

## SECTION 019113 - COMMISSIONING REQUIREMENTS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.
- B. Related Sections:
1. Division 07 Section "Commissioning of Thermal and Moisture Protection Systems" for commissioning process activities for the building envelope, systems, equipment and components.
  2. Division 22 Section "Commissioning of Plumbing Systems" for commissioning process activities for plumbing systems, equipment, and components.
  3. Division 23 Section "Commissioning of Mechanical Systems" for commissioning process activities for HVAC&R systems, assemblies, equipment, and components.
  4. Division 26 Section "Commissioning of Electrical Systems" for commissioning process activities for electrical systems, equipment, and components.

## 1.3 DEFINITIONS

- A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- B. CxA: Commissioning Authority.
- C. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

## 1.4 SYSTEMS TO BE COMMISSIONED

- A. Division 07 – The following building envelope systems will be commissioned in this project.
- Roofing
  - Wall structures i.e. masonry, metal panels, etc.
  - Mock-up review
  - Envelope water and air tightness
  - Door, window and louver installation

- Thermographic Imaging if specified
- Building pressurization test if specified

B. Division 22 - The following plumbing systems will be commissioned in this project.

- Domestic Hot Water System

C. Division 23 - The following mechanical system will be commissioned in this project.

- Hydronic Piping (Chilled and Heating)
- Pumps
- Rooftop Air-handling Units (RTU)
- Dedicated Outside Air-handling Units
- Split Systems
- Cabinet Unit Heaters
- Unit Heaters
- Testing, Adjusting and Balancing work
- VAV Units
- Fans (Exhaust and Supply)
- Building Automation System (controlled devices, control loops and system integration)

D. Division 26 - The following electrical system will be commissioned in this project.

- The electrical system down to the panel level
- Thermographic imaging of power panels
- Lighting Controls / Occupancy Sensors
- Emergency Generator
- Automatic Transfer Switch

## 1.5 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
- B. Members Appointed by Owner:
1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process.
    - a. The CxA is: The Brewer-Garrett Company
  2. Representatives of the facility user and operation and maintenance personnel.
  3. Architect and engineering design professionals.

## 1.6 OWNER'S RESPONSIBILITIES

- A. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

## 1.7 CxA'S RESPONSIBILITIES

- A. Organize and lead the commissioning team.
- B. Provide commissioning plan.
- C. Convene commissioning team meetings.
- D. Provide project-specific pre-functional checklists and commissioning functional test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract and fall within the CxA's scope of work.
- E. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 10 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the owner's project requirements. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.
- F. Prepare and maintain the Issues Log.
- G. Witness systems, assemblies, equipment, and component startup.
- H. Verify testing, adjusting, and balancing of work is complete.
- I. Direct and witness the functional testing of systems, assemblies, equipment, and components to insure proper functioning prior to owner occupancy.
- J. Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

## 1.8 CONTRACTORS' RESPONSIBILITIES

- A. The purpose of this section is to specify the contractors' and their sub-contractors' responsibilities in the commissioning process.
- B. Commissioning requires the participation of CMR OR HIS SUBCONTRACTOR to ensure that all systems are operating in a manner consistent with the Contract Documents. CMR OR HIS SUBCONTRACTOR shall be familiar with all parts of the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- C. All Contractors. The general commissioning responsibilities applicable to each of the contractors are as follows (all references apply to commissioned equipment only):
  - 1. Construction and Acceptance Phases

- a. Include and itemize the cost of commissioning in the contract price.
- b. Attend a commissioning kick-off meeting and other meetings necessary to facilitate the Cx process.
- c. Provide a copy of the O&M manuals, cut sheets, and shop drawing submittals of commissioned equipment, through normal channels, to the CxA for review.
- d. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.
  - 1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting, emergency, and maintenance procedures, full details of any owner-contracted tests, equipment performance diagrams, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
- e. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- f. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup.
- g. Perform, complete, and clearly document all full start-up and initial checkout plans, providing a typed copy electronically to the CxA. These documents should be returned to the CxA within two weeks of the start-up of the equipment.
- h. Review, comment, and accept the specific functional performance test procedures provided by the CxA; samples of which are included in Part 4. CMR OR HIS SUBCONTRACTOR shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- i. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
- j. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
- k. Respond to Commissioning Issues Log items that are relevant to your scope of work within one week of notification.
- l. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, CMR, and A/E and retest the equipment.
- m. Provide information requested by the CxA for final commissioning documentation.
- n. Provide measuring instruments to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- o. Provide documentation requested by the CxA regarding owner training and adjust training as directed by the CxA to best meet the needs of the owner's operating personnel. Training to use expert qualified personnel, as specified.

