

Preparing Activity: NAVFAC

Superseding
UFGS-23 08 00.00 20 (February 2021)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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05/23

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USACE / NAVFAC / AFCEC UFGS-23 08 00 (May 2023)

Preparing Activity: NAVFAC

Superseding
UFGS-23 08 00.00 20 (February 2021)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

SECTION 23 08 00

COMMISSIONING OF MECHANICAL[AND PLUMBING] SYSTEMS
05/23

NOTE: This specification covers commissioning requirements for HVAC[and plumbing] systems.

Adhere to [UFC 1-300-02](#) Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a [Criteria Change Request \(CCR\)](#).

PART 1 GENERAL

NOTE: This section contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, GOVT HIRED COMMISSIONING PROVIDER, INTEGRATED SYSTEMS TESTS, DESIGN-BUILD, DESIGN-BID-BUILD, ARMY, and NAVY.

Select KTR HIRED COMMISSIONING PROVIDER tailoring for projects that require the Commissioning Provider to be provided by the Construction Contractor.

Select GOVT HIRED COMMISSIONING PROVIDER tailoring for projects where the Commissioning Provider is retained under a separate contract with the Government.

Select ARMY tailoring for projects that will be managed by the U.S. Army Corps of Engineers (USACE). Army managed projects will always have a

KTR HIRED COMMISSIONING PROVIDER in accordance with Engineering Regulations. Do NOT select GOVT HIRED COMMISSIONING PROVIDER tailoring for Army managed projects. Refer to Notes in Section 01 91 00.15 BUILDING COMMISSIONING and Engineering Regulations for further information.

Army Engineering Regulation (ER) 1110-345-723 describes Army project commissioning leadership structure. In all cases, the construction contractor will be required to provide a Contractor's Commissioning Specialist (CxC), herein referred to as the Lead Commissioning Specialist, to perform the duties listed. The Army will utilize a Government Commissioning Specialist (CxG) as described in the ER. Regardless of whether the CxG is provided by Army personnel or third party contract, all communication and coordination with the CxG will be managed through the Contracting Officer via processes established in other specification sections such as Quality Control, and Submittal Procedures.

Select NAVY tailoring for projects that will be managed by the Naval Facilities Engineering Systems Command (NAVFAC).

Select DESIGN-BUILD tailoring for Design-Build project execution.

Select DESIGN-BID-BUILD tailoring for Design-Bid-Build project execution.

Select INTEGRATED SYSTEMS TESTING tailoring for buildings with central control systems and interactive operation among different systems. (Examples include mission critical facilities such as hospitals, laboratories, mission operations, or other essential (RCIV) and strategic asset (RCV) facilities.)

Building Commissioning is a systematic, quality-focused process for enhancing the delivery of a project that focuses on verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the project requirements. The purpose is to reduce the cost and performance risks associated with delivering facilities projects, and to increase value to owners, occupants, and users. Comply with specification Section 01 91 00.15 BUILDING COMMISSIONING.

1.1 SEQUENCING AND SCHEDULING

NOTE: The following paragraph contains tailoring for ARMY and NAVY. Tailoring and deletions to this list will require renumbering the list items.

Complete functional performance testing prior to performance verification testing required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Complete the following prior to starting Functional Performance Tests of mechanical systems:

- a. All equipment and systems completed, cleaned, flushed, disinfected, calibrated, tested, and operate in accordance with contract documents and construction plans and specifications
- b. Final DALT Report submitted and approved in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC
- c. Pre-final Testing, Adjusting, and Balancing Report submitted in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

NOTE: This item contains tailoring for ARMY.

- d. Performance Verification Tests of the controls systems have been completed and the Performance Verification Test Report has been submitted and approved in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.
- e. The Certificate of Readiness submitted and approved in accordance with Section 01 91 00.15 BUILDING COMMISSIONING
- [f. Air Leakage Test Reports and Diagnostic Test Reports submitted and approved in accordance with Section 01 91 19 BUILDING ENCLOSURE COMMISSIONING
-]g. Tests, Flushing, and Disinfection in accordance with Section [22 00 00 PLUMBING, GENERAL PURPOSE][22 00 70 PLUMBING FOR HEALTHCARE FACILITIES]
-]h. Inspection and Testing in accordance with Section 22 33 30.00 10 SOLAR WATER HEATING EQUIPMENT

