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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005

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SECTION 15995

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01/06

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SECTION 15995

COMMISSIONING OF HVAC SYSTEMS 01/06

NOTE: This guide specification covers the requirements for commissioning of HVAC systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

NOTE: Use of this specification is mandatory for all projects. A properly functioning HVAC system assures a comfortable, healthy and productive environment for the user. The "Design Agent's Representative" will be a member of the HVAC design team, i.e. from the AE or Engineering Division. The "Design Agent's Representative" will actively participate in the process, including review of all submittals contained herein.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in

the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL Commissioning Group (ACG)

ACG Commissioning Guideline (2005) Commissioning Guideline

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Commissioning Standard (1999) Procedural Standards for Building Systems Commissioning

SHEET METAL AND AIR-CONDITIONING ContractorRS' NATIONAL ASSOCIATION (SMACNA)

SMACNA Commissioning Manual (1994) HVAC Systems Commissioning Manual

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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, Air Force, and NASA projects.

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

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Commissioning Plan[; G,][;G, [____]]

Commissioning Plan prepared in accordance with Commissioning Standard, no later than 28 days after the approval of the Commissioning Specialist.

SD-03 Product Data

Pre-Functional Performance Test Checklists[; G,][;G, [____]]

At least 28 days prior to the start of Pre-Functional Performance Test Checks. The schedule for the test checks shall be submitted at least 14 days prior to the start of Pre-Functional Performance Test Checks.

Functional Performance Tests[; G,][;G, [____]]

Test procedures at least 28 days prior to the start of Functional Performance Tests. The schedule for the tests at least 14 days prior to the start of Functional Performance Tests.

SD-06 Test Reports

Commissioning Report[; G][; G, [____]]

No later than 14 days after completion of Functional Performance Tests.

SD-07 Certificates

Commissioning Firm[; G][; G, [____]]

Certification of the proposed Commissioning Firm's qualifications by one of the following ACG, NEBB, or TABB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in

Certification of the proposed Commissioning Firm or disciplinary action taken by ACG, NEBB, or TABB against the proposed Commissioning Firm shall be described in detail.

Commissioning Specialist[; G][; G, [____]]

Certification of the proposed Commissioning Specialist's qualifications by one of the following ACG, NEBB, or TABB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed Commissioning Specialist or disciplinary action taken by ACG, NEBB, or TABB against the proposed Commissioning Specialist shall be described in detail.

1.3 SIMILAR TERMS

In some instances, terminology differs between the Contract and the Commissioning Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding ACG, NEBB, or TABB requirements where differences exist.

| <u>SIMILAR TERMS</u> | | | |
|--------------------------|-----------------------------------|---|---|
| <u>Contract Term</u> | <u>ACG</u> | <u>NEBB</u> | <u>TABB</u> |
| Commissioning Standard | ACG Commissioning Guideline | Procedural Standards for Building Systems Commissioning | SMACNA HVAC Commissioning Guideline |
| Commissioning Specialist | ACG Certified Commissioning Agent | NEBB Qualified Commissioning Administrator | TABB Certified Commissioning Supervisor |

1.4 COMMISSIONING STANDARDS

Commissioning shall be performed in accordance with the requirements of the standard under which the Commissioning Firm's qualifications are approved, i.e., ACG Commissioning Guideline, NEBB Commissioning Standard, or SMACNA Commissioning Manual unless otherwise stated herein. All recommendations and suggested practices contained in the Commissioning Standard shall be considered mandatory. The Commissioning Standard shall be used for all aspects of Commissioning, including qualifications for the Commissioning Firm and Specialist and calibration of Commissioning instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the Commissioning Standard, the manufacturer's recommendations shall be adhered to. All quality assurance provisions of the Commissioning Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the Commissioning Standard, Commissioning procedures shall be developed by the Commissioning Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the Commissioning Standard used (ACG, NEBB, or

TABB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

1.5 QUALIFICATIONS

1.5.1 Commissioning Firm

The Commissioning Firm shall be either a member of ACG or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another Commissioning Firm for approval. Any firm that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including Commissioning.

All work specified in this Section and in other related Sections to be performed by the Commissioning Firm shall be considered invalid if the Commissioning Firm loses its certification prior to Contract completion and must be performed by an approved successor. These Commissioning services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The Commissioning Firm shall be a subContractor of the prime Contractor and shall be financially and corporately independent of all other subContractors. The Commissioning Firm shall report to and be paid by the prime Contractor.

1.5.2 Commissioning Specialist

The Commissioning Specialist shall be an ACG Certified Commissioning Agent, a NEBB Qualified Commissioning Administrator, or a TABB Certified Commissioning Supervisor and shall be an employee of the approved Commissioning Firm. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Commissioning Specialist loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another Commissioning Specialist for approval. Any individual that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including Commissioning. All work specified in this Section and in other related Sections performed by the Commissioning Specialist shall be considered invalid if the Commissioning Specialist loses his certification prior to Contract completion and must be performed by the approved successor.

1.6 COMMISSIONING SPECIALIST RESPONSIBILITIES

All Commissioning work specified herein and in related sections shall be performed under the direct guidance of the Commissioning Specialist. The Commissioning Specialist shall prepare the Commissioning Plan, which will be a comprehensive schedule and shall include all submittal requirements for procedures, notifications, reports and the Commissioning Report. After approval of the Commissioning Plan, the Contractor shall revise the Contract NAS schedule to reflect the schedule requirements in the Commissioning Plan.

1.7 SEQUENCING AND SCHEDULING

The work described in this Section shall begin only after all work required

in related Sections has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Pre-Functional Performance Test Checklists shall be performed at appropriate times during the construction phase of the Contract.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 COMMISSIONING TEAM AND TEST FORMS AND CHECKLISTS

NOTE: The "Design Agent's Representative" will be included as a member of the commissioning team for the pre-commissioning checklists and will participate in the functional performance tests.

The checklists provided are to be used as guides for the preparation of project checklists. The appropriate checklist should be included in the project specification for each HVAC equipment component. The designer will add additional checklists for equipment or systems not included in this guide specification or modify the checklists where necessary for specific project requirements. If, for example, a system needs to be tested with certain internal load, each appropriate checklist should be modified to include this requirement along with specifics on how load should be generated.

The Contractor shall designate Contractor team members to participate in the Pre- Functional Performance Test Checklists and the Functional Performance Tests specified herein. In addition, the Government team members will include a representative of the Contracting Officer, the Design Agent's Representative, and the Using Agency's Representative. The team members shall be as follows:

Designation

Function

| | |
|------------------|--|
| A | Contractor's Commissioning Specialist |
| M | Contractor's Mechanical Representative |
| E | Contractor's Electrical Representative |
| T | Contractor's Testing, Adjusting, and Balancing |
| (TAB) Specialist | |
| C | Contractor's Controls Representative |
| D | Design Agency Representative |
| O | Contracting Officer's Representative |
| U | Using Agency's Representative |

Appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each Pre- Functional Performance Test Checklist item shall be indicated by initials and date unless an "X" is shown indicating that participation by that individual is not required. Acceptance by each commissioning team member of each functional performance test item shall be indicated by signature and date.

3.2 TESTS

The pre-functional performance test checklists and functional performance tests shall be performed in a manner that essentially duplicates the checking, testing, and inspection methods established in the related Sections. Where checking, testing, and inspection methods are not specified in other Sections, methods shall be established which will provide the information required. Testing and verification required by this section shall be performed during the Commissioning phase. Requirements in related Sections are independent from the requirements of this Section and shall not be used to satisfy any of the requirements specified in this Section. The Contractor shall provide all materials, services, and labor required to perform the pre- functional performance tests checks and functional performance tests. A functional performance test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating non-Government commissioning team member of which participation is specified is not present for the test.

3.2.1 Pre-Functional Performance Test Checklists

Pre-Functional Performance Test Checklists shall be performed for the items indicated in Appendix A. Deficiencies discovered during these checks shall be corrected and re-inspected in accordance with the applicable contract requirements.

3.2.2 Functional Performance Tests

Functional Performance Tests shall be performed for the items indicated in Appendix B. Functional Performance Tests shall begin only after all Pre-Functional Performance Test Checklists have been successfully completed. Tests shall prove all modes of the sequences of operation, and shall verify all other relevant contract requirements. Tests shall begin with equipment or components and shall progress through subsystems to complete systems. Upon failure of any Functional Performance Test item, the Contractor shall correct all deficiencies in accordance with the applicable contract requirements. The item shall then be retested until it has been completed with no errors.