- p. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
  - 2. Warranty Period
    - a. Execute seasonal or deferred functional performance testing, witnessed by the CxA.
    - b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
- D. General Trades Contractor. The responsibilities of the General Trades contractor, during construction and acceptance phases in addition to those listed in (C) are:
  - 1. Include Commissioning in preinstall meetings for Fluid Applied Membrane, Roofing, and Wall mock-up.
  - 2. Conduct water infiltration testing if contract requires.
- E. Mechanical Contractor. The responsibilities of the HVAC mechanical contractor, during construction and acceptance phases in addition to those listed in (C) are:
  - 1. Provide startup for all HVAC equipment, including the building automation control system.
  - 2. Assist with the TAB contractor and CxA by:
    - a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
    - b. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
  - 3. List and clearly identify on the as-built drawings the locations of all air-flow stations.
  - 4. Prepare a preliminary schedule for pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.
  - 5. Notify the CMR or CxA depending on protocol, when pipe system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the CMR or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.
- F. Controls Contractor. The commissioning responsibilities of the controls contractor, during construction and acceptance phases in addition to those listed in (C) are:
  - 1. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
    - a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
    - b. All interactions and interlocks with other systems.

- c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
  - d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
  - e. Start-up sequences.
  - f. Warm-up mode sequences.
  - g. Normal operating mode sequences.
  - h. Unoccupied mode sequences.
  - i. Shutdown sequences.
  - j. Capacity control sequences and equipment staging.
  - k. Temperature and pressure control: setbacks, setups, resets, etc.
  - l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
  - m. Effects of power or equipment failure with all standby component functions.
  - n. Sequences for all alarms and emergency shut downs.
  - o. Seasonal operational differences and recommendations.
  - p. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
  - q. Schedules, if known.
  - r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.
2. Control Drawings Submittal
- a. The control drawings shall have a key to all abbreviations.
  - b. The control drawings shall contain graphic schematic depictions of the systems and each component.
  - c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
  - d. Provide a full points list with at least the following included for each point:
    - 1) Controlled system
    - 2) Point abbreviation
    - 3) Point description
    - 4) Display unit
    - 5) Control point or setpoint (Yes / No)
    - 6) Monitoring point (Yes / No)
    - 7) Intermediate point (Yes / No)
    - 8) Calculated point (Yes / No)

**Key:**

Point Description:	DB temp, airflow, etc.
Control or Setpoint:	Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
Intermediate Point:	Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).

Monitoring Point:	Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
Calculated Point:	“Virtual” point generated from calculations of other point values.

3. The Controls Contractor shall keep the CxA informed of all changes to this list during programming and setup.
4. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
5. Assist and cooperate with the TAB contractor in the following manner:
  - Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
    - a. For a given area, have all required pre-functional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CxA prior to TAB.
    - b. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
6. Assist and cooperate with the CxA in the following manner:
  - a. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system.
  - b. Assist in the functional testing of all equipment specified as part of the commissioning scope. Provide two-way radios during the testing.
  - c. Execute all control system trend logs specified.
7. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
  - a. System name.
  - b. List of devices.
  - c. Step-by-step procedures for testing each controller after installation, including:
    - 1) Process of verifying proper hardware and wiring installation.
    - 2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
    - 3) Process of performing operational checks of each controlled component.
    - 4) Plan and process for calibrating valve and damper actuators and all sensors.
    - 5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
  - d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each

- point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
  - e. A description of the instrumentation required for testing.
  - f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CxA and TAB contractor for this determination.
8. Provide a signed and dated certification to the CxA and CMR upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.
  9. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified in the commissioning plan.
  10. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

G. TAB Contractor. The duties of the TAB contractor, in addition to those listed in (C) are:

1. Six weeks prior to starting TAB, submit to the CMR the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead.
2. Submit the outline of the TAB plan and approach for each system and component to the CxA, CMR and the controls contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.
3. The submitted plan will include:
  - a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
  - b. An explanation of the intended use of the building control system. The controls contractor will comment on feasibility of the plan.
  - c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
  - d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
  - e. Final test report forms to be used.
  - f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
  - g. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
  - h. Details of how *total* flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
  - i. The identification and types of measurement instruments to be used and their most recent calibration date.



- j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
  - k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.
  - l. Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, zone, etc.).
  - m. Details of how building static and exhaust fan / relief damper capacity will be checked.
  - n. Proposed selection points for sound measurements and sound measurement methods.
  - o. Details of methods for making any specified coil or other system plant capacity measurements.
  - p. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
  - q. Details regarding specified deferred or seasonal TAB work.
  - r. Details of any specified false loading of systems to complete TAB work.
  - s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
  - t. Details of any required interstitial cavity differential pressure measurements and calculations.
  - u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
  - v. Plan for formal progress reports (scope and frequency).
  - w. Plan for formal deficiency reports (scope, frequency and distribution).
- 4. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CxA and CMR least twice a week.
  - 5. Communicate in writing to the controls contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
  - 6. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CxA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.
  - 7. Provide the CxA with any requested data, gathered, but not shown on the draft reports.
  - 8. Provide a final TAB report for the CxA with details, as in the draft.
  - 9. Conduct functional performance tests and checks on the original TAB as specified for TAB in the commissioning plan.
- H. Plumbing Contractor. The responsibilities of the plumbing contractor, during construction and acceptance phases in addition to those listed in (C) are:
- 1. Provide pressure test reports for all piping systems to be commissioned.
  - 2. Provide certificate for piping used in medical gas piping systems.
- I. Electrical Contractor. The responsibilities of the electrical contractor, during construction and acceptance phases in addition to those listed in (C) are:

1. Provide equipment test reports for all electrical systems to be commissioned.
2. Conduct Thermographic imaging of the power panels in one of two ways:
  - a. Conduct with in-house qualified resources or
  - b. Contract with a qualified third party company
3. Assist commissioning with the checkout of the lighting control system.
4. Include commissioning in the standby power Generator in the initial startup and in the final full load test.
5. Include commissioning in the renewable energy systems initial startup and in the final full load test.

#### 1.9 COMMISSIONING DOCUMENTATION

A. Contractor to provide the following information to the CxA for inclusion in the Systems Manual:

1. A plan for delivery and review of submittals, O&M manuals, and other documents and reports.
2. Detailed manufacturer installation and start-up, operating, troubleshooting, emergency, and maintenance procedures, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.
3. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
4. Process and schedule for completing pre-functional checklists and manufacturer's pre-start and startup checklists for systems, assemblies, equipment, and components to be verified and tested.
5. Certificate of completion certifying that installation, pre-start checks, and startup procedures have been completed.
6. Certificate of readiness certifying that systems, subsystems, equipment, and associated controls are ready for testing.
7. Test and inspection reports and certificates.
8. Corrective action documents.
9. Verification of testing, adjusting, and balancing reports.

#### 1.10 SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

## PART 2 - PRODUCTS (Not Used)

## PART 3 - EXECUTION

## 3.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the CMR OR HIS SUBCONTRACTOR contractor for the equipment being tested. For example, the HVAC contractor shall ultimately be responsible for all standard testing equipment for the HVAC system, controls system and TAB work.
- B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, shall be included in the base bid price and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances noted elsewhere 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°F and a resolution of + or - 0.1°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.