]1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for

Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy and Air Force projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Test Equipment; G[, [_____]]

SD-06 Test Reports

Pipe Flushing, Testing, And Water Treatment Reports; G[, [_____]]

Completed Pre-Functional Checklists; G[, [_____]]

[Seasonal Test Report; G[, [_____]]

][Full-Load Test Report; G[, [_____]]

][Post-Construction Trend Log Report; G[, [_____]]

] SD-07 Certificates

Certificate Of Readiness; G[, [_____]]

1.3 ACCESSIBILITY REQUIREMENTS

Equipment, systems, and devices for commissioned systems must be accessible. Make necessary modifications if systems and devices are not accessible for inspections and testing.

Assist commissioning team in testing by removing equipment covers, opening access panels, and other required activities that assist with visual oversight. Furnish ladders, flashlights, meters, gauges, or other inspection equipment as necessary.

1.4 COORDINATION

**NOTE: This paragraph contains tailoring options for
ARMY and NAVY.**

Refer to Section 01 91 00.15 BUILDING COMMISSIONING for requirements pertaining to coordination during the commissioning process. Coordinate with the Commissioning Provider Lead Commissioning Specialist in accordance with Section 01 91 00.15 and in accordance with the Commissioning Plan to schedule inspections as required to support the commissioning process. Furnish additional information requested by the Commissioning Provider Lead Commissioning Specialist. Coordinate scheduling of Functional Performance Testing with the commissioning team. Provide plans, reports, notes, and other documentation to the Commissioning Provider Lead Commissioning Specialist as specified in the commissioning plan, as it is completed.

1.5 PIPE FLUSHING, TESTING, AND WATER TREATMENT REPORTS

Test requirements are specified in Division [22 and]23 piping Sections. Prepare a pipe system cleaning, flushing, and hydrostatic testing log. Provide cleaning, flushing, testing, and water treatment log and final reports.

Include the following in the pipe system cleaning, flushing, and hydrostatic testing log:

- a. Minimum flushing water velocity.
- b. Water treatment reports.
- c. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

1.6 CERTIFICATE OF READINESS

**NOTE: This paragraph contains tailoring options for
ARMY and NAVY.**

**NOTE: Include the bracketed option Air Leakage Test
Reports and Diagnostic Test Reports for Army
projects that include this report in Section 01 91 19
BUILDING ENCLOSURE COMMISSIONING.**

Submit Certificate of Readiness documentation in accordance with Section 01 91 00.15 BUILDING COMMISSIONING for all equipment and systems including start-up reports; completed Pre-Functional Checklists; Testing, Adjusting, and Balancing (TAB) Report; Issues Log; HVAC Controls Start-Up Reports; Performance Verification Test Reports; [and the building envelope Air Leakage Test Reports and Diagnostic Test Reports]. Do not schedule Functional Performance Tests for the system until the Certificate of Readiness for that system receives approval by the Government. The CxC, CQC System Manager, QC Manager, and the Mechanical, Electrical, Controls, and TAB subcontractor representatives must sign and date the Certificate of Readiness.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

Provide all testing equipment required to perform testing for the systems to be commissioned, except for equipment specific to and used by TAB as required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Provide a sufficient quantity of two-way radios for each subcontractor. Submit list of Test Equipment and instrumentation to be used for testing including equipment/instrument identification number, equipment application or planned use, manufacturer, make, model, and serial number, and calibration history with certificates. Also list special equipment and proprietary tools specific to a piece of equipment required for testing.

2.1.1 Proprietary Equipment

Provide manufacturer's proprietary test equipment and software required by any equipment manufacturer for programming and start-up, whether specified or not. Provide manufacturer test equipment, demonstrate its use, and assist in the commissioning process as needed. Provide data logging equipment and software required to test equipment.

2.1.2 Calibration and Accuracy

Comply with equipment manufacturer's test equipment calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to Contracting Officer upon request.

