

September 26, 2013

**Addendum No. 1**

**Construct Research Center 516-328  
DEPARTMENT OF VETERANS AFFAIRS  
10000 Bay Pines Blvd.  
Bay Pines, Florida 33744**

This Amendment supplements and amends the original Drawings and Specifications for the above referenced project. This Amendment shall be forwarded to all Prime Bidders. This Amendment shall be taken into account in the preparation of bids and shall become a part of the Contract Documents. Receipt of this Amendment must be acknowledged on the Form of Proposal.

**This Amendment consists of 2 Written Narrative pages, 2 attached Specification sections and door hardware data attached.**

**THE DRAWINGS ARE REVISED AS FOLLOWS:**

**THE SPECIFICATIONS ARE REVISED AS FOLLOWS:**

1. **Section 01 00 00 General Requirements:** Paragraph 01 00 00.1.1.D: Delete entire paragraph and replace with the following:  
"Before placement and installation of work subject to testing by testing laboratory, retained and paid for by the contractor, the contractor shall notify the COR a minimum of 24 hours in advance of placement and/or installation of work."
2. **Section 01 41 50 Special Inspections:** Special Inspection services are retained and paid for by the owner. Inspections will be performed at the owner's discretion.
3. **Section 01 45 29 Testing Laboratory Services:** Paragraph 1.1 should read:  
"This section specifies materials testing activities and inspection services required during project construction to be provided by a Testing Laboratory retained and paid for by the Contractor."
4. **Section 01 91 00 General Commissioning Requirements:** Replace entire specification section with revised section attached.
5. **Section 08 71 00 Door Hardware:**
  - a. Core Type: Keymark X4 interchangeable cores by Medeco (reference attached).
  - b. Locks and cylinders: equal to ML2000 Corbin Russwin series mortise locks. Cylindrical locks must be equal to 73 K Best series.
  - c. "All key and core information must go through the Police service here at Bay Pines." This will need to be addressed during the submittal / approval process
6. **Section 10 11 23 Tackboards:** Delete this spec section, no tack boards required.
7. **Section 14 24 00 Hydraulic Elevators:** Elevator finishes as follows:
  - a. Wall finish: Plastic Laminate: Wilsonart, 7909 Fusion Maple, or equal.
  - b. Floor finish: Vinyl tile: Mannington, Century Cherry 12151 Spicy Cider
  - c. Misc. trim to be stainless steel.

8. **Section 31 63 16 Auger Cast Grout Piles:** Replace entire specification section with revised section attached.
9. **Section 21 08 00 Commissioning of Fire Suppression System:**  
**Section 22 08 00 Commissioning of Plumbing Systems:**  
**Section 23 08 00 Commissioning of HVAC Systems:**  
**Section 26 08 00 Commissioning of Electrical Systems:**  
**Section 27 08 00 Commissioning of Communications Systems:**  
**Section 28 08 00 Commissioning of Electronic Safety and Security Systems:**

Replace Paragraph 1.1-B of all sections listed in Item 9 with the following paragraph:

This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) will manage the commissioning process. The Commissioning Agent shall be paid by the Contractor and shall work through and report to the VA Resident Engineer. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for specific requirements.

**End of Addendum #1**

**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 7, Division 21, Division 22, Division 23, Division 26, Division 27, Division 28, and Division 31 series sections of these specifications are intended to be provided in coordination with the commissioning services and are not intended to duplicate services. The Contractor shall coordinate the work required by individual specification sections with the commissioning services requirements specified herein.
- C. Where individual testing, adjusting, or related services are required in the project specifications and not specifically required by this commissioning requirements specification, the specified services shall be provided and copies of documentation, as required by those specifications shall be submitted to the VA and the Commissioning Agent to be indexed for future reference.
- D. Where training or educational services for VA are required and specified in other sections of the specifications, including but not limited to Division 7, Division 8, Division 21, Division 22, Division 23, Division 26, Division 27, Division 28, and Division 31 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.

## **1.2 CONTRACTUAL RELATIONSHIPS**

- A. For this construction project, the Department of Veterans Affairs contracts with a Contractor to provide construction services. The contracts are administered by the VA Contracting Officer and the Resident Engineer as the designated representative of the Contracting Officer. On this project, the authority to modify the contract in any way is strictly limited to the authority of the Contracting Officer 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 07 08 00 FACILITY EXTERIOR CLOSURE COMMISSIONING.
- C. Section 21 08 00 COMMISSIONING OF FIRE PROTECTION SYSTEMS.
- D. Section 22 08 00 COMMISSIONING OF PLUMBING SYSTEMS.
- E. Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.
- F. Section 26 08 00 COMMISSIONING OF ELECTRICAL SYSTEMS.
- G. Section 27 08 00 COMMISSIONING OF COMMUNICATIONS SYSTEMS.
- H. Section 28 08 00 COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS.
- I. Section 31 08 00 COMMISSIONING OF UTILITIES.

### **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.
- 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 VA requirements developed for the project.
  - 1. Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" and the 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.
- D. The commissioning activities have been developed to support the Green Buildings Initiative Green Globes rating program and to support delivery of project performance in accordance with the VA requirements developed for the project.

## 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. The qualified Commissioning Professional who administers the Cx process by managing the Cx team and overseeing the Commissioning Process. Where CxA is used in this specification it means the Commissioning Agent, members of his staff or appointed members of the commissioning team. The Commissioning Agent shall work through and report to the VA Resident Engineer. **The Commissioning Agent shall be paid by the Contractor.**
- C. CxM: Commissioning Manager. A qualified individual appointed by the Contractor to manage the commissioning process on behalf of the Contractor.
- D. CxR: Commissioning Representative. An individual appointed by a sub-contractor to manage the commissioning process on behalf of the sub-contractor.
- E. Commissioning Plan: a document that is an overall plan that outlines the commissioning process, commissioning team responsibilities, schedule for commissioning activities, and commissioning documents.
- F. 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.
- G. 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.
- H. 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.

- I. 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.
- J. 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.

**K. Seasonal Functional Performance Testing:** a test or tests that are deferred until the system will experience conditions closer to their design conditions.

**L. VA:** Includes the Contracting Officer, Resident Engineer, or other authorized representative of the Department of Veterans Affairs.

**M. AABC: Associated Air Balance Council**

**N. ACG: Associated Air Balance Council Commissioning Group**

**O. NEBB: National Environmental Balancing Bureau**

**P. TABB: TESTING, ADJUSTING, AND BALANCING BUREAU**

#### **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. Facility exterior closure (Division 7 and Division 8)

- a. Roofs (Asphalt shingles, slate shingles, wood shingles, clay roof tiles, built-up bituminous, modified bituminous, EPDM, PVC, fluid-applied, sprayed polyurethane, flashing & sheet metal, metal roofing, roof specialties, and roof accessories)
- b. Exterior Insulation and Finish Systems (EIFS)
- c. Curtain Wall Systems (Mullions, glazing, and sealing)
- d. Exterior Doors (Revolving, glass leaf, emergency exit, and service)
- e. Exterior Windows (Aluminum, steel, glazing, storm)
- f. Louvers and Vents
- g. Sealants (Caulking, mechanical seals, and wind and vapor barriers)

2. Fire Suppression (Division 21)

- a. Fire Protection System (Fire pump, jockey pump, fire pump automatic transfer switch/controller, Wet-pipe fire suppression, Dry-pipe fire suppression, Pre-action fire suppression, dry

system air compressors and motors, and clean agent fire suppression).

3. Plumbing (Division 22)

- a. Domestic Hot Water systems (Steam-to-hot water converters, hot water circulating pumps and motors, controls).
- b. Medical Gas systems (Laboratory compressed air and laboratory vacuum).
- c. Sewage Ejection Pumps (Sump level controls, pump alternator, alarms and alarm panel, pumps and motors).
- d. Domestic Water Softener Systems (Tanks and casings, gages and instruments, controls, packaged piping, alarms).
- e. Chemical Waste System & Equipment
- f. Emergency Plumbing Fixtures (Showers, eye wash stations, water tempering valves, instruments and gages).

4. HVAC (Division 23)

- a. Air Handling Systems (Terminal units, 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 recovery coils and control valves, 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 (Convertors, controls, instrumentation and gages, heating water pumps and motors, Variable Speed Drives).
- d. Condensate Return Systems (Condensate receivers and transfer pumps, motors, controls, pump alternator, alarms and instrumentation, and safeties).
- e. Exhaust Fans (Fan, motor, Variable Speed Drives, controls and safeties).
- f. Steam System (Controls, gages and instrumentation, safety relief valves).
- g. 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).
  - h. Laboratory Exhaust Systems (Fume hoods, pressure controls, system alarms, fans, motors, and Variable Speed Drives).
  - i. Laboratory Ventilation Systems (Supply air terminal units and controls, pressure controls and alarms, fans, motors, and Variable Speed Drives).
  - j. Room Pressurization Equipment (Pressure sensors, terminal units/dampers, and controls and alarms).
  - k. HVAC Water Treatment Systems (Closed circuits - including shot feeders and final water analysis).
5. Electrical (Division 26)
- a. Service Entrance Switchboard (Fuses and circuit breaker settings, metering, mimic diagram, gages, and controls).
  - b. Standby Generator Systems (Automatic transfer switches, fuel delivery pumps and motors, battery charging and instrumentation, muffler and exhaust system, and vibration isolation).
  - c. Generator Distribution Switchboards (Fuses and circuit breaker settings, metering, gages, and controls).
  - d. Pad Mounted Transformers (Tap settings, fuses and circuit breaker settings, metering, gages, and controls).
  - e. Automatic Transfer Switches (Test with associated generator).
  - f. Normal Power Distribution Systems (Grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls).
  - g. Emergency Power Distribution Systems (Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls).
  - h. Optional Standby Distribution Systems (Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls).
  - i. Lighting Controls (Control system hardware and software, scene settings, zone settings, occupancy sensor interface, and unoccupied cycle control).
6. Communications (Division 27)
- a. Facility Telecommunications and Data Distribution Systems.

- b. Public Address and Mass Notification Systems (Amplifiers and head-end hardware, speaker volume, and background noise - i.e. hiss or similar interference).
- 7. Electronic Safety and Security (Division 28)
  - a. Fire Detection and Alarm (Master panel and software, addressable units - i.e. pull stations, flow detectors, heat detectors, etc., controls and alarm functions, horns/bells/door releases and other output devices, and fire command center functions - stairwell communications, stairwell pressurization fan start, mechanical systems shutdowns).
- 8. Site Utility Systems (Division 31)
  - a. Sanitary Sewage Lift Stations (Lift station sump or tank level controls, pump alternator, alarms and alarm panel, pumps and motors).
  - c. Storm Drainage Pump Systems (Sump level controls, pump alternator, alarms and alarm panel, pumps and motors).

#### **1.7 COMMISSIONING TEAM**

##### **A. Members Appointed by Contractor:**

- 1. Commissioning Agent: The designated person, company, or entity that plans, schedules and coordinates the commissioning team to implement the commissioning process. The Commissioning Agent shall be paid by the Contractor.
- 2. Contractor's Commissioning Manager: The designated person, company, or entity that plans, schedules and coordinates the commissioning activities for the construction team.
- 3. 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. Representatives of the facility user and operation and maintenance personnel.
- 2. Architect and engineering design professionals.

## 1.8 VA'S COMMISSIONING RESPONSIBILITIES

- A.** 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.
- B.** 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 contract with an individual, company or firm to act as the Commissioning Agent. The Commissioning Agent shall either be certified by the NEBB or the TABB, or be a member of ACG, or shall provide and utilize the services of a Commissioning Authority that meets the above qualifications as a sub-consultant to the Commissioning Agent for performance of all commissioning services under this project. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, immediately notify the Contracting Officer and submit another Commissioning Firm for approval. Any firm that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the project commissioning. All work specified to be performed by the Commissioning Agent shall be considered invalid if the Commissioning Agent or sub-consulting firm loses its certification prior to Contract completion and must be performed by an approved successor. These Commissioning services are to assist the VA in performing the quality oversight for which it is responsible. The Commissioning or sub-consulting firm shall be an agent acting of and for the VA and shall be financially and corporately independent of all other sub-contractors. The Commissioning Agent shall be working through and reporting to the VA Resident Engineer. The Commissioning Agent shall be paid by the Contractor.

