SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

1.0 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals. The following shall be submitted in accordance with Section 01 33 00, SUBMITTAL PROCEDURES:

SD-01 Data

Commissioning Team.

List of team members who will represent the Contractor in the pre-commissioning checks and functional performance testing, at least 2 weeks prior to the start of pre-commissioning checks. Proposed revision to the list, prior to the start of the impacted work.

SD-06 Instructions

Test Procedures

Detailed procedures for pre-commissioning checks and functional performance tests, at least 4 weeks prior to the start of pre-commissioning checks.

SD-07 Schedules

Test Schedule

Schedule for pre-commissioning checks and functional performance tests, at least 2 weeks prior to the start of pre-commissioning checks.

SD-09 Reports

Test Reports

Completed pre-commissioning checklists and functional performance test checklists organized by system and by subsystem and submitted as one package. The results of failed tests shall be included along with a description of the corrective action taken.

1.2 SEQUENCING AND SCHEDULING

The work described in this Section shall begin only after all work required in related Sections, including Section 23 73 33, HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS and Section 23 05 93, TESTING, ADJUSTING AND BALANCING OF HVAC SYSTEMS, has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Seismic details shall be in accordance with Sections 13 48 00, SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 22 05 48, SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as indicated

1.3 PRODUCTS (NOT APPLICABLE)

3.0 EXECUTION

3.1 COMMISSIONING TEAM AND CHECKLISTS

The Contractor shall designate team members to participate in the pre-commissioning checks and the functional performance testing specified herein. In addition, the Government will be represented by a representative of the Contracting Officer, the Design Agent's Representative, and the Using Agency. The team members shall be as follows:

Designation	Function
Q	Contractor's Chief Quality Control Representative
M	Contractor's Mechanical Representative
E	Contractor's Electrical Representative
T	Contractor's Testing, Adjusting, and Balancing Representative
C	Contractor's Controls Representative
D	Design Agent's Representative
O	Contracting Officer's Representative
U	Using Agency's Representative

Each checklist shown in appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each pre-commissioning 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 checklist shall be indicated by signature and date.

3.2 TESTS

The pre-commissioning checks and functional performance tests shall be performed in a manner which 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-commissioning checks and functional performance tests. A pre-commissioning check or 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. The Contractor shall reimburse the Government for all costs associated with effort lost due to tests that are aborted. These costs shall include salary, travel costs and per diem (where applicable) for Government commissioning team members.

3.2.1 Pre-Commissioning Checks

Pre-commissioning checks shall be performed for the items indicated on the checklists in Appendix A, as required. Deficiencies discovered during these checks shall be corrected and retested in accordance with the applicable contract requirements.

3.2.2 Functional Performance Tests

Functional performance tests shall be performed for the items indicated on the checklists in Appendix B, as required. Functional performance tests shall begin only after all pre-commissioning checks 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 checklist item, the Contractor shall correct all deficiencies in accordance with the applicable contract requirements. The checklist shall then be repeated until it has been completed with no errors.

APPENDIX A

PRE-COMMISSIONING CHECKLISTS

Pre-commissioning checklist - Piping

For Indicated Piping System

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Piping complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Piping flushed and cleaned.	___	___	X	___	X	___	___	___
d. Strainers cleaned.	___	___	X	___	X	___	___	___
e. Valves installed as required.	___	___	X	___	X	___	___	___
f. Piping insulated as required.	___	___	X	___	X	___	___	___
g. Thermometers and gauges installed as required.	___	___	X	___	X	___	___	___
h. Verify operation of valves.	___	___	X	___	___	___	___	___
i. Air vents installed as specified.	___	___	X	X	X	___	___	___
j. Flexible connectors installed as specified	___	___	X	X	X	___	___	___
k. Verify that piping has been labeled and valves identified as specified.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Hydrostatic test complete.	___	___	X	___	X	___	___	___
b. TAB operation complete.	___	___	X	___	___	___	___	___

Pre-commissioning Checklist - Ductwork

For Air Handler: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Ductwork complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Ductwork leak test complete.	___	___	X	___	X	___	___	___
d. Fire dampers, smoke dampers, and access doors installed as required with installation of each verified by the specified team members initialing each location on a copy of the as-built drawings.	___	___	X	___	X	___	___	___
e. Ductwork insulated as required.	___	___	X	___	X	___	___	___
f. Thermometers and gauges installed as required.	___	___	___	___	___	___	___	___
g. Verify open/closed status of dampers.	___	___	X	___	X	___	___	___
h. Verify smoke dampers operation.	___	___	X	___	___	___	___	___
i. Flexible connectors installed as specified	___	___	X	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. TAB operation complete.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - Multizone Air Handling Unit

For Air Handling Unit: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed [and freed to float with adequate Movement and seismic restraint] as specified.	___	___	X	X	X	___	___	___
b. Inspection and access doors are operable and sealed.	___	___	X	___	X	___	___	___
c. Casing undamaged.	___	___	X	X	X	___	___	___
d. Insulation undamaged.	___	___	X	X	X	___	___	___
e. Condensate drainage is unobstructed. (Visually verify pan drains completely By pouring a cup of water into drain pan.)	___	___	X	X	X	___	___	___
f. Fan belt adjusted.	___	___	X	___	X	___	___	___
g. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___	___	___
Electrical								
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	___	___	___	___
Coils								
a. Chilled water piping properly connected.	___	___	X	X	X	___	___	___

a. Refrigerant piping properly connected.	___	___	X	X	X	___	___	___
b. Chilled water piping pressure tested.	___	___	X	X	X	___	___	___
b. Refrigerant piping pressure tested.	___	___	X	X	X	___	___	___
c. Hot water piping properly connected.	___	___	X	X	X	___	___	___
c. Steam and condensate piping properly connected.	___	___	X	X	X	___	___	___
d. Hot water piping pressure tested.	___	___	X	X	X	___	___	___
d. Steam and condensate piping pressure tested.	___	___	X	X	X	___	___	___
e. Air vents installed on water coils with shutoff valves as specified.	___	___	X	X	X	___	___	___
f. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
Controls								
a. Control valves/actuators properly installed.	___	___	X	___	___	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___	___	___
c. O.A. dampers/actuators properly installed.	___	___	X	___	___	___	___	___
d. O.A. dampers/actuators operable.	___	___	X	___	___	___	___	___
e. Zone dampers/actuators properly installed.	___	___	X	___	___	___	___	___
f. Zone dampers/actuators operable.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Construction filters removed and replaced.	___	___	X	___	X	___	___	___
b. TAB report submitted.	___	___	X	___	X	___	___	___

c. TAB results within +10%/-0% of cfm shown on drawings

d. TAB results for outside air intake within +10%/-0% of CFM shown on drawings. ___ ___ X ___ X ___ ___ ___

Pre-commissioning Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed.	___	___	X	X	X	___	___	___
b. Inspection and access doors are operable and sealed.	___	___	X	___	X	___	___	___
c. Casing undamaged.	___	___	X	X	X	___	___	___
d. Insulation undamaged.	___	___	X	X	X	___	___	___
e. Condensate drainage is unobstructed. (Visually verify drainage by pouring a cup of water into drain pan.)	___	___	X	X	X	___	___	___
f. Fan belt adjusted.	___	___	X	___	X	___	___	___
g. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___	___	___
Electrical	Q	M	E	T	C	D	O	U
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	X	___	___	___
Coils	Q	M	E	T	C	D	O	U
a. Chilled water piping properly connected.	___	___	X	X	X	___	___	___
b. Refrigerant piping properly connected.	___	___	X	X	X	___	___	___

b. Chilled water piping pressure tested.	___	___	X	X	X	___	___	___
b. Refrigerant piping pressure tested.	___	___	X	X	X	___	___	___
c. Hot water piping properly connected.	___	___	X	X	X	___	___	___
c. Steam and condensate piping properly connected.	___	___	X	X	X	___	___	___
d. Hot water piping pressure tested.	___	___	X	X	X	___	___	___
d. Steam and condensate piping pressure tested.	___	___	X	X	X	___	___	___
e. Air vents installed on water coils with shutoff valves as specified.	___	___	X	X	X	___	___	___
f. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___

Controls	Q	M	E	T	C	D	O	U
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, installation and calibration of duct static pressure sensor.	___	___	X	___	___	___	___	___
f. Fan air volume controller operable.	___	___	X	___	___	___	___	___
g. Air handler controls system operational.	___	___	X	___	___	___	___	___

Testing, Adjusting, and Balancing (TAB)	Q	M	E	T	C	D	O	U
a. Construction filters removed and replaced.	___	___	X	___	___	___	___	___
b. TAB report submitted.	___	___	X	___	X	___	___	___
c. TAB results within +10%/-0% of cfm shown on drawings								

d. TAB results for outside air intake within +10%/-0% of both the minimum and maximum cfms shown on drawings.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - VAV Terminal

For VAV Terminal: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. VAV terminal in place.	___	___	X	X	X	___	___	___
b. VAV terminal ducted.	___	___	X	X	X	___	___	___
c. VAV terminal connected to controls.	___	___	X	X	___	___	___	___
d. Reheat coil connected to hot water pipe.	___	___	X	___	X	___	___	___
e. Electric reheat coil connected to local disconnect.	___	___	___	___	X	___	___	___
f. Manufacturer's required maintenance clearance provided.						___	___	X
X ___ ___ ___								

Controls	Q	M	E	T	C	D	O	U
a. Cooling only VAV terminal controls set.	___	___	X	X	___	___	___	___
b. Cooling only VAV controls verified.	___	___	X	X	___	___	___	___
c. Reheat VAV terminal controls set.	___	___	X	X	___	___	___	___
d. Reheat terminal/coil controls verified.	___	___	X	X	___	___	___	___

Testing, Adjusting, and Balancing (TAB)	Q	M	E	T	C	D	O	U
a. Verify terminal maximum air flow set.	___	___	X	___	___	___	___	___
b. Verify terminal minimum air flow set.	___	___	X	___	___	___	___	___
c. TAB operation complete.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - DX Air Cooled Condensing Unit

For Condensing Unit: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation	___	___	X	X	X	___	___	___
b. Refrigerant pipe leak tested.	___	___	X	X	X	___	___	___
c. Refrigerant pipe evacuated and charged in accordance with manufacturer's instructions.	___	___	X	X	X	___	___	___
d. Check condenser fans for proper rotation.	___	___	X	___	X	___	___	___
e. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
f. Manufacturer's required maintenance/ operational clearance provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	X	___	___	___
b. Power available to unit control panel.	___	___	___	X	___	___	___	___
c. Verify that power disconnect is located within sight of the unit it controls	___	___	___	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-commissioning Checklist - Pumps

For Pump: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Pumps grouted in place.	___	___	X	X	X	___	___	___
b. Pump vibration isolation devices functional.	___	___	X	X	X	___	___	___
c. Pump/motor coupling alignment verified.	___	___	X	X	X	___	___	___
d. Piping system installed.	___	___	X	X	X	___	___	___
e. Piping system pressure tested.	___	___	X	X	X	___	___	___
f. Pump not leaking.	___	___	X	X	X	___	___	___
g. Field assembled couplings aligned to meet manufacturer's prescribed tolerances.	___	___	X	X	X	___	___	___
Electrical	Q	M	E	T	C	D	O	U
a. Power available to pump disconnect.	___	___	___	X	X	___	___	___
b. Pump rotation verified.	___	___	___	X	X	___	___	___
c. Control system interlocks functional.	___	___	___	X	___	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Pressure/temperature gauges installed.	___	___	X	___	X	___	___	___
b. Piping system cleaned.	___	___	X	X	X	___	___	___
c. Chemical water treatment complete.	___	___	X	X	X	___	___	___
d. Water balance complete.	___	___	X	___	X	___	___	___
e. Water balance with design maximum flow.	___	___	X	___	X	___	___	___

f. TAB Report submitted.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - Packaged Air Cooled Chiller

For Chiller: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Chiller properly piped.	___	___	X	___	___	___	___	___
b. Chilled water pipe leak tested.	___	___	X	X	X	___	___	___
c. Verify that refrigerant used complies with specified requirements.	___	___	X	X	X	___	___	___
d. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
e. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	___	___	___	___
b. Power available to unit control panel.	___	___	___	X	___	___	___	___
c. Separate power is supplied to electric heating tape.	___	___	___	X	___	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Controls								
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-commissioning Checklist - Centrifugal Chiller

For Chiller: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Chilled water connections properly piped.	__	__	X	__	__	__	__	__
b. Condenser water connections properly piped.	__	__	X	__	__	__	__	__
c. Chilled water pipe leak tested.	__	__	X	X	X	__	__	__
d. Condenser water pipe leak tested.	__	__	X	X	X	__	__	__
e. High efficiency purge unit installed and operating as specified.	__	__	X	X	X	__	__	__
f. Refrigerant leak detector installed.	__	__	__	__	__	__	__	__
g. Oxygen sensor installed and tested.	__	__	__	__	__	__	__	__
h. Mechanical room ventilation installed as specified.	__	__	__	__	__	__	__	__
i. Manufacturer's required maintenance clearance provided.	__	__	X	X	__	__	__	__
j. Field assembled couplings aligned to meet manufacturer's prescribed tolerances.	__	__	X	X	X	__	__	__
Electrical								
a. Power available to unit starter.	__	__	__	X	__	__	__	__
b. Power available to unit control panel.	__	__	__	X	__	__	__	__
c. Verify that power disconnect is located within sight of the unit it controls.	__	__	__	X	__	__	__	__

Controls	Q	M	E	T	C	D	O	U
a. Factory startup and checkout complete.	__	__	X	X	__	__	__	__
b. Chiller safety/protection devices tested.	__	__	__	X	__	__	__	__

c. Chilled water flow switch installed.	__	__	X	X	__	__	__	__
d. Chilled water flow switch tested.	__	__	X	X	__	__	__	__
e. Chilled water pump interlock installed.	__	__	__	X	__	__	__	__
f. Chilled water pump interlock tested.	__	__	__	X	__	__	__	__
g. Condenser water flow switch installed.	__	__	X	__	__	__	__	__
h. Condenser water flow switch tested.	__	__	__	X	__	__	__	__
i. Condenser water pump interlock installed.	__	__	__	X	__	__	__	__
j. Condenser water pump interlock tested.	__	__	__	X	__	__	__	__

Pre-commissioning Checklist - Cooling Tower

For Cooling Tower: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Cooling tower in place.	__	__	X	__	__	__	__	__
b. Cooling tower piped.	__	__	X	X	__	__	__	__
c. Cooling tower fan drive adjusted.	__	__	__	__	X	__	__	__
d. Cooling tower makeup water supply piped.	__	__	X	X	__	__	__	__
e. Verify makeup control valve shutoff.	__	__	X	__	X	__	__	__
f. Fan lubricated and blade pitch adjusted.	__	__	X	__	X	__	__	__
g. Manufacturer's required maintenance/ operational clearance provided.	__	__	X	X	X	__	__	__
Electrical								
a. Power available to tower disconnect.	__	__	__	X	__	__	__	__
b. Power available to electric sump heater.	__	__	__	X	__	__	__	__
c. Control system interlocks functional.	__	__	__	X	__	__	__	__
d. Motor and fan rotation checked.	__	__	__	X	__	__	__	__
e. Verify that power disconnect is located within sight of the unit is controls.	__	__	__	X	__	__	__	__
Piping								
a. Tower basin is clean and filled.	__	__	X	X	X	__	__	__
b. Condenser water treatment functional.	__	__	X	X	X	__	__	__
c. Water balance with design flow verified.	__	__	X	__	X	__	__	__
d. Water distribution headers balanced.	__	__	X	__	X	__	__	__

Pre-commissioning Checklist - Hot Water Boiler

For Boiler: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Boiler flue installed.	__	__	X	__	__	__	__	__
b. Boiler hot water piping installed.	__	__	X	__	__	__	__	__
c. Boiler hot water piping tested.	__	__	X	X	__	__	__	__
d. Boiler makeup water piping installed.	__	__	X	__	__	__	__	__
e. Boiler fuel oil piping installed.	__	__	X	X	X	__	__	__
f. Boiler fuel oil piping tested.	__	__	X	X	X	__	__	__
g. Boiler gas piping installed.	__	__	X	X	X	__	__	__
h. Boiler gas piping tested.	__	__	X	X	X	__	__	__
i. Manufacturer's required maintenance clearance provided.	__	__	X	__	__	__	__	__
Startup								
a. Boiler system cleaned and filled with treated water.	__	__	X	__	__	__	__	__
b. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre and post purge, have been tested.	__	__	__	X	__	__	__	__
c. Verify that PRV rating conforms to boiler rating.	__	__	__	X	__	__	__	__
d. Boiler water treatment system functional.	__	__	X	X	__	__	__	__
e. Boiler startup and checkout complete.	__	__	X	X	__	__	__	__
f. Combustion efficiency demonstrated.	__	__	X	__	X	__	__	__
Electrical								
a. Verify that power disconnect is located within sight of the unit served.	__	__	__	X	__	__	__	__
Controls								

a. Hot water pump interlock installed.	__	__	__	X	__	__	__	__
b. Hot water pump interlock tested.	__	__	__	X	__	__	__	__
c. Hot water heating system balanced.	__	__	X	X	__	__	__	__
d. Hot water heating controls operational.	__	__	X	X	__	__	__	__

Pre-commissioning Checklist - Steam Boiler

For Boiler: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Boiler flue installed.	__	__	X	X	X	__	__	__
b. Boiler steam piping installed.	__	__	X	X	X	__	__	__
c. Boiler steam piping tested.	__	__	X	X	X	__	__	__
d. Boiler makeup water piping installed.	__	__	X	__	X	__	__	__
e. Boiler makeup water piping tested.	__	__	X	X	X	__	__	__
f. Boiler fuel oil piping installed.	__	__	X	X	X	__	__	__
g. Boiler fuel oil piping tested.	__	__	X	X	X	__	__	__
h. Boiler gas piping installed.	__	__	X	X	X	__	__	__
i. Boiler gas piping tested.	__	__	X	X	X	__	__	__
j. Manufacturer's required maintenance clearance provided.	__	__	X	X	X	__	__	__
Startup								
a. Boiler system cleaned and filled with treated water.	__	__	X	X	X	__	__	__
b. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre and post purge, have been tested.	__	__	__	X	__	__	__	__
c. Verify that PRV rating conforms to boiler rating.	__	__	__	X	__	__	__	__
d. Boiler feed water system operational.	__	__	__	X	__	__	__	__
e. Boiler water treatment system functional.	__	__	X	X	X	__	__	__
f. Boiler startup and checkout complete.	__	__	__	X	__	__	__	__
g. All steam traps operational.	__	__	X	X	X	__	__	__
h. All condensate return pumps operational.	__	__	__	__	X	__	__	__

i. Combustion efficiency demonstrated.	__	__	X	__	X	__	__	__
Electrical								
a. Verify that power disconnect is located within sight of the unit served.	__	__	__	X	__	__	__	__

Pre-commissioning Checklist - Steam/Hot Water Converter

For Converter: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Converter steam piping installed.	__	__	X	__	X	__	__	__
b. Converter steam piping tested.	__	__	X	X	X	__	__	__
c. Hot water piping installed.	__	__	X	__	__	__	__	__
d. Hot water piping tested.	__	__	X	X	X	__	__	__
e. Makeup water piping installed.	__	__	X	X	X	__	__	__
f. Vacuum breaker installed on shell of shell and tube unit.	__	__	X	X	X	__	__	__
g. Air vent installed as specified.	__	__	X	X	X	__	__	__
h. Manufacturer's required maintenance clearance provided.	__	__	X	X	X	__	__	__
Startup								
a. Hot water system cleaned and filled.	__	__	X	X	X	__	__	__
b. All steam traps operational.	__	__	X	X	X	__	__	__
c. All condensate return pumps operational.	__	__	__	X	__	__	__	__
d. Converter safety/protection devices tested.	__	__	X	X	X	__	__	__
e. Converter startup and checkout complete.	__	__	X	X	X	__	__	__
Controls								
a. Control valves/actuators properly installed.	__	__	X	__	__	__	__	__
b. Control valves/actuators operable.	__	__	X	__	__	__	__	__

