Functional Test (Cover Sheet)

Project ________________________________

FT-________ TERMINAL UNITS (VAV w/ hot water reheat, single duct)
DATA COMMON FOR ALL UNITS

1. Participants (fill out once, to cover all TU's)

Party	Participation	Party	Participation

Party filling out this form and witnessing testing ______________________________
Dates of tests ______________________ Dates of tests ______________________

2. Test Prerequisites (fill out once, to cover all TU's)

a. The following have been started up and startup reports and prefunctional checklists submitted and approved:
 __ All terminal units, except ____
 __ All air handlers serving terminal units, except ______________________________
 __ Hot water pumps

b. __ All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules and with debugging, loop tuning and sensor and device calibrations completed. ______________________ ______________________
 Controls Contractor Signature or Verbal Date

c. __ Piping system flushing complete, water treatment system complete and required report approved.

d. __ Airside test and balance calibration of BAS readings of TU flows complete (system total flow need not be complete).

e. __ All A/E punchlist items for this equipment corrected.

f. __ These functional test procedures reviewed and approved by installing contractor.

g. __ Test requirements and sequences of operation attached.

h. __ Schedules and setpoints attached.

i. __ Have all energy savings control strategies, setpoints and schedules been incorporated that this TU and control system are capable of? If not, list recommendations below.

j. __ The controller & actuator runtime accumulator set to 0 after prefunctional checkout of the entire system.

k. __ Obtain and review the full program of 5% (randomly chosen) of all TU's of each type (parameters & setpoints, etc.). Examine variances. Clarify as needed, reconcile and document differences with controls contractor. If too many corrections exist with this sample, controls contractor shall recheck all programming.

3. Sampling and Additional Testing.

The terminal unit testing requirements in the specifications call for a random sample of _____% of all TU's of each type to be tested. Total number to be tested of this type = __________. The specifications also require that if _____% of the sampled TU's fail in the testing (any No Pass items), then another _____% of the total population must be tested. This applies to the subsections of the test, i.e., if sub-sections fail, only subsections of additional TU's need to be tested. Record results in the table below.

Sub-Section	% Failed of 1st Sample	% Failed of 2nd Sample
I. Sensor calibration		
II. Actuator calibration		
III. Static inspections		

Sub-Section	% Failed of 1st Sample	% Failed of 2nd Sample
IV. Programming		
V. Functional tests		

4. Testing of TU 3-Way Valves

All TU 3-way heating valves shall be verified to have been programmed and setup properly. When programmed or wired backwards, the valve will open when being commanded to close, causing the space to overheat. To verify proper wiring and programming, during a period of general cooling, verify that the actual space temperature is within 2F of the (setpoint plus any user adjustment), unless in a fluctuating area (entry, etc.). Space temperatures more than 2F above the net setpoint indicate possible 3-way valve problems. Investigate.

TU Space Temperature Control for TU's With Three-Way Valves

TU ID	Actual Space Temp.	Setpoint	User Adjust-ment	OK?

TU ID	Actual Space Temp.	Setpoint	User Adjust-ment	OK ?

Notes:

Functional Test Record

Project ____________________________________

FT-______ TERMINAL UNIT ___________ (VAV w/ hot water reheat, single duct)

Common values for all terminal units are recorded on the Cover Sheet. The following five pages of procedures are to be filled out for each TU tested.

Seasonal Testing and General Conditions of Test

Air handler or rooftop unit and boiler (if applicable) should be running in normal and occupied mode, unless noted. The tests may be performed in any season, if any temperature lockouts can be overridden.

Testing Procedures and Record

___ Computer printout or list made and attached of the current TU setpoints and control parameters and schedules, lockouts, etc. of other systems that may be changed to accomodate testing.

I. Sensor Calibration Checks. Check the sensors listed below for calibration and adequate location. "In calibration" means making a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) compared to the test instrument-measured value is within the tolerances specified in the prefunctional checklist requirements (__________________________). If not, install offset in BAS, calibrate or replace sensor. Use the same test instruments as used for the original calibration, if possible.

Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instrument Measured Value	**Final** Gage or BAS Value	Pass Y/N?
Space temp.					

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

II. Device Calibration Checks. Check the actuators or devices listed below for calibration. "In calibration" means observing a readout in the BAS and going to the actuator or controlled device and verifying that the BAS reading is correct. For items out of calibration or adjustment, fix now <u>if easy</u>, via an offset in the BAS, or a mechanical fix.
<u>HCV</u>: Set pumps to normal mode. <u>*Procedure 1.*</u> Command valve to a few intermediate positions. Verify that reading in BAS reasonably correspond to the actual positions. <u>For heating coil valves (NO)</u>: <u>*Procedure 2a.*</u> Set heating setpoint 20°F above room temperature. Verify BAS reading says 100% open. Visually verify valve is fully open. *2b*. Remove control air or electricity from the valve and verify that the valve stem and actuator position do not change. <u>*Procedure 3.*</u> Restore to normal. Set heating setpoint to 20°F below room temperature. Observe the valve close. *4*. For pneumatic actuators, by override in the EMS, increase pressure to valve by 3 psi (do not exceed actuator rating). Verify valve stem & actuator position does not change. Restore to normal.
<u>Damper or Flow</u>: --Checked during Functional Testing Section.