- B.** The Contractor shall assign a Commissioning Manager to manage commissioning activities of the Contractor, and subcontractors.
- C.** 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.
- D.** 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 Plan: A document, prepared by Commissioning Agent, that outlines the schedule, allocation of resources, and documentation requirements of the commissioning process, and shall include, but is not limited, to the following:
  - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports. Identification of the relationship of these documents to other functions and a detailed description of submittals that are required to support the commissioning processes. Submittal dates shall include the latest date approved submittals must be received without adversely affecting commissioning plan.
  - 2. Description of the organization, layout, and content of commissioning documentation (including systems manual) and a detailed description of documents to be provided along with identification of responsible parties.
  - 3. Identification of systems and equipment to be commissioned.
  - 4. Schedule of Commissioning Coordination meetings.
  - 5. Identification of items that must be completed before the next operation can proceed.

6. Description of responsibilities of commissioning team members.
  7. Description of observations to be made.
  8. Description of requirements for operation and maintenance training.
  9. Schedule for commissioning activities with dates coordinated with overall construction schedule.
  10. Process and schedule for documenting changes on a continuous basis to appear in Project Record Documents.
  11. Process and schedule for completing prestart and startup checklists for systems, subsystems, and equipment to be verified and tested.
  12. Preliminary Systems Functional Performance Test procedures.
- B. Systems Functional Performance Test Procedures: The Commissioning Agent shall 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 shall include a separate entry, with space for comments, for each item to be tested. Preliminary Systems Functional Performance Test Procedures shall be provided to the VA, Architect/Engineer, and Contractor for review and comment. The Systems Performance Test Procedure shall 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(s) performing test and of the witness, if applicable.
  6. Individuals present for test.
  7. Observations and Issues.
  8. Issue number, if any, generated as the result of test.
- C. Pre-Functional Checklists: The Commissioning Agent shall 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 shall spot check Pre-Functional Checklists to

verify accuracy and readiness for testing. Inaccurate or incomplete Pre-Functional Checklists shall be returned to the Contractor for correction and resubmission.

- D. Test and Inspection Reports: The Commissioning Agent shall record test data, observations, and measurements on Systems Functional Performance Test Procedure. The report shall 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 shall compile test and inspection reports and test and inspection certificates and include them in systems manual and commissioning report.
- E. Corrective Action Documents: The Commissioning Agent shall document corrective action taken for systems and equipment that fail tests. The documentation shall include any required modifications to systems and equipment and/or revisions to test procedures, if any. The Commissioning Agent shall witness and document any retesting of systems and/or equipment requiring corrective action and document retest results.
- F. Commissioning Issues Log: The Commissioning Agent shall 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 shall 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 shall also track the status of unresolved issues.
1. Creating a Commissioning Issues Log Entry:
- a. Identify the issue with unique numeric or alphanumeric identifier by which the issue may be tracked.
  - b. Assign a descriptive title for the issue.
  - c. Identify date and time of the issue.
  - d. Identify test number of test being performed at the time of the observation, if applicable, for cross reference.
  - e. Identify system, subsystem, and equipment to which the issue applies.
  - f. Identify location of system, subsystem, and equipment.

- g. Include information that may be helpful in diagnosing or evaluating the issue.
  - h. Note recommended corrective action.
  - i. Identify commissioning team member responsible for corrective action.
  - j. Identify expected date of correction.
  - k. Identify person that identified the issue.
2. Documenting Issue Resolution:
- a. Log date correction is completed or the issue is resolved.
  - b. Describe corrective action or resolution taken. Include description of diagnostic steps taken to determine root cause of the issue, if any.
  - c. Identify changes to the Contract Documents that may require action.
  - d. State that correction was completed and system, subsystem, and equipment are ready for retest, if applicable.
  - e. Identify person(s) who corrected or resolved the issue.
  - f. Identify person(s) verifying the issue resolution.
- G. Final Commissioning Report: The Commissioning Agent shall document results of the commissioning process, including unresolved issues, and performance of systems, subsystems, and equipment. The Commissioning Report shall 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 shall include, but is not limited to, the following:
- 1. Lists and explanations of substitutions; compromises; variances with the Contract Documents; record of conditions; and, if appropriate, recommendations for resolution. Design Narrative documentation maintained by the Commissioning Agent.
  - 2. Commissioning plan.
  - 3. Pre-Functional Checklists completed by the Contractor, with annotation of the Commissioning Agent review and spot check.

4. Systems Functional Performance Test Procedures, with annotation of test results and test completion.
  5. Commissioning Issues Log.
  6. Listing of deferred and off season test(s) not performed, including the schedule for their completion.
- H. Addendum to Final Commissioning Report: The Commissioning Agent shall prepare an Addendum to the Final Commissioning Report near the end of the Warranty Period. The Addendum shall indicate whether systems, subsystems, and equipment are complete and continue to perform according to the Contract Documents. The Addendum to the Final Commissioning Report shall include, but is not limited to, the following:
1. Documentation of deferred and off season test(s) results.
  2. Completed Systems Functional Performance Test Procedures for off season test(s).
  3. Documentation that unresolved system performance issues have been resolved.
  4. Updated Commissioning Issues Log, including status of unresolved issues.
  5. Identification of potential Warranty Claims to be corrected by the Contractor.
- I. Systems Manual: The Commissioning Agent shall gather required information and compile the Systems Manual. The Systems Manual shall include, but is not limited to, the following:
1. Design Narrative, including system narratives, schematics, single-line diagrams, flow diagrams, equipment schedules, and changes made throughout the Project.
  2. Reference to Final Commissioning Plan.
  3. Reference to Final Commissioning Report.
  4. Approved Operation and Maintenance Data as submitted by the Contractor.

#### **1.12 SUBMITTALS**

- A. Preliminary Commissioning Plan Submittal: The Commissioning Agent shall prepare a Preliminary Commissioning Plan based on the final Construction Documents. The Preliminary Commissioning Plan shall include 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 shall prepare the Final Commissioning Plan as described in this section. The Commissioning Agent shall 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 shall incorporate review comments into the Final Commissioning Plan as directed by the VA.
- C. Systems Functional Performance Test Procedure: The Commissioning Agent shall 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 **shall** 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 **shall** 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 **shall** submit corrective action documents to the VA Resident Engineer with copies to the Contractor and Architect.
- G. Preliminary Commissioning Report Submittal: The Commissioning Agent **shall** 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 **shall** submit four sets of electronically formatted information of the final commissioning report to the VA. The final submittal **shall** incorporate comments as directed by the VA.
- I. Data for Commissioning:
  - 1. The Commissioning Agent **shall** 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. **Within 30 days of contract award, the Contractor shall designate a specific firm or individual as the Commissioning Agent (CxA).** The Commissioning Agent **shall** 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 (CxM) to manage and lead the commissioning effort on behalf of the Contractor. The Commissioning Manager shall be the single point of contact and communications for all commissioning related services by the Contractor.
- C. Within 30 days of contract award, the Contractor shall ensure that each subcontractor designates specific individuals as Commissioning Representatives (CxR) to be responsible for commissioning related tasks. The Contractor shall ensure the designated Commissioning Representatives participate in the commissioning process as team members providing commissioning testing services, equipment operation, adjustments, and corrections if necessary. The Contractor shall ensure that all Commissioning Representatives shall have sufficient authority to direct their respective staff to provide the services required, and to speak on behalf of their organizations in all commissioning related contractual matters.

#### **1.14 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 shall coordinate the commissioning activities with the VA and Contractor. The Commissioning Agent shall submit commissioning documents and information to the VA. All commissioning team members shall work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.
- B. Scheduling: The Contractor shall work with the Commissioning Agent and the VA to incorporate the commissioning activities into the

construction schedule. The Commissioning Agent shall 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 Schedule as directed by the VA.

- C. Initial Schedule of Commissioning Events: The Commissioning Agent shall provide the initial schedule of primary commissioning events in the Commissioning Plan and at the commissioning coordination meetings. The Commissioning Plan shall provide a format for this schedule. As construction progresses, more detailed schedules shall be developed by the Contractor with information from the Commissioning Agent.
- D. Commissioning Coordinating Meetings: The Commissioning Agent shall 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 shall 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 shall 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, CO<sub>2</sub> 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 shall 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 shall review the report and submit comments to the VA. The Commissioning Agent shall 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 shall be added to the master construction schedule and the commissioning schedule.

### **3.4 DDC TRENDING FOR COMMISSIONING**

- A. Trending is a method of testing as a standalone method or to augment manual testing. The Contractor shall trend any and all points of the system or systems at intervals specified below.
- B. Alarms are a means to notify the system operator that abnormal conditions are present in the system. Alarms shall be structured into three tiers - Critical, Priority, and Maintenance.
  - 1. Critical alarms are intended to be alarms that require the immediate attention of and action by the Operator. These alarms shall be displayed on the Operator Workstation in a popup style window that

- is graphically linked to the associated unit's graphical display. The popup style window shall be displayed on top of any active window within the screen, including non DDC system software.
2. Priority level alarms are to be printed to a printer which is connected to the Operator's Work Station located within the engineer's office. Additionally Priority level alarms shall be able to be monitored and viewed through an active alarm application. Priority level alarms are alarms which shall require reaction from the operator or maintenance personnel within a normal work shift, and not immediate action.
  3. Maintenance alarms are intended to be minor issues which would require examination by maintenance personnel within the following shift. These alarms shall be generated in a scheduled report automatically by the DDC system at the start of each shift. The generated maintenance report will be printed to a printer located within the engineer's office.
- C. The Contractor shall provide a wireless internet network in the building for use during controls programming, checkout, and commissioning. This network will allow project team members to more effectively program, view, manipulate and test control devices while being in the same room as the controlled device.
- D. The Contractor shall provide graphical trending through the DDC control system of systems being commissioned. Trending requirements are indicated below and included with the Systems Functional Performance Test Procedures. Trending shall occur before, during and after Systems Functional Performance Testing. The Contractor shall be responsible for producing graphical representations of the trended DDC points that show each system operating properly during steady state conditions as well as during the System Functional Testing. These graphical reports shall be submitted to the Resident Engineer and Commissioning Agent for review and analysis before, during dynamic operation, and after Systems Functional Performance Testing. The Contractor shall provide, but not limited to, the following trend requirements and trend submissions:
1. Pre-testing, Testing, and Post-testing - Trend reports of trend logs and graphical trend plots are required as defined by the Commissioning Agent. The trend log points, sampling rate, graphical plot configuration, and duration will be dictated by the Commissioning Agent. At any time during the Commissioning Process

the Commissioning Agent may recommend changes to aspects of trending as deemed necessary for proper system analysis. The Contractor shall implement any changes as directed by the Resident Engineer. Any pre-test trend analysis comments generated by the Commissioning Team should be addressed and resolved by the Contractor, as directed by the Resident Engineer, prior to the execution of Systems Functional Performance Testing.

2. Dynamic plotting - The Contractor shall also provide dynamic plotting during Systems Functional Performance testing at frequent intervals for points determined by the Systems Functional Performance Test Procedure. The graphical plots will be formatted and plotted at durations listed in the Systems Functional Performance Test Procedure.
3. Graphical plotting - The graphical plots shall be provided with a dual y-axis allowing 15 or more trend points (series) plotted simultaneously on the graph with each series in distinct color. The plots will further require title, axis naming, legend etc. all described by the Systems Functional Performance Test Procedure. If this cannot be sufficiently accomplished directly in the Direct Digital Control System then it is the responsibility of the Contractor to plot these trend logs in Microsoft Excel.
4. 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.

<b>Air Handling Unit Trending and Alarms</b>
--

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		
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		
OA Supply Temp	AI	15 Min	24 hours	3 days	P		
CHW Valve Position	AI	15 Min	24 hours	3 days	N/A	±5°F from SP	10 min
HW Valve Position	AI	15 Min	24 hours	3 days	N/A		
OA Flow	AI	15 Min	24 hours	3 days	P		
Duct Pressure	AI	15 Min	24 hours	3 days	C	±10% from SP	5 min
Supply Fan Status	DI	COV	24 hours	3 days	C	±10% from SP	5 min
High Static Status	DI	COV	24 hours	3 days	P		
Fire Alarm Status	DI	COV	24 hours	3 days	C	Status <> Command	6 min
Freeze Stat	DI	COV	24 hours	3 days	C	Status <> Command	10 min
Fire/Smoke Damper Status	DI	COV	24 hours	3 days	P	True	10 Min
Emergency AHU Shutdown	DI	COV	24 hours	3 days	P	True	1 min
Exhaust Fans Status	DI	COV	24 hours	3 days	C	True	5 min
OA Alarm	DI	COV	24 hours	3 days	C	Status <> Command	1 min
High Static Alarm	DI	COV	24 hours	3 days	C	Status <> Command	1 min

<b>Air Handling Unit Trending and Alarms</b>							
<b>Point</b>	<b>Type</b>	<b>Trend Interval</b>	<b>Operational Trend Duration</b>	<b>Testing Trend Duration</b>	<b>Alarm Type</b>	<b>Alarm Range</b>	<b>Alarm Delay</b>
Power Failure	DI	COV	24 hours	3 days	P	True	10 min
Supply Fan Speed	AO	15 Min	24 hours	3 days	N/A	True	10 min
CHW Valve Position	AO	15 Min	24 hours	3 days	N/A		10 min
HW Valve Position	AO	15 Min	24 hours	3 days	N/A		1 min
Supply Fan S/S	DO	COV	24 hours	3 days	N/A		
Exhaust Fans S/S	DO	COV	24 hours	3 days	N/A		
AHU Energy	Calc	1 Hour	30 day	N/A	N/A		

<b>Terminal Unit (VAV, CAV, etc.) Trending and Alarms</b>							
<b>Point</b>	<b>Type</b>	<b>Trend Interval</b>	<b>Operational Trend Duration</b>	<b>Testing Trend Duration</b>	<b>Alarm Type</b>	<b>Alarm Range</b>	<b>Alarm Delay</b>
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 Set-point	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
Damper Position	AO	15 Minutes	12 hours	3 days	N/A		
Heating coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		

<b>4-Pipe Fan Coil Trending and Alarms</b>
--

Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Space Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
SA Temperature	AI	15 Minutes	12 hours	3 days	P	±5°F from SP	10 min
Pre-Filter Status	AI	None	None	None	M	> SP	1 hour
Water Sensor	DI	COV	12 hours	3 days	M	N/A	30 Min
Cooling Coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		
Heating coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		
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

Steam and Condensate Pumps Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Steam Flow (LB/HR)	AI	15 Minutes	12 hours	3 days	N/A		

Steam and Condensate Pumps Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Condensate Pump Run Hours	AI	15 Minutes	12 hours	3 days	N/A		
Water Meter (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
Electric Meter (KW/H)	AI	15 Minutes	12 hours	3 days	N/A		
Chilled Water Flow (TONS)	AI	15 Minutes	12 hours	3 days	N/A		
Condensate Flow (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
High Water Level Alarm	DI	COV	12 hours	3 days	C	True	5 Min
Condensate Pump Start/Stop	DO	COV	12 hours	3 days	P	Status <> Command	10 min

Domestic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Domestic HW Setpoint	AI	15 Minute	12 Hours	3 days	N/A		
Domestic HW Temperature	AI	15 Minute	12 Hours	3 days	P	±5°F from SP	10 Min
Dom. Circ. Pumps Status	DI	COV	12 Hours	3 days	M	Status <> Command	30 min
Dom. Circ. Pumps Start/Stop	DO	COV	12 Hours	3 days	N/A		
Domestic HW Start/Stop	DO	COV	12 Hours	3 days	N/A		

Hydronic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
System HWS Temperature	AI	15 min	12 hours	3 days	C	±5°F from SP	10 Min
System HWR Temperature	AI	15 min	12 hours	3 days	M	±15°F from SP	300 Min
HX Entering Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
HX Leaving Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
System Flow (GPM)	AI	15 min	12 hours	3 days	N/A		
System Differential Pressure	AI	15 min	12 hours	3 days	P	±10% from SP	8 Min
				3 days			
HW Pumps Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
HW Pumps VFD Speed	AO	15 Min	12 Hours	3 days	N/A		
Steam Stations 1/3 Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Stations 2/3 Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Stations Bypass Valve Position	AO	15 Min	12 Hours	3 days	N/A		
HW Pumps Start/Stop	DO	COV	12 Hours	3 days	N/A		
HWR Valves	DO	COV	12 Hours	3 days	N/A		
Hot Water Supply Temperature	AI	15 Minutes	12 Hours	3 days	P	±5 °F from SP	10 Min
Hot Water Return Temperature	AI	15 Minutes	12 Hours	3 days	N/A		

Hydronic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Secondary Loop Differential Pressure	AI	15 Minutes	12 Hours	3 days	C	±5% from SP	10 Min
Primary Pump 1 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Primary Pump 2 Status	DI	COV	12 Hours	3 days	P	Status <> Command	10 min
Primary Pump 1 VFD Speed	AO	COV	12 Hours	3 days	N/A		
Primary Pump 2 VFD Speed	AO	COV	12 Hours	3 days	N/A		
Hot Water System Enable	DO	COV	12 Hours	3 days	N/A		
Primary Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Primary Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		

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 will be issued as a separate document and made 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 shall 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 shall 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 shall record the results of the Systems Functional Performance Tests on the procedure or test form. All items of nonconformance issues shall 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 shall 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 shall 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 shall 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 shall 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 shall 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 shall 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 shall 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 21, Division 22, Division 23, Division 26, Division 27,

Division 28, and Division 31 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.
  - l. 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 31 63 16**  
**AUGER CAST GROUT PILES**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This section specifies excavation and concrete required for construction of auger-placed concrete piles.

**1.2 DEFINITION**

Auger-placed concrete pile (ACP): Pile formed by rotation of a continuous flight hollow-shaft pile augured into the ground to the indicated depth. Grout is injected through auger shaft as auger is being withdrawn in such a way as to exert removing pressure on withdrawing earth-filled auger as well as lateral pressure on soil surrounding hole.

**1.3 RELATED WORK**

- A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
- B. Concrete: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- C. Subsurface investigation: Section 01 00 00, GENERAL REQUIREMENTS, Article, PHYSICAL DATA.

**1.4 CONTRACT BASIS**

- A. Contract price for ACP's will be based upon total length of piles shown on the Contract Documents. Length of piles will be measured as shown.
  - 1. Adjustment of contract price shall be based upon total length of piles placed, and not on length of individual piles placed. When total length of completed piles is greater or less than length shown, contract price adjustment will be made in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.
  - 2. Contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable when artificial materials that are not shown are encountered.

**1.5 CONTRACTOR QUALIFICATIONS**

- A. Approval by Contracting Officer is required of service of proposed Contractor and will be based upon submission by Contractor of certification that:

1. Contractor has technical qualifications, experience, trained personnel and facilities to install auger placed concrete piles as specified. Approval will not be given, however, where an experience record is one of unsatisfactory performance.
2. Contractor has installed ACP's on three installations similar and equivalent to this project for 5 years. Submit list of installations.

#### **1.6 TOLERANCES**

Install piling with a maximum variation of 75 mm (3 inches) of center of any pile from the location shown. Piles shall not be out of plumb more than 2 percent. (Checked by using a hand level prior to the start of drilling.

#### **1.7 DESIGN MODIFICATIONS**

- A. Where piles are installed exceeding specified tolerances for plumb or location, the foundation design will be analyzed by the Resident Engineer and if necessary redesigned by Resident Engineer Government. Costs for analysis, redesign, and remediation shall be responsibility of Contractor.
- B. Additional piles and pile cap modifications necessitated by redesign shall be furnished and installed, at no additional cost to the Government.

#### **1.8 SUBMITTALS**

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Certification to Examination of Site and Records: Before proceeding with the Work, submit copy of certification in acceptable form signed by the Contractor, stating that careful examination has been made of the site, existing structures, and records of utility lines, test boring records, soil samples, and subsurface exploration reports by the Owner's Geotechnical Engineer, Drawings, and Specifications.
- C. Shop Drawings and Miscellaneous Submittals:
  1. Description of pile drilling equipment.
  2. Description of grout pump and pressure gage calibration reports.
  3. Pile Installation Recorder (PIR) calibration reports.
  4. Complete description of method for ACP pile installation with a pile layout plan referenced to the structural plans, including a numbering system capable of identifying each individual pile, pile sizes, including pile length and tip elevations, reinforcing steel,

- and waterproofing details. In addition, furnish a detailed description of construction procedures, including steel shells, if used, and auguring methods.
5. Steel Reinforcement Shop Drawings: Comply with ACI 315. Furnish shop drawings prepared by a Professional Engineer licensed in the state of installation that include placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
    - a. Prior to fabrication: Indicate steel grades, sizes, bending details, protective coatings, spacing, placement and supports.
    - b. Supplementary Product Literature: Furnish manufacturer's literature describing general properties of each product to be used in the Work.
    - c. Certifications: Furnish manufacturer's certified reports of mill tests for reinforcing steel and anchorage devices, including physical and chemical analysis.
  6. Pile Installation records for all ACP's.
- D. Reports:
1. Installation of each pile
  2. Pile location and plumbness
  3. Total quantity of grout placed
  4. Load Test
- E. Product Data: Submit copies of manufacturers' specifications for the following products, including copies of laboratory test reports and other data as may be required to show compliance with these specifications.
1. Fly Ash or Ground Granulated Blast Furnace Slag: ASTM C618, Class C or F and ASTM C989, Grade 100 or 120, respectively.
  2. Plasticizing admixture: ASTM C1017/C1017M, Type II.
  3. Grout Fluidifier: ASTM C937
  4. Aggregate sieve analysis: ASTM C33.
  5. Aggregate sodium sulfate soundness tests: ASTM C88.
  6. Portland cement: ASTM C150, Type I, Test Piles Type III.
  7. Reinforcing Steel: ASTM A615/A615M, Grade 60 ASTM A722/A722M, Type II, Thread Bar Type

- F. Certificates: Contractor's qualifications as specified: Experienced specialty piling subcontractor having a minimum of 5 years successful experience installing Work of same type required for this project, and evidence of satisfactory completion of at least ten ACP installations comparable in scope of the Work and subsurface conditions. Employ only skilled tradesmen who are thoroughly experienced with the materials and equipment to be used in the Work.
- G. Contractor's Concrete Testing: Submit 3 copies of the laboratory testing reports to the Resident Engineer, the owner's Geotechnical Consultant, and other pertinent parties.
1. Submit report and certification of aggregate.
  2. Laboratory Test Reports: Submit for evaluation grout materials and mix designs.
- H. Pile Load Testing:
1. A schedule and sequencing plan for pile testing and installation.
  2. Pile Installation Recorder (PIR) details.
  3. Pile Installation Recorder (PIR) reports.
  4. Pile Load Test Work Plan:
    - a. At least two weeks before commencing pile load testing work, the Contractor shall submit a pile load test work plan describing the equipment, apparatus, procedures, and schedule for testing ACP's in accordance with ASTM D1143, ASTM D3966 and as specified herein, to verify the design pile capacity. The work plan shall also include the proposed instrumentation of the test pile indicating depth, location, and details of the pile.
    1. Pile load testing is required and shall include the following:
      - a. Minimum one (1) compression test in accordance with ASTM D1143 and the Florida Building Code loaded to twice the design load. After completion of this test, reload the test pile to failure or three (3) times the design load, whichever occurs first.
      - b. One (1) tension test in accordance with ASTM D3689 loaded to twice the design loads.
      - c. One (1) lateral test in accordance with ASTM D3966 loaded to twice the design loads.