3.3 COMMISSIONING REPORT

The Commissioning Report shall consist of completed Pre- Functional Performance Test Checklists and completed Functional Performance Tests organized by system and by subsystem and submitted as one package. The Commissioning Report shall also include all HVAC systems test reports, inspection reports (Preparatory, Initial and Follow-up inspections), start-up reports, TAB report, TAB verification report, Controls start-up test reports and Controls Performance Verification Test (PVT) report. The results of failed tests shall be included along with a description of the corrective action taken.

APPENDIX A

PRE-FUNCTIONAL PERFORMANCE TEST CHECKLISTS

Pre-Functional Performance Test Checklist - Multizone Air Handling Unit

For Air Handling Unit: [_____]

| | | | | | | |
|----------------|---|---|---|---|---|---|
| Checklist Item | A | M | E | T | C | O |
|----------------|---|---|---|---|---|---|

Installation

- | | | | | | | |
|--|-----|-----|---|-----|---|-----|
| a. Inspection and access doors are operable and sealed. | ___ | ___ | X | ___ | X | ___ |
| b. Condensate drainage is unobstructed. (Visually verify pan drains completely by pouring a cup of water into drain pan.) | ___ | ___ | X | X | X | ___ |
| c. Fan belt adjusted. | ___ | ___ | X | ___ | X | ___ |

| | | | | | | |
|------------|---|---|---|---|---|---|
| Electrical | A | M | E | T | C | O |
|------------|---|---|---|---|---|---|

- | | | | | | | |
|--|-----|---|-----|-----|---|-------|
| a. Power available to unit disconnect. | ___ | X | ___ | X | X | ___ |
| b. Power available to unit control panel. | ___ | X | ___ | X | X | ___ |
| c. Proper motor rotation verified. | ___ | X | ___ | ___ | X | ___ |
| d. Verify that power disconnect is located within sight of the unit it controls. | ___ | X | ___ | X | X | ___ |
| [e. Power available to electric heating coil. | ___ | X | ___ | X | X | ___] |

| | | | | | | |
|-------|---|---|---|---|---|---|
| Coils | A | M | E | T | C | O |
|-------|---|---|---|---|---|---|

- | | | | | | | |
|---|-----|-----|---|---|---|-------|
| [a. Chilled water piping properly connected. | ___ | ___ | X | X | X | ___] |
| [a. Refrigerant piping properly connected. | ___ | ___ | X | X | X | ___] |
| [b. Hot water piping properly connected. | ___ | ___ | X | X | X | ___] |
| [b. Steam and condensate piping properly connected. | ___ | ___ | X | X | X | ___] |

| | | | | | | |
|----------|---|---|---|---|---|---|
| Controls | A | M | E | T | C | O |
|----------|---|---|---|---|---|---|

- | | | | | | | |
|---|-----|---|---|---|-----|-----|
| a. Control valves/actuators properly installed. | ___ | X | X | X | ___ | ___ |
| b. Control valves/actuators operable. | ___ | X | X | X | ___ | ___ |
| c. O/A dampers/actuators properly installed. | ___ | X | X | X | ___ | ___ |
| d. O/A dampers/actuators operable. | ___ | X | X | X | ___ | ___ |

Pre-Functional Performance Test Checklist - Multizone Air Handling Unit
(cont)

| | | | | | |
|---|---|---|---|---|---|
| A | M | E | T | C | O |
|---|---|---|---|---|---|

| | | | | | | |
|--|-----|-----|---|-----|-----|-----|
| e. Zone dampers/actuators properly installed & dampers leak checked. | ___ | X | X | X | ___ | ___ |
| f. Zone dampers/actuators operable. | ___ | X | X | X | ___ | ___ |
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. Construction filters removed and replaced. | ___ | ___ | X | ___ | X | ___ |
| b. TAB report approved. | ___ | ___ | X | X | ___ | X |

Pre-Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: [_____]

| Checklist Item | A | M | E | T | C | O |
|---|-----|-----|-----|-----|---|------|
| Installation | | | | | | |
| a. Inspection and access doors are operable and sealed. | ___ | ___ | X | ___ | X | ___ |
| b. Condensate drainage is unobstructed. (Visually verify drainage by pouring a cup of water into drain pan.) | ___ | ___ | X | X | X | ___ |
| c. Fan belt adjusted. | ___ | ___ | X | ___ | X | ___ |
| Electrical | | | | | | |
| a. Power available to unit disconnect. | ___ | X | ___ | X | X | ___ |
| b. Power available to unit control panel. | ___ | X | ___ | X | X | ___ |
| c. Proper motor rotation verified. | ___ | X | ___ | ___ | X | ___ |
| d. Verify that power disconnect is located within sight of the unit it controls. | ___ | X | ___ | X | X | ___ |
| [e. Power available to electric heating coil. | ___ | X | ___ | X | X | ___] |
| Coils | | | | | | |
| [a. Chilled water piping properly connected. | ___ | ___ | X | X | X | ___] |
| [a. Refrigerant piping properly connected. | ___ | ___ | X | X | X | ___] |
| [b. Hot water piping properly connected. | ___ | ___ | X | X | X | ___] |
| [b. Steam and condensate piping properly connected. | ___ | ___ | X | X | X | ___] |

Pre-Functional Performance Test Checklist - Variable Volume Air Handling Unit

| Controls | A | M | E | T | C | O |
|---|-----|-----|---|-----|-----|-----|
| a. Control valves/actuators properly installed. | ___ | X | X | X | ___ | ___ |
| b. Control valves/actuators operable. | ___ | X | X | X | ___ | ___ |
| c. Dampers/actuators properly installed. | ___ | X | X | X | ___ | ___ |
| d. Dampers/actuators operable. | ___ | X | X | X | ___ | ___ |
| e. Verify proper location, installation and calibration of duct static pressure sensor. | ___ | X | X | X | ___ | ___ |
| f. Fan air volume controller operable. | ___ | X | X | X | ___ | ___ |
| g. Air handler controls system operational. | ___ | X | X | X | ___ | ___ |
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. Construction filters removed and replaced. | ___ | ___ | X | ___ | ___ | ___ |
| b. TAB report approved. | ___ | X | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - VAV Terminal

For VAV Terminal: [_____]

| Checklist Item | A | M | E | T | C | O |
|---|-----|-----|-----|-----|-----|------|
| Installation | | | | | | |
| [a. Reheat coil connected to hot water pipe. | ___ | ___ | X | ___ | X | ___] |
| [b. Electric reheat coil connected to local disconnect. | ___ | X | ___ | ___ | X | ___] |
| Controls | | | | | | |
| a. Cooling only VAV terminal controls set. | ___ | X | X | X | ___ | ___ |
| b. Cooling only VAV controls verified. | ___ | X | X | X | ___ | ___ |
| c. Reheat VAV terminal controls set. | ___ | X | X | X | ___ | ___ |
| d. Reheat terminal/coil controls verified. | ___ | X | X | X | ___ | ___ |
| Testing, Adjusting, and Balancing (TAB) | | | | | | |
| a. TAB report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - DX Air Cooled Condensing Unit
 For Condensing Unit: [_____]

| Checklist Item | A | M | E | T | C | O |
|---|-----|-----|-----|-----|-----|-----|
| Installation | | | | | | |
| a. Check condenser fans for proper rotation. | ___ | ___ | X | ___ | X | ___ |
| Electrical | | | | | | |
| a. Power available to unit disconnect. | ___ | X | ___ | X | X | ___ |
| b. Power available to unit control panel. | ___ | X | ___ | X | ___ | ___ |
| c. Verify that power disconnect is located within sight of the unit it controls | ___ | X | ___ | X | ___ | ___ |
| Controls | | | | | | |
| a. Unit safety/protection devices tested. | ___ | ___ | X | X | ___ | ___ |
| b. Control system and interlocks installed. | ___ | ___ | X | X | ___ | ___ |
| c. Control system and interlocks operational. | ___ | ___ | X | X | ___ | ___ |

Pre-Functional Performance Test Checklist - Pumps

For Pump: [_____]

Checklist Item

A M E T C O

Installation

a. Piping system installed.

___ ___ X X X ___

Electrical

A M E T C O

a. Power available to pump disconnect.

___ X ___ X X ___

b. Pump rotation verified.

___ X ___ X X ___

c. Control system interlocks functional.

___ X ___ X ___ ___

Testing, Adjusting, and Balancing (TAB)

A M E T C O

a. Pressure/temperature gauges installed.

___ ___ X ___ X ___

b. TAB Report approved.

___ ___ X ___ X ___

Pre-Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller: [_____]

Checklist Item

A M E T C O

Installation

a. Chiller properly piped.

___ ___ X ___ ___ ___

Electrical

A M E T C O

a. Power available to unit disconnect.