Device or Actuator & Location	**Procedure / State**	BAS Value	Site Observation	Corrections	Pass Y/N
Heating coil valve (HCV) position or command and stroke	1. Intermediate positions				
	2a. Full open				
	2b. Remove power or air (full open)				
	3. Closed				
	4. Increase pressure (close)				

Proced. No. & Spec. Seq. ID[1]	**Req ID No.**[2]	**Test Procedure**[3] (including special conditions)	**Expected and Actual Response**[4] [Write ACTUAL response or finding in brackets or circle]	**Pass Y/N & Note #**
III. STATIC INSPECTIONS				
1.		Verify sufficient clearance around equipment for servicing.		
2.		Verify installation of specified sound wrapping and joint sealant.		
3.		Unit secured per spec.		
4.		Model and tag checked against plans & equipment list. TU & valve tags affixed.		
5.		Verify that inlet conditions are OK: Smooth, round, straight duct for at least 3 duct diameters when possible and 2 diameters minimum for velocity pressure sensor and 3 to 5 diameters for single point electronic sensors, else airflow straighteners.		
6.		*(Verify for only 1/2 of the tested TU's)* For autoflow control valves, with water system in normal, check pressure drop across valve. Compare with valve requirements.	Pressure drop should be in the range of _______ to _______ psi [_________]. If out of range, investigate.	
7.		*(Verify for the other 1/2 of the tested TU's that didn't have valve pressure drops checked.)* Valve off TU. Remove and check strainer for cleanliness..	To pass, <u>basket</u> strainers must have an unclogged area >= 80% of the strainer area. <u>In-line</u> strainers with area = to pipe cross section must be 90% clean.	
8.		<u>Auto TU Diagnostics.</u> In the control system diagnostics, check the controller and actuator accumulated run times, the moving avg. flow error and moving avg. space temp. deviation from setpoint.	The ratio of actuator to controller runtime should be ideally < 3% & < 5% is acceptable. [______%]. Moving avg. flow error should be < 10% of max. cooling cfm [______%]. The moving avg. space temp. deviation should be < 3F [______F].	
IV. CONTROL PROGRAMMING. **In the procedures of this section, compare specified written sequences and parameters with that found programmed in the TU or BAS. Variances that, in the CA's opinion, reduce performance, must be corrected. Variances that make no difference or enhance performance pass. Document all variances.**				
9.		Control drawing sequences of operation	Per spec and detail adequate.	
10.		Verify that the TU address matches the TU location and ID on the plan drawings and control drawings.	Address matches.	
11.		Verify that the TU max and min setpoints in the BAS match (within 10%) the latest plan drawings and balance report (TAB).	<u>Cooling:</u> Drawing max =_____ min =_____ BAS max = [______] min = [______] TAB max = ______ min = ______ <u>Heating:</u> Drawing max =_____ min =_____ BAS max = [______] min = [______] TAB max = ______ min = ______	
12.		Verify that BAS TU K factor is within 20% of K on the submitted control drawings, unless explained by TAB.	Drawing K = _____ BAS K = [_____] TAB K = _______	

<u>Notes:</u>

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
13.		Temperature adjustment range by tenants (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
14.		Cooling-- occupied zone temp. setpoint (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
15.		Heating-- occupied zone temp. setpoint (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
16.		Unoccupied zone temperature setpoint (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
17.		Occupied zone temp. bias (deadband) (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
18.		Unnuccupied zone temp. bias (deadband) (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
19.		Heating coil valve stroke time (for incremental valves)	Actual timed ________ Input found in BAS _______	
20.		Cooling space setpoint proportional band (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
21.		Heating space setpoint proportional band (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
22.		Cooling cfm proportional band (indicate if a setting was spec'd)	Spec'd or reasonable value _______ Found [_______]	
23.		Duct area (sf)	From prints ______ Found [______]	
24.		Damper stroke time (Spec'd value comes from controller spec, unless oval duct, which should then be timed)	Spec'd ________ Found [_______]	
25.		Auto-zero function schedule set and enabled.	Set and enabled.	
26.				
V. FUNCTIONAL TESTING.				
27.		<u>CFM Capacity Test, Cooling.</u> With the duct SP setpoint being met, lower the space temp. setpoint 20F. Verify in the BAS that the specified max. cfm is achieved (within deadband). For TU's controlled by damper position only, observe that the damper goes to max. as expected.	Specified max. cooling cfm = ______ Achieved cfm or position= [______] Within deadband? _______	
28.		<u>CFM Capacity Test, Heating.</u> With the duct SP setpoint being met, raise the space temp. setpoint 20F. Verify in the BAS that the specified min. or heating cfm is achieved (within deadband). For TU's controlled by damper position only, observe that the damper goes to min. as expected.	Specified min. or heating cfm = _________ Achieved cfm or position= [______] Within deadband? _______	

<u>Notes:</u>

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure**[3] (including special conditions)	**Expected and Actual Response**[4] [Write ACTUAL response or finding in brackets or circle]	**Pass Y/N & Note #**
29.		*(Verify for only 1/2 of the tested TU's)* Warmup cycle--heating. Adjust schedule or time so TU will be in warmup mode. Adjust the space setpoint to be 5F above space.	Does the TU damper go to heating minimum? Does HCV go to full open?	
30.		*(Verify for only 1/2 of the tested TU's)* Warmup cycle--cooling. Adjust schedule or time so TU will be in warmup mode. Adjust the space setpoint to be 5F below space.	Does the TU damper go to cooling maximum?	
31.		HCV leakage. *Method 1.* Use any of three methods. With the TU in cooling, with the damper in a stable position, using matched sensors, measure the duct air temperature within 4 ft. upstream and downstream of the coil.	Upstream: _____F Down: _____F The temperature down stream should not be warmer than the air up stream. If more than 1.0F greater, unit fails. Investigate.	
32.		HCV leakage. *Method 2.* Use any of three methods. Turn off the air handler during test. Command HCV open. After 5 min., slide temp. sensor 3/4" underneath insulation near actuated valve. Shut isolation valves to stop flow. Record ambient & initial pipe temp. and temp. after 10 min. Open isolation valves, allow temp. to reach within 3F of initial temp. and record pipe and ambient temp. Command HCV closed. Record temp. after 10 min.	Isolation valves closed (no flow): Ambient=____F. Initial pipe=____F @ 10 min=____F. T. drop = ____F Isolation valves open, HCV closed: Ambient=____F. Initial pipe=____F @ 10 min=____F. T. drop = ____F Isolation valves closed T. drop *minus* isolation valves open T. drop must be *less than* +2F [_____], else valve is leaking.	
33.		HCV leakage. *Method 3.* Use any of three methods. With the heating water system in normal and the TU in full cooling, close coil supply isolation valve, open air bleed cap, open drain-down cock and drain water from coil. Return all to normal. This method is not applicable for 3-way valves.	Water should stop draining, else there may be a leak through the control valve.	
34.		Unoccupied Mode--Night Low Limit.		
35.		Unoccupied Mode--Night High Limit.		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
36.		Trending: HCV and Damper Control. Over an 26 hour occupied and unoccupied period, trend at 2 min. intervals, the HCV position, the HCV command, the damper position or cfm, the damper or cfm command, the space temperature, OSAT and the duct static pressure at the controlling sensor. The trend period shall have both heating and cooling conditions. Simulate if necessary.	Compare actuals to cfm and space temp. setpoints. Compare to the schedule. Observe that there is little or no overshoot of space temperature or hunting of the damper or valve, that cfm is within its deadband and that the cfm and valve change from heating to cooling as the space temp goes outside deadbands.	
37.		*(Trend for only 1/2 of the tested TU's)* Trending. Over a 3 day period, during near design conditions for heating and cooling, trend space temp. at 10 minute intervals. Omit this test if auto diagnostics has a moving avg. space temp. deviation log and it was completed.	Observe that the space temp. does not drift more than 1°F outside the deadband range around the setpoint.	
38.	--	**Return all changed control parameters and conditions to their pre-test values[5]**	**Check off in program printout when completed**	

MONITORING AND TREND LOGGING

Monitoring via BAS trend logs are required for test procedures 36; 37. Attach representative graphs or columnar data and explanatory analysis to this test report. The data should have time down the left column and four to six columns of parameters to the right. Provide a key to all abbreviations and attach setpoints and schedules for all trended parameters.

**Abbreviations: BAS = building automation system, CA = commissioning agent, HCV = heating coil valve, TU = terminal unit, SA = supply air, plan drawing = building drawings and schedules from design engineer.

[1]Sequences of operation attached to this test.
[2]Mode or function ID being tested from testing requirements section of the project Specifications.
[3]Step-by-step procedures for manual testing, trend logging or data-logger monitoring.
[4]Include tolerances for a passing condition. Fill-in spaces or lines not in brackets denote sequence parameters still to be specified by the A/E, conrols contractor or vendor. Write "Via BAS" for verifications of device position from BAS readout or "Via obs" for actual observation or from test instrument reading.
[5]Record any permanently changed parameter values and submit changes to Owner.

A SUMMARY OF DEFICIENCIES IDENTIFIED DURING TESTING IS ATTACHED

-- END OF TEST --

Notes: