Functional Test (Cover Sheet)

Project _____

TERMINAL UNITS

DATA COMMON FOR ALL UNITS of ALL TYPES

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 construction 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).

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

g. __ Test requirements and sequences of operation attached.

h. __ Schedules and setpoints attached.

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

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

l. __Misc. tools needed: __two-way radios (general c.), __original calibration temperature probe (controls c.), pressure gages for coil water dP (TAB).

3. Sampling

The specifications call for the following percentage of the terminal units to be tested:

Type	Qt.	% to Test	# to Test
VAV w/ HW reheat			
VAV cooling only			

Type	Qt.	% to Test	# to Test
VAV w/ elec. booster coil			

Functional Test Record (one form per TU)

Project _____

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

Test prerequisites for all terminal units are recorded on the Cover Sheet. The following six 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 accommodate testing.

Sampling and Additional Testing.

The specifications call for a random sample of _____% of all TU's of this 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 line item feature / procedure of the test, i.e., if a feature fails, only that feature of additional TU's need to be tested. Record results in the table below.

Feature	% Failed of 1st Sample	% Failed of 2nd Sample

Feature	% Failed of 1st Sample	% Failed of 2nd Sample

I. 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:

II. Sensor Calibration Checks. *Check the sensors listed below for calibration.*

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** BAS Value	Instrument Measured Value	**Final** BAS Value	Pass Y/N?
Space temp.					

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

III. 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 if easy, via an offset in the BAS, or a mechanical fix.

Heating Coil Valve, HCV: Set pumps to normal mode. *Procedure 1.* Command valve to a few intermediate positions. Verify that reading in BAS reasonably correspond to the actual positions. For heating coil valves (NO): *Procedure 2a.* 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. *Procedure 3.* 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.

Damper or Flow: --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)				

IV. Static Inspections *(check each test procedure on all units of the sample, unless noted otherwise)*

Proced. No.	**Seq. ID[1]**	**Test Procedure** (including special conditions)	**Expected and Actual Response[2]** [Write ACTUAL response or finding in brackets or circle]	**Pass Y/N & Note #**
1.		Verify sufficient clearance around equipment for servicing.		
2.		Verify installation of specified sound wrapping and joint sealant.		
3.		Filter is clean (fan powered units)		
4.		Unit secured per spec.		
5.		Model and tag checked against plans & equipment list. TU & valve tags affixed.		
6.		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.		

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
7.		***(Verify for 1/2 of the tested TUs).*** For autoflow control valves, with water system in normal, check pressure drop across valve. Compare with valve requirements. With non-autoflow valves, with valve fully open, measure dP across coil and from coil chart determine flow.	Pressure drop should be in the range of _____ to _____ psi [_____]. If out of range, investigate. Design flow = _____. Actual = _____. Must be within 10%.	
8.		***(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.	

V. Control Programming Check *(check each test procedure on all units of the sample, unless noted otherwise)*

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 pass that make no difference or enhance performance. Document all variances.

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
9.		<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].	
10.		Control drawing sequences of operation	Per spec and detail adequate.	
11.		Verify that the TU address matches the TU location and ID on the plan drawings and control drawings.	Address matches.	
12.		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 = _____	

<u>Notes:</u>

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
13.		Verify that BAS TU K factor is within 20% of K on the submitted control drawings, unless explained by TAB. If K is < 0.5 or > 4, then investigate.	Drawing K = _____ BAS K = [_____] TAB K = _____	
14.		Temperature adjustment range by tenants (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
15.		Cooling-- occupied zone temp. setpoint (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
16.		Heating-- occupied zone temp. setpoint (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
17.		Unoccupied zone temperature setpoint (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
18.		Occupied zone temp. bias (deadband) (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
19.		Unnuccupied zone temp. bias (deadband) (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
20.		Heating coil valve stroke time (for incremental valves)	Actual timed _____ Input found in BAS _____	
21.		Cooling space setpoint proportional band (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
22.		Heating space setpoint proportional band (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
23.		Cooling cfm proportional band (indicate if a setting was spec'd)	Spec'd or reasonable value _____ Found [_____]	
24.		Duct area (sf)	From prints _____ Found [_____]	
25.		Damper stroke time (Spec'd value comes from controller spec, unless oval duct, which should then be timed)	Spec'd _____ Found [_____]	
26.		Auto-zero function schedule set and enabled.	Set and enabled.	
27.		Delay timer programmed so all fan powered units don't start at once.		

Notes:

VI. Sequence Testing *(perform each test procedure on all units of the sample, unless noted otherwise)*

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
28.		CFM Capacity Test, Cooling. 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? _____	
29.		CFM Capacity Test, Heating. 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). Measure the TU supply air and ensure its not >15F above the space temperature (to minimize stratification per ASHRAE). 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? _____	
30.		***(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?	
31.		***(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?	
32.		**HCV leakage.** Verify that there is not leak-by past the valve when it is commanded closed. Either of the following methods will only detect significant leaks and thus must be done on 75% of all TUs in the project. Use one of the methods in the following procedures. Document this test on another form.		

Notes:

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
33.		**Leak-by Method 1. Infrared Thermometer.** Setup. For air terminal boxes, command the central air handler supply fans ON and the respective primary air valves 100% open. Command all the heating coil valves being tested 100% closed. This will typically be by floor or group of floors. Wait at least 30 minutes more before taking any temperature measurements so that any residual heat in the coil has fully dissipated and the coil temperature is near supply air stream temperature for air terminal boxes and near room temperature for radiant coils or radiators. Make sure heating water is being supplied to all zones to be tested. Command the distribution water pumps and the heating plant ON. The pump flow rate can be left in normal mode, but should be variable if all valves will be shut at once. The hot water supply temperature set point can be left in normal mode with any reset sequence in place.		
34.		Infrared Test. Using an infrared thermometer as close as possible, take a temperature reading on the exposed coil ends near the supply side, or on a section of exposed supply side piping or fitting close to the coil for air terminal units. For radiant coils or fin tubes take a reading directly on the fins. The reading will likely be picking up some other surfaces, so don't expect a value real close to either the air temperature (no leak-by) or to the heating water temperature (leak-by). Only take readings near the supply end of the coil, since hot water from a small leak may be totally cooled off by the time it gets to the other end of the coil.	An exposed coil end near the entering supply should read within 10F to 20F of the supply air temperature or there is likely leak-by. Exposed pipe just prior to entering the coil will read between the supply air temperature and the heating water temperature. Exposed fin tube should read close to the ambient air temperature or leak-by is likely.	
35.		**Leak-by Method 2. Air Temperature Across Coil** (when TU DAT is monitored). Use the set up procedure in Method 1. Utilizing only sensors calibrated to within +/- 0.2F, compare the AHU supply air temperature with the TU discharge air temperature.	If the TU DAT is more than 2F greater than the AHU SAT there is likely leak-by.	

Notes:

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
36.		Unoccupied and