SECTION 20 08 16 – HVAC, Plumbing/Fire supression systems functional performance tests

1. GENERAL
	* + 1. RELATED DOCUMENTS
				1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
				2. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.
				3. Related sections include, but are not limited to, the following:

20 08 00 Fire Suppression, Plumbing, and HVAC Systems Commissioning

20 08 13 Fire Suppression, Plumbing, and HVAC Prefunctional Checklist and Testing

25 08 00 BJC BAS Commissioning

* + - 1. SUMMARY
				1. This Section expands on and defines responsibilities of the Contractor in regards to Functional Performance Tests (FPT’s) of the Commissioning process.
				2. Contractor shall oversee the Commissioning activities with the Contractor’s Subcontractors and the Architect/Engineer (AE).
				3. Prefunctional Checklists, tests and Start-ups are to be completed and documented for the record prior to commencing with FPT’s. Refer to Section 20 08 00 and 20 08 13 for additional requirements.
				4. Completed FPT Forms for all pieces of equipment and systems shall be submitted to the Owner prior to Substantial Completion.
				5. Refer to Attachments A and B at the end of this Section for example forms that indicate level of documentation required for the Commissioning process.
			2. REFERENCE STANDARDS
				1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
				2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
				3. All materials, installation and workmanship shall comply with all applicable requirements and standards.
			3. SUBMITTALS
				1. Maintain and use an action item tracking system, “Action Item List,” that indicates as a minimum, required information, identified deficiencies, work required, etc.. Each item shall be tracked with the initiator, the parties responsible, due date, the date of closure, and a description of the resolution. Each item shall be categorized for sorting and tracking and for documentation on applicable forms. Action Item List shall be distributed and documented using Microsoft Excel or a database format approved by Owner.
				2. Disseminate this list as appropriate to keep all parties involved with the FPT informed.
				3. Functional Performance Test procedure forms must include the following:

System and equipment or component name(s).

Equipment location and identification number

Asset number

Unique test identification number and reference to unique Prefunctional Checklist and Start-up Documentation Identification Numbers for the equipment.

Date and time of test.

Project name.

Participating parties.

Specific sequence of operation or other specified parameters, including performance data being verified.

Instructions for setting up a Functional Performance Test.

Specific script-type, step-by-step procedures to perform a Functional Performance Test, in a clear, sequential and repeatable format that is customized for the system being tested.

A Yes/No checkbox (or data entry box as appropriate) for clearly indicating whether or not proper performance of each part of a Functional Performance Test was achieved with space for actual readings.

Section for comments.

Signatures and date block for participants and Owner approvals.

* + - * 1. Refer to Division 01 and 20 08 00 Fire Suppression, Plumbing and HVAC Commissioning for additional documentation requirements.
1. PRODUCTS
	* + 1. GENERAL
				1. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
			2. TEST EQUIPMENT
				1. Refer to Section 20 08 00 – HVAC, Plumbing, and Fire Suppression System Commissioning.
2. EXECUTION
	* + 1. PREPARATION
				1. The objective of FPT’s is to demonstrate that each system operates according to the Contract Documents through all specified modes of operation.
				2. Contractor shall operate each system through all modes of operation (occupied, unoccupied, warm-up, cool-down, etc.) where there is a specified system response. Verification of each sequence in the sequences of operation is required.
				3. All equipment, components and devices applicable to the FPT must be started and this Start-up must be documented. This documentation includes completion of the Prefunctional Checklists, pressure testing of equipment, duct, pipe, etc., flushing/cleaning of applicable systems, completed labeling and identification, completed insulation of applicable systems, etc. Refer to Section 20 08 13 Fire Suppression, Plumbing and HVAC Systems Commissioning for additional Prefunctional Checklist and Start-up requirements.
				4. Unless specifically agreed to by the Commissioning Team, all support systems shall be complete prior to FPT.

The electrical system serving it is completed and tested.

The hydronic systems serving it have been balanced and FPT completed.

Balancing has been accomplished on the air and water sides.

The building automation system (BAS) has been started and calibrated.