## 3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment to be commissioned, according to Section 1.4.
- B. Pre-functional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full pre-functional checkout. No sampling strategies are used. The pre-functional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system. Representative test formats and examples are found in the Part 4.
- C. Start-up and Initial Checkout Plan
  - 1. The CxA shall guide the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of

the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for pre-functional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms

2. The CxA adapts, if necessary, the representative pre-functional checklists and procedures. The checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.
3. These checklists and tests are provided by the CxA to the Contractor.
4. The CMR OR HIS SUBCONTRACTOR contractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will 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. The full start-up plan could consist of something as simple as:
  - a. The CxA's pre-functional checklists.
  - b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
  - c. The manufacturer's normally used field checkout sheets.
5. The CMR OR HIS SUBCONTRACTOR submits the full startup plan to the CxA for review and approval.
6. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

D. Sensor and Actuator Calibration.

1. All field-installed temperature, relative humidity, CO, CO<sub>2</sub> and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed *in* the unit at the factory with calibration certification provided need not be field calibrated.
2. 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.

E. Execution of Pre-functional Checklists and Startup.

1. Four weeks prior to startup, the CMR OR HIS SUBCONTRACTOR and vendors schedule startup and checkout with the CxA. The performance of the pre-functional checklists, startup and checkout are directed and executed by the CMR OR HIS SUBCONTRACTOR or vendor. When checking off pre-functional checklists, signatures may be required of other CMR OR HIS SUBCONTRACTOR for verification of completion of their work.
2. The CxA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as

- approved by the CxA). In no case will the number of units witnessed be less than four on any one building, nor less than 20% of the total number of identical or very similar units.
3. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA shall observe a sampling of the pre-functional and start-up procedures. The sampling procedures are identified in the commissioning plan.
  4. The CMR OR HIS SUBCONTRACTOR and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and pre-functional tests and checklists.
  5. Only individuals that have direct knowledge and witnessed that a line item task on the pre-functional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

F. Deficiencies, Non-Conformance and Approval in Checklists and Startup.

1. The CMR OR HIS SUBCONTRACTOR shall clearly list any outstanding items of the initial start-up and pre-functional 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 are provided to the CxA within two days of test completion.
2. The CxA reviews the report and submits either a non-compliance report or an approval form to the CMR . The CxA shall work with the CMR OR HIS SUBCONTRACTOR and vendors to correct and retest deficiencies or uncompleted items. The CxA will involve the CMR OR HIS SUBCONTRACTOR and others as necessary. The installing CMR OR HIS SUBCONTRACTOR or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CMR OR HIS SUBCONTRACTOR as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA recommends approval of the execution of the checklists and startup of each system to the CMR OR HIS SUBCONTRACTOR using a standard form.

### 3.3 FUNCTIONAL PERFORMANCE TESTING

- A. The general list of equipment to be commissioned is found in Part 1.4. The parties responsible to execute each test are listed with each test.
- B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and CMR OR HIS SUBCONTRACTOR. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.
- C. Objectives and Scope
  1. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion

to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

2. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.

D. Development of Test Procedures

1. When final equipment selections have been determined (by contractor submittals), the CxA shall review the submittals and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. With input from Cx team members, the CxA shall finalize the preliminary test procedures included in this spec section and create forms to verify and document proper operation of each piece of equipment and system. Each CMR OR HIS SUBCONTRACTOR or vendor responsible to execute a test, shall provide assistance to the CxA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CxA shall provide a copy of the test procedures to the CMR OR HIS SUBCONTRACTOR(s) who shall review the tests for feasibility, safety, equipment and warranty protection.
2. The purpose of any given specific 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 Part 4. The test procedure forms developed by the CxA shall include (but not be limited to) the following information:
    - a. System and equipment or component name(s)
    - b. Equipment location and ID number
    - c. Unique test ID number, and reference to unique pre-functional checklist and start-up documentation ID numbers for the piece of equipment
    - d. Date
    - e. Project name
    - f. Participating parties
    - g. A copy of the specification section describing the test requirements
    - h. A copy of the specific sequence of operations or other specified parameters being verified
    - i. Formulas used in any calculations
    - j. Required pre-test field measurements
    - k. Instructions for setting up the test.
    - l. Special cautions, alarm limits, etc.
    - m. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
    - n. 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.
    - o. A section for comments
    - p. Signatures and date block for the CxA

E. Test Methods

1. Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers.
2. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
  - 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 AC compressor lockout work at an outside air temperature below 55F, when the outside air temperature is above 55F, temporarily change the lockout setpoint to be 2F 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 is completed during pre-functional testing.
6. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The CMR OR HIS SUBCONTRACTOR executing the test 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 CMR OR HIS SUBCONTRACTOR shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