___ X ___ X ___ ___

b. Power available to unit control panel.

___ X ___ X ___ ___

c. Separate power is supplied to electric heating tape.

___ X ___ X ___ ___

d. Verify that power disconnect is located within sight of the unit it controls.

___ X ___ X ___ ___

Controls

A M E T C O

a. Factory startup and checkout complete.

___ ___ X X ___ ___

b. Chiller safety/protection devices tested.

___ ___ X X ___ ___

c. Chilled water flow switch installed.

___ ___ X X ___ ___

d. Chilled water flow switch tested.

___ ___ X X ___ ___

e. Chilled water pump interlock installed.

___ ___ X X X ___

f. Chilled water pump interlock tested.

___ ___ ___ X

Pre-Functional Performance Test Checklist - Centrifugal Chiller

For Chiller: [_____]

Checklist Item

| Installation | A | M | E | T | C | O |
|--|-----|-----|-----|-----|-----|------|
| a. Chilled water connections properly piped. | ___ | ___ | X | ___ | ___ | ___ |
| b. Condenser water connections properly piped | ___ | ___ | X | ___ | ___ | ___ |
| c. Refrigerant leak detector installed. | ___ | ___ | ___ | ___ | ___ | ___ |
| [d. Oxygen sensor installed and tested. | ___ | ___ | ___ | ___ | ___ | ___] |
| e. Mechanical room ventilation installed as specified. | ___ | ___ | ___ | ___ | ___ | ___ |
| Electrical | A | M | E | T | C | O |
| a. Power available to unit starter. | ___ | X | ___ | X | ___ | ___ |
| b. Power available to unit control panel. | ___ | X | ___ | X | ___ | ___ |
| c. Verify that power disconnect is located within sight of the unit it controls. | ___ | X | ___ | X | ___ | ___ |
| Controls | A | M | E | T | C | O |
| a. Factory startup and checkout complete. | ___ | ___ | X | X | ___ | ___ |
| b. Chiller safety/protection devices tested. | ___ | ___ | ___ | X | ___ | ___ |
| c. Chilled water flow switch installed and tested. | ___ | ___ | X | X | ___ | ___ |
| e. Chilled water pump interlock installed and tested. | ___ | ___ | ___ | X | ___ | ___ |
| g. Condenser water flow switch installed and tested. | ___ | ___ | ___ | X | ___ | ___ |
| i. Condenser water pump interlock installed and tested. | ___ | ___ | ___ | X | ___ | ___ |

Pre-Functional Performance Test Checklist - Cooling Tower

For Cooling Tower: [_____]

Checklist Item

| Installation | A | M | E | T | C | O |
|---|-----|-----|-----|-----|-----|-----|
| a. Cooling tower properly piped. | ___ | ___ | X | X | ___ | ___ |
| b. Cooling tower fan drive adjusted. | ___ | ___ | ___ | ___ | X | ___ |
| c. Cooling tower makeup water supply piped. | ___ | ___ | X | X | ___ | ___ |
| d. Verify makeup control valve shutoff. | ___ | ___ | X | ___ | X | ___ |
| e. Fan lubricated and blade pitch adjusted. | ___ | ___ | X | ___ | X | ___ |

| Electrical | A | M | E | T | C | O |
|--|-----|-----|-----|---|-----|-----|
| a. Power available to tower disconnect. | ___ | X | ___ | X | ___ | ___ |
| b. Power available to electric sump heater. | ___ | X | ___ | X | ___ | ___ |
| c. Control system interlocks functional. | ___ | ___ | ___ | X | ___ | ___ |
| d. Motor and fan rotation checked. | ___ | X | ___ | X | ___ | ___ |
| e. Verify that power disconnect is located within sight of the unit is controls. | ___ | X | ___ | X | ___ | ___ |

| Piping | A | M | E | T | C | O |
|---|-----|-----|-----|-----|-----|-----|
| a. Condenser water treatment functional. | ___ | ___ | X | X | X | ___ |
| b. All required temperature sensing wells, pressure ports and flow sensors have been installed for performance tests. | ___ | ___ | ___ | ___ | ___ | ___ |

| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
|---|-----|-----|---|-----|---|-----|
| a. TAB report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Hot Water Boiler

For Boiler: [_____]

Checklist Item

| | | | | | | |
|--|-----|-----|---|-----|-----|-----|
| Installation | A | M | E | T | C | O |
| a. Boiler hot water piping installed. | ___ | ___ | X | ___ | ___ | ___ |
| b. Boiler makeup water piping installed. | ___ | ___ | X | ___ | ___ | ___ |
| c. Boiler fuel oil piping installed. | ___ | ___ | X | X | X | ___ |
| d. Boiler gas piping installed. | ___ | ___ | X | X | X | ___ |

| | | | | | | |
|--|-----|-----|-----|-----|-----|-----|
| Startup | A | M | E | T | C | O |
| a. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre- and post-purge, have been tested. | ___ | ___ | ___ | X | ___ | ___ |
| b. Verify that PRV rating conforms to boiler rating. | ___ | ___ | ___ | X | ___ | ___ |
| c. Boiler water treatment system functional. | ___ | ___ | X | X | ___ | ___ |
| d. Boiler startup and checkout complete. | ___ | ___ | X | X | ___ | ___ |
| e. Combustion efficiency demonstrated. | ___ | ___ | X | ___ | X | ___ |

| | | | | | | |
|---|-----|---|-----|---|-----|-----|
| Electrical | A | M | E | T | C | O |
| a. Verify that power disconnect is located within sight of the unit served. | ___ | X | ___ | X | ___ | ___ |

| | | | | | | |
|--|-----|-----|-----|---|-----|-----|
| Controls | A | M | E | T | C | O |
| a. Hot water pump interlock installed and tested. | ___ | ___ | ___ | X | ___ | ___ |
| b. Hot water proof-of-flow switch installed and tested | ___ | ___ | X | X | ___ | ___ |
| c. Hot water heating controls operational. | ___ | ___ | X | X | ___ | ___ |

| | | | | | | |
|---|-----|-----|---|-----|---|-----|
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. TAB report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Steam Boiler

For Boiler: [_____]

Checklist Item

| | | | | | | |
|--|-----|-----|---|-----|---|-----|
| Installation | A | M | E | T | C | O |
| a. Boiler steam piping installed. | ___ | ___ | X | X | X | ___ |
| b. Boiler makeup water piping installed. | ___ | ___ | X | ___ | X | ___ |
| c. Boiler fuel oil piping installed. | ___ | ___ | X | X | X | ___ |
| d. Boiler gas piping installed. | ___ | ___ | X | X | X | ___ |

| | | | | | | |
|---|-----|-----|-----|-----|-----|-----|
| Startup | A | M | E | T | C | O |
| a. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre and post purge, have been tested. | ___ | ___ | ___ | X | ___ | ___ |
| b. Verify that PRV rating conforms to boiler rating. | ___ | ___ | ___ | X | ___ | ___ |
| c. Boiler feed water system operational. | ___ | ___ | ___ | X | ___ | ___ |
| d. Boiler water treatment system functional. | ___ | ___ | X | X | X | ___ |
| e. Boiler startup and checkout complete. | ___ | ___ | ___ | X | ___ | ___ |
| f. All steam traps operational. | ___ | ___ | X | X | X | ___ |
| g. All condensate return pumps operational. | ___ | ___ | ___ | ___ | X | ___ |
| h. Combustion efficiency demonstrated. | ___ | ___ | X | ___ | X | ___ |

| | | | | | | |
|---|-----|---|-----|---|-----|-----|
| Electrical | A | M | E | T | C | O |
| a. Verify that power disconnect is located within sight of the unit served. | ___ | X | ___ | X | ___ | ___ |

| | | | | | | |
|---|-----|-----|---|-----|---|-----|
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. TAB report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Steam/Hot Water Converter

For Converter: [_____]

Checklist Item

| Installation | A | M | E | T | C | O |
|--|-----|-----|-----|-----|-----|-----|
| a. Converter steam piping installed. | ___ | ___ | X | ___ | X | ___ |
| b. Hot water piping installed. | ___ | ___ | X | ___ | ___ | ___ |
| c. Makeup water piping installed. | ___ | ___ | X | X | X | ___ |
| d. Vacuum breaker installed on shell of shell and tube unit. | ___ | ___ | X | X | X | ___ |
| Startup | A | M | E | T | C | O |
| a. All steam traps operational. | ___ | ___ | X | X | X | ___ |
| b. All condensate return pumps operational. | ___ | ___ | ___ | X | ___ | ___ |
| c. Converter safety/protection devices tested. | ___ | ___ | X | X | X | ___ |
| d. Converter startup and checkout complete. | ___ | ___ | X | X | X | ___ |
| Controls | A | M | E | T | C | O |
| a. Control valves/actuators properly installed. | ___ | ___ | X | ___ | ___ | ___ |
| b. Control valves/actuators operable. | ___ | ___ | X | ___ | ___ | ___ |

