maintain the System according the descriptions identified in this SPEC.
 - a) The Contractor shall arrange all Facility visits with the RE or Facility Contracting Officer prior to performing the required maintenance visits.
 - b) The Contractor in accordance with the OEM's recommended practice and service intervals shall perform preventive maintenance during a non-busy time agreed to by the RE or Facility Contracting Officer and the Contractor.
 - c) The preventive maintenance schedule, functions and reports shall be provided to and approved by the RE or Facility Contracting Officer.
 - 2) The Contractor shall provide the COR or Facility Contracting Officer a type written report itemizing each deficiency found and the corrective action performed during each required visit or official reported trouble call. The Contractor shall provide the RE with sample copies of these reports for review and approval at the beginning of the Total System Acceptance Test. The following reports are the minimum required:
 - a) Monthly Report: The Contractor shall provide a monthly summary all equipment and sub-systems serviced during this guarantee period to COR or Facilities Contracting Officer by the fifth working day after the end of each month. The report shall clearly and concisely describe the services rendered, parts replaced and repairs performed. The report shall prescribe anticipated future needs of the equipment and Systems for preventive and predictive maintenance

- b) Contractor Log: The Contractor shall maintain a separate log entry for each item of equipment and each sub-system of the System. The log shall list dates and times of all scheduled, routine, and emergency calls. Each emergency call shall be described with details of the nature and causes of emergency steps taken to rectify the situation and specific recommendations to avoid such conditions in the future.
- 3) The COR or Facility Contracting Officer shall provide the Facility Engineering Officer, two (2) copies of actual reports for evaluation.
 - a) The COR or Facility Contracting Officer shall ensure copies of these reports are entered into the System's official acquisition documents.
 - b) The Facilities Chief Engineer shall ensure copies of these reports are entered into the System's official technical as-installed documents.
- B. Work Not Included: Maintenance and repair service shall not include the performance of any work due to improper use, accidents, other vendor, contractor, owner tampering or negligence, for which the Contractor is not directly responsible and does not control. The Contractor shall immediately notify the COR or Facility Contracting Officer in writing upon the discovery of these incidents. The COR or Facility Contracting Officer will investigate all reported incidents and render findings concerning any Contractor's responsibility.

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