* + - * 1. Commissioning Team members shall assist in development and review of the optimal sequence of testing.
			1. INSTALLATION
				1. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
				2. All installation shall be in accordance with manufacturer’s published recommendations.
			2. Functional Performance TesT PROCEDURES
				1. The purpose of a Functional Performance Test is to verify and document compliance with the stated criteria of acceptance. Contractor shall develop specific script-type test procedures and associated test forms to verify and document proper operation of each piece of equipment and system.
				2. Contractor shall operate, or cause to be operated, each system, device, or equipment item, both intermittently and continuously, for a duration period as indicated in the Specification Section(s) for such item and/or in accordance with the manufacturer's written recommendations, the Contract Documents, and the Commissioning Plan.
				3. Contractor shall operate each component device and each building system to the full extent of its capability, from minimum to maximum, and under automatic control and manual control.
				4. Contractor and manufacturer's representatives shall supervise and coordinate adjustments and balancing of all devices and systems for proper operation prior to requesting the Functional Performance Test(s).
				5. Where final balancing of a system is to be performed by Owner or Owner’s consultants, such as final air balancing, Contractor shall provide all services indicated in the applicable Technical Sections and under this Section, including the following prior to Owner’s final balancing:

Operational verification of all component devices and the total system, including automatic controls when applicable. Operational verification includes verification that all motors, fans, dampers, and other operable devices are performing in compliance with Specifications throughout their operable range and that all devices are controlled as described in the specified sequence of operation.

All tabulated data, motor amperage readings, valve tag verifications, and other data required by Technical Specifications.

* + - * 1. Where final balancing of a system or particular components of a system are not specifically indicated to be performed by Owner or Owner's consultants, Contractor shall provide final balancing and adjustments for operation within specified tolerances prior to Functional Performance Test of such system.
				2. Sampling: Some types of identical equipment (such as terminal devices) will be tested using a sampling strategy. The sample percentage is indicated below. **[Insert equipment list and sampling percentage.]**
				3. Failure Limit on Sample Tests: With the sampling percentages is listed a failure limit. This limit indicates the maximum percentage of the tested devices that may have any test that fails before an entirely new sample must be tested. When the maximum number of failures is reached, testing on that sample will be terminated and re-testing will be scheduled.

Where sample tests involve multiple systems (i.e.: Checking strainers on different hydronic systems) the maximum failure limit will apply per system.

* + - * 1. Deferred Tests: Contractor shall schedule with the Owner and complete Deferred Tests as part of this Contract during the Warranty Period. Testing procedures shall be repeated and/or conducted as necessary during appropriate seasons. Deferred or “Opposite season” tests will be required where scheduling prohibits thorough testing in all modes of operation. Air Handler and central heating system testing for heating related modes of operation and control loops shall be tested during outside air temperatures below 50 degrees F. Air handler and central cooling system testing for cooling related modes of operation and control loops shall be tested during outside air temperatures above 85 degrees F.
				2. Provide and deliver the required submitted documentation convenient to testing area. Validate that all required documentation has been submitted to the Owner and is per the Contract Document requirements.
				3. Review the Start-up documentation at the start of FPT’s. Ensure that any items indicated as outstanding in the Prefunctional Checklist is entered as an Action Item and enter one if it is not. The Prefunctional Checklists and Start-up tests/measurements shall be spot checked at the beginning of FPT’s to ensure accuracy. Complete a test that indicates Contractor has reviewed the Prefunctional Checklists and finds the Prefunctional Checklists acceptable and notes any outstanding items.
				4. Check for and as applicable direct the Subcontractor to demonstrate that access is sufficient to perform required maintenance.
				5. Validate that all prerequisite work is complete and confirm this validation via a test record for documentation.
				6. Specifically check labeling and ensure conformance to the Contract Documents.
				7. Analyze trends of the system operating parameters to evaluate normal system functionality. The trending requirements are specified in the BAS Commissioning Specification, however all systems must be trended and reviewed prior to and as part of functional performance trending. Subcontractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the Contractor. Analyzed trends shall be organized and/or grouped in a manner that clearly demonstrates the individual components of a piece of equipment is under total control and display this information together. The trend group data shall be labeled with the system name or the purpose of the trend group or data and submitted in a Microsoft Excel spreadsheet.
				8. Check proof indication, alarming on failure and restart/acknowledgement as applicable.
				9. Observe operating conditions encountered at the start of the FPT. Contractor shall examine for normal functionality and record parameters as a test.
				10. All dynamic systems powered by electricity shall be tested to simulate a power outage to ensure proper sequencing. Those on emergency power or uninterruptible power shall be tested on all sources. This test shall generally be coordinated with electrical power systems testing addressed in the Contract Documents.