F. Coordination and Scheduling.

1. The CMR OR HIS SUBCONTRACTOR shall provide sufficient notice to the CxA regarding their completion schedule for the pre-functional checklists and startup of all equipment and systems. The CxA will coordinate functional tests with assistance from the CMR OR HIS SUBCONTRACTOR. The CxA shall direct, witness, document and approve the functional testing of all equipment and systems. The CMR OR HIS SUBCONTRACTOR shall execute the tests.
  - In general, functional testing is conducted after pre-functional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CxA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before

functional testing of air-related or water-related equipment or systems. Testing proceeds 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 is checked.

- G. Test Equipment. Refer to section 3.1 for test equipment requirements.
- H. Problem Solving. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CMR OR HIS SUBCONTRACTOR and A/E.

### 3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Documentation. The CxA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. The CxA will include the filled out forms in the O&M manuals.
- B. Non-Conformance.
  - 1. The CxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CMR OR HIS SUBCONTRACTOR on a standard non-compliance form.
  - 2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.
  - 3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues.
  - As tests progress and a deficiency is identified, the CxA discusses the issue with the executing contractor and the Cx Team.
    - a. When there is no dispute on the deficiency and the CMR OR HIS SUBCONTRACTOR accepts responsibility to correct it:
      - 1) The CxA documents the deficiency and the CMR OR HIS SUBCONTRACTOR response and intentions and they go on to another test or sequence. A copy is provided to the CMR and CxA. The CMR OR HIS SUBCONTRACTOR corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.
      - 2) The CxA reschedules the test and the test is repeated.
    - b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:



- 1) The deficiency shall be documented on the non-compliance form with the CMR OR HIS SUBCONTRACTOR response and a copy given to the owner with copies to the Project Team.
  - 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Owner.
  - 3) The CxA documents the resolution process.
  - 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA reschedules the test and the test is repeated until satisfactory performance is achieved.
4. Cost of Retesting.
- a. The cost for the CMR OR HIS SUBCONTRACTOR to retest a pre-functional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the Owner
  - b. For a deficiency identified, not related to any pre-functional checklist or start-up fault, the following shall apply: The CxA will direct the retesting of the equipment once at no “charge” to the CMR OR HIS SUBCONTRACTOR for their time. However, the CxA’s time for a second retest will be charged to the CMR OR HIS SUBCONTRACTOR.
  - c. The time for the CxA to direct any retesting required because a specific *pre-functional* checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the CMR OR HIS SUBCONTRACTOR.
- Refer to the sampling section of part 3.6 for requirements for testing and retesting identical equipment.
5. The Contractor shall respond in writing to the CxA through the CMR OR HIS SUBCONTRACTOR at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
6. The CxA retains the original non-conformance forms until the end of the project.
- C. 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 to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CxA or PM. In such case, the CMR OR HIS SUBCONTRACTOR shall provide the Owner with the following:
1. Within one week of notification from the CMR OR HIS SUBCONTRACTOR or PM, the CMR OR HIS SUBCONTRACTOR or manufacturer’s representative shall examine all other identical units making a record of the findings. The findings shall be provided to the CMR or PM within two weeks of the original notice.
  2. Within two weeks of the original notification, the CMR OR HIS SUBCONTRACTOR or manufacturer 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 PM will determine whether a replacement of all identical units or a repair is acceptable.
  4. Two examples of the proposed solution will be installed by the CMR OR HIS SUBCONTRACTOR, and the CMR OR HIS SUBCONTRACTOR will be allowed to test the installations for up to one week, upon which the CMR or PM will decide whether to accept the solution.
  5. Upon acceptance, the CMR OR HIS SUBCONTRACTOR and/or manufacturer 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.
- D. Approval. The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA.

### 3.5 DEFERRED TESTING

- A. Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM. These tests will be conducted in the same manner as the seasonal tests as soon as possible.
- B. Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CxA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate CMR OR HIS SUBCONTRACTOR, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

## PART 4 - SAMPLE CHECKLISTS AND TEST FORMS

## AIR HANDLING UNIT CHECKLIST

### 1. Model verification

Equip Tag →							
Manuf.							
Model							
Serial #							
Supply Fan	Capacity						
	Volts/phase						
	Amps/HP						
	# of Belts						
	Belt Size						
	# of Fuses						
	Fuse Size						
	# of Filters						
	Filter Size						
	# of Filters						
	Filter Size						
Relief Fan	Capacity						
	Volts/phase						
	Amps/HP						
	# of Belts						
	Belt Size						
	# of Fuses						
Energy Wheel	Capacity						
	Volts/phase						
	Amps/HP						
	# of Belts						
	Belt Size						
	# of Fuses						
	Fuse Size						

### 2. Installation Checks

	Equip Tag →						
<b>Cabinet and General Installation</b>							
Permanent labels affixed, including for fans							
Casing condition good: no dents, leaks, door gaskets installed							
Access doors close tightly - no leaks							
Boot between duct and unit tight and in good condition (supply and return air)							
Vibration isolation equipment installed & released from shipping locks							
Maintenance access acceptable for unit and components							
Instrumentation installed and labeled according to specification (thermometers, pressure gages, flow meters, etc.)							

## AIR HANDLING UNIT CHECKLIST

Equip Tag →						
Clean up of equipment completed						
Filters installed and replacement type and efficiency permanently affixed to housing						
<b>Valves, Piping and Coils</b> (see full piping checklists)						
Pipes properly labeled						
Pipes properly insulated						
Strainers in place and clean						
All coils are clean and fins are in good condition						
All condensate drain pans clean and slope to drain, per spec						
Condensate drain trap installed appropriate for use at the units static pressure						
Valves properly labeled						
Valves installed in proper direction						
<b>Fans and Dampers</b>						
Supply fan and motor alignment correct						
Supply fan belt tension & condition good						
Supply fan protective shrouds for belts in place and secure						
Supply fan area clean						
Supply fan and motor lube lines installed and lubed						
Return/exhaust fan and motor alignment correct						
Return/exhaust fan belt tension & condition good						
Return/exhaust fan protective shrouds for belts in place and secure						
Return/exhaust fan area clean						
Return/exhaust fan and motor lube lines installed and lubed						
Heat wheel fan and motor alignment correct						
Heat wheel fan belt tension & condition good						
Heat wheel fan protective shrouds for belts in place and secure						
Heat wheel fan area clean						
Heat wheel fan and motor lube lines installed and lubed						
Filter pressure differential measuring device installed and functional (Magnehelic, inclined manometer, etc.)						
All dampers close tightly						
All damper linkages have minimum play						
<b>Electrical and Controls</b>						
Power disconnects in place and labeled						
All electric connections complete						
Safeties in place and operable						
Low temperature (freeze stat) sensor properly installed and operable						
Smoke detector(s) in place						
All control devices and wiring complete and labeled						

**3. Operational Checks** (Theses augment mfr's list. This is not the functional performance testing.)

Equip Tag →						
Supply fan rotation correct						
Return/exhaust fan rotation correct						
Return /exhaust fan has no unusual noise or vibration						
Supply fan has no unusual noise or vibration						
Heat wheel has no unusual noise or vibration						
All dampers (outside air, return air, heat wheel bypass, relief air, etc.) stroke fully without binding						
All heating and chilled water valves stroke fully and easily						
The HOA switch properly activates and deactivates the unit						

## PUMPS CHECKLIST

### 1. Model verification

Equip Tag	Manufacturer	Model #	Serial #	RPM	Volts/Ph/A

### 2. Installation Checks

Equip Tag #						
Label Permanently affixed (I.D. Tag on pump, starter and disconnect switch by contractor)						
Pumps mounted securely						
Vibration isolation devices installed and functional						
Pump alignment verified correct						
Temperature and pressure gauges installed						
Verify pump and valve lubrication						
Maintenance access acceptable for unit and components						
All electrical connections complete						
All control devices and wiring complete						

### 3. Operational Checks

The HOA switch properly activates and deactivates the unit						
Pump rotation verified correct						
No unusual noise or vibration						
No leaking apparent around fittings or seals						

**Notes:**

## AIR HANDLING UNIT FUNCTIONAL TEST

Date: \_\_\_\_\_

### 1. Testing Parameters

Equip Tag →							
Outside Air Temp (deg F)							
Supply Air Set Point (deg F)							
Static Air Discharge Set Point (inches of W.C.)							
Static Air Low Limit Set Point (inches of W.C.)							
Static Air High Limit Set Point (inches of W.C.)							
Dirty Filter Set Point (inches of W.C.)							
Chilled Water Available (yes/no)							
Heating Water Available (yes/no)							
Supply Air	CFM						
	VFD (hz)						
Return/Exhaust Air	CFM						
	VFD (hz)						
Outside Air	CFM						

### 2. Installation Checks

Equip Tag →							
<b>Cabinet and General Installation</b>							
Permanent labels affixed, including for fans							
Casing condition good: no dents, leaks, door gaskets installed							
Access doors close tightly – no leaks							
Boot between duct and unit tight and in good condition (supply and return air)							
Vibration isolation equipment installed & released from shipping locks							
Maintenance access acceptable for unit and components							
Instrumentation installed and labeled according to specification (thermometers, pressure gages, flow meters, etc.)							
Clean up of equipment completed							
Filters installed and replacement type and efficiency permanently affixed to housing							
<b>Valves, Piping and Coils</b>							
Pipes properly labeled							
Pipes properly insulated							
Strainers in place and clean							
All coils are clean and fins are in good condition							
All condensate drain pans clean and slope to drain, per spec							
Condensate drain trap installed appropriate for use at the units static pressure							
Valves properly labeled							
Valves installed in proper direction							
<b>Fans and Dampers</b>							
Supply fan and motor alignment correct							
Supply fan belt tension & condition good							
Supply fan protective shrouds for belts in place and secure							

## AIR HANDLING UNIT FUNCTIONAL TEST

Equip Tag →						
Supply fan area clean						
Supply fan and motor lube lines installed and lubed						
Return/exhaust fan and motor alignment correct						
Return/exhaust fan belt tension & condition good						
Return/exhaust fan protective shrouds for belts in place and secure						
Return/exhaust fan area clean						
Return/exhaust fan and motor lube lines installed and lubed						
Heat wheel fan and motor alignment correct						
Heat wheel fan belt tension & condition good						
Heat wheel fan protective shrouds for belts in place and secure						
Heat wheel fan area clean						
Heat wheel fan and motor lube lines installed and lubed						
Filter pressure differential measuring device installed and functional (Magnehelic, inclined manometer, etc.)						
All dampers close tightly						
All damper linkages have minimum play						
<b>Electrical and Controls</b>						
Power disconnects in place and labeled						
All electric connections complete						
Safeties in place and operable						
Low temperature (freeze stat) sensor properly installed and operable						
Smoke detector(s) in place						
All control devices and wiring complete and labeled						

### 3. Operational Checks

Equip Tag →						
Supply fan rotation correct						
Return/exhaust fan rotation correct						
Return /exhaust fan has no unusual noise or vibration						
Supply fan has no unusual noise or vibration						
Heat wheel has no unusual noise or vibration						
<b>Shut unit down by the BAS (go unoccupied)</b>						
Outside air dampers are closed						
Exhaust air dampers are closed						
Relief air dampers above and below energy wheel are closed						
All fans are stopped						
Energy wheel is stopped						
Return air dampers are full open						
Cooling valve is closed						
Heating valve is open						
<b>With BAS set to unoccupied mode, generate the call for heat (heating season)</b>						
Verify supply fan start						
Exhaust fan remains shut down						
Heat wheel remains shut down						
Outside air dampers remains closed						
Return dampers remain open						
Bypass dampers remain closed						
Heat and cooling valves operate						