2. Test piles shall not become part of the permanent foundation system, but shall be installed with the same equipment, materials, and procedures.

3. Provide adequate support for the load testing apparatus and cooperate with the testing laboratory.

4. The design of the uplift reinforcement and grout strength for tension tests and the reaction piles for compression tests and the number of reaction piles is to be by the pile contractor.

5. In event of test failure, at least one supplementary pile shall be placed and tested for each failure, at the Contractor's expense.

- I. Independent Testing and Inspection Agency: The Contractor shall retain an Independent Testing and Inspection Agency (Agency) to document, monitor, and observe load test, probe pile, test pile, and production pile work. This Agency shall submit field reports and test results required by Section 3.2 for pile load tests, pile installations, and grout testing and inspection. They shall submit a pile installation report for each pile no later than three days after the installation is complete.
- J. Welding Certificates.
- K. Qualification Data: For Installer, Land Surveyor, and Testing and Inspection Agency.
- L. Upon completion of ACP installations, the Contractor shall submit five copies of drawings indicating actual in-place pile locations. The Contractor shall pay for all surveying costs. Drawings must be submitted prior to beginning any pile cap or mat installation. One electronic copy of the drawings shall be submitted in AutoCAD DWG format on CD-ROM.
- M. Record drawings at Project closeout according to Division 01 Section "Closeout Procedures."

## 1.9 QUALITY CONTROL

- A. Contractor's Quality Control Responsibilities: Contractor is solely responsible for quality control of the Work.
- B. A Quality Control Program shall be submitted by the Contractor at least two weeks prior to the commencement of work. The implementation of a Contractor Quality Control Program does not relieve the Contractor from the responsibility to provide work in accordance with the Contract Documents, applicable codes, regulations, and Governing Authorities.

- C. Contractor's Independent Testing and Inspection Agency (Agency): The Contractor shall retain at his own expense, the services of a qualified Independent Testing and Inspection Agency, licensed in the state of the project, to provide testing and inspection services during the installation of all foundation piling involved in this Work. This firm shall also provide consultation services to the Contractor if problems are encountered during the execution of the Work. The Agency shall be primarily concerned with the testing and construction methods which will result in finished foundation piling of the required quality and strength. The Agency shall also be concerned with preventing settlement and/or damage to surrounding structures, roads, utilities, embankments, etc., both within the property lines and on adjoining properties during the construction.
- D. The Agency shall be experienced in the testing and installation of ACP foundations. It shall have been involved in at least 8 different ACP projects in the last 5 years, and shall have experience in recommending, testing, and specifying ACP's for similar subsurface conditions.
- E. Survey Work: The Contractor shall engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for ACP's. The surveyor shall record actual measurements of each ACP's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
- F. Contractor's Grout Mix Designer: The Contractor shall employ, at his own expense, a testing laboratory to design grout mixes, conduct tests and submit reports for the design mixes. The Grout Mix Designer shall be qualified according to ASTM C1077 and ASTM E329 to perform material evaluation tests and to design concrete mixes, as documented according to ASTM E548.
- G. Welding Standards: Qualify procedures and personnel according to the following:
1. AWS D1.1
  2. AWS D1.4
- H. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities.

**1.10 QUALITY ASSURANCE**

- A. The Contractor shall retain the services of a Geotechnical Consultant (Consultant) to provide general observation of all pile operations and to provide technical advice to the Owner with regard to pile operations and performance.
- B. The Consultant shall have been involved in at least 8 different ACP projects in the last 5 years, and shall have experience in recommending, testing, and specifying ACP's for similar subsurface conditions.

**1.11 APPLICABLE PUBLICATIONS**

- A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.
- B. American Society for Testing and Materials (ASTM):
  - A615/A615M-06a.....Standard Specification for Deformed and Plain Carbon-Steel Bar for Concrete Reinforcement
  - A722/A722M-05.....Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
  - C33-03.....Standard Specification for Concrete Aggregates
  - C88-05.....Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
  - C109/C109M-05.....Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-in. or [50 mm] Cube Specimens)
  - C150-05.....Standard Specification for Portland Cement
  - C404-06.....Standard Specification for Aggregates for Masonry Grout
  - C618-05.....Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
  - C937-02.....Standard Specification for Grout Fluidifier for Preplaced-Aggregate Concrete
  - C942-99 (2004).....Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
  - C989-05.....Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

- C1017/C1017M-03.....Standard Specification for Chemical Admixtures  
for Use in Producing Flowing Concrete
- C1077-06.....Standard Practice for Laboratories Testing  
Concrete and Concrete Aggregates for Use in  
Construction and Criteria for Laboratory  
Evaluation
- D1143-81(1994)e1.....Standard Test Method for Piles Under Static  
Axial Compressive Load
- D3689-90(1995).....Standard Test Method for Individual Piles Under  
Static Axial Tensile Load
- D3966-90(1995).....Standard Test Method for Piles Under Lateral  
Loads
- E329-05bel.....Standard Specification for Agencies Engaged in  
Construction Inspections and/or Testing
- E548-94.....Standard Guide for General Criteria Used for  
Evaluating Laboratory Competence
- C..American Concrete Institute (ACI):
- C33-03.....Standard Specification for Concrete Aggregates
- 315-99.....Manual of Standard Practice for Detailing  
Reinforced Concrete Structures
- D..American Welding Society (AWS):
- D1.1 (2006).....Structural Welding Code - Steel
- D1.4 (2005).....Structural Welding Code - Reinforcing Steel

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Portland Cement: ASTM C150, Type I, Test piles Type III.
- B. Grout Fluidifier: ASTM C937.
- C. Plasticizing admixture: ASTM C1017/C1017M, Type II
- D. Ash or Ground Granulated Blast Furnace Slag: ASTM C618, Class C or F  
and ASTM C989, Grade 100 or 120, respectively.
- E. Water: Fresh, clean, and potable.
- F. Aggregate: ASTM C404, Size No. 1 or Size No. 2.
- G. Reinforcing Steel: ASTM A615, Grade 60.
- H. Fine Aggregate: ASTM C33.
- I. High Strength Reinforcing Steel: ASTM A722, Type II, Thread Bar Type
- J. Except for probe pile, pile load test and test pile purposes, no pile  
materials shall be ordered or delivered to the job site until the

required load tests have been made and are acceptable to the Resident Engineer. Materials ordered or delivered to the project site prior to verification of the assumed pile length, will be at the Contractor's risk.

- K. After pile lengths are verified by the pile load test program, deliver materials to the project site in such quantities and at such times to assure the continuity of pile augering operations to the project schedule.
- L. Clearly mark pile leads in 300 mm (1 foot) increments.

## **2.2 MIXES**

- A. Concrete: The grout used shall consist of a mixture of portland cement, sand, fluidifier, and water so proportioned and mixed to be pumped and to fill all voids in the foundation material. Mixture shall be proportioned to provide a minimum compressive strength of Mpa (1900 psi) at 28 days.
- B. Mix Design: Testing Laboratory, retained by Contractor, shall design a mix to produce concrete as specified and perform tests as required. Certified test reports (duplicate) shall be submitted. Reports shall include proportions of design mix.
- C. Concrete-mix design adjustments may be considered if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant. Resubmit and obtain approval from the Resident Engineer of proposed changes to concrete-mix design.
- D. Improper Mix: Immediately notify the Concrete Testing Laboratory and the Resident Engineer if at any time during construction the accepted mix design proves to be unsatisfactory for any reason. The Contractor's Concrete Mix Designer shall modify the design, subject to the review of the Resident Engineer, until a satisfactory mix is obtained.

## **2.3 EQUIPMENT**

- A. Augering Equipment:
  - 1. Equipment shall consist of a continuous-flight, hollow-shaft auger which shall be rotated into the ground to the required pile depth as established by the pile load tests. Advance the auger at a continuous rate that prevents removal of excess soil. Stop advancement after reaching the required depth. The hole in the bottom of the auger shall be closed with a suitable plug while being advanced into the ground. The plug shall be removed by grout or with a reinforcing bar. At the start of pumping grout, raise the

auger from 150 to 300 mm (6 to 12 inches) and after the grout pressure builds sufficiently, redrill the auger to the previously established tip elevation. Cement grout shall then be injected through the auger shaft as the auger is being withdrawn, in such a way as to exert removing pressure on the withdrawing earth filled auger flights as well as lateral pressure on the soil surrounding the grout-filled pile hole. Grout pumping pressures shall be measured and shall be maintained high enough at all times to offset hydrostatic and lateral earth pressures. The auger shall rotate in a positive direction and shall be withdrawn in a steady continuous motion.

2. The auger flighting shall be continuous from the auger head to the top of auger without gaps or other breaks. The auger flighting shall be uniform in diameter throughout its length and shall be the diameter specified for the piles less a maximum of 3 percent.
3. The hole through which the high-strength grout is pumped during the placement of the pile shall be located at the bottom of the auger head below the bar containing the cutting teeth.
4. Augers over 12000 mm (40 feet) in length shall contain a middle guide.
5. The piling leads should be prevented from rotating by a stabilizing arm or by firmly placing the bottom of the leads into the ground or by some other acceptable means. Leads shall be marked at 300 mm (1 foot) intervals to facilitate measurement of auger penetration.

**B. Mixing and Pumping Equipment:**

1. Only approved pumping and mixing equipment shall be used in the preparation and handling of the grout. A screen to remove over-size particles shall be placed at the pump inlet. All oil or other rust inhibitor shall be removed from mixing drums and grout pumps. All materials shall be such as to produce a homogeneous grout of the desired consistency.
  - a. The grout pump shall be a positive displacement piston type pump capable of developing displacing pressures at the pump not less than 2.5 Mpa (350 psi). The grout pump shall be provided with a pressure gauge in clear view of the equipment operator. The grout pump shall be calibrated at the beginning of the work to determine the volume of grout pumped per stroke. A positive method of counting grout pump strokes shall be provided by the

Pile Contractor. Such methods may include digital or mechanical stroke counters or other acceptable methods.

C. Pile Installation Recorder (PIR):

1. The Contractor shall provide a PIR for ACP's for use by the Agency and the Consultant during pile installation. The PIR shall be used for each piling rig. The PIR shall record appropriate information during both the augering phase and during the grouting phase of the installation to assure minimum grout volume pumped per unit depth increment, and shall print results immediately upon completion of each pile.

**PART 3 - EXECUTION**

**3.1 GENERAL**

- A. Survey: Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS, shall establish lines and levels and stake pile locations.
- B. Before installing piles adjacent to any existing utilities, the Contractor shall notify the utility owner to ensure that protective Work will be coordinated and performed in accordance with the requirements of the utility owner. If any existing service lines, utilities and utility structures to remain in service are uncovered or encountered during these operations, protect, from damage and provide support if necessary.
- C. Should uncharted or incorrectly charted piping or other utilities be encountered during piling operations, immediately notify the Resident Engineer and the utility owner. Cooperate with the utility owner in keeping their respective services, utilities and facilities in operation.
- D. After all ACP's are in place, the Surveyor shall make a field survey of completed piles and shall submit a drawing to the Resident Engineer showing the plumbness of the piles and the actual pile locations with respect to planned pile locations.
- E. Pile Record: Submit complete and accurate record of all auger-placed piles to the Resident Engineer. Record shall indicate the pile location, diameter, length, elevation of bottom and top of pile, and the quantity of grout used in each pile. Any unusual conditions encountered during pile installation shall also be noted.
- F. Completion Certificate: The Contractor shall provide a written statement, stamped by a Professional Engineer registered in the State

of the Work, verifying that the piles were installed per the Contract Documents, and that any piles not installed per the Contract Documents were installed in such a manner that they will not have an negative impact on the proposed structure.

### **3.2 ALLOWABLE LOAD ON PILES**

#### **A. Probe Piles:**

1. A minimum of ten probe piles shall be installed prior to the installation of the production piles in manner utilizing identical equipment, methods, and materials for all piling.
2. probe piles shall be used by the Contractor to refine the operations of the equipment and shall not be installed at production pile locations.
3. The location of the probe piles shall be submitted to the Resident Engineer prior to their installation. If, in the opinion of Resident Engineer, the probe pile locations shown are not representative of the area, alternate locations will be provided by Resident Engineer.
4. Reaction piles for the load test pile may not be used as probe piles.

#### **B. Load test piles:**

1. Load tests will be performed on a minimum of two probe piles. The data from the load test will be used to verify pile design load.
2. Contractor shall conduct load tests in accordance with ASTM D1143, ASTM D3966 standard loading procedure. These tests will be conducted at no additional cost to the Government. No additional piles shall be installed until test reports of test piles are received and approved by Resident Engineer.
3. Additional load tests or an increase in production pile length may be required if the test pile fails the load test.

### **3.3 INSTALLATION**

- A. The length and drilling criteria of production piles will be determined by the Resident Engineer from the installation of the probe piles, reaction piles, test piles, and the pile load tests. The installation shall be performed in an orderly sequence.
- B. Advance the auger at a continuous rate that prevents removal of excess soil. Stop advancement after reaching the required depth or refusal criteria.
- C. Auger refusal is defined as a rate of auger penetration of less than 300 mm (1 foot) per minute of drilling.

- D. The hole in the bottom of the auger shall be closed while being advanced into the ground with a suitable plug. The plug shall be removed by grout pressure or with the reinforcing bar.
- E. Place continuous center reinforcing through the hollow-stemmed auger prior to placement of grout. Tie top of reinforcing in place after removal of auger. Use bar spacers to center reinforcing bars.
- F. At the start of pumping grout, raise the auger from 150 to 300 mm (6 to 12 inches) and after the grout pressure builds up sufficiently, redrill the auger to the previously established tip elevation.
- G. Maintain at least 3000 mm (10 feet) of grout on the auger flighting above the injection point during raising of the auger. Positive rotation of the auger shall be maintained throughout placement of the grout. Rate of grout injection and rate of auger withdrawal from the soil shall be coordinated as to maintain at all times the minimum grout head and a positive pressure on the gauges. The total volume of grout shall be at least 115 percent of the theoretical volume for each pile, except, after grout is flowing at the ground surface from the auger flighting, the rate of grout injection and auger withdrawal shall be coordinated so that there is a constant grout flow at the surface. If pumping of grout is interrupted for any reason, the Contractor shall reinsert the auger at least 1500 mm (5 feet) into the pile and regROUT.
- H. Minimum volume of grout placed in hole shall be at least the nominal volume plus 15 percent of hole. Volume of grout per linear meter (linear foot) of pile shall be not less than volume of grout per meter (volume of grout per foot) of the load test pile. Make volume measurements in the presence of Resident Engineer.
- I. Auger hoisting equipment shall be provided that will enable the auger to be rotated while being withdrawn smoothly and steadily.
- J. The spoil that accumulates around the auger during injection of the grout shall be promptly cleared away upon completion of the installation.
- K. Provide OSHA protective caps on all projecting reinforcement.
- L. Materials shall be accurately measured by volume or by weight as they are fed to the mixer. Order of placing the materials in mixer shall be as follows: (1) water, (2) fluidifier, and (3) other solids in order of increasing particle size. Provide grout injection equipment with a pressure gage in clear view of the equipment operator. A second pressure gauge shall be located near auger rig where it can be

observed. Rate of injection and rate of auger withdrawal from soil shall be so coordinated as to maintain at all times a positive pressure on gage which will indicate existence of a removing pressure on bottom of auger flight. Magnitude of this pressure and performance of other augering and grouting procedures, such as rate of augering, rate of grout injection, and control of grout return around the auger flight, are dependent on soil conditions, and equipment capability shall be at option of Contractor, subject to approval of Resident Engineer. Equipment for pumping grout shall be positive displacement pump capable of developing a pressure at pump not less than 2.5 MPa (350 psi). Pump shall be calibrated by an approved method to verify accuracy of indicated discharge. Remove oil or other rust inhibitors from mixing drums and pumps. Auger hoisting equipment shall be capable of withdrawing auger smoothly and at a constant rate. If the auger jumps upward during withdrawal, it shall be reinserted, and rate of withdrawal decreased to prevent further jumping.

- M. Locate piles as shown unless otherwise directed by Resident Engineer. Do not place piles closer than 1050 mm (3.5 feet) center to center until grout in adjacent piles has set for 24 hours. In locations where there are no concrete slabs or other means of distributing load of the equipment placing piles, the equipment shall be kept at least 3000 mm (10 feet) away from pile location, or upper 3000 mm (10 feet) of pile shall be cased.
- N. Where pile top is near surface or above bottom of excavation, place metal sleeves of proper diameter around pile top.
- O. Cut off the tops of piles, square with pile axis and at the elevations indicated by removing fresh grout from the top of the pile or by cutting off hardened grout down to final cutoff point at any time after initial set has occurred. Where the pile cut-off is near the surface or above the bottom of the excavation, sleeves or casing of the proper diameter and at least 457 mm (18 inches) in length shall be placed around the pile tops. (Special conditions may require metal sleeves of additional length).
- P. Redrill the pile to the original depth at no additional cost to the Owner if any of the following occurs:
  - 1. The design pile reinforcement cannot be placed manually in the top of any pile following completion of grouting.

2. The trap door at the bottom discharge outlet fails to open completely, effectively creating a side discharge condition.
  3. Loss of grout head occurs for any reason during pile installation.
  4. There is more than a twenty-minute delay during the grouting of any individual pile.
  5. There is a drop in grout level after completion of the pile, which exceeds the average for the remainder of the pile installations by more than 600 mm (2 feet).
- Q. The Contractor shall install additional piles at no additional cost for damaged, misaligned and/or mislocated piles. Contractor shall also be responsible for costs of concrete and reinforcing for required modifications to pile caps/grade beams due to damaged piles and/or misaligned or mislocated piles.
- R. If the grout level in any completed pile drops, the pile shall be rejected and replaced.
- S. No pile shall be loaded until the grout has attained full design strength.

#### 3.4 OBSTRUCTIONS:

- A. The advancement of the augers through naturally occurring materials such as cobbles, boulders and rock ledges, as outlined in the Geotechnical Report, is the responsibility of the Contractor. The Contractor is responsible for providing the necessary means and methods of advancing the augers through this material. The contractor shall be responsible to provide the overall length of auger cast piles as shown on drawings. The contractor may be eligible for additional payment for installed auger cast piles only if the linear foot sum of all the installed auger cast piles is greater than the linear foot sum of all the auger cast piles shown on the structural drawings.
- B. In the event that unforeseen non-augerable material is encountered, such as cobbles, boulders, rock ledge, metal timbers or debris which causes the rate of penetration to be reduced to less than 300 mm (1 foot) per minute above the desired tip elevation, or causes the pile to drift from its location, then the pile shall be completed to the depth of the non-augerable material in accordance with these specifications. The contractor shall be responsible to provide the overall length of auger cast piles as shown on drawings. The contractor may be eligible for additional payment for installed auger cast piles only if the linear foot sum of all the installed auger cast piles is greater than

the linear foot sum of all the auger cast piles shown on the structural drawings.

### 3.5 QUALITY CONTROL AND ASSURANCE:

- A. The Contractor shall retain and pay for the services of a qualified Independent Testing and Inspection Agency (Agency), licensed in the state of the project, to provide Quality Control through testing and inspection services during the installation of all foundation piling involved in this Work.
- B. The Contractor shall employ a Geotechnical Consultant (Consultant) to provide Quality Assurance through general observation and consultation of all pile operations.
- C. The Contractor and their Agency shall cooperate with the Consultant and the Resident Engineer in the performance of the Work. The presence of Consultant shall in no way relieve the Contractor of his obligation to perform the pile installation in accordance with the Contract Documents and these Specifications.
- D. Grout Mix: The grout mix shall be tested by making a minimum of six, 50 mm (2 inches) cubes for each day during which piles are placed. A set of six cubes shall consist of two cubes to be tested at seven days, and two cubes to be tested at 28 days and two cubes held in reserve. Test cubes shall be cured and tested in accordance with ASTM C109/C109M. Cube specimens may be restrained from expansion as described in ASTM C942.
- E. Pile Acceptance: The Agency shall immediately notify the Consultant and the Resident Engineer if any pile is not in conformance with these Specifications. The volume of grout placed in each pile shall be a minimum of 115% of theoretical volume of the pile. The amount of grout placed in each 1500 mm (5 feet) increments of the pile shall be checked continuously during installation. The cost of removing and replacing Auger Cast Piles, which are not in conformance, shall be borne by the Pile Contractor.
- F. Reports: The Agency shall maintain an installation record of each pile. The record shall note the project name and number, name of Contractors, pile location, design pile capacity, pile tip elevation, pile top elevation, depth of auger advancement, (total and continuous) quantity of grout placed, reinforcing steel placement, and any unusual occurrences during the pile installation. The grout quantity shall be determined by recording grout pump displacement or by other acceptable

means. The Consultant shall also maintain a daily report, which summarizes all work performed by the Contractor.

### **3.6 CORRECTIONS OF DEFICIENCIES:**

- A. The contractor shall notify the Resident Engineer in writing, of the failure of a pile to meet any requirement of the Section. Such written notification shall include all information required for the evaluation of remedial measures, including all information required for redesign.
- B. Based on the survey provided, if a pile fails to comply with the location or tolerance requirements of 1.6, or the design load requirements noted on the Contract Documents, the Resident Engineer will calculate the load capacity requirements of that pile or, if in a pile group, each pile in that pile group, based on the actual, "as-driven" locations and inclinations. If the calculation indicates that the loading on that pile or, if in a pile group, on any pile in that pile group, exceeds the design load, then the Contractor shall perform such remedial work as the Resident Engineer in his sole discretion may require including but not limited to furnishing and installing additional piles at locations approved by the Resident Engineer and modifying concrete or reinforcement steel. These corrective measures shall be performed solely at the Contractor's expense.
- C. If a pile fails to comply with the requirements of this Section and the Resident Engineer of record determines that modification to concrete or reinforcement steel, or the driving of additional piles is necessary, the Engineer of record will perform all required reanalysis, redesign and detailing. All reanalysis, redesign and redetailing costs will be the responsibility of the contractor and reimbursed as a change to the contract.
- D. The Contractor, at his option and at any time that he determines that a pile will not satisfy the requirements of this Section for a reason other than encountering an unforeseen underground obstruction, may, subject to the provisions of this specification, abandon such pile and replace it with a new pile or piles rather than await direction or approval from the Resident Engineer. However, the Contractor, in exercising this option, assumes the risk that such replacement pile or piles will be acceptable to the Engineer.
- E. Abandoned piles shall be cut off 300 mm (1 foot) below the elevation of the bottom of the pile cap or mat as shown on the Contract Drawings and will not be paid for.

**3.7 CLEAN UP:**

- A. All debris from excavation of objectionable material, removal of obstructions, and any material not to remain as part of the construction are to be removed and disposed of by the subcontractor in a legal manner at no additional cost to the Owner.
- B. The site shall be cleaned at frequent intervals and no material shall be stored on the site in a manner, which would obstruct the easy access of equipment and personnel.

- - - E N D - - -

# ***KeyMark x4***

by **medeco**

## Technical Service Manual Addendum

Medeco Customer Service 800-839-3157

### History of KeyMark X4 by Medeco®

The birth of key control and high security locks took place in October 1968 in Salem, Virginia. Roy N. Oliver, Elvis C. Flora, Paul A. Powell and Roy Spain, of newly formed Medeco High Security Locks, developed a unique locking principle of elevating and rotating pin tumblers that provided millions of key combinations and a level of security that was unmatched in its time. Special angled cuts on the key were used to rotate unique bottom pins, and a sidebar and hardened steel inserts were used to produce a cylinder that was highly resistant to virtually all forms of attack. Medeco locks soon became the standard for high security and key control.

The angled cuts on the key and the design of the cylinder were so unique that a utility patent was issued. The utility patent protected the operation of the cylinder and also covered the key so that no other manufacturer could produce the cylinder or key blank. The principle of exclusive manufacturing rights over key blanks was tested in court many times over the 17 year life of the patent.

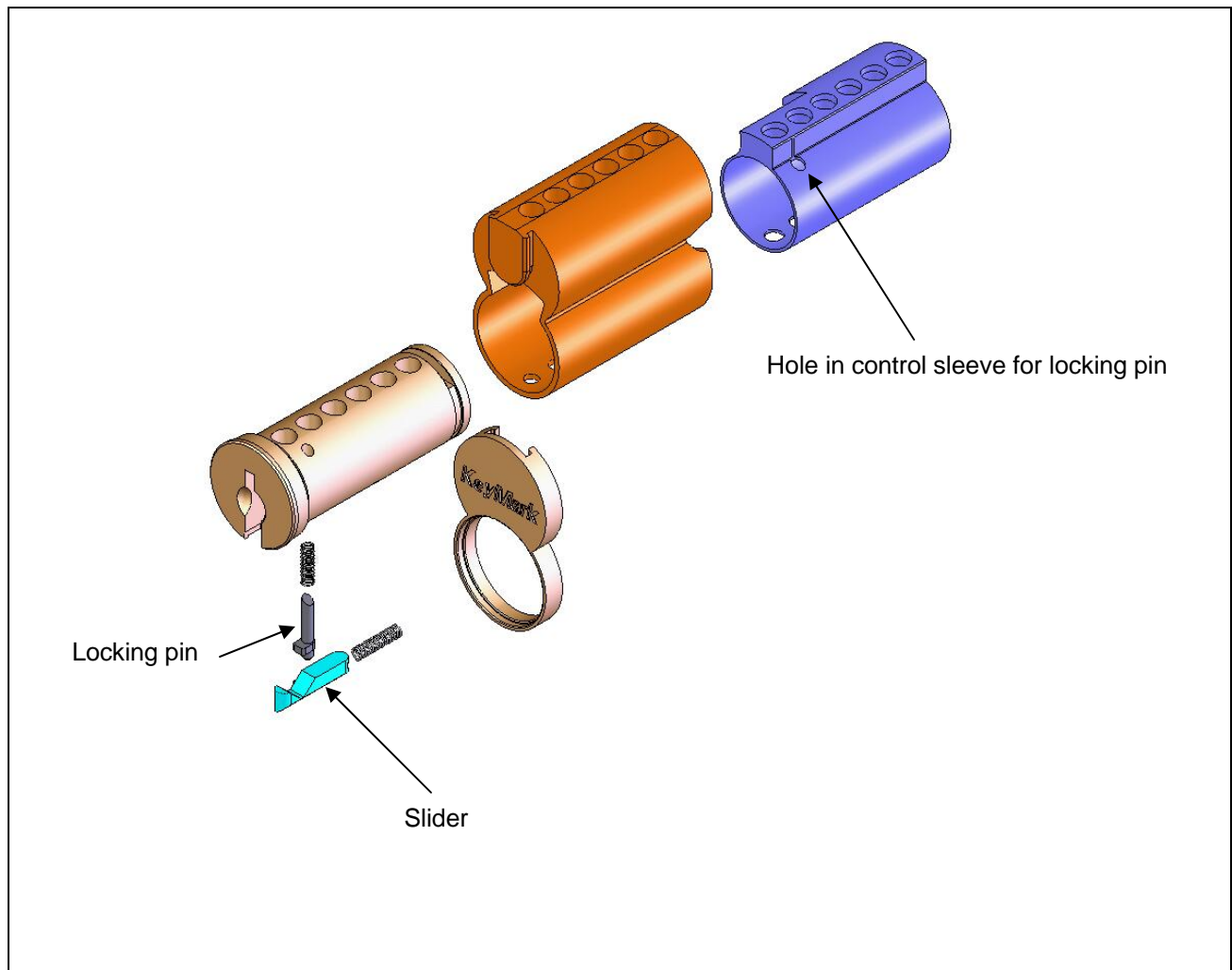
Medeco's use of utility patents to provide the ultimate in key control was so successful that in 1985 a design called Biaxial® was developed. Biaxial also provided high security and key control through the use of the elevating and rotating tumbler design and provided enhanced master keying capability with the addition of an offset pin tip. Utility patents on both the cylinder and key provided protection from unauthorized manufacture and duplication until expiration in 2004 and 2005.

Medeco's current utility patent technology called Medeco 3 adds to the proven high security design of elevating and rotating pins and sidebar with the addition of a slider mechanism. A utility patent is still used today to provide protection against unauthorized manufacture and duplication of key blanks.

In 1921 a removable core lock was designed by Best Lock Co. which would allow quick and easy changing of a lock by an untrained person. This design was the industry standard for many decades but it didn't always meet the customer's need for strict key control over duplication of their keys.

In 1995 Medeco introduced KeyMark, available in an interchangeable core design that could retrofit the Best® style core. KeyMark cylinders were protected by a utility patent (U.S. Patent #5,176,015) on both the cylinder and the key to provide the ultimate in patent key control. An exclusive utility leg design gave the key blank its unique shape and provided an extraordinary number of unique keyway systems. In addition to excellent key control, KeyMark also brought a full line of single shear line retrofit cylinders for conventional, non-interchangeable core locks to the table.

In 2008, Medeco proudly introduced the next generation of quality key control cylinders called KeyMark x4. Like the original KeyMark product line, KeyMark x4 is available in SFIC, LFIC for Schlage, Yale, and Corbin Russwin, as well as a large variety of conventional non-interchangeable core cylinders. The addition of a special locking pin and slider mechanism greatly increases the number of possible keying combinations allowing KeyMark x4 to provide much larger master keying capability compared to other SFIC products.



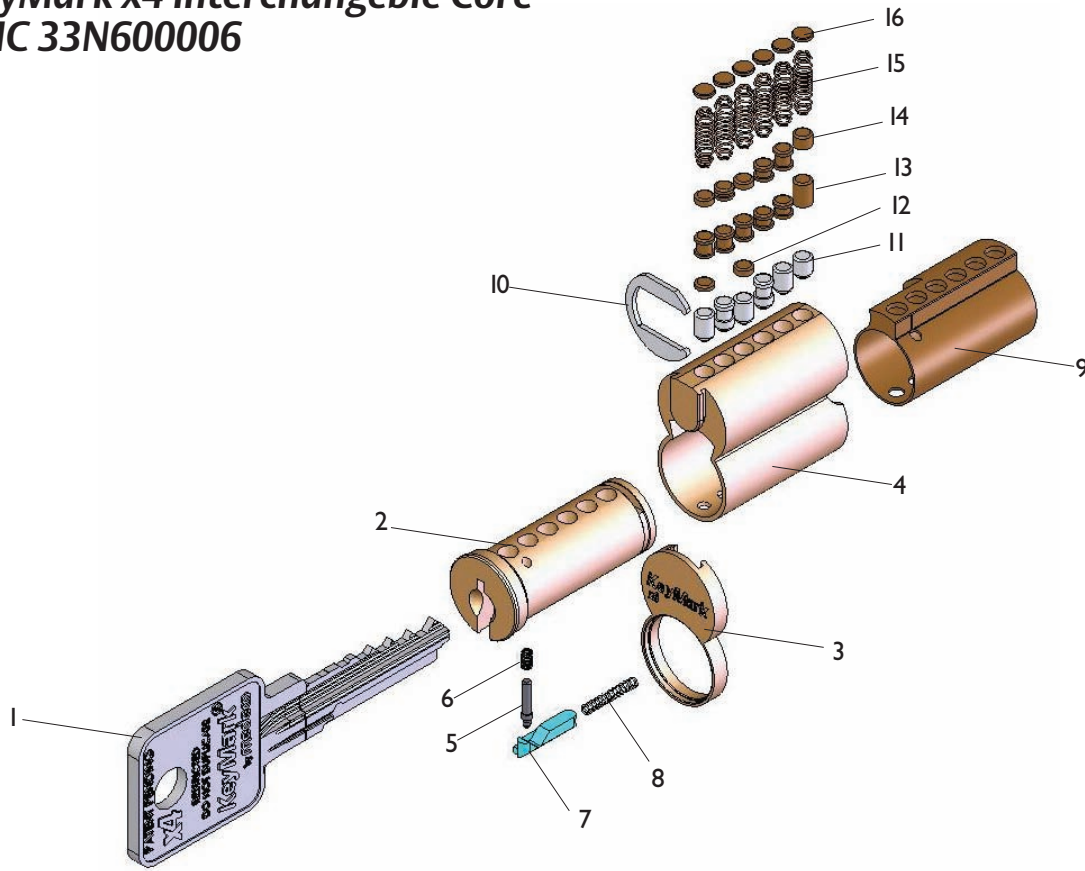
The KeyMark X4 technology incorporates a proprietary slider and locking pin mechanism paired with the A2 pinning specification into SFIC and conventional KIK, rim and mortise cylinders.

**SFIC:** The plug diameter for SFIC cylinders is .434.

**Conventional Cylinders:** The plug diameter for conventional cylinders is .511.

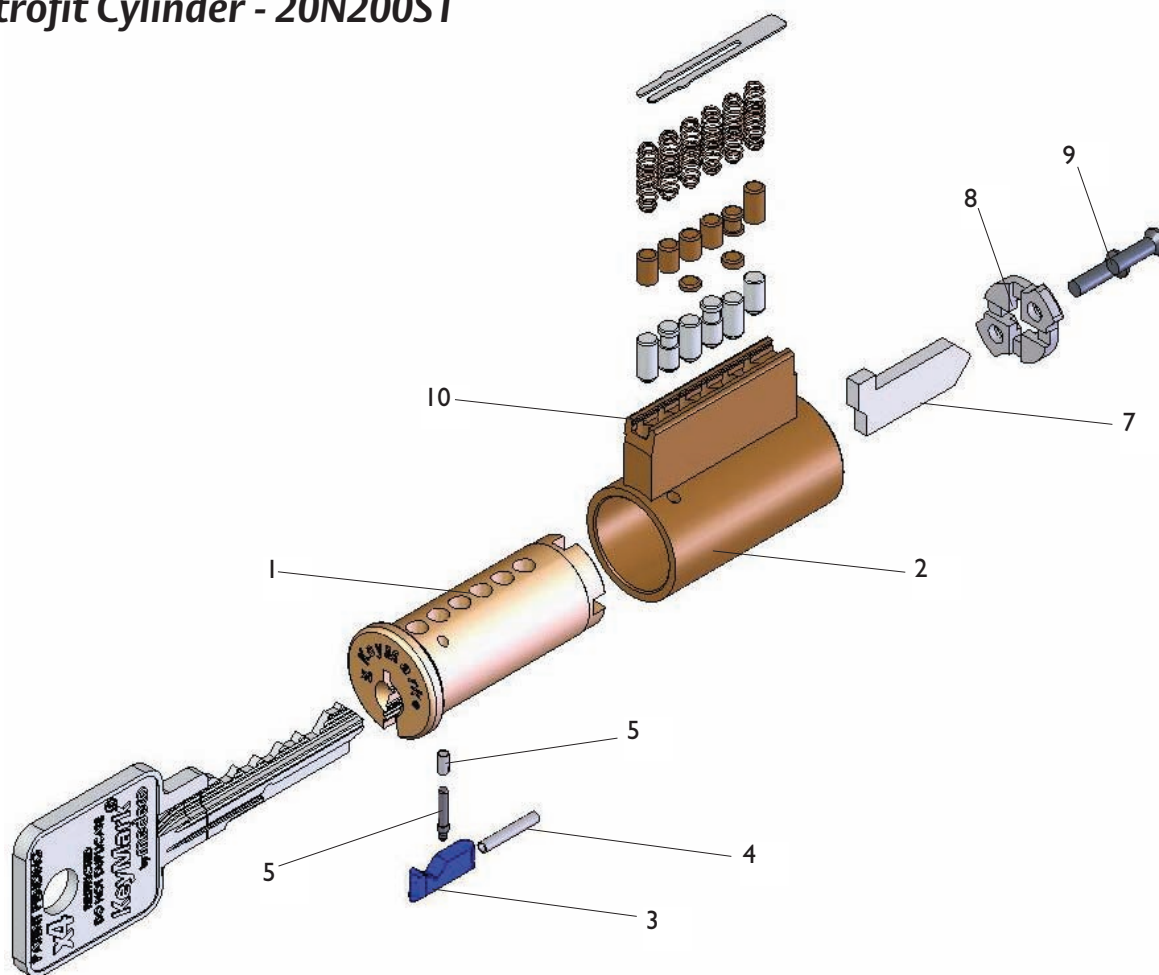
*Note:* Different bottom pins are used for SFIC and conventional cylinders due to the difference in plug diameter.

**KeyMark x4 Interchangeable Core**  
**SFIC 33N600006**



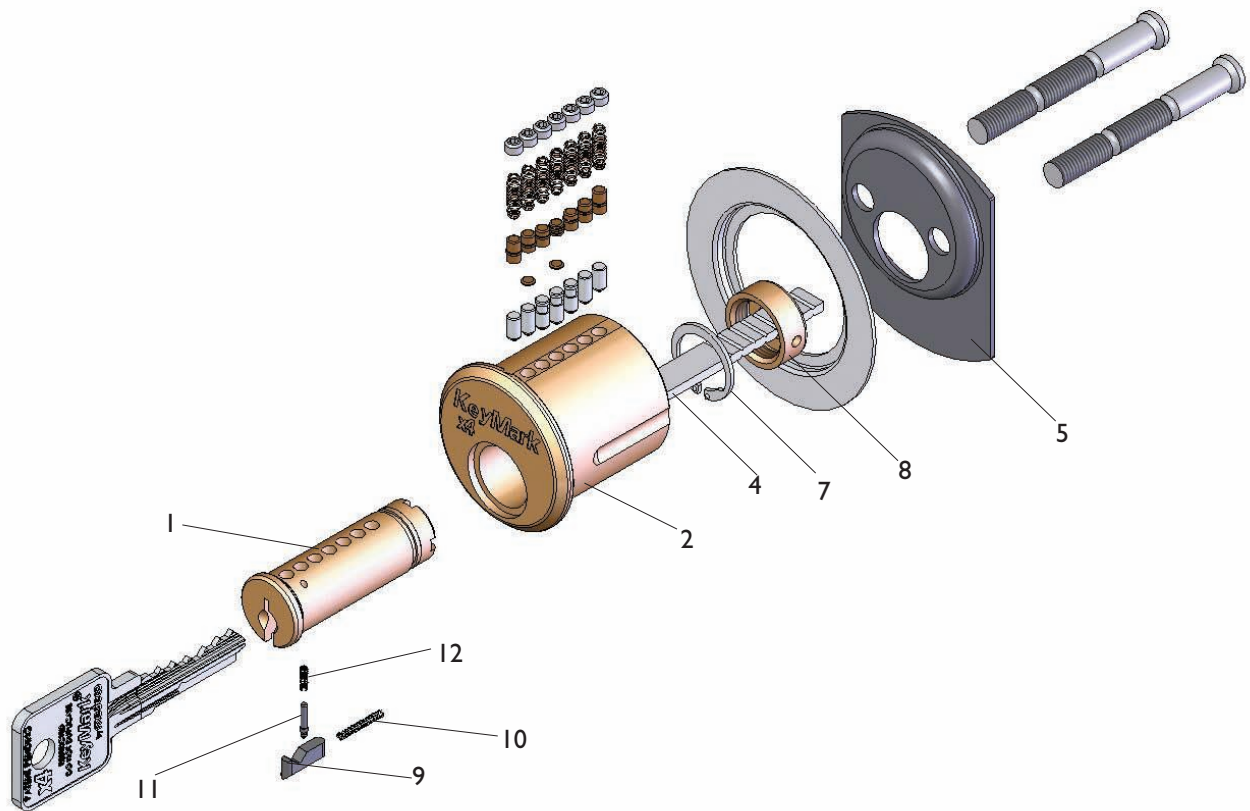
Item	Description	Part Number
1	Key	As Required
2	Plug	12-36800N-XX-XX
3	Shell Front	CP-18281-XX
4	Shell	13-55800K
5	x4 Locking Pin	CP-064231
6	x4 Locking Pin Spring	CP-031170
7	x4 Slider	CP-087690
8	x4 Slider Spring	CP-031180
9	Cylinder Retainer Sleeve	CP-022161
10	Plug Retainer	CP-021810
11	Bottom Pins	As Required
12	Master Pins	As Required
13	Build Up Pins	As Required
14	Top Pins	As Required
15	Springs (Phosphor Bronze)	CP-030580
16	Pin Chamber Spring Caps	CP-170440

## KeyMark x4 Knob, Lever, & Padlock Retrofit Cylinder - 20N200S1



Item	Description	Part Number
1	Plug	12-220XXX
2	Shell	13-39100K
3	Slider	CP-084690-XX
4	Slider Spring	CP-031180
5	Locking Pin, KeyMark x4	CP-064231
6	Locking Pin Spring	CP-031170
7	Tailpiece Package	94-0036
8	Retainer	CP-021370
9	Screw	CP-010203-050
10	Spring Cover	CP-170730-6

## KeyMark x4 Rim Cylinder



Item	Description	Part Number
1	Plug	12-21600N-
2	Shell	13-50282N-XX
3	Tumbler Pins	As Required
4	Tailpiece	As Required
5	Back Plate Package	94-0053
6	Escutcheon Ring (As Required)	CP-180021-XX
7	Retainer	CP-020010
8	Tailpiece Retainer	CP-021121
9	Slider	CP-084690-XX
10	Slider Spring	CP-031180
11	Locking Pin KeyMark x4	CP-064231
12	Locking Pin Spring	CP-031170

---

**Finishes Available:**

---

605 (US3) Bright Brass

606 (US4) Satin Brass

609 (US6) Antique Brass

612 (US10) Satin Bronze

613 (US10B) Oil Rubbed Bronze

624 (US20D) Dark Bronze

625 (US26) Bright Chrome

626 (US26D) Satin Chrome

### Key Machines Available From Medeco



KeyMark Electric Key Machine

95-001201 Air Assist

95-001301 Hand operated



KeyMark Key Punch

95-001100

### Key Machines Available From Other Manufacturers



HPC 1200

\* Use existing Best/Falcon card and cutter



HPC Code MAX

\* Use existing Best/Falcon code and cutter



ITL 9000

\* \* Use existing Best/Falcon MFG code

### Program Policies

The combination of a Best style I-Core with a full line of retrofit cylinders and legally protected principles and practices of strict key control is the essence of KeyMark x4. As with other Medeco products, several key control program options are available to you and your customers.

#### Explanation of Key Control Programs

KeyMark x4 is available in End User & Dealer keyways.

##### A. End User

This level of key control is designed for use by large institutions that have their own locksmith on staff. Institutions that wish to order their keyway product line are free to do so through any of our KeyMark x4 authorized dealer/distributors by presenting a properly signed letter of authorization to Medeco as part of their order. All key blanks will be shipped directly to the end user. Product (including cut keys) may be shipped to the dealer/distributor. Entirely unique families of multiplex keyways are available at this level. Typically an end user customer will meet the following criteria:

1. Institution has 250 or more lockable doors.
2. Locksmith on staff.
3. Contract between end user and Medeco.
4. Key blanks are drop shipped to the end user, not dealer or distributor.
5. End user must purchase a KeyMark x4 key punch machine.
6. Product not sold direct to the institution, rather sold through authorized distribution or retail based locksmiths.
7. Letter of authorization required from end user to distributor/dealer to provide KeyMark x4 product.

##### B. Locksmith Dealer Restricted

(Ask your Medeco representative about availability)

Restricted keyways will be assigned geographically and each dealer will have exclusive rights over the system he sells on his keyway.

### KeyMark x4 End User Contracts

#### A. Contract Overview

KeyMark x4 was created to provide key control. To preserve the integrity of KeyMark x4, Medeco, the locksmith, and the end user must all work together to control the issuance of keys. Medeco will set up strong procedures to preserve the secure distribution of the KeyMark x4 patented key blanks, the storage of those key blanks, and the procedures of for cutting authorized keys.

#### B. Contract Highlights

The following topics are covered in the KeyMark x4 End User Contract:

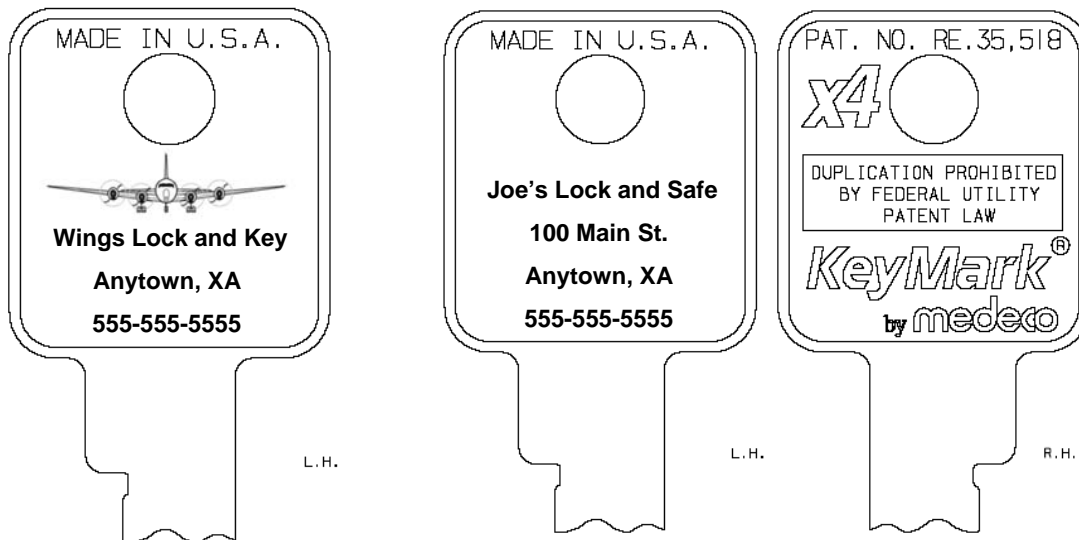
1. Necessary security of blanks and key machines
2. Key control record keeping
3. Specific keyway assignment
4. Custom coining policies
5. Prohibition on resale of KeyMark x4 products
6. Necessary signature authorization
7. Indemnification and termination
8. Contract is between end user and Medeco

A complete KeyMark x4 contract can be obtained from Medeco Technical Services. Contact your Medeco sales representative or call Medeco customer service at 1-800-839-3157 for a contract request form.

### Custom Coining

To further enhance the safety and control of KeyMark x4 keys and blanks, all key blanks released to the field must be custom coined with a unique identifiable name, number, or code. Custom coining, which is the same process the United States mint uses to produce coins, produces a jewelry-quality finish and is an excellent advertisement for a KeyMark x4 dealer or end user. If, for security reasons, a **Level XX** end user chooses not to explicitly identify their key blanks by the name of the institution, an appropriate blind code can be assigned instead.

Custom coining designs can be as elaborate or simple as desired. It is available in two KeyMark x4 bow styles, large (38 bow) and small (32 bow).

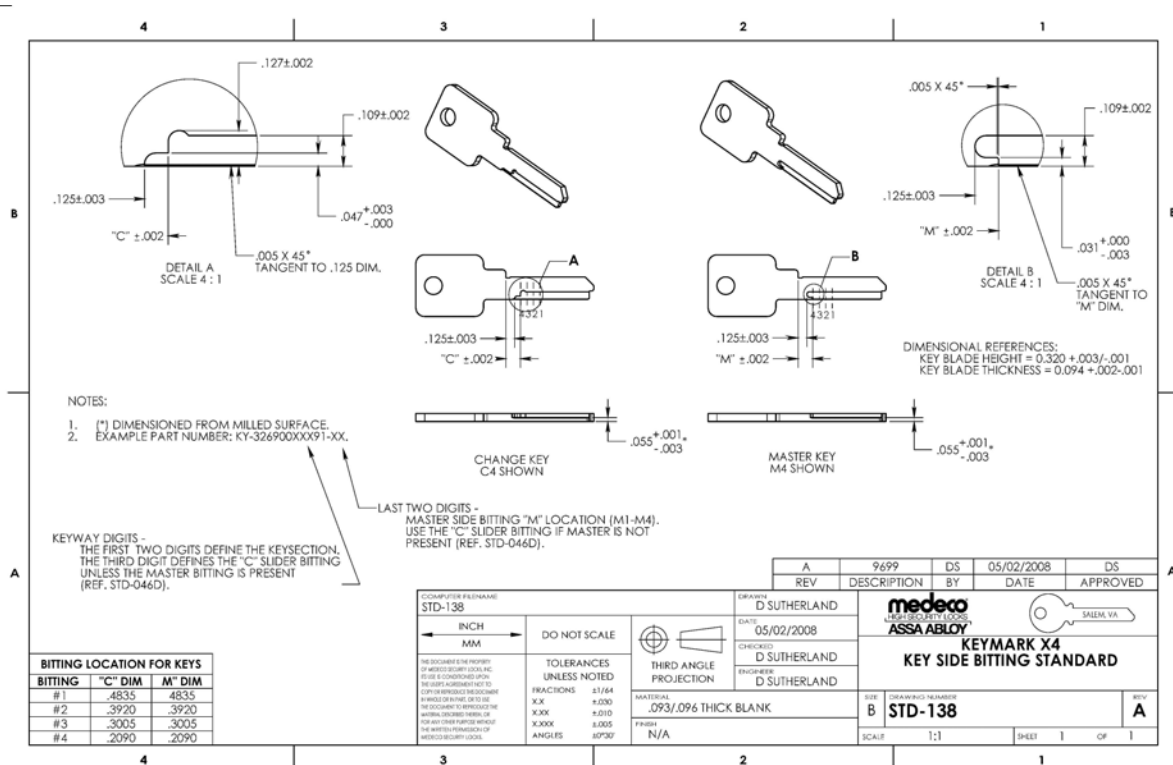


All KeyMark x4 key blanks are coined with a unique, identifiable name, number or code.

You must purchase a Custom Coining die (if you already have a die, it will work with KeyMark x4) and obtain all your key blanks custom coined with any message, graphics and text you desire. Custom coining produces a look, feel and finish of jewelry-like quality and is an excellent advertisement for a dealer or end user. Die charge is \$325 and then order quantities of a minimum of 200 key blanks. Contact your Medeco sales representative or call customer service at 1-800-839-3152 to get a Custom Coin Key Blank order form.

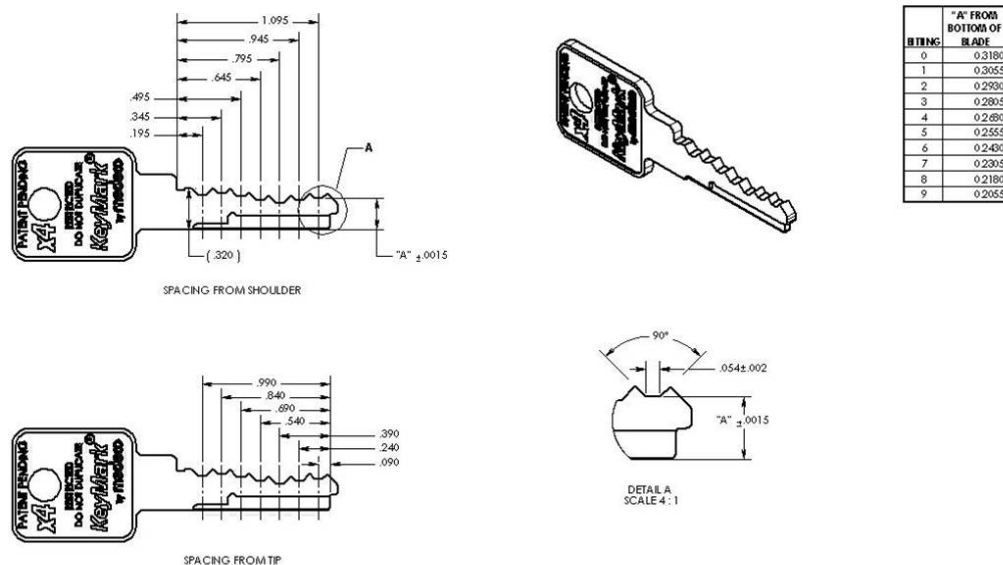
After your keyway number in the KeyMark x4 part number for key blanks, specify "99" for Custom Coining.

# KeyMark X4 Key Specification



KeyMark X4 Keys have a unique side bitting that interacts with the slider mechanism in the cylinder. These side bittings are cut at the factory and can not be created or modified in the field.

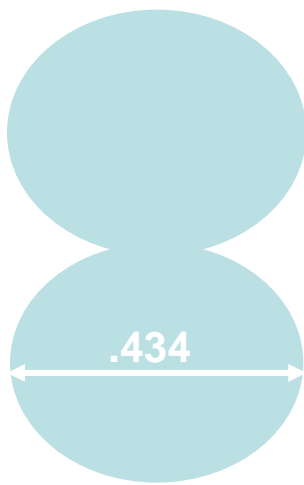
KeyMark X4 keys can be 6 or 7 pin and have both a shoulder stop (used for conventional cylinders) and a tip stop (used for SFIC). These two stops allow you to mix SFIC and conventional cylinders in one keying system.



---

KeyMark X4 SFIC have a plug diameter of .434 and use the same pins as first generation KeyMark. KeyMark X4 SFIC cylinders are also pinned in the same manner as first generation KeyMark cylinders. Detailed keying instructions can be found on pages 13-20 in the original KeyMark Technical Service Manual (Part Number LT-107000).

KeyMark X4 conventional KIK, Mortise and Rim cylinders have a .511 plug diameter and must use different bottom pins that are longer than the SFIC bottom pins.



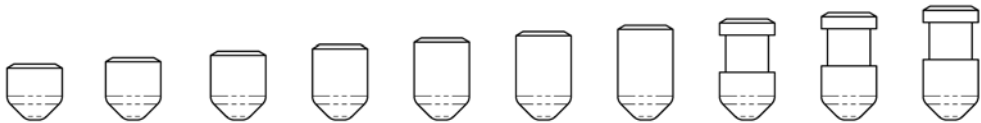
**SFIC**



**KIK, Rim &  
Mortise**

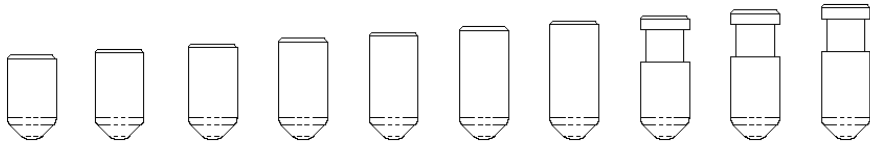
**.434 Bottom  
Pins**

PART NUMBER	PIN #	LENGTH
TP-K40-00-B	0	0.1100
TP-K40-01-B	1	0.1225
TP-K40-02-B	2	0.1350
TP-K40-03-B	3	0.1475
TP-K40-04-B	4	0.1600
TP-K40-05-B	5	0.1725
TP-K40-06-B	6	0.1850
TP-K40-07-B	7	0.1975
TP-K40-08-B	8	0.2100
TP-K40-09-B	9	0.2225

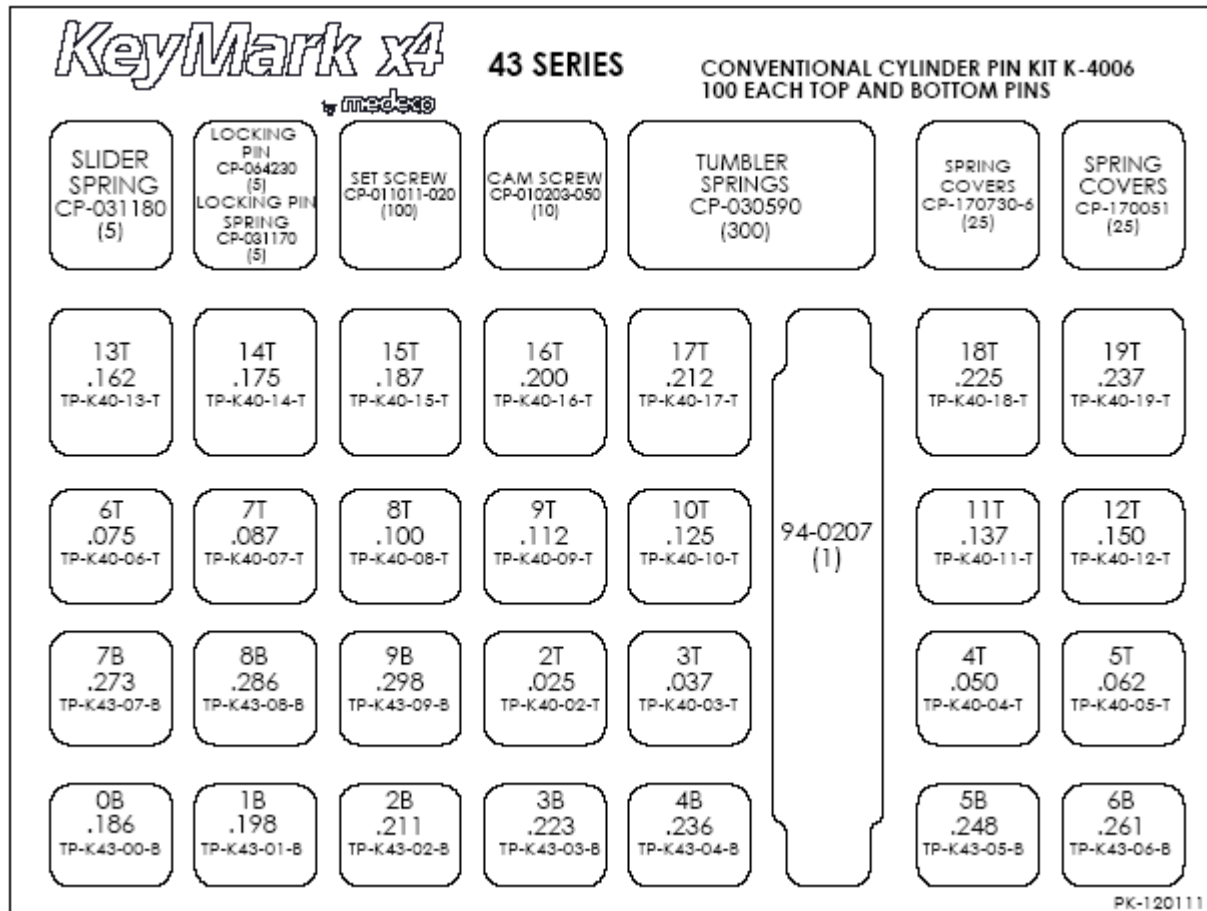


**.511 Bottom  
Pins**

PART NUMBER	PIN #	LENGTH
TP-K43-00-B	0	0.1860
TP-K43-01-B	1	0.1985
TP-K43-02-B	2	0.2110
TP-K43-03-B	3	0.2235
TP-K43-04-B	4	0.2360
TP-K43-05-B	5	0.2485
TP-K43-06-B	6	0.2610
TP-K43-07-B	7	0.2735
TP-K43-08-B	8	0.2860
TP-K43-09-B	9	0.2985



## Conventional Cylinder Pin Kit



A separate pin kit is required for KeyMark X4 conventional cylinders. The pin kit part number is K4006