Emergency power tests for mechanical systems will be conducted in concert with the testing of the emergency power systems. Testing Contractor shall be available for the power outage test to test their systems under a power outage. This is in addition to the requirement specified by system.

* + - * 1. Inspect the installation and compare it to the Contract Documents. Record the inspection as a test.
				2. Capacities and adjusted and balanced conditions as applicable will generally be checked.
				3. Verify all sequence modes and sequences of operation. Contractor must initiate all modes and may not refer to or rely on a Prefunctional Test done by the building automation system. Some examples of generic modes that apply to most systems include:

Off mode.

Failed mode: Proof, safeties, power outage etc. See below for crash testing.

Start sequence in various modes.

Stop sequences in various modes.

* + - * 1. All adjusted, balanced, controlled systems shall be assessed to determine the optimal setting for the system as applicable. The optimal settings should be determined to establish reliable, efficient, safe and stable operation. The Contractor is responsible for placing systems in optimal condition for occupancy and not simply relying on initial design estimated settings.
				2. Dynamic Graphics: The graphic for all components, systems, and areas sampled and required to be represented by a graphic shall be checked for adequacy and accuracy. Furthermore, when setpoints are required to be adjustable, verify that they can be adjusted directly from the graphic screen.
				3. All interfaces between two systems or equipment of different manufacturers must be checked for accuracy and functionality.
				4. Contractor shall to the extent possible, load the heating and cooling systems during initial FPT’s to check the capacity of the building central systems and initially optimize system settings. This will typically be done using the preheat system to false load the cooling system. This test will incorporate varying the load to check central systems response.
				5. “Crash Testing”: Contractor shall analyze systems to identify possible conditions where functionality may be compromised. Contractor shall design non-destructive tests that will demonstrate either the automated response to the conditions or so that team can identify the best method for responding or fixing the condition. All tests and their findings shall be documented in a Microsoft Excel spreadsheet.
			1. Participation
				1. Required participating parties are indicated with the individual tests. Typically, multiple parties are required for any given test, yet participation for any given party is only required for the respective portion of the test for which the party is responsible. In many cases, the maximum required time in hours is indicated in parenthesis for any given test. The time is typically per unit system unless indicated otherwise. If no time is indicated, participation is required throughout the entire test.
				2. Frequently, on multiple samples where a given party does not directly conduct the test, the participation of that party will only be required for an initial quantity of systems/equipment. It is required that the parties be available on-site throughout the testing of any given system for which they are required participants. Therefore time for which they are not directly involved can be spent performing other work (typically addressing identified punch list items or failed test).
				3. No party involved with the Project is prohibited from participation in or witnessing of any tests. Any Subcontractor may elect to witness all tests on their systems even if their involvement is not directly required.
				4. Coordinate effectively with the individual Subcontractors throughout the development and execution of FPT’s and maximize Subcontractors’ involvement.
			2. NON-CONFORMANCE
				1. Record results of Functional Performance Tests. Contractor shall report all deficiencies and non-conformance issues to Owner on the Functional Performance Test report form and in a Commissioning deficiency report.
				2. At the sole discretion of Owner, Owner may permit the Contractor to make corrections of minor deficiencies observed during a Functional Performance Test. However, the Contractor must document the deficiency and resolution on the appropriate report form.
				3. Contractor and Owner will attempt to resolve deficiencies in the following manner:

When there is no dispute about a deficiency and Contractor accepts responsibility for correction.

Contractor documents the deficiency and the corrective actions, and then proceeds to another test or sequence. Contractor submits a deficiency report to Owner. Contractor corrects the deficiency, completes the statement of correction form certifying that the equipment or system is ready for retesting, and sends the certification to Owner.

Contractor reschedules test with Owner.

When there is a dispute about whether or not the test indicates a Deficiency, or the Contractor’s responsibility for the correction of the apparent Deficiency.

Contractor documents the apparent Deficiency and proceeds to another test or sequence. Contractor submits a Deficiency report to Owner, including the apparent Deficiency.

Contractor facilitates resolution of Deficiency and provides recommendations to the Owner. Contractor and Owner may bring other parties into the discussions as needed. Final technical interpretive authority is with the Architect/Engineer. Final acceptance authority is with the Owner.

Contractor documents resolution process.

If Owner agrees with Contractor’s interpretation and proposed resolution, Contractor forwards response to Owner. Contractor reschedules test with Owner. Contractor must repeat this process until satisfactory performance and Owner’s approval is obtained.