## AIR HANDLING UNIT FUNCTIONAL TEST

Equip Tag →						
<b>With BAS set to unoccupied mode, generate the call for cooling (cooling season)</b>						
Verify supply fan start						
Exhaust fan remains shut down						
Heat wheel remains shut down						
Outside air dampers remains closed						
Return dampers remain open						
Bypass dampers remain closed						
Heat and cooling valves operate						
<b>While shut down operate the following devices</b>						
Outside air damper strokes fully without binding						
Minimum outside air damper strokes fully without binding						
Return air damper strokes fully without binding						
Heat wheel outside air bypass damper strokes fully without binding						
Heat wheel return air bypass damper strokes fully without binding						
Exhaust air damper strokes fully without binding						
Heating water valves stroke fully and easily						
Chilled water valves stroke fully and easily						
The supply fan HOA switch properly activates and deactivates the motor						
The return fan HOA switch properly activates and deactivates the motor						
The energy wheel HOA switch properly activates and deactivates the motor						
<b>Have BAS place unit in Morning Warm-up Mode</b>						
Verify supply fan is on						
Verify exhaust fan is off						
Heat wheel is off						
Outside air dampers are closed						
Return air dampers are open						
Heat wheel bypass dampers are closed						
Heating or cooling valve opens						
<b>Have BAS place unit in Economizer Mode</b>						
Verify supply fan is on						
Verify exhaust fan is on						
Heat wheel is (on/off) [verify with unit sequence of operation]						
Outside air dampers are open full						
Return air dampers are closed						
Heat wheel bypass air dampers are (open/closed) [verify with unit sequence]						
Heating valve closes and cooling valve closes						
<b>Have BAS place unit in Occupied Mode (cooling season) Lower discharge supply air temperature (via lowering set-point or raising space temperature average)</b>						
Verify supply fan is on						
Verify exhaust fan is on						
Heat wheel is on						
Outside air dampers are at minimum						
Return air dampers modulate						
Heat wheel bypass air dampers are closed.						
Cooling valve opens and heating valve closes unless in dehumidification mode						
<b>Have BAS place unit in Occupied Mode (heating season). Raise discharge supply air temperature (via raising set-point or lowering space temperature average)</b>						
Verify supply fan is on						



## AIR HANDLING UNIT FUNCTIONAL TEST

Equip Tag →						
Verify exhaust fan is on						
Heat wheel is on						
Outside air dampers are at minimum						
Return air dampers modulate						
Heat wheel bypass air dampers are closed						
Heating valve opens and cooling valve closes unless in dehumidification mode						
<b>Manually shut down supply fan at the VFD</b>						
Return/ relief fan shuts down						
Heat wheel shuts down						
<b>High Static - With units running, utilizing a Magnehelic, simulate an increase in discharge air static pressure.</b>						
Verify that BAS indicates an alarm condition at 4" WG.						
<b>Low Static - With units running, utilizing a Magnehelic, simulate a decrease in discharge air static pressure.</b>						
Verify that BAS indicates an alarm condition at 4" WG.						
<b>Filter Differential Pressure - Set pressure across the filter to simulate dirty filters.</b>						
Verify that BAS indicates an alarm condition.						
<b>Place the unit into "heat wheel defrost"</b>						
The outside air heat wheel bypass damper should go to open.						
The heat wheel should continue to run						
The return heat wheel bypass damper should close.						
<b>Trip the Freeze protection safety device.</b>						
The system alarms						
All fans stop						
The OA dampers close						
The relief dampers close						
The return air dampers open						
The heating valve opens						
The cooling valve closes						

Notes:

1	The exterior general appearance is good, clean, no damage, and un obstructed.
2	Vibration isolation is installed/released
3	There is adequate maintenance access
4	The interior equipment is clean.
5	The equipment tag is attached
6	Verify there is no unusual noise or vibration.
7	Is the sensor location O.K.?

[illegible]

1	Record Set-point prior to testing
2	Adjust set-point until it is 5°F above space temperature. Does fan start?
3	Does heat valve open?
4	Is warm air delivered?
5	Does speed switch function properly? (not for unit heaters)
6	Lower set-point to a satisfied condition. Does fan shut off?
7	Record final temperature setting.

CABINET HEATERS  
UNIT HEATERS  
RADIANT PANELS  
FUNCTIONAL TEST

[illegible]

CABINET HEATERS  
UNIT HEATERS  
RADIANT PANELS  
FUNCTIONAL TEST

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END OF SECTION 019113

SAMPLE