Provide all testing equipment of sufficient quality and accuracy to test and measure system performance with the tolerances specified. Unless otherwise noted, the following minimum requirements apply: Provide temperature sensors and digital thermometers with a certified calibration within the past year to an accuracy of 0.3 degrees C 0.5 degrees F and a resolution of plus or minus 0.1 degrees C 0.1 degrees F. Provide pressure sensors with an accuracy of plus or minus 2.0 percent of the value range being measured (not full range of meter) and calibrated within the last year.

PART 3 EXECUTION

3.1 MEETINGS

**NOTE: This paragraph contains tailoring options for
ARMY and NAVY.**

Attend all meetings in accordance with Section 01 91 00.15 BUILDING COMMISSIONING.

Provide timely updates on construction schedule changes to allow the Commissioning Provider Lead Commissioning Specialist to execute commissioning process efficiently. Notify Contracting Officer of anticipated construction delays to commissioning activities not yet performed or not yet scheduled.

3.2 COMMISSIONING CONSTRUCTION OBSERVATION CHECKLISTS

NOTE: This paragraph contains tailoring options for INTEGRATED SYSTEMS TESTS and ARMY.

Commissioning construction observation checklists include Pre-Functional Checklists, *Integrated Systems Test Checklists*, and Functional Performance Test Checklists. Provide commissioning construction observation checklists for the Interim and Final Construction Phase Commissioning Plan in accordance with Section 01 91 00.15 BUILDING COMMISSIONING.

Download example Pre-Functional Checklists, *Integrated Systems Test Checklists*, and Functional Performance Test Checklists for Section 01 91 00.15 BUILDING COMMISSIONING at the following location: <http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables>. The checklists submitted in the Interim and Final Construction Phase Commissioning Plans must contain the same level of detail shown in the examples. The submitted checklists are not required to match the format of the examples.

3.2.1 Pre-Functional Checklists

NOTE: This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

The Pre-Functional Checklists must include items for physical inspection or testing that demonstrate that installation and start-up of equipment and systems is complete. Refer to paragraph PRE-FUNCTIONAL CHECKS. Pre-functional checklists must be tailored to verify the specific installation requirements and details of the construction documents and manufacturer's instructions.

Use the Pre-Functional Checklists prepared by the CxC for physical inspection or testing to demonstrate that installation and start-up of equipment and systems is complete. Refer to paragraph PRE-FUNCTIONAL CHECKS.

3.2.2 Functional Performance Test Checklists

NOTE: This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, GOVT HIRED COMMISSIONING PROVIDER, and INTEGRATED SYSTEMS TEST.

This paragraph contains tailoring for ARMY. Choose bracketed "and the Owner's Project Requirements" for projects that require one. Refer to specifier notes regarding the Owner's Project Requirements Document in Section 01 91 00.15 BUILDING COMMISSIONING.

Functional Performance Test Checklists must include procedures that explain, step-by-step, the actions and expected results that will demonstrate that the system performs in accordance with the contract[and

Owner's Project Requirements Document]. Refer to paragraph FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING. Include the following sections and details appropriate to the systems being tested in the Functional Performance Test Checklists:

- a. Notable system features including information about controls to facilitate understanding of system operation and maintenance
- b. Conclusions and recommendations. Conclusions must clearly indicate if system does or does not perform in accordance with contract requirements and specifications[and Owner's Project Requirements Document]. Recommendation must clearly indicate that the system should or should not be approved by the Government.
- c. Test conditions including date, beginning and ending time, and beginning and ending outdoor air conditions
- d. Attendees
- e. Identification of the equipment involved in the test
- f. **System feature identification**
- g. Point-to-point observations including demonstrating system flow meters and sensors have been calibrated and are correctly displayed on the Operator work station
- h. Actuator operation observations demonstrating actuator responses to commands from the control system
- i. As-found condition of the system operation
- j. List of test items with step numbers along with the corresponding feature or control operation, intended test procedure, expected system response, and pass/fail indication.
- k. Space for comments for each test item.

Use the Functional Performance Test Checklists prepared by the CxC that list, step-by-step, the actions and expected results that will demonstrate that the system performs in accordance with the contract. Refer to paragraph FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING.

3.2.3 Integrated Systems Test Checklists

This paragraph is tailored for INTEGRATED SYSTEMS TEST and contains tailoring options for KTR HIRED COMMISSIONING PROVIDER and GOVT HIRED COMMISSIONING PROVIDER.