* + - 1. Acceptance Criteria
				1. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

END OF SECTION 20 08 16

**EXAMPLE – FUNCTIONAL PERFORMANCE TEST**

**HVAC Pumps**

**Project**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **BJC Project** #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Identification of Equipment or System:[equipment tag per drawings and/or system being tested]***\_

**Asset Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Location of Equipment or System: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Specification Section: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Detail/Drawing Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Manufacturer / Supplier: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***This Date:*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ***Time of Test:*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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### Functional Performance Test Procedure Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Prefunctional Checklist Number: \_\_\_\_\_\_\_\_\_\_\_

Components Included:

\_\_\_ VFD for pump, \_\_\_ Heat Exchanger, \_\_\_ Other \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Other Related Functional Performance Tests: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. General:
	1. This Functional Performance Test is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Commissioning Deficiency Report upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
	2. \_\_\_ Commissioning Deficiency Report attached.
2. Participants:

| **Name**  | **Company**  | **Role/Participation** |
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1. Functional Performance Test Prerequisites:

|  |  |  |  |
| --- | --- | --- | --- |
| **Specified Requirement** | **Yes** | **No** | **Date to be Submitted** |
| a) | The Prefunctional Checklist for this system is complete and approved |  |  |  |
| b) | The Prefunctional Checklist for the pump variable frequency drive system is complete and approved |  |  |  |
| c) | The Prefunctional Checklfor the air handling unit related to this pump variable frequency drive system is complete and approved |  |  |  |
| d) | All Architect/Engineer punchlist items for this system and related equipment have been addressed and corrected |  |  |  |
| e) | Sequence of operation is attached |  |  |  |
| f) | Test, adjust, and balance (TAB) completed and approved for the associated systems |  |  |  |
| g) | TAB report provided |  |  |  |
| h) | Design setpoint information included on forms |  |  |  |
| Controls: |  |  |  |
| i) DDC loops operational, temperature/pressure setpoints met without hunting |  |  |  |
| ii) Master transmission diagram is updated on device graph |  |  |  |
| iii) Graphic programming is complete and operational |  |  |  |
| iv) System communicates with main controller |  |  |  |
| v) Pump is set to design/final setpoints |  |  |  |
| vi) Local reading of setpoints agree with remote readings |  |  |  |
| i) | These Functional Performance Test procedures have been reviewed and approved by installing contractor and applicable subcontractors |  |  |  |

1. Functional Performance Test Procedure:

| **Step** | **Mode** | **Test Procedure** | **Expected Response** | **Pass** |
| --- | --- | --- | --- | --- |
| **Yes** | **No** |
| 1 | Pump Off | Standby check. HOA in Auto position. Unit commanded Off by BAS. | Verify by visual inspection that:1. Discharge gauge pressure equals suction gauge pressure.
2. No rotation of pump shaft.
3. Pump light indication shows pump is off.

Pump indication shows pump as being Off at the BAS. |  |  |
| 2 | Pump Start-up | HOA in Auto position. Unit commanded On by BAS. | Verify by visual inspection that:1. Discharge gauge pressure greater than suction gauge pressure.
2. Rotation of pump shaft.
3. Pump light indication shows pump is On.

Pump indication shows pump as being On at the BAS. |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 3 | Pump Operation | HOA in Auto position.Test results are recorded in table. | Verify by local and remote reading that test results correspond with TAB report and sequence of operation as described in the Contract Documents.  |  |  |
| 4 | Simulate Pump Overload Trip | HOA in Auto position.Test results are recorded in table. | BAS indicates an alarm for Pump Trip condition. |  |  |
| 5 | Simulate Loss of Pump Flow | HOA in Auto position.Test results are recorded in table. Isolate DP switch across suction and discharge of pump and open sensing line vent valves to relieve pressure across DP switch. | BAS indicates an alarm condition for Loss of Pump condition. |  |  |
|  |  |  |  |  |  |

1. Comments:

|  |
| --- |
|  |

##### FINAL SIGN-OFF

**Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Commissioning Deficiency Report.**

|  |  |  |
| --- | --- | --- |
| General Contractor: | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |
|  |
| Mechanical Subcontractor | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |
|  |
| Other Subcontractor: | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |

**Functional Performance Test procedure received and reviewed for completeness by BJC HealthCare representatives. Integrated System Test can proceed.**

|  |  |  |
| --- | --- | --- |
| BJC: | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |
|  |
| BJC: | Print Name: |  |
| Signature: |  |
| Title:  |  |
| Date: |  |

**EXAMPLE – FUNCTIONAL PERFORMANCE TEST**

**Air Handling Units - Modular**

**Project**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **BJC Project** #:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Identification of Equipment or System:*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Location of Equipment or System: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Specification Section: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Detail/Drawing Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Manufacturer / Supplier: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***This Date:*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ***Time of Test:*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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### Functional Performance Test Procedure Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Prefunctional Checklist Number: \_\_\_\_\_\_\_\_\_\_\_

Components Included:

\_\_\_ VFD for AHU, \_\_\_ Return Fans (RF), \_\_\_ Outside Air Handling Unit, AHU \_\_\_\_\_\_\_,

Other \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Other Related Functional Performance Tests: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. General:
	1. This Functional Performance Test is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Commissioning Deficiency Report upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
	2. \_\_\_ Commissioning Deficiency Report attached.
2. Participants:

| **Name**  | **Company**  | **Role/Participation** |
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1. Functional Performance Test Prerequisites:

|  |  |  |  |
| --- | --- | --- | --- |
| **Specified Requirement** | **Yes** | **No** | **Date to be Submitted** |
| a) | The Prefunctional Checklist for this system is complete and approved |  |  |  |
| b) | The Prefunctional Checklist for the following systems and components are complete and approved: |  |  |  |
| i) Chilled water system |  |  |  |
| ii) Chilled water piping and valves |  |  |  |
| iii) Condenser water pumps |  |  |  |
| iv) Cooling towers |  |  |  |
| iii) Associated terminal units |  |  |  |
| iv) Variable frequency drives for associated pumps |  |  |  |
| c) | All control system functions for this and all interlocking systems are programmed and operable per the Contract Documents including final setpoints and schedules with debugging, loop tuning, and sensor calibrations completed. |  |  |  |
| d) | Piping system flushing complete and required test reports approved |  |  |  |
| e) | Water treatment system complete and operational |  |  |  |
| f) | Vibration control report approved |  |  |  |
| g) | Test, adjust, and balance (TAB) completed and approved for the hydronic systems and associated terminal units. |  |  |  |
| h) | TAB report provided |  |  |  |
| i) | All Architect/Engineer punchlist items for this system and related equipment have been addressed and corrected |  |  |  |
| j) | Safeties and operating ranges reviewed |  |  |  |
| k) | Sequences of operation is attached |  |  |  |
| l) | Schedules and setpoints attached |  |  |  |
| m) | False loading equipment, system, and procedures ready (boilers, preheat or reheat coils, control loops, override on outside air (OSA) dampers, etc.) |  |  |  |
| n) | Have all energy savings control strategies, setpoints, and schedules been incorporated that this equipment and control system are capable of? If not, list recommendations below: |  |  |  |
| o) | Control Program Review: Review the software control program(s) for this equipment. Parameters, setpoints, and logic sequences appear to follow the specified written sequences. |  |  |  |
| p) | These Functional Performance Test procedures have been reviewed and approved by installing contractor and applicable subcontractors |  |  |  |

1. Current Setpoints for Functional Performance Test Procedure:
	1. Record all values for current setpoints (SP), control parameters, limits, delays, lockouts, schedules, etc., changed to accommodate testing.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Pre-Test Values** | **Returned to Pre-Test Values √** |  | **Parameter** | **Pre-Test Values** | **Returned to Pre-Test Values √** |
| Discharge air static pressure (SP) |  |  |  | Building static pressure |  |  |
| Discharge air temp. |  |  |  | Dirty filter D.P. |  |  |
| Static P. reset schedule |  |  |  | OSA CFM |  |  |
| Discharge air reset schedule |  |  |  |  |  |  |

1. Sensor Calibration Checks:
	1. Check the sensors listed below for calibration and adequate location. This is a sampling check of calibrations done during Prefunctional Checklist.
	2. “In calibration” means making a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage, or building automation system (BAS)) compared to the test instrument-measured value is within the tolerances specified in the Prefunctional Checklist requirements (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_). If not, install offset in BAS, calibrate or replace sensor. Use the same test instruments as used for the original calibration, if possible.

| Sensor & Location | Loc-ationOK1 | 1stGage or BAS Value | Instr. Meas’d Value | FinalGage or BAS Value | PassY/N? |  | Sensor & Location | Loc-ationOK1 | 1stGage or BAS Value | Instr. Measd Value | FinalGage or BAS Value | PassY/N? |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DAT |  |  |  |  |  |  | Dis-charge SP |  |  |  |  |  |
| RAT |  |  |  |  |  |  |  |  |  |  |  |  |
| OSAT |  |  |  |  |  |  |  |  |  |  |  |  |

1Sensor location is appropriate and away from causes of erratic operation.

1. Device Calibration Checks:
	1. The actuators or devices listed below checked for calibration. This is a spot check on a sample of calibrations done during Prefunctional Checklist and start-up.
	2. “In calibration” means observing a readout in the BAS and going to the actuator or controlled device and verifying that the BAS reading is correct. Fix items out of calibration or adjustment, via an offset in the BAS, or a mechanical fix.

| **Device or Actuator & Location** | Procedure / State | 1st BAS Value | SiteObservation | Final BAS Reading | PassY/N |
| --- | --- | --- | --- | --- | --- |
| Cooling coil valve (CCV) | 1. Intermediate positions |  |  |  |  |
| position or command and | 2. Full open |  |  |  |  |
| stroke\* | 3. Increase pressure (open)  |  |  |  |  |
|  | 4. Closed |  |  |  |  |
|  | 5. Remove power or air (closed) |  |  |  |  |
| Relief damper position \*\* | 1. Closed |  |  |  |  |
|  | 2. Full open |  |  |  |  |
| Mixed air damper position \*\* | 1. Closed |  |  |  |  |
|  | 2. Full open |  |  |  |  |
| Main OSA damper position\*\* | 1. Closed |  |  |  |  |
|  | 2. Full open |  |  |  |  |
| Min. OSA damper position\*\* | 1. Closed |  |  |  |  |
|  | 2. Full open |  |  |  |  |
| Variable frequency drive speed  | 1. Min.: \_\_\_\_\_\_\_\_\_\_% |  |  |  |  |
| (VFD)\*\*\* | 2. Max.: \_\_\_\_\_\_\_\_\_\_% |  |  |  |  |

\* Set pumps to normal mode. Procedure 1. Command valve to a few intermediate positions. Verify that readings in BAS reasonably correspond to the actual positions. For cooling coil valves (NO): Procedure 2. Lower space setpoint to 20 deg. F. below space temperature. Verify BAS reading says CCV is 100% open. Visually verify valve is 100% open. Procedure 3. For pneumatic actuators, by override in the BAS, increase pressure to valve by \_\_\_\_ psi (do not exceed actuator rating). Verify valve stem and actuator position does not change. Restore to normal. Procedure 4. Set space setpoint to 20F above space temperature. Verify BAS reading says CCV is closed. Visually verify valve is closed. Procedure 5. Remove control air or electricity from the valve and verify that the valve stem and actuator position do not change.

\*\* 1. Command damper closed and verify that damper is shut and BAS reads shut.

1. Do the same, commanding damper fully open.

\*\*\* VFD: Procedure 1. Lower the controlling static pressure setpoint (duct or discharge) to be 1/4 of its current value. Verify that the vanes are shut, or fan speed is at minimum for VFD and packaged controller reads the same. Return the static pressure setpoint to normal. Procedure 2. Lower the space temperature setpoint to be 20F below space temperature and cause TU dampers to go to full cooling. Raise the static pressure setpoint as necessary to cause the setpoint to not be met. Verify that the inlet vanes are fully open or the fan speed is at its maximum and verify that the packaged controller reads the same. Return all to normal.

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| --- |
| **Notes:** |

1. Functional Performance Test Procedure:

| **Step1** | **Mode2** | **Test Procedure3** | **Expected Response4** | **Pass** |
| --- | --- | --- | --- | --- |
| **Yes** | **No** |
| 1 | Fan Off | Standby check with units commanded Off by BAS. | Verify by visual inspection that:1. Return Air Dampers to AHU- are Open.
2. Outside Air Dampers in AHU- are Closed.
3. Isolation Dampers on AHU- are Closed.
4. Relief Dampers in RF- are Closed.
5. Cooling Coil Valve on Cooling Coil of AHU- is Closed.
 |  |  |
| 2 | Unit Start-up | With units commanded on by BAS. | 1. Supply Fan Isolation Dampers Open in AHU-
2. Supply Fan start through VFDs
3. Supply Fan Isolation Dampers in AHU- Open
4. AHU- Fans Start
5. RF- Isolation Dampers Open
6. RF- Fans start through VFDs
7. Exhaust Fans EF- start.
 |  |  |
| 3 | RF Volume Control | 1. Verify RF Volume, utilizing airflow meters in Return Fans RF\_\_\_\_, Supply Fans in AHU-\_\_\_\_ and Garage Exhaust Fan EF-1, and TAB established CFMs for Exhaust Fans EF- \_\_, and \_\_\_, TAB established Fixed Differential, make the following calculation: (Return Air Flow=Supply Air Flow, - EF-1and2 Flow, -SF1 Flow-Fixed Differential}2. Trend Log RF\_\_\_\_, AHU \_\_\_\_, and SF-1 airflow rates at 5 min. intervals. Command off EF-1 and 2 sequentially at 5 min. Intervals. | Verify that RF airflow meter readings correspond to calculation.Verify that RF airflow meter readings continue to correspond to calculation |  |  |
| 4 | Duct Static Pressure Control | Disable Duct Static Pressure Reset utilizing BAS Software. Adjust space temperature setpoint on significant quantity of zones to be well below observed reading. | Verify that VFD’s modulate as required to maintain SP setpoint without hunting or overshooting setpoint. |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 5 | High Static Pressure Alarm and Shutdown | With units running at low flow condition, utilizing a squeeze bulb, simulate an increase in discharge air static pressure. | Verify that BAS indicates an alarm condition at \_\_\_” WG and shuts fans down at \_\_\_”WG |  |  |
| 6 | Static Pressure Reset | 1. For Perimeter Terminal Units on floors 9-16, Reset space temperature setpoints to be below space temperatures. Utilizing BAS trend logging capabilities, Record at 5 min. intervals, Discharge Air SP Spt, Perimeter TU Units in saturation.2. Reset space temperature setpoints to be above space temperatures. Utilizing the same Trending as above, Record the same data points. | Verify that DA SP Spts increase by \_\_\_” WG at \_\_ min intervals until only one Perimeter TU remains in saturation. Verify that setpoints are met and maintained without excessive hunting.Verify that DA SP Spt decreases by \_\_\_”WG at \_\_ min intervals until one Perimeter TU reaches saturation. |  |  |
| 7 | Discharge Temp. Reset | 1. For Perimeter Terminal Units Floors 1-2, Reset space sensor setpoints to be above space temperatures. Utilizing BAS Trend Logging, at 6 min intervals, record DAT setpoint, DAT, and perimeter TU cooling Flow rates. 2. For Perimeter Terminal Units Floors 1-2, Reset space sensor setpoints to be below space temperatures. Utilizing BAS Trend Logging, at 6 min intervals, record DAT setpoint, DAT, and perimeter TU cooling Flow rates.  | Verify that Discharge Air Temperature Setpoint is reset upwards at 2 deg increments every 6 min to maintain design cooling CFM at 5 perimeter TU’s to maintain design cooling CFM Verify that Discharge Air Temperature Setpoint is reset downwards at 2 deg increments every 6 min to reach design cooling CFM at only 5 perimeter TU’s. Both should happen without excessive hunting. |  |  |
| 8 | Smoke Conditions | Interfacing with EC, simulate a fire mode with the Fire Alarm System. | Verify that AHU System returns to FAN OFF Status, with OSA and Relief Dampers in a Closed Position. |  |  |
| 9 | Warm-up Control | Place Unit’s BAS Control Mode into Warmup. Overwrite RAT Sensor Reading to be 65 Deg. F. | Verify that dampers assume a 100% Return Air Mode. |  |  |
| 10 | Warm-up Control | Place Unit’s BAS Control Mode in Warmup. Overwrite RAT Sensor Reading to be \_\_\_ Deg. F. | Verify that unit returns to Normal Operation Mode. |  |  |
| 11 | Freeze Condition | Overwrite Low Limit Detection Thermostat reading to be \_\_ Deg. F. | Verify that system alarms, fans stop, OSA Dampers close, Relief Dampers Close, and RA dampers open. |  |  |
| 12 | Return Fan Static Pressure | With AHU Unit \_\_ running at low air flow condition, Overwrite RF \_\_ return air fan inlet SP to a reading below -\_\_\_” W.G. | Verify that system alarms and that all Fans are shut down. |  |  |
| 13 | Manual Smoke Pressuriz. System | With Fire Alarm System in alarm, utilizing control panel in Fireman Control Center, select a floor and place floor into purge mode. | Verify that Single Fan operates, Isolation dampers open only on selected Fans, Return Fans are off, Outside Air Handling Units are off, OSA dampers open, and return air dampers close. |  |  |
| 14 | Minimum OSA Unit Fan Off | Command AHU-1&2 System off. | Verify that AHU \_\_\_ isolation dampers are closed, and if OSA temperature is above \_\_ Deg. F, heating coil control valve is closed. |  |  |
| 15 | Minimum OSA Unit Fan Off | Simulate a OSA temperature below 35 Deg. F. | Verify that heating coil control valve opens. |  |  |
| 16 | Minimum OSA Unit Temp. Control | Utilizing BAS software, reset discharge air setpoint to 80 Deg. F. | Verify that Face and Bypass Dampers and Heating Coil Control Valves modulate in sequence to maintain \_\_ Deg. F. Setpoint. |  |  |
| 17 | Minimum OSA Unit Freeze Condition | Simulate a condition at low limit detection thermostat of below 40 Deg. F. | Verify that BAS system goes into alarm, AHU- \_\_ Fans Shut Down, AHU-\_\_\_ Isolation Dampers Close, and Heating Valve Opens. |  |  |
| 18 | On-Floor Return Fan Operation | Place AHU-\_\_\_\_ in normal operating mode. | Verify that RAF \_\_-\_\_ Start and Run. |  |  |
| 19 | Building Static Pressure | Trend log the supply fan speed, the relief fan speed, relief damper position and the building static pressure for 12 hrs at 20 min. intervals. During the trend, force, if necessary, the economizer damper to be full open and at minimum. Document these times. | Observe in the trends that the building static pressure is maintained within +/- 0.05” of setpoint without excessive hunting. Carefully examine during the extreme economizer damper positions. Observe that any relief dampers modulate as expected relative to relief fan operation and static pressure. |  |  |
| 20 | AHU Filter Drop | Reset the Filter Differential Pressure to exceed the setting recommended by the filter manufacturer. | Verify that the BAS reports an alarm. |  |  |
| 21 | Chilled Water Valve Closing Efficiency | 1. Utilizing BAS, place AHU Units in WARMUP Mode.
2. Manually close isolation Valve in Chilled Water Supply to AHU Coil.
3. Place thermometer in Chilled Water Return Piping adjacent to AHU. Record temp. at 1 min. intervals for 15 min.
4. Manually open isolation Valve in Chilled Water Supply to AHU Coil.
5. Repeat Step 3.