Pre-Functional Performance Test Checklist - Fan Coil Unit

For Fan Coil Unit: [_____]

Checklist Item

| | | | | | | |
|--|-----|-----|-----|-----|-----|------|
| Installation | A | M | E | T | C | O |
| a. Access doors/removable panels are operable and sealed. | ___ | ___ | X | ___ | X | ___ |
| b. Condensate drainage is unobstructed. | ___ | ___ | X | X | X | ___ |
| c. Fan belt adjusted. | ___ | ___ | X | ___ | X | ___ |
| Electrical | A | M | E | T | C | O |
| a. Power available to unit disconnect. | ___ | ___ | ___ | X | ___ | ___ |
| b. Power available to unit control panel. | ___ | ___ | ___ | X | ___ | ___ |
| c. Proper motor rotation verified. | ___ | ___ | ___ | ___ | X | ___ |
| d. Verify that power disconnect is located within sight of the unit it controls. | ___ | ___ | ___ | X | ___ | ___ |
| [e. Power available to electric heating coil. | ___ | ___ | ___ | X | X | ___] |
| Coils | A | M | E | T | C | O |
| [a. Dual temperature piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| [b. Chilled water piping properly connected. | ___ | ___ | X | X | X | ___] |
| [c. Hot water piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| Controls | A | M | E | T | C | O |
| a. Control valves/actuators properly installed. | ___ | ___ | X | ___ | ___ | ___ |
| b. Control valves/actuators operable. | ___ | ___ | X | X | ___ | ___ |
| c. Verify proper location and installation of thermostat. | ___ | ___ | X | ___ | ___ | ___ |
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. TAB Report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Unit Heater

For Unit Heater: [_____]

Checklist Item

| Installation | A | M | E | T | C | O |
|---|-----|-----|---|-----|-----|------|
| [a. Hot water piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| [a. Steam and condensate piping properly connected. | ___ | ___ | X | X | X | ___] |

| Electrical | A | M | E | T | C | O |
|--|-----|-----|-----|---|-----|-----|
| a. Power available to unit disconnect. | ___ | ___ | ___ | X | ___ | ___ |
| b. Proper motor rotation verified. | ___ | ___ | ___ | X | X | ___ |
| c. Verify that power disconnect is located within sight of the unit it controls. | ___ | ___ | ___ | X | ___ | ___ |
| d. Power available to electric heating coil. | ___ | ___ | ___ | X | ___ | ___ |

| Controls | A | M | E | T | C | O |
|---|-----|-----|---|-----|-----|-----|
| a. Control valves properly installed. | ___ | ___ | X | ___ | ___ | ___ |
| b. Control valves operable. | ___ | ___ | X | X | ___ | ___ |
| c. Verify proper location and installation of thermostat. | ___ | ___ | X | ___ | ___ | ___ |

| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
|---|-----|-----|---|-----|---|-----|
| a. TAB Report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Exhaust Fan

For Exhaust Fan: [_____]

Checklist Item

| | | | | | | |
|-----------------------|-----|-----|---|-----|---|-----|
| Installation | A | M | E | T | C | O |
| a. Fan belt adjusted. | ___ | ___ | X | ___ | X | ___ |

| | | | | | | |
|--|-----|-----|-----|-----|-----|-----|
| Electrical | A | M | E | T | C | O |
| a. Power available to fan disconnect. | ___ | ___ | ___ | X | ___ | ___ |
| b. Proper motor rotation verified. | ___ | ___ | ___ | ___ | X | ___ |
| c. Verify that power disconnect is located within sight of the unit it controls. | ___ | ___ | ___ | X | ___ | ___ |

| | | | | | | |
|---|-----|-----|-----|-----|-----|-----|
| Controls | A | M | E | T | C | O |
| a. Control interlocks properly installed. | ___ | ___ | ___ | X | ___ | ___ |
| b. Control interlocks operable. | ___ | ___ | ___ | X | ___ | ___ |
| c. Dampers/actuators properly installed. | ___ | ___ | X | ___ | ___ | ___ |
| d. Dampers/actuators operable. | ___ | ___ | X | ___ | ___ | ___ |
| e. Verify proper location and installation of thermostat. | ___ | ___ | X | ___ | ___ | ___ |

| | | | | | | |
|---|-----|-----|---|-----|---|-----|
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. TAB Report approved. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Computer Room Unit

For Computer Room Unit: [_____]

Checklist Item

| | | | | | | |
|--|-----|-----|-----|-----|-----|------|
| Installation | A | M | E | T | C | O |
| a. Access doors are operable and sealed. | ___ | ___ | X | ___ | X | ___ |
| b. Condensate drainage is unobstructed and routed to floor drain. | ___ | ___ | X | X | X | ___ |
| c. Fan belt adjusted. | ___ | ___ | X | ___ | X | ___ |
| Electrical | A | M | E | T | C | O |
| a. Power available to unit disconnect. | ___ | X | ___ | X | X | ___ |
| b. Proper motor rotation verified. | ___ | X | ___ | ___ | X | ___ |
| c. Proper motor rotation verified. | ___ | X | ___ | ___ | X | ___ |
| d. Verify that power disconnect is located within sight of the unit it controls. | ___ | X | ___ | X | ___ | ___ |
| [e. Power available to reheat coils. | ___ | X | ___ | ___ | X | ___] |
| Coils/Humidifier | A | M | E | T | C | O |
| [a. Chilled water piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| [a. Refrigerant piping properly connected. | ___ | ___ | X | X | X | ___] |
| [b. Hot water piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| [b. Steam piping properly connected. | ___ | ___ | X | X | X | ___] |
| [c. Humidifier makeup water connected. | ___ | ___ | X | X | X | ___] |
| Controls | A | M | E | T | C | O |
| a. Control valves operable. | ___ | ___ | X | X | ___ | ___ |
| b. Unit control system operable and verified. | ___ | ___ | ___ | X | ___ | ___ |
| c. Verify proper location and installation of thermostat. | ___ | ___ | X | ___ | ___ | ___ |
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
| a. TAB Report submitted. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - HVAC System Controls

For HVAC System: [_____]

Checklist Item

| Installation | A | M | E | T | C | O |
|---|-----|-----|---|---|-----|-----|
| a. Layout of control panel matches drawings. | ___ | ___ | X | X | ___ | ___ |
| b. Framed instructions mounted in or near control panel. | ___ | ___ | X | X | ___ | ___ |
| c. Components properly labeled (on inside and outside of panel). | ___ | ___ | X | X | ___ | ___ |
| d. Control components piped and/or wired to each labeled terminal strip. | ___ | ___ | X | X | ___ | ___ |
| e. EMCS connection made to each labeled terminal strip as shown. | ___ | ___ | X | X | ___ | ___ |
| f. Control wiring and tubing labeled at all terminations, splices, and junctions. | ___ | ___ | X | X | ___ | ___ |

Main Power and Control Air

| | | | | | | |
|---|-----|-----|-----|---|-----|-----|
| a. 120 volt AC power available to panel. | ___ | ___ | ___ | X | ___ | ___ |
| b. 138 kPa gauge (20 psig) compressed air available to panel. | ___ | ___ | X | X | ___ | ___ |

Testing, Adjusting, and Balancing (TAB)

| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |
|---|-----|-----|---|-----|---|-----|
| a. TAB Report submitted. | ___ | ___ | X | ___ | X | ___ |

Pre-Functional Performance Test Checklist - Single Zone Air Handling Unit

For Air Handling Unit: [_____]

Checklist Item

| | | | | | | |
|--|-----|-----|-----|-----|-----|------|
| Installation | A | M | E | T | C | O |
| a. Inspection and access doors are operable and sealed. | ___ | ___ | X | ___ | X | ___ |
| b. Condensate drainage is unobstructed. | ___ | ___ | X | X | X | ___ |
| c. Fan belt adjusted. | ___ | ___ | X | ___ | X | ___ |
| Electrical | A | M | E | T | C | O |
| a. Power available to unit disconnect. | ___ | ___ | ___ | X | X | ___ |
| b. Power available to unit control panel. | ___ | ___ | ___ | X | ___ | ___ |
| c. Proper motor rotation verified. | ___ | ___ | ___ | ___ | X | ___ |
| d. Verify that power disconnect is located within sight of the unit it controls. | ___ | ___ | ___ | X | ___ | ___ |
| e. Power available to electric heating coil. | ___ | ___ | ___ | X | ___ | ___ |
| Coils | A | M | E | T | C | O |
| [a. Chilled water piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| [a. Refrigerant piping properly connected. | ___ | ___ | X | X | X | ___] |
| [c. Hot water piping properly connected. | ___ | ___ | X | ___ | ___ | ___] |
| [c. Steam and condensate piping properly connected. | ___ | ___ | X | X | X | ___] |
| Controls | A | M | E | T | C | O |
| a. Control valves/actuators properly installed. | ___ | ___ | X | ___ | ___ | ___ |
| b. Control valves/actuators operable. | ___ | ___ | X | ___ | ___ | ___ |
| c. Dampers/actuators properly installed. | ___ | ___ | X | ___ | ___ | ___ |
| d. Dampers/actuators operable. | ___ | ___ | X | ___ | ___ | ___ |
| e. Verify proper location and installation of thermostat. | ___ | ___ | X | ___ | ___ | ___ |
| Testing, Adjusting, and Balancing (TAB) | A | M | E | T | C | O |

a. TAB Report approved.

___ ___ X ___ X ___

Pre-Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System: [_____]

Checklist Item

Installation

A M E T C O

a. Recovery system piping installed.

___ ___ X ___ X ___

Startup

A M E T C O

a. Startup and checkout complete.

___ ___ X X X ___

Controls

A M E T C O

a. Control valves/actuators properly installed.

___ ___ X ___ ___ ___

b. Control valves/actuators operable.

___ ___ X ___ ___ ___

- End of Appendix A -

APPENDIX B

FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

Functional Performance Test - Pump []

NOTE: Prior to performing this test, for closed loop systems ensure that the system is pressurized and the make-up water system is operational, or for open loop systems ensure that the sumps are filled to the proper level.

1. Activate pump start using control system commands.

a. Verify correct operation in:

HAND _____ OFF _____ AUTO _____

b. Verify pressure drop across strainer:

Strainer inlet pressure _____ [kPa gauge] [psig]

Strainer outlet pressure _____ [kPa gauge] [psig]

c. Verify pump inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report and pump design conditions.

| | DESIGN | TAB | ACTUAL |
|---|--------|-------|--------|
| Pump inlet pressure [kPa gauge] [psig] | _____ | _____ | _____ |
| Pump outlet pressure [kPa gauge] [psig] | _____ | _____ | _____ |

d. Operate pump at shutoff and at 100 percent of designed flow when all components are in full flow. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

| | SHUTOFF | 100 percent |
|---|---------|-------------|
| Pump inlet pressure [kPa gauge] [psig] | _____ | _____ |
| Pump outlet pressure [kPa gauge] [psig] | _____ | _____ |
| Pump flow rate [L/s] [gpm] | _____ | _____ |

| | SETPOINT |
|-----------------------------------|----------|
| Differential Pressure Transmitter | _____ |

Functional Performance Test (cont) - Pump []

e. For variable speed pumps, operate pump at shutoff (shutoff to be done in manual on variable speed drive at the minimum rpm that the system is being controlled at) and at minimum flow or when all components are in full by-pass. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

| | | |
|---|----------|-------------|
| | SHUTOFF | 100 percent |
| Pump inlet pressure [kPa gauge] [psig] | _____ | _____ |
| Pump outlet pressure [kPa gauge] [psig] | _____ | _____ |
| Pump flow rate [L/s] [gpm] | _____ | _____ |
| | SETPOINT | |
| Differential Pressure Transmitter | _____ | |

2. Measure motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions. Compare amperage to nameplate FLA

a. Full flow:

| | | | |
|------------------|-------|---------------|---------------|
| Nameplate FLA | _____ | | |
| Amperage Phase 1 | _____ | Phase 2 _____ | Phase 3 _____ |
| Voltage Ph1-Ph2 | _____ | Ph1-Ph3 _____ | Ph2-Ph3 _____ |
| Voltage Ph1-gnd | _____ | Ph2-gnd _____ | Ph3-gnd _____ |

b. Minimum flow:

| | | | |
|------------------|-------|---------------|---------------|
| Amperage Phase 1 | _____ | Phase 2 _____ | Phase 3 _____ |
| Voltage Ph1-Ph2 | _____ | Ph1-Ph3 _____ | Ph2-Ph3 _____ |
| Voltage Ph1-gnd | _____ | Ph2-gnd _____ | Ph3-gnd _____ |

3. Note unusual vibration, noise, etc.

Functional Performance Test (cont) - Pump []

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Contracting Officer's Representative | _____ |
| Design Agency Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test - Centrifugal Chiller []

Note: If water-cooled chiller perform in conjunction with Cooling Tower test.

1. Demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows:

- a. Time of day startup program initiates chiller start: _____
- b. Start condenser water pump and establish condenser water flow. Verify chiller condenser water proof-of-flow switch operation. _____
- c. Start chilled water pump and establish chilled water flow. Verify chiller chilled water proof-of-flow switch operation. _____
- d. Verify control system energizes chiller start sequence. _____
- e. Verify chiller senses chilled water temperature above set point and control system activates chiller start. _____
- f. Verify functioning of "soft start" sequence. _____
- g. Record data in 2, 3 and 4 below on fully load chiller.
- h. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed. _____
- i. Restart air-handling equipment one minute after chiller shut down. Verify condenser water pump, cooling tower, and chiller restart sequence. _____

2. Verify chiller inlet/outlet pressure and flow reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

| | DESIGN | TAB REPORT | ACTUAL |
|--|--------|------------|--------|
| Chiller inlet pressure [kPa gauge] [psig] | _____ | _____ | _____ |
| Chiller outlet pressure [kPa gauge] [psig] | _____ | _____ | _____ |
| Chiller flow [L/sec] [GPM] | _____ | _____ | _____ |

3. Measure chiller amperage each phase and voltage phase to phase and phase to ground for both the fully loaded condition.

| | | | Motor F/L AMPS |
|----------|---------------|---------------|----------------|
| Amperage | Phase 1 _____ | Phase 2 _____ | Phase 3 _____ |
| Voltage | Ph1-Ph2 _____ | Ph1-Ph3 _____ | Ph2-Ph3 _____ |
| Voltage | Ph1-gnd _____ | Ph2-gnd _____ | Ph3-gnd _____ |

Functional Performance Test (cont) - Centrifugal Chiller []

4. a. Record the following information: Design

| | | | |
|--|---------|---------|-------|
| Ambient dry bulb temperature _____ | [deg C] | [deg F] | _____ |
| Entering chilled water temperature _____ | [deg C] | [deg F] | _____ |
| Leaving chilled water temperature _____ | [deg C] | [deg F] | _____ |

b. Calculate chiller load at ambient conditions and compare to chiller rated capacity from manufacturer's literature. Calculated _____
[Ton] [KWs] Rated _____ [Ton] [KWs].

5. Unusual vibration, noise, etc.

6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Contracting Officer's Representative | _____ |
| Design Agency Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test - Cooling Tower []

1. Demonstrate operation of the cooling tower as per specification and the following:

a. Activate cooling tower fan start using control system command. This should first start condenser water pump, establish flow, delay fan start, as specified, to equalize flow in distribution basin and sump. Verify fan start after timed delay. _____

b. After chiller startup, control system should modulate bypass valve and two-speed fan motor to maintain condenser water set point. Verify function of bypass valve under varying loads. _____

c. Verify cooling tower interlock with chiller. _____

d. Verify makeup water float valve is functioning. _____

e. Activate chemical treatment feed valve, verify makeup of chemical treatment system, pump, and controls. _____

f. Record the following:

Entering water temperature _____ [deg C] [deg F]
Leaving water temperature: _____ [deg C] [deg F]
Measured water flow: _____ [L/s] [gpm]
Entering air wet bulb temperature: _____ [deg C] [deg F]

2. Compare results with test results from cooling tower specification test.

3.

a. Stop all building cooling equipment so that cooling tower pumps stop. Observe tower for at least 15 minutes and verify no overflow occurs _____.

b. Start cooling tower pumps in hand and observe pumps for air binding/cavitation , none allowed _____.

4.Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Design Agency Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - VAV Terminals

The Contracting officer will select VAV terminals to be spot-checked during the functional performance test. The number of terminals selected shall not exceed 10 percent.

1. Functional Performance Test: Contractor shall demonstrate operation of selected VAV boxes as per specifications including the following:

a. Cooling only VAV boxes:

(1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to [5 degrees F] [3 degrees C] below ambient and measure maximum airflow. Turn thermostat to [5 degrees F] [3 degrees C] above ambient and measure minimum airflow.

| | Setting | Measured | Design | | |
|--------------|---------|----------|---------|-------|-------|
| Maximum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |
| Minimum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |

b. Cooling with reheat VAV boxes:

(1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to 3 degrees C (5 degrees F) above ambient and measure maximum airflow. Turn thermostat to 3 degrees C (5 degrees F) below ambient and measure minimum airflow.

| | Setting | Measured | Design | | |
|--------------|---------|----------|---------|-------|-------|
| Maximum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |
| Minimum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |

(2) Verify reheat coil operation range (full closed to full open) by turning room thermostat 3 degrees C (5 degrees F) above ambient _____.

With heating water system and boiler in operation providing design supply hot water temperature record the following:

Design HW supply temperature _____ [deg F] [deg C]
Actual HW supply temperature _____ [deg F] [deg C]
AHU supply air temperature _____ [deg F] [deg C]
VAV supply air temperature _____ [deg F] [deg C]
Calculate coil capacity and compare to design:
Design _____ [W] [BTU/hr] Actual _____ [w] [BTU/hr]

Functional Performance Test Checklist (cont)- VAV Terminals

c. Parallel Fan powered VAV boxes:

(1) Verify VAV box responses to call for heating via set point adjustment. Change from cooling set point to heating set point. Verify cooling damper closes to minimum position, blower fan energizes according to sequence of operation, and upon further drop in space temperature, heating coil activation. _____

With heating water system in operation providing design supply hot water temperature record the following:

Design HW supply temperature _____ [deg F] [deg C]
Actual HW supply temperature _____ [deg F] [deg C]
AHU supply air temperature _____ [deg F] [deg C]
VAV supply air temperature _____ [deg F] [deg C]
Calculate coil capacity and compare to design:
Design _____ [W] [BTU/hr Actual _____ [w] [BTU/hr]]

(2) Check primary air damper maximum/minimum flow settings and compare to actual measured flows.

| | Setting | Measured | Design | | |
|--------------|---------|----------|---------|-------|-------|
| Maximum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |
| Minimum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |

(3) Check blower fan flow. [_____] [L/S] [cfm]

(4) Verify free operation of fan backdraft damper (insure no primary air is being discharged into plenum space).

d. Series Fan Powered VAV boxes

(1) Ensure VAV fan starts prior to AHU fan

(2) Verify VAV box response to sensor call for heating via set point adjustment. Change from cooling set point to heating set point. Verify cooling damper closes to minimum position and upon further drop in space temperature, heating coil activation. With heating water system and boiler in operation providing design supply hot water temperature record the following:

Design HW supply temperature _____ [deg F] [deg C]
Actual HW supply temperature _____ [deg F] [deg C]
AHU supply air temperature _____ [deg F] [deg C]
VAV supply air temperature _____ [deg F] [deg C]
Calculate coil capacity and compare to design:
Design _____ [W] [BTU/hr Actual _____ [w] [BTU/hr]]

(3) Check primary air damper maximum/minimum flow settings and compare to actual measured flows.

| | Setting | Measured | Design | | |
|--------------|---------|----------|---------|-------|-------|
| Maximum flow | [_____] | [_____] | [_____] | [L/s] | [cfm] |

Minimum flow [_____] [_____] [_____] [L/s] [cfm]

Functional Performance Test Checklist (cont) - VAV Terminals

(4) Verify that minimal primary air is discharging into the plenum space when in full cooling mode.

(5) Verify that no plenum air is being induced from the plenum space into the supply air during full cooling by measuring supply air temperature and comparing to primary air temperature

Primary air temp _____ [deg F] [deg C]
Supply air temp _____ [deg F] [deg c]

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

| | Signature and Date |
|--|--------------------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Contracting Officer's Representative | _____ |
| Design Agency Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: [_____]

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions_____.

b. The following shall be verified [supply fan operating] [supply and return fans operating] mode is initiated:

(1) All dampers in normal position prior to fan start_____.

(2) All valves in normal position prior to fan start_____.

(3) System safeties allow start if safety conditions are met._____

(4) VAV fan controller shall "soft-start" fan. _____

(5) Modulate all VAV boxes to minimum air flow and verify that the static pressure does not exceed the high static pressure shutdown setpoint_____.

(6) Return all VAV boxes to auto _____.

c. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position. _____

(2) Return air damper open. _____

(3) Relief air damper [at minimum position] [closed]. _____

(4) Chilled water control valve modulating to maintain leaving air temperature set point. Setpoint _____[deg F][deg C] Actual _____[deg F][deg C]

(5) Fan VAV controller receiving signal from duct static pressure sensor and modulating fan to maintain supply duct static pressure set point.
Setpoint _____[kpa][inches-wg] Actual _____[kpa][inches-wg]

d. Occupied mode of operation - economizer energized.

(1) Outside air damper modulated to maintain mixed air temperature set point. Setpoint _____[deg F][deg C], Actual _____[deg F][deg C], Outside air damper position _____%.

(2) Relief air damper modulates with outside air damper according to sequence of operation. Relief air damper position_____%.

(3) Chilled water control valve modulating to maintain leaving air temperature set point. Setpoint _____[deg F][deg C] Actual _____[deg F][deg C]

(4) Hot water control valve modulating to maintain leaving air temperature set point. Setpoint _____[deg F] [deg C] Actual _____[deg F] [deg C]

Functional Performance Test Checklist (cont) - Variable Volume Air Handling Unit

(5) Fan VAV controller receives signal from duct static pressure sensor and modulates fan to maintain supply duct static pressure set point.

Setpoint [kpa] [inches-wg] _____ Actual
[kpa] [inches-wg] _____

e. Unoccupied mode of operation

(1) Observe fan starts when space temperature calls for heating and/or cooling. _____ Note: This does not apply to series boxes.

(2) All dampers in normal position. _____

(3) Verify space temperature is maintained as specified in sequence of operation. _____

f. The following shall be verified when the [supply fan off] [supply and return fans off] mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) Fan de-energizes. _____

g. Verify the chilled water coil control valve operation by setting all VAV's to maximum and minimum cooling.

Max Cooling

Supply air temp. _____ [deg C] [deg F] Verify cooling valve operation _____.

Min cooling

Supply air temp. _____ [deg C] [deg F] Verify cooling valve operation _____.

h. Verify safety shut down initiated by low temperature protection thermostat. _____

i. Verify occupancy schedule is programmed into time clock/UMCS _____.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Design Agency Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Single Zone Air Handling Unit

For Air Handling Unit: [_____]

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

a. The following shall be verified when the [supply fan operating] [supply and return fans operating] mode is initiated:

(1) All dampers in normal position prior to fan start_____.

(2) All valves in normal position prior to fan start_____.

(3) System safeties allow start if safety conditions are met. ____

b. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position._____

(2) Return air damper open._____

(3) Relief air damper [at minimum position] [closed]._____

(4) Chilled water control valve modulating to maintain space cooling temperature set point. Setpoint _____[deg F] [deg C] Actual _____[deg F] [deg C]

(5) Hot water control valve modulating to maintain space heating temperature set point input from outside air temperature controller. _____

c. Occupied mode of operation - economizer energized.

(1) Outside air damper modulated to maintain mixed air temperature set point. Setpoint _____[deg F] [deg C] Actual _____[deg F] [deg C] O/A damper position _____% Return Air Temperature _____[deg F] [deg C] Outside Air Temperature _____[deg F] [deg C]

(2) Relief air damper modulates with outside air damper according to sequence of operation. Relief air damper position _____%

(3) Chilled water control valve modulating to maintain space cooling temperature set point. Setpoint _____[deg F] [deg C] Actual _____[deg F] [deg C] Return sensor overrides to normal operation.

d. Unoccupied mode of operation.

(1) Observe fan starts when space temperature calls for heating/cooling ____.

(2) All dampers in normal position. _____

(3) Verify low limit space temperature is maintained as specified in sequence of operation. _____

Functional Performance Test Checklist (cont) - Single Zone Air Handling Unit

e. The following shall be verified when the [supply fan off] [supply and return fans off] mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) Fan de-energizes. _____

f. Verify cooling coil and heating coil operation by varying thermostat set point from cooling set point to heating set point and returning to cooling set point _____.

g. Verify safety shut down initiated by low temperature protection thermostat _____.

h. Verify occupancy schedule is programmed into time clock/UMCS _____.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contracting Officer's Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - Multi-zone Air Handling Unit

For Air Handling Unit: [_____]

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

b. The following shall be verified when the supply and return fans operating mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) System safeties allow start if safety conditions are met. ____

b. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position. _____

(2) Return air damper open. _____

(3) Relief air damper [at minimum position] [closed]. _____

(4) Chilled water control valve modulating to maintain cold deck supply air temperature set point. Setpoint _____ [deg F] [deg C] Actual _____ [deg F] [deg C]

(5) Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. Setpoint _____ [deg F] [deg C] Actual _____ [deg F] [deg C] O/A _____ [deg F] [deg C]

c. Occupied mode of operation - economizer energized. Note outside air and return air temperature sensors may need to be simulated.