Choose bracketed "and the Owner's Project Requirements" for projects that require one. Refer to specifier notes regarding the Owner's Project Requirements Document in Section 01 91 00.15 BUILDING COMMISSIONING.

Integrated Systems Test Checklists must include test procedures that

explain, step-by-step, the actions and expected results that will demonstrate that the interactive operations between systems performs in accordance with the contract[and Owner's Project Requirements Document]. Refer to paragraph FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING. Include the following sections in the Integrated Systems Test Checklists:

- a. Notable features of the interconnected systems organized by discipline including information to facilitate understanding of system operation
- b. Conclusions and recommendations. Conclusions must clearly indicate if the systems do or do not perform in accordance with contract requirements and specifications[and the Owner's Project Requirements Document]. Recommendation must clearly indicate that the systems should or should not be approved by the Government
- c. Test conditions including date and beginning and ending time
- d. Identification of the equipment and systems involved in the test
- e. List of test items with step numbers along with the corresponding feature or control operation, intended test procedure, expected system response, and pass/fail indication.
- f. Space for comments for each test item.

Use the Integrated Systems Test Checklists prepared by the CxC that list, step-by-step, the actions and expected results that will demonstrate that the interactive operations between systems performs in accordance with the contract. Refer to paragraph FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING.

3.3 PRE-FUNCTIONAL CHECKS

This paragraph contains tailoring for ARMY and NAVY. Choose bracketed "and the Owner's Project Requirements" for projects that require one. Refer to specifier notes regarding the Owner's Project Requirements Document in Section 01 91 00.15 BUILDING COMMISSIONING.

Pre-Functional Checks are a type of Commissioning Inspection in accordance with Section 01 91 00.15 BUILDING COMMISSIONING. Complete one Pre-Functional Checklist for each individual item of equipment or system for each system required to be commissioned including, but not limited to, ductwork, piping, equipment, fixtures, and controls. Include manufacturer start-up checklists associated with equipment with the submission of the Pre-Functional Checklists. Provide manufacturer's installation manual for each type of unit. Indicate commissioning team member inspection and validation of each Pre-Functional Checklist item by initials. Validation of each Pre-Functional Checklist item by each team member indicates that item conforms to the contract documents and validated design in their area of responsibility. Validation of each item by each team member must occur immediately following completion of their respective duties related to the item. Commissioning Specialist validation of each Pre-Functional Checklist item indicates that each item has been installed correctly and in accordance with contract documents[and the Owner's Project Requirements Document]. Required commissioning team members for

Pre-Functional Checks includes the CxC, Mechanical Commissioning Specialist, [Quality Control Manager](#), [CQC System Manager](#), sub-contractor representative for each trade responsible for construction/installation of the checklist item, and the TAB representative (for items impacting TAB). Submit the initialed and [Completed Pre-Functional Checklists](#) no later than 7 calendar days after completion of inspection of all checklists items for each system.

3.4 STARTUP AND INITIAL CHECKOUT

Document start-up and initial testing procedures, and include in the Completed Pre-Functional Checklists submittal, including:

- a. Startup tests and factory testing reports.
- b. Manufacturer's representative start-up, operating, troubleshooting and maintenance procedures.
- [c. Additional documentation necessary for third party certification programs.
-] d. Perform and clearly document system operational checks and quality control checks as they are completed, and providing a copy to the commissioning team.
- e. Correct deficiencies and sign the Certificate of Readiness for each system before functional performance testing

3.5 DUCT AIR LEAKAGE TEST (DALT) REPORT REVIEW AND VERIFICATION

[3.5.1 Duct Air Leakage Test (DALT) Report Review

NOTE: Coordinate with project team to determine if CxC review of DALT report is necessary. For Navy projects, in-house personnel are responsible for technical oversight and final acceptance of DALT work. CxC may be leveraged to support DALT report review as necessary. This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

The Mechanical System Technical Commissioning Specialist must review the pre-final DALT Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for reviewing the pre-final DALT Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

]3.5.2 Duct Air Leakage Test (DALT) Report Verification

NOTE: Coordinate with project team to determine if

CxC witnessing DALT verification is necessary. For Navy projects, in-house personnel are responsible for technical oversight and final acceptance of DALT work. CxC may be leveraged to support DALT verification as necessary. This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

The Mechanical System Technical Commissioning Specialist must witness the DALT Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for witnessing the DALT Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

][3.6 TESTING, ADJUSTING, AND BALANCING REPORT REVIEW AND VERIFICATION

[3.6.1 Testing, Adjusting, and Balancing (TAB) Report Review

NOTE: Coordinate with project team to determine if CxC review of TAB report is necessary. For Navy projects, in-house personnel are responsible for technical oversight and final acceptance of TAB work. CxC may be leveraged to support TAB report review as necessary. This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

The Mechanical System Technical Commissioning Specialist must review the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for reviewing the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.

][3.6.2 Testing, Adjusting, and Balancing (TAB) Report Verification

NOTE: Coordinate with project team to determine if CxC witnessing TAB verification is necessary. For Navy projects, in-house personnel are responsible for technical oversight and final acceptance of TAB work. CxC may be leveraged to support TAB verification as necessary. This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

PROVIDER.

The Mechanical System Technical Commissioning Specialist must witness the TAB Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for witnessing the TAB Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.

]]3.7 HVAC CONTROLS START-UP AND PERFORMANCE VERIFICATION TEST REVIEW

NOTE: Coordinate with project team to determine if CxC controls submittal review is necessary. For Navy projects, in-house personnel are responsible for technical oversight and final acceptance of HVAC controls work. CxC may be leveraged to support controls submittal review as necessary. This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

The Mechanical System Technical Commissioning Specialist must review the Start-Up Testing Report, PVT Procedures and PVT Reports, including endurance testing trend submittals, required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC[and Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION]. The Mechanical System Technical Commissioning Specialist must review each submittal and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for reviewing the Start-Up Testing Report, PVT Procedures and PVT Reports including endurance testing trend data required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC[and Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION] and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to final acceptance.

]3.8 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

This paragraph contains tailoring for ARMY and INTEGRATED SYSTEMS TEST. Choose bracketed "and the Owner's Project Requirements" for projects that require one. Refer to specifier notes regarding the Owner's Project Requirements Document in Section 01 91 00.15 BUILDING COMMISSIONING.

Functional Performance and Integrated Systems Testing are a type of Commissioning Testing in accordance with Section 01 91 00.15 BUILDING COMMISSIONING. Conduct Functional Performance Testing in accordance with

Section 01 91 00.15 BUILDING COMMISSIONING and requirements in this Section. Prior to Functional Performance Testing, complete all prerequisites in accordance with paragraph SEQUENCING AND SCHEDULING. Demonstrate that all system components have been installed, that each control device and item of equipment operates, and that the systems operate and perform, including interactive operation between systems, in accordance with contract documents[and the Owner's Project Requirements Document].

Perform Integrated Systems Tests only after the Functional Performance Tests for each associated system are completed with all deficiencies resolved and after the related Functional Performance Test Checklists have been signed by each commissioning team member.

3.8.1 Test Scheduling and Coordination

**NOTE: The following paragraph contains tailoring
for NAVY and INTEGRATED SYSTEMS TEST.**

Schedule and conduct Initial Functional Performance Tests as soon as all contract work is completed, regardless of the season. Develop and implement means of artificial loading to demonstrate, to a reasonable level of confidence, the ability of the HVAC systems to handle peak seasonal loads. Schedule Functional Performance Tests for each system only after the Certificate of Readiness has been approved by the Government for the system. Correct all deficiencies identified through any prior review, inspection, or test activity before the start of Functional Performance Tests.

Functional Performance Tests and Integrated Systems Tests must be performed with the CxC present. Government reserves the right to witness all tests. Coordinate test schedule with Government representatives.

3.8.2 Preparation

Put equipment and systems into operation and continue operation during each working day of functional performance and integrated systems testing, as required. Verify temperature and pressure taps in accordance with Contract Documents. Provide a pressure/temperature plug at each water sensor which is an input point to control system.

Perform minor adjustments to equipment and systems during Functional Performance Tests as deemed necessary by the commissioning team. Where calibrated DDC sensors cannot be used to record test data, provide measuring instruments, logging devices, and data acquisition equipment to record data for the complete range of test data for the required test period.

3.8.3 Testing Procedures

Provide all necessary materials and system modifications to produce the necessary flows, pressures, temperatures, and other conditions necessary to execute the test according to the specified conditions. At completion of the test, return the affected building equipment and systems to their pre-test condition.

Follow the Functional Performance Test from the approved Final

Construction Phase Commissioning Plan. Perform Functional Performance Tests for each item of equipment and each system required to be commissioned. Verify all sensor calibrations, control responses, safeties, interlocks, operating modes, sequences of operation, capacities, and all other performance requirements comply with contract, regardless of the specific items listed within the checklists provided. In general, testing must progress from equipment or components to subsystems to systems to interlocks and connections between systems. Commissioning Specialists are responsible for determining the order of components and systems to be tested.

Indicate validation of each item of equipment and systems tested by signature of each commissioning team member for each test. The Quality Control Representative, Commissioning Specialists, and Contracting Officer's Representative, if present, must indicate validation after the equipment and systems are free of deficiencies.

3.8.4 Simulating Conditions

Functional performance testing is conducted by simulating conditions at control devices to initiate a control system response. Before testing, calibrate all sensors, transducers and devices. Over-writing control input values through the control system is not acceptable unless approved by the Contracting Officer. Perform each test under conditions that simulate actual conditions as close as is practically possible. Specific examples of simulating conditions are provided below. Do not simulate conditions when damage to the system or building may result.

- a. When varying static pressures inside ductwork cannot be simulated within the duct, and where a sensor signals the controls system to initiate sequences at various duct static pressures, it is acceptable to simulate the various pressures with a Pneumatic Squeeze-Bulb Type Signaling Device with gauge temporarily attached to the sensing tube leading to the transmitter. It is not acceptable to reset the various set-points, nor to simulate an electric analog signal (unless approved as noted above).
- b. Dirty filter pressure drops can be simulated by partially blocking filter face.
- c. Freeze-stat safeties can be simulated by packing portion of sensor with ice.
- d. High outside air temperatures can be simulated with a hair blower.
- e. Raising entering cooling coil temperatures by activating a heating/preheat coil can be used to simulate entering cooling coil conditions.
- f. Do not use signal generators to simulate sensor signals unless approved by the Contracting Officer, as noted above, for special cases.
- g. Control set points can be altered. For example, to see the air conditioning compressor lockout work at an outside air temperature below 12 degrees C 55 degrees F, when the outside air temperature is above 12 degrees C 55 degrees F, temporarily change the lockout set point to be minus 17 degrees C 0 degrees F above the current outside air temperature. Caution: Set points are not to be raised or lowered to a point to cause damage to the components, systems, or the building

structure and contents.

- h. Test duct mounted smoke detectors in accordance with the manufacturer's recommendations. Perform the tests with air system at minimum airflow condition.
- i. Test current sensing relays used for fan and pump status signals to control system to indicate unit failure and run status by resetting the set point on the relay to simulate a lost belt or unit failure while the unit is running. Confirm that the failure alarm was generated and received at the control system. After the test is conducted, return the set point to its original set-point or a set-point as indicated by the Contracting Officer.

3.8.5 Manufacturer's Representative

NOTE: A factory trained representative is recommended for major equipment. Add equipment as required by scope of work and as determined necessary by the project delivery team.

Choose the bracketed paragraph below for systems with package controls.

Provide a factory trained representative authorized by the equipment manufacturer to perform Functional Performance Testing for the following equipment:

- [Chillers
-][Cooling towers and evaporatively cooled condensers
-][Boilers
-][Packaged Direct-Expansion Refrigeration Equipment, including variable refrigerant flow (VRF) systems
-][Packaged Computer Room [Air Handlers (CRAH)] [Air Conditioners (CRAC)]
-][Booster Pumps
-][Packaged Air Compressors
-][Water Quality and Chemical Treatment Systems
-][Solar Water Heating Systems
-] Ensure the test representative reviews, approves, and signs the completed field test report. Include person's name with signatures.

3.8.6 Integrated Systems Tests

NOTE: This paragraph is tailored for INTEGRATED SYSTEMS TEST.

Follow the Integrated Systems Test Checklists from the approved Final Construction Phase Commissioning Plan. Integrated Systems Tests must be performed for the interactive operation between HVAC systems and other systems such as fire protection systems, smoke control systems, or back-up electrical supply. Verify correct interactive operation, acceptable speed of response, and other contract requirements for both normal and failure modes. Examples of Integrated Systems Tests include the correct operation of HVAC systems during emergency system activation or correct operation of uninterruptible power supplies or energy generators and connected systems.

3.8.7 Sample Strategy

NOTE: This paragraph contains tailoring options for DESIGN-BID-BUILD, DESIGN-BUILD, ARMY, and NAVY. For Design-Bid-Build, select the percentage sample size for large groups of identical equipment as determined by the project delivery team. Higher percentages may be appropriate for critical systems or projects or for small numbers of equipment.

Perform Functional Performance Tests using the following sample strategy. Perform Functional Performance Tests using the sample strategy identified herein. Test all central plant equipment, primary air handling units, and process cooling or heating equipment. Test all system-level equipment serving multiple zones. [Twenty-five] [Fifty] [_____] percent sample testing is allowed for large groups of identical equipment with identical controllers serving single zones such as air terminal units, fan coil units, unitary equipment, and plumbing fixtures. Sample size may be no less than three units. Refer to Section 01 91 00.15 BUILDING COMMISSIONING for sample strategy. Complete a Functional Performance Test Checklist for each item of equipment or system to be tested. During testing, Government representatives may select the specific equipment or system to be tested for sample sizes less than 100 percent. Equipment Identifiers are as indicated on the design drawings:

Equipment Identifier	Sample Size (Percent)
AHU	[_____]
VAV	[_____]
CUH	[_____]
CWP	[_____]
DWH	[_____]

Perform Integrated Systems Tests and complete an Integrated Systems Test Checklist for for all (100 percent) systems and equipment having interactive operation.

3.8.7.1 100 Percent Sample Procedures

Systems or equipment for which 100 percent sample size are tested fail if one or more of the test procedures results in discovery of a deficiency and the deficiency cannot be resolved within 5 minutes during the test.

Re-test to the extent necessary to confirm that the deficiencies have been corrected without negatively impacting the performance of the rest of the system.

3.8.7.2 Less than 100 Percent Sample Procedures

Randomly test each sample group of identical equipment. If 10 percent of the units in the first sample fail the functional performance tests, test a second sample group, the same size as the first sample group. The second sample must not include any units from the first sample group.

If 10 percent of the units in the second sample fail, test all remaining units. If at any point frequent failures occur the CxC may stop the testing and require the contractor to perform and document a checkout of the remaining units prior to continuing functional testing.

3.9 INTEGRATED SYSTEMS TEST

**NOTE: The following paragraph is tailored for
INTEGRATED SYSTEMS TEST.**

Perform Integrated Systems Tests only after the Functional Performance Tests for each associated system are completed with all deficiencies resolved and after the related Functional Performance Test Checklists have been signed by each commissioning team member.

3.10 RETESTING REQUIREMENTS

Abort tests if any deficiency prevents successful completion of the test or if any required commissioning team member is not present for the test. Re-test only after all deficiencies identified during the original tests have been corrected.

Contracting Officer may withhold payment equivalent to lost time, re-testing, and aborted tests. These costs may include salary, travel costs, and per diem for Government team members. Correct deficiencies as identified by the commissioning team and retest the systems to be commissioned.

3.11 SYSTEM ACCEPTANCE

**NOTE: Partial acceptance is acceptance of those
parts of the system that could be tested and
verified to function in conformance with the
construction contract during initial Functional
Performance Tests.**

Systems may be partially accepted prior to seasonal testing if they comply with all construction contract and accepted design requirements that can be tested during initial Functional Performance Tests. All test procedures must be successful completed prior to full systems acceptance.

[3.12 SEASONAL TESTS

NOTE: Performing seasonal testing under maximum heating or cooling conditions is recommended for mission critical or humidity controlled facilities such as hospitals, laboratories, armories, mission operations, or other essential (RCIV) and strategic asset (RCV) facilities.

Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover, regardless of the season.

In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems during peak heating and cooling seasons during outdoor air condition design extremes. Schedule Seasonal Functional Performance Tests in coordination with the Contracting Officer. Submit [Seasonal Test Report](#) within 14 days of test completion. Include seasonal test report in the Updated Final Commissioning Report as specified in Section 01 91 00.15 BUILDING COMMISSIONING

Execute seasonal functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

]3.13 FULL-LOAD TESTS

NOTE: Performing full-load testing for equipment serving process loads is recommended for facilities where tight environmental control is required such as simulators, electronic equipment facilities, and industrial process facilities.

When full-load testing cannot be performed under actual loading, retain the bracketed sentence to require artificial loading.

Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover. In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems under full-load conditions.[Develop and implement means of artificial loading to demonstrate the ability of the process cooling systems to handle peak process loads.] Schedule Full-Load Functional Performance Tests in coordination with the Contracting Officer. Submit [Full-Load Test Report](#) within 14 days of test completion.

Execute full-load functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any full load testing.

]3.14 TRAINING

NOTE: This paragraph contains tailoring options for KTR HIRED COMMISSIONING PROVIDER, NAVY, and GOVT HIRED COMMISSIONING PROVIDER.

The Mechanical Systems Technical Commissioning Specialist must review the training plan required by Section 01 78 00 OPERATION AND MAINTENANCE DATA and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel.

The Commissioning Provider is responsible for overseeing and approving the training plan required by Section 01 78 00 OPERATION AND MAINTENANCE DATA and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel.

Coordinate, schedule, and document all required training. At a minimum, include the following items in the training report for commissioned systems:

- a. Complete commissioning documentation
- b. Complete O&M data
- c. Complete Training
- d. Purpose of equipment.
- e. Principle of how the equipment works.
- f. Important parts and assemblies.
- g. How the equipment achieves its purpose and necessary operating conditions.
- h. Most likely failure modes, causes and corrections.
- i. On site demonstration.
- j. Provide updates to O&M manuals based on field modifications.
- k. Provide training of the post-occupancy operations and maintenance staff.

3.15 COMMISSIONING REPORT

**NOTE: This paragraph contains tailoring for
INTEGRATED SYSTEMS TEST.**

Include all completed Pre-Functional Checklists and Functional Performance and Integrated Systems Test Checklists in the Commissioning Report as specified in Section 01 91 00.15 BUILDING COMMISSIONING. Include the approved TAB Report.

[3.16 POST-CONSTRUCTION ENDURANCE TEST

**NOTE: Post-Construction Endurance Tests evaluate
HVAC system performance under actual operating load
during normal operation. This activity is highly
recommended. The Endurance Tests provide improved
probability of identifying deficiencies prior to**

warranty expiration. If the building operators plan to monitor system performance closely or this activity is not funded, delete this paragraph.

NOTE: This paragraph contains tailoring options for ARMY, NAVY, and KTR HIRED COMMISSIONING PROVIDER.

Choose bracketed "and the Owner's Project Requirements" for projects that require one. Refer to specifier notes regarding the Owner's Project Requirements Document in Section 01 91 00.15 BUILDING COMMISSIONING.

Perform an Endurance Test in accordance with the paragraph ENDURANCE TEST ENDURANCE TESTING in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC once during the peak heating season and once during the peak cooling season during outdoor air condition extremes with the exception that network bandwidth usage measurement and recording is not required.[Use the Temporary Trending Hardware, if necessary, in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.]

The Mechanical System Commissioning Specialists must review the trend logs from the Endurance Tests to ensure that the systems have stable operation and operate as required by the construction contract, the accepted design [, and the Owner's Project Requirements Document]. The Commissioning Specialists must provide a Post-Construction Trend Log Report that identifies any deficiencies noted in operation, recommendations for correction, and includes a graphical representation of the trends. Provide one Trend Log Report for the peak cooling season and one Trend Log Report for the peak heating season. Submit the Post-Construction Trend Log Reports no later than 14 calendar days following receipt of the trend log data by the Commissioning Specialist. Provide a Post-Construction Trend Log Report meeting the same requirements as the Endurance Testing Results Format in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Provide one Trend Log Report for the peak cooling season and one Trend Log Report for the peak heating season. Submit the Post-Construction Trend Log Reports no later than 14 calendar days following download of the trended data. Include the Post-Construction Trend Log Reports in the Updated Final Commissioning Report as specified in Section 01 91 00.15 BUILDING COMMISSIONING

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