Pre-commissioning Checklist - Fan Coil Unit

For Fan Coil Unit: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed.	__	__	X	X	X	__	__	__
b. Access doors/removable panels are operable and sealed.	__	__	X	__	X	__	__	__
c. Casing undamaged.	__	__	X	X	X	__	__	__
d. Insulation undamaged.	__	__	X	X	X	__	__	__
e. Condensate drainage is unobstructed.	__	__	X	X	X	__	__	__
f. Fan belt adjusted.	__	__	X	__	X	__	__	__
g. Any damage to coil fins has been repaired.	__	__	X	__	X	__	__	__
h. Manufacturer's required maintenance clearance provided.	__	__	X	X	X	__	__	__
Electrical								
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. Dual temperature piping properly connected.	__	__	X	__	__	__	__	__
a. Chilled water piping properly connected.	__	__	X	X	X	__	__	__
b. Dual temperature piping pressure tested.	__	__	X	__	__	__	__	__
b. Chilled water piping pressure tested.	__	__	X	X	X	__	__	__
c. Hot water piping properly connected.	__	__	X	__	__	__	__	__

d. Hot water piping pressure tested.	__	__	X	__	__	__	__	__
Controls								
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. Construction filters removed and replaced.	__	__	X	__	__	__	__	__
b. TAB results +10%/-0% of cfm shown on drawings								
c. TAB Report submitted.	__	__	X	__	X	__	__	__

Pre-commissioning Checklist - Unit Heater

For Unit Heater: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Hot water piping properly connected.	__	__	X	__	__	__	__	__
a. Steam and condensate piping properly connected.	__	__	X	X	X	__	__	__
b. Hot water piping pressure tested.	__	__	X	__	__	__	__	__
b. Steam and condensate piping pressure tested.	__	__	X	X	X	__	__	__
c. Air vent installed on hot water coil with shutoff valve as specified.	__	__	X	X	X	__	__	__
d. Any damage to coil fins has been repaired.	__	__	X	__	X	__	__	__
e. Manufacturer's required maintenance/ operational clearance provided.	__	__	X	X	X	__	__	__
Electrical								
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. 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. TAB Report submitted.	__	__	X	__	X	__	__	__

Pre-commissioning Checklist - Exhaust Fan

For Exhaust Fan: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Fan belt adjusted.	__	__	X	__	X	__	__	__
Electrical								
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. 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. TAB results +10%/-0% to cfm shown on drawings	__	__	X	__	X	__	__	__
b. TAB Report submitted.	__	__	X	__	X	__	__	__

Pre-commissioning Checklist - Computer Room Unit

For Computer Room Unit: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Unit properly supported.	__	__	X	X	X	__	__	__
b. Access doors are operable and sealed.	__	__	X	__	X	__	__	__
c. Casing undamaged.	__	__	X	X	X	__	__	__
d. Insulation undamaged.	__	__	X	X	X	__	__	__
e. Condensate drainage is unobstructed and routed to floor drain.	__	__	X	X	X	__	__	__
f. Fan belt adjusted.	__	__	X	__	X	__	__	__
g. Manufacturer's required maintenance operational clearance provided.	__	__	X	X	X	__	__	__
Electrical								
a. Power available to unit disconnect.	__	__	__	X	X	__	__	__
b. Proper motor rotation verified.	__	__	__	__	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 reheat coils.	__	__	__	__	X	__	__	__
Coils/Humidifier								
a. Chilled water piping properly connected.	__	__	X	__	__	__	__	__
a. Refrigerant piping properly connected.	__	__	X	X	X	__	__	__
b. Chilled water piping pressure tested.	__	__	X	X	X	__	__	__
b. Refrigerant piping pressure tested.	__	__	X	X	X	__	__	__
c. Hot water piping properly connected.	__	__	X	__	__	__	__	__
c. Steam piping properly connected.	__	__	X	X	X	__	__	__
d. Hot water piping pressure tested.	__	__	X	X	__	__	__	__

d. Steam piping pressure tested.	__	__	X	X	X	__	__	__
e. Humidifier makeup water connected.	__	__	X	X	X	__	__	__
Controls								
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. Construction filters removed and replaced.	__	X	__	X	__	__	__	
b. TAB results +10%/-0% cfm shown on drawings.	__	__	X	___	X	__	__	__
c. TAB Report submitted.	__	__	X	__	X	__	__	__