(1) Outside air damper modulates to maintain mixed air temperature set point. Setpoint _____ [deg F] [deg C] Actual _____ [deg F] [deg C] Return Air Temperature _____ [deg F] [deg C] Outside Air Temperature _____ [deg F] [deg C]

(2) Relief air damper modulates with outside air damper according to sequence of operation. _____

(3) Chilled water control valve modulating to maintain cold deck supply air temperature set point. Setpoint _____ [deg F] [deg C] Actual _____ [deg F] [deg C]

(4) Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. Setpoint _____ [deg F] [deg C] Actual _____ [deg F] [deg C] O/A _____ [deg F] [deg C]
Return temperature sensors to normal operation.

Functional Performance Test Checklist (cont) - Multi-zone Air Handling Unit

d. Unoccupied mode of operation note time clock and space temperature sensor may require simulation.
(4) Observe fan starts when space temperature calls for heating/cooling.
(5) All dampers in normal position. _____
(6) Verify low limit space temperature is maintained as specified in sequence of operation. _____

e. The following shall be verified when the supply and return fans off mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) Fan de-energizes. _____

Note: return time clock and space temperature sensors to normal operation.

f. Verify zone damper operation by varying zone thermostat set points from cooling set point to heating set point and returning to cooling set point. _____

g. Verify safety shut down initiated by low temperature protection thermostat. _____

h. Index room thermostats to full cooling then to full heating. Measure and record cold deck, hot deck, and supply air temperatures and determine damper leakage for a minimum of 2 zones.

Cold deck temperature _____ degrees C (_____ degrees F)

Hot deck temperature _____ degrees C (_____ degrees F)

Zone _____

Zone _____ Supply Air Temperature at Max Cooling _____ [deg C] [deg F]

Zone _____ Supply Air Temperature at Max Heating _____ [deg C] [deg F]

Zone _____ Hot Deck Damper leakage at Max cooling _____ [l/S] [CFM]

Zone _____ Cold Deck Damper leakage at Max heating _____ [l/S] [CFM]

Zone _____

Zone _____ Supply Air Temperature at Max Cooling _____ [deg C] [deg F]

Zone _____ Supply Air Temperature at Max Heating _____ [deg C] [deg F]

Zone _____ Hot Deck Damper leakage at Max cooling _____ [l/S] [CFM]

Zone _____ Cold Deck Damper leakage at Max heating _____ [l/S] [CFM]

i. Verify occupancy schedule is programmed into time clock/UMCS _____.

Functional Performance Test Checklist (cont) - Multi-zone Air Handling Unit

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's TAB Representative

Contractor's Controls Representative

Design Agency Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows.

a. Start chilled water pump and establish chilled water flow. Verify chiller-chilled water proof-of-flow switch operation. _____

b. Verify control system energizes chiller start sequence. _____

c. Verify chiller senses chilled water temperature above set point and control system activates chiller start. Setpoint _____ [deg C] [deg F]
Actual _____ [deg C] [deg F]

d. Verify functioning of "soft start" sequence. _____

e. Verify and record chiller data per 2, 3 and 4 below on fully loaded chiller.

f. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed. _____

g. Restart air handling equipment one minute after chiller shut down. Verify chiller restart sequence. _____

2. Verify chiller inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

| | | DESIGN | TAB TEST | ACTUAL |
|-------------------------|---------------|--------|----------|--------|
| Chiller inlet pressure | (kPa gauge) | _____ | _____ | _____ |
| Chiller inlet pressure | (psig) | _____ | _____ | _____ |
| Chiller outlet pressure | (kPa gauge) | _____ | _____ | _____ |
| Chiller outlet pressure | (psig) | _____ | _____ | _____ |
| Chiller flow | (L/sec) (GPM) | _____ | _____ | _____ |

3. Verify chiller amperage each phase and voltage phase-to-phase and phase-to-ground.

| | | | | Motor F/L AMPS |
|----------|---------|-------|---------|----------------|
| Amperage | Phase 1 | _____ | Phase 2 | _____ |
| | | | Phase 3 | _____ |
| Voltage | Ph1-Ph2 | _____ | Ph1-Ph3 | _____ |
| | | | Ph2-Ph3 | _____ |
| Voltage | Ph1-gnd | _____ | Ph2-gnd | _____ |
| | | | Ph3-gnd | _____ |

Functional Performance Test Checklist (cont) - Packaged Air Cooled Chiller

4.

a. Record the following information:

| | | | | Design | | | | |
|------------------------------------|-------|---------|---------|--------|---------|---------|--|--|
| Ambient dry bulb temperature | _____ | degrees | [C] [F] | _____ | degrees | [C] [F] | | |
| Entering chilled water temperature | _____ | degrees | [C] [F] | _____ | degrees | [C] [F] | | |
| Leaving chilled water temperature | _____ | degrees | [C] [F] | _____ | degrees | [C] [F] | | |

b. Calculate chiller load at ambient conditions and compare to chiller rated capacity from manufacturer's literature. Calculated _____
[Ton] [KW] Rated _____ [Ton] [KW].

5. Unusual vibration, noise, etc.

6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contracting Officer's Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - Air Cooled Condensing Unit

For Condensing Unit: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of refrigeration system as per specifications including the following: Start building air handler to provide load for condensing unit. Activate controls system start sequence as follows.

a. Start air handling unit. Verify control system energizes condensing unit start sequence. _____

b. Verify and record data in 2 and 3 below.

c. Shut off air handling equipment to verify condensing unit de-energizes. _____

d. Restart air handling equipment one minute after condensing unit shut down. Verify condensing unit restart sequence. _____

2. Verify condensing unit amperage each phase and voltage phase to phase and phase to ground.

Motor Full-Load Amps _____

Amperage Phase 1 _____ Phase 2 _____ Phase 3 _____

Voltage Ph1-Ph2 _____ Ph1-Ph3 _____ Ph2-Ph3 _____

Voltage Ph1-gnd _____ Ph2-gnd _____ Ph3-gnd _____

3. Record the following information:

| | | |
|------------------------------|-------|--------------------|
| Ambient dry bulb temperature | _____ | degrees [C] [F] |
| Suction pressure | _____ | [kPa gauge] [psig] |
| Discharge pressure | _____ | [kPa gauge] [psig] |

4. Unusual vibration, noise, etc.

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Design Agency Representative _____

Contracting Officer's Representative _____

Using Agency's Representative

Functional Performance Test Checklist - Hot Water Boiler

For Boiler: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of hot water system as per specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.

a. Start hot water pump and establish hot water flow. Verify boiler hot water proof-of-flow switch operation. _____

b. Verify control system energizes boiler start sequence. _____

c. Verify boiler senses hot water temperature below set point and control system activates boiler start. Setpoint _____ [deg C] [deg F]

2. Verify boiler inlet/outlet pressure reading, compare to Test and Balance (TAB) Report, boiler design conditions, and boiler manufacturer's performance data.

| | DESIGN | SYSTEM TEST | ACTUAL |
|---|--------|-------------|--------|
| Boiler inlet water temperature [deg C/F] | _____ | _____ | _____ |
| Boiler outlet water temperature [deg C/F] | _____ | _____ | _____ |
| Boiler outlet pressure (kPa gauge) [psig] | _____ | _____ | _____ |
| Boiler flow rate (L/s) [gpm] | _____ | _____ | _____ |
| Flue-gas temperature at boiler outlet [deg C] [deg F] | _____ | _____ | _____ |
| Percent carbon dioxide in flue-gas | _____ | _____ | _____ |
| Draft at boiler flue-gas exit [kpa] [inches-wg] | _____ | _____ | _____ |
| Stack emission pollutants concentration | _____ | _____ | _____ |
| Fuel type | _____ | _____ | _____ |
| Combustion efficiency | _____ | _____ | _____ |

3. Record the following information:

Ambient dry bulb temperature to determine reset schedule _____ degrees [C] [F]
Building Entering hot water temperature _____ degrees [C] [F]
Building Leaving hot water temperature _____ degrees [C] [F]

4. Verify temperatures in item 3 are in accordance with the reset schedule. _____

5. Verify proper operation of boiler safeties. _____
- a. Low water _____
 - b. Water flow _____
 - c. Flame failure _____
 - d. Pilot failure _____
 - e. Pre and Post Purge failure _____
 - f. Pressure relief _____
 - g. High temperature _____

6. Shut off building heating equipment to remove load on hot water system. Verify boiler shutdown sequence is initiated and accomplished after load is removed. _____

Functional Performance Test Checklist (cont) - Hot Water Boiler

7. Unusual vibration, noise, etc.

8. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's TAB Representative

Contractor's Controls Representative

Design Agency Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Steam Boiler

For Boiler: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of steam heating system as per specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.

a. Start steam heating system. Verify control system energizes boiler start sequence. _____

b. Verify boiler senses steam pressure below set point and control system activates boiler start. _____

c. Shut off building heating equipment to remove load on steam heating system. Verify boiler shutdown sequence is initiated and accomplished after load is removed. _____

d. Verify that water level and makeup water system are operational.

2. Verify boiler inlet/outlet pressure reading, compare to boiler design conditions and manufacturer's performance data.

| | DESIGN | SYSTEM TEST | ACTUAL |
|---|--------|-------------|--------|
| Boiler inlet feedwater temp (deg C/F) | _____ | _____ | _____ |
| Boiler outlet pressure (kPa gauge) [psig] | _____ | _____ | _____ |
| Flue-gas temperature at boiler outlet (deg C/F) | _____ | _____ | _____ |
| Percent carbon dioxide in flue-gas | _____ | _____ | _____ |
| Draft at boiler flue-gas exit [kpa] [inches-wg] | _____ | _____ | _____ |
| Stack emission pollutants concentration | _____ | _____ | _____ |
| Fuel type | _____ | _____ | _____ |
| Combustion efficiency | _____ | _____ | _____ |

3. Record the following information:

Ambient temperature _____ [deg C] [deg F]

4. Verify proper operation of boiler safeties. _____

5. Unusual vibration, noise, etc.

6. Visually check refractory for cracks or spalling and refractory and tubes for flame impingement. _____

Functional Performance Test Checklist (cont) - Steam Boiler

7. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contracting Officer's Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - Fan Coil Units

The Contracting Officer will select fan coil units to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent. Hot water and chilled water systems must be in operation providing design water temperatures.

1. Functional Performance Test: Contractor shall demonstrate operation of selected fan coils as per specifications including the following:

a. Cooling only fan coils:

(1) Verify fan coil unit response to room temp set point adjustment.

1. Check blower fan airflow. _____ [L/s] [cfm]
2. Check cooling coil water flow. _____ [L/s] [gpm]
3. Verify proper operation of cooling water control

valve. _____

4. Cooling mode inlet air temperature _____ [deg F] [deg C]
5. Cooling mode outlet air temperature _____ [deg F] [deg C]
6. Calculate coil sensible capacity and compare to design:
Calculated _____ [BTU/hr] [Watts] Design _____ [BTU/hr] [Watts]

b. Cooling/heating fan coils:

(1) Verify fan coil unit response to room temp set point adjustment.

1. Check blower fan airflow. _____ [L/s] [cfm]
2. Check cooling coil water flow. _____ [L/s] [gpm]
3. Verify proper operation of cooling water control valve. _____
4. Check cooling mode inlet air temperature. _____ [deg C] [deg F]
5. Check cooling mode outlet air temperature. _____ [deg C] [deg F]
6. Calculate cooling coil sensible capacity and compare to

design:

7. Calculated _____ [BTU/hr] [watts] Design _____ [BTU/hr] [watts]
8. Check heating coil water flow. _____ [L/s] [gpm]
9. Verify proper operation of heating water control valve. _____
10. Check heating mode inlet air temperature. _____ [deg C] [deg F]
11. Check heating mode outlet air temperature. _____ [deg C] [deg F]
12. Calculate heating coil capacity and compare to design:
Calculated _____ [BTU/hr] [watts] design _____ [BTU/hr] [watts]

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's TAB Representative

Contractor's Controls Representative

Design Agency Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Unit Heaters

The Contracting Officer will select unit heaters to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent. Hot water systems {for hot water unit heaters} must be in operation and supplying design hot water supply temperature water.

1. Functional Performance Test: Contractor shall demonstrate operation of selected unit heaters:

- a. Verify unit heater response to room temperature set point adjustment. _____
- b. Check heating mode inlet air temperature. _____ [deg C] [deg F]
- c. Check heating mode outlet air temperature. _____ [deg C] [deg F]
- d. Record manufacturer's submitted fan capacity _____ [L/sec] [cfm]
- e. Calculate unit heater capacity using manufacturer's fan capacity and recorded temperatures and compare to design.
 - i. Calculated _____ [BTU/hr] [watts] Design _____ [BTU/hr] [Watts]

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contracting Officer's Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - Steam/Hot Water Converter

For Converter: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of heating system as per specifications including the following: Start building heating equipment to provide load for converter.

a. Verify control system energizes. _____

b. Verify converter senses hot water temperature below set point and control system modulates steam valve. _____

c. Shut off building heating equipment to remove load on heating system. Verify converter steam valve closes after load is removed. _____

2. Verify converter inlet/outlet pressure reading, compare to converter design conditions and manufacturer's performance data.

| | DESIGN | ACTUAL |
|---|------------------|--------------------|
| Converter inlet water temp (deg C/F) | _____ | _____ |
| Converter outlet water temp (deg C/F) | _____ | _____ |
| Converter inlet steam pressure (kpa) [pasg] | _____ | _____ |
| Determine water flow rate based on pressure drop through converter [L/S] [GPM] | _____ | _____ |
| Determine water flow rate with flow measuring device [L/S] [GPM] | _____ | _____ |
| Verify that temperature of water is in accordance with outdoor air reset schedule | Current Setpoint | Actual Temperature |
| | _____ | _____ |

3. Verify proper operation of converter safeties. _____

4. Check and report unusual vibration, noise, etc. _____

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contracting Officer's Representative | _____ |

Using Agency's Representative

Functional Performance Test Checklist - Computer Room Unit

For Computer Room Unit: [_____]

1. Functional Performance Test: Contractor shall verify operation of computer room unit as per specification including the following:

- a. System safeties allow start if safety conditions are met. _____
- b. Verify cooling and heating operation by varying thermostat set point from space set point to space set point plus 10 degrees, space set point minus 10 degrees, and returning to space set point. _____
- c. Verify humidifier operation by varying humidistat set point from space set point to space set point plus 20 percent RH, and returning to space set point.

- d. Verify that airflow is within tolerance specified in Section 15990.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contracting Officer's Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - HVAC Controls

For HVAC System: [_____]

The Contracting Officer will select HVAC control systems to undergo functional performance testing. The number of systems shall not exceed 10 percent. Perform this test simultaneously with FPT for AHU or other controlled equipment.

1. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the Performance Verification Test {PVT} test for that system. Contractor to provide blank PVT test procedures previously done by the controls Contractor.

2. Verify interlock with UMCS system_____.

3. Verify all required I/O points function from the UMCS system_____.

4. Certification: We the undersigned have witnessed the Performance Verification Test and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

| | |
|--|-------|
| Contractor's Commissioning Specialist | _____ |
| Contractor's Mechanical Representative | _____ |
| Contractor's Electrical Representative | _____ |
| Contractor's TAB Representative | _____ |
| Contractor's Controls Representative | _____ |
| Design Agency Representative | _____ |
| Contractor's Officer's Representative | _____ |
| Using Agency's Representative | _____ |

Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of energy recovery system as per specifications including the following: Start equipment to provide energy source for recovery system.

a. Verify energy source is providing recoverable energy. _____

b. Verify recovery system senses available energy and activates. _____

2. Verify recovery system inlet/outlet readings, compare to design conditions and manufacturer's performance data.

| | Design | Actual |
|--|--------|--------|
| Primary loop inlet temp (degrees C/F) | _____ | _____ |
| Primary loop outlet temp (degrees C/F) | _____ | _____ |
| Primary loop flow rate [l/S] [gpm] [cfm] | _____ | _____ |
| Secondary loop inlet temp (degrees C/F) | _____ | _____ |
| Secondary loop outlet temp (degrees C/F) | _____ | _____ |
| Secondary loop flow rate [l/S] [gpm] [cfm] | _____ | _____ |
| Primary loop energy (watts) [BTU/hr] | _____ | _____ |
| Secondary loop energy (watts) [BTU/hr] | _____ | _____ |

3. Verify that recovery system deactivates when recoverable energy is no longer available. _____

4. Check and report unusual vibration, noise, etc. _____

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Design Agency Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

- End of Appendix B -

-End of 15995 document
-- End of Section --