6. Graph Results on Temperature-Time Basis. | Chilled Water Return Temperature should approach RAT. If significant divergence is noted, review specified performance requirements of Chilled Water Control Valves. |  |  |
| 22 | Supply Fan Isolation Damper | Utilizing BAS, Command AHU-1, SF-1 into the off position. | Verify that AHU-1, SF-1 Isolation Dampers Close. |  |  |
| 23 | Review | Review schedules, current setpoints and sequences with Specification Section 15\_\_\_ and Control Drawings prepared by BAS Provider. | Submit approved differences to be incorporated into as-built record documentation. |  |  |
|  |  |  |  |  |  |

**Record Footnotes:**

1Sequences of operation specified in Contract Documents (attached).

2Mode or function ID being tested from testing requirements of the Contract Documents.

3Step-by-step procedures for manual testing, trend logging, or data-logger monitoring.

4Include tolerances for a passing condition.

5Record any permanently changed parameter values and submit to Owner.

1. Comments:

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##### FINAL SIGN-OFF

**Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Commissioning Deficiency Report.**

|  |  |  |
| --- | --- | --- |
| General Contractor: | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |
|  |
| Mechanical Subcontractor | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |
|  |
| Other Subcontractor: | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |

**Functional Performance Test procedure received and reviewed for completeness by BJC HealthCare representatives. Integrated System Test can proceed.**

|  |  |  |
| --- | --- | --- |
| BJC: | Print Name: |  |
| Signature: |  |
| Title: |  |
| Date: |  |
|  |
| BJC: | Print Name: |  |
| Signature: |  |
| Title:  |  |
| Date: |  |