Pre-commissioning Checklist - HVAC System Controls

For HVAC System: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. As-built shop drawings submitted.	__	__	X	X	__	__	__	__
b. Layout of control panel matches drawings.	__	__	X	X	__	__	__	__
c. Framed instructions mounted in or near control panel.	__	__	X	X	__	__	__	__
d. Components properly labeled (on inside and outside of panel).	__	__	X	X	__	__	__	__
e. Control components piped and/or wired to each labeled terminal strip.	__	__	X	X	__	__	__	__
f. EMCS connection made to each labeled terminal strip as shown.	__	__	X	X	__	__	__	__
g. Control wiring and tubing labeled at all terminations, splices, and junctions.	__	__	X	X	__	__	__	__
h. Shielded wiring used on electronic sensors.	__	__	X	X	__	__	__	__
i. Air dryer installed as specified.	__	__	X	X	__	__	__	__
j. Water drain installed as specified.	__	__	X	X	__	__	__	__
Main Power and Control Air								
a. 110 volt AC power available to panel.	__	__	__	X	__	__	__	__
b. 20 psig compressed air available to panel.	__	__	X	X	__	__	__	__
Testing, Commissioning, and Balancing								
a. Testing, Commissioning, and Balancing Report submitted.	__	__	X	__	__	__	__	__

Pre-commissioning Checklist - Single Zone Air Handling Unit

For Air Handling Unit: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed.	__	__	X	X	X	__	__	__
b. Inspection and access doors are operable and sealed.	__	__	X	__	X	__	__	__
c. Casing undamaged.	__	__	X	X	X	__	__	__
d. Insulation undamaged.	__	__	X	X	X	__	__	__
e. Condensate drainage is unobstructed.	__	__	X	X	X	__	__	__
f. Fan belt adjusted.	__	__	X	__	X	__	__	__
g. Any damage to coil fins has been repaired.	__	__	X	__	X	__	__	__
h. Manufacturer's required maintenance clearance provided.	__	__	X	X	X	__	__	__
Electrical								
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. Chilled water piping properly connected.	__	__	X	__	__	__	__	__
a. Refrigerant piping properly connected.	__	__	X	X	X	__	__	__
b. Chilled water piping pressure tested.	__	__	X	X	X	__	__	__
b. Refrigerant piping pressure tested.	__	__	X	X	X	__	__	__
c. Hot water piping properly connected.	__	__	X	__	__	__	__	__
c. Steam and condensate piping properly								

connected.	__	__	X	X	X	__	__	__
d. Hot water piping pressure tested.	__	__	X	X	__	__	__	__
d. Steam and condensate piping pressure tested.	__	__	X	X	X	__	__	__
e. Air vents installed on water coils with shutoff valves as specified.	__	__	X	X	X	__	__	__
f. Any damage to coil fins has been repaired.	__	__	X	__	X	__	__	__
Controls								
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. Construction filters removed and replaced.	__	__	X	__	X	__	__	__
b. TAB results +10%/-0% cfm shown on drawings.	__	__	X	__	X	__	__	__
c. TAB Report submitted.	__	__	X	__	X	__	__	__

Pre-commissioning Checklist - Energy Recovery System

For Energy Recovery System: (as specified)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Recovery system piping installed.	__	__	X	__	X	__	__	__
b. Recovery system piping tested.	__	__	X	X	X	__	__	__
c. Air vent installed as specified.	__	__	X	X	X	__	__	__
d. Manufacturer's required maintenance clearance provided.	__	__	X	X	X	__	__	__
Startup								
a. Recovery system piping cleaned and filled.	__	__	X	X	X	__	__	__
b. Converter startup and checkout complete.	__	__	X	X	X	__	__	__
Controls								
a. Control valves/actuators properly installed.	__	__	X	__	__	__	__	__
b. Control valves/actuators operable.	__	__	X	__	__	__	__	__

APPENDIX B

FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

Functional Performance Test Checklist - Pumps

For Pump: (as specified)

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

1. Activate pump start using control system commands (all possible combination, on/auto, etc.). ON_____ AUTO_____ OFF_____

a. Verify pressure drop across strainer:

Strainer inlet pressure _____ psig
Strainer outlet pressure _____ psig

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

	DESIGN	TAB	ACTUAL
Pump inlet pressure (psig)	_____	_____	_____
Pump outlet pressure (psig)	_____	_____	_____

c. 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 (psig)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (gpm)	_____	_____

d. Operate pump at shutoff 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 (psig)	_____	_____

Pump outlet pressure	_____	_____
Pump flow rate (gpm)	_____	_____

2. Verify motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions.

a. Full flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

b. Minimum flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

3. Unusual vibration, noise, etc.

_____

_____

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 Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing, Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____
Functional Performance Test Checklist - Centrifugal Chiller

For Chiller: (as specified)

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

h. Restart air handling equipment one minute after chiller shut down. Verify condenser water pump, cooling tower, and chiller restart sequence. _____

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Cooling Tower

For Cooling Tower: (as specified)

1. Functional Performance Test: Contractor shall 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: _____ Activate chemical treatment feed valve, verify makeup of chemical treatment system, pump, and controls: _____

e. Entering water temperature _____ degrees F
Leaving water temperature: _____ degrees F
Air volume measured: _____ cfm
Air volume calculated: _____ cfm
Entering wet bulb temperature: _____ degrees F
Measured water flow: _____ gpm

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's 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 shall not exceed 10 percent, or as indicated.

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 above ambient and measure maximum air flow. Turn thermostat to 5 degrees F below ambient and measure minimum air flow.

Maximum flow _____ cfm
Minimum flow _____ cfm

(2) Check damper maximum/minimum flow settings.

Maximum flow setting _____ cfm
Minimum flow setting _____ cfm

b. Cooling with reheat VAV boxes:

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

Maximum flow _____ cfm
Minimum flow _____ cfm

(2) Check damper maximum/minimum flow settings.

Maximum flow setting _____ cfm
Minimum flow setting _____ cfm

Reheat coil operation range (full open to full closed) _____

c. Fan powered VAV boxes:

(1) Verify VAV box response to sensor call for heating via set point adjustment. Changes to be cooling setpoint to heating set point and return to cooling 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 and deactivation. _____

(2) Check primary air damper maximum/minimum flow settings.

Maximum flow setting _____ cfm
Minimum flow setting _____ cfm

(3) Check blower fan flow. _____ cfm

(4) Verify free operation of fan back-draft damper (insure no primary air is being discharged through the re-circulated air register). _____

(5) Verify that no re-circulated air is being induced when box is in full cooling. _____

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: (as specified)

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.

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

a. The following shall be verified when the supply fan operating, or supply and return fans operating, as indicated, mode is initiated:

(1) All dampers in normal position and fan inlet vanes modulate to maintain the required static pressure as indicated. _____

(2) All valves in normal position. _____

(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 design static pressure Class shown. _____

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 or closed, as indicated. _____

(4) Chilled water control valve modulating to maintain leaving air temperature set point. _____

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

c. Occupied mode of operation - economizer energized.

(1) Outside air damper modulated to maintain mixed air temperature set point. _____

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

(3) Chilled water control valve modulating to maintain leaving air temperature set point. _____

(4) Hot water control valve modulating to maintain leaving air temperature set point. _____

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

d. Unoccupied mode of operation

(1) All dampers in normal position. _____

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

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

	Max cooling	Min cooling
Supply air volume (_____ cfm)		_____
Supply air temp. (_____ degrees F)		_____

g. Verify safety shut down initiated by smoke detectors. _____

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

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

Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Single Zone Air Handling Unit

For Air Handling Unit: (as specified)

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

a. The following shall be verified when the supply fan operating or supply and return fans operating, as indicated, 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 or closed as indicated. _____

(4) Chilled water control valve modulating to maintain space cooling temperature set point. _____

(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. _____

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

(3) Chilled water control valve modulating to maintain space cooling temperature set point. _____

d. Unoccupied mode of operation

(1) All dampers in normal position. _____

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

e. The following shall be verified when the supply fan off or supply and return fans off, as indicated, 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 smoke detectors. _____

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

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist – Multi-zone Air Handling Unit

For Air Handling Unit: (as specified)

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.

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

a. 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. _____

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

c. Occupied mode of operation - economizer energized.

(1) Outside air damper modulates to maintain mixed air temperature set point. _____

(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. _____

(4) Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. _____

d. Unoccupied mode of operation

(1) All dampers in normal position. _____

(2) 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. _____

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 smoke detectors._____

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

i. 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 F
Hot deck temperature _____ degrees F

Zone _____
Cooling temperature _____ degrees F
Heating temperature _____ degrees F
Damper leakage cooling ____ degrees F
Damper leakage heating ____ degrees

Zone _____
Cooling temperature _____ degrees F
Heating temperature _____ degrees F
Damper leakage cooling ____ degrees F
Damper leakage heating ____ degrees F

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller: (as specified)

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._____

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

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

f. 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	ACTUAL
Chiller inlet pressure (psig)	_____	_____	_____
Chiller outlet pressure (psig)	_____	_____	_____

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

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

4. Record the following information:

Ambient dry bulb temperature _____ degrees F
Ambient wet bulb temperature _____ degrees F
Entering chilled water temperature _____ degrees F

Leaving chilled water temperature _____ degrees F

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Air Cooled Condensing Unit

For Condensing Unit: (as specified)

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

c. 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.

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

3. Record the following information:

Ambient dry bulb temperature	_____	degrees F
Ambient wet bulb temperature	_____	degrees F
Suction pressure	_____	psig
Discharge pressure	_____	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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing, Adjusting and Balancing _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Hot Water Boiler

For Boiler: (as specified)

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. _____

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

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

	DESIGN	TAB	ACTUAL
Boiler inlet pressure (psig)	_____	_____	_____
Boiler outlet pressure (psig)	_____	_____	_____
Boiler flow rate (gpm)	_____	_____	_____
Flue-gas temperature at boiler outlet	_____	_____	_____
Percent carbon dioxide in flue-gas	_____	_____	_____
Draft at boiler flue-gas exit	_____	_____	_____
Draft or pressure in furnace	_____	_____	_____
Stack emission pollutants concentration	_____	_____	_____
Fuel type	_____	_____	_____
Combustion efficiency	_____	_____	_____

3. Record the following information:

Ambient temperature	_____	degrees F
Entering hot water temperature	_____	degrees F
Leaving hot water temperature	_____	degrees F

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

5. Verify proper operation of boiler safeties. _____

6. Unusual vibration, noise, etc.

_____

_____

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

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Steam Boiler

For Boiler: (as specified)

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	TAB	ACTUAL
Boiler inlet water temp (degrees F)	_____	_____	_____
Boiler outlet pressure (psig)	_____	_____	_____
Flue-gas temperature at boiler outlet (degrees F)	_____	_____	_____
Percent carbon dioxide in flue-gas	_____	_____	_____
Draft at boiler flue-gas exit	_____	_____	_____
Draft or pressure in furnace	_____	_____	_____
Stack emission pollutants concentration	_____	_____	_____
Fuel type	_____	_____	_____
Combustion efficiency	_____	_____	_____

3. Record the following information:

Ambient temperature
Ambient temperature _____ degrees 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.

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative_____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls 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 or as indicated.

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 temperature set point adjustment. Changes to be cooling set point to cooling set point minus 10 degrees and return to cooling set point. _____

(2) Check blower fan air flow.
Check blower fan air flow. _____ cfm

(3) Check cooling coil water flow.
Check cooling coil water flow. _____ gpm

(4) Verify proper operation of cooling water control valve.

b. Cooling/heating fan coils:

(1) Verify fan coil unit response to room temperature set point adjustment. Changes to be cooling set point to heating set point and return to cooling set point. _____

(2) Check blower fan air flow.
Check blower fan air flow. _____ cfm

(3) Check cooling coil water flow.
Check cooling coil water flow. _____ cfm

(4) Verify proper operation of cooling water control valve.
_____

(5) Check cooling mode inlet air temperature.
Check cooling mode inlet air temperature._____ degrees F

(6) Check cooling mode outlet air temperature.
Check cooling mode outlet air temperature. ____ degrees F

(7) Check heating coil water flow.
Check heating coil water flow. _____ gpm

(8) Verify proper operation of heating water control valve.
_____

(9) Check heating mode inlet air temperature.

Check heating mode inlet air temperature. _____ degrees F

(10) Check heating mode outlet air temperature.
Check heating mode outlet air temperature. ____ degrees F

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative_____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative_____

Contractor's Controls 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 [2] [10] [10 percent].

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

a. Verify unit heater response to room temperature set point adjustment. Changes to be heating set point to heating set point minus 10 degrees and return to heating set point. _____

b. Check blower fan speed. _____rpm

c. Check heating mode inlet air temperature. Check heating mode inlet air temperature. _____ degrees F

d. Check heating mode outlet air temperature. Check heating mode outlet air temperature. _____ degrees F

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative_____

Contracting Officer's Representative _____

Using Agency's Representative_____

Functional Performance Test Checklist - Steam/Hot Water Converter

For Converter: (as specified)

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 (degrees F)	_____	_____
Converter outlet water temp (degrees F)	_____	_____
Converter inlet steam pressure (psig)	_____	_____
Determine water flow rate based on pressure drop through converter	_____	_____
Determine water flow rate with flow measuring device	_____	_____
Verify that temperature of water is in accordance with outdoor air reset schedule	_____	_____

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Computer Room Unit

For Computer Room Unit: (as specified)

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 +10/-0 percent of design airflow. _____

e. Verify unit shut down during fire event initiated by smoke/heat sensors. _____

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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative_____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - HVAC Controls

For HVAC System: (as specified)

The Contracting Officer will select HVAC control systems to undergo functional performance testing. The number of systems shall not exceed 10 percent, or as indicated.

1. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the following tests:

a. Verify that controller is maintaining the set point by manually measuring the controlled variable with a thermometer, sling psychrometer, inclined manometer, etc.

b. Verify sensor/controller combination by manually measuring the controlled medium. Take readings from control panel display and compare readings taken manually. Record all readings.

Sensor _____
Manual measurement _____
Panel reading value _____

c. Verify system stability by changing the controller set point as follows:

(1) Air temperature - 10 degrees F

(2) Water temperature - 10 degrees F

(3) Static pressure - 10 percent of set point

(4) Relative humidity - percent (RH)

The control system shall be observed for 10 minutes after the change in set point. Instability or excessive hunting will be unacceptable.

d. Verify interlock with other HVAC controls.

e. Verify interlock with fire alarm control panel.

f. Verify interlock with EMCS.

g. Change controller set point 10 percent with EMCS and verify correct response.

2. Verify that operation of control system conforms to that specified in the sequence of operation.

3. 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
Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System: (as specified)

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. ____

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

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

	Design	Actual
Primary loop inlet temp (degrees F)	_____	_____
Primary loop outlet temp (degrees F)	_____	_____
Primary loop flow rate	_____	_____
Secondary loop inlet temp (degrees F)	_____	_____
Secondary loop outlet temp (degrees F)	_____	_____
Energy recovered BTU's)	_____	_____

3. Check and report unusual vibration, noise, etc.

_____

_____

_____

_____

_____

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
Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing,
Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

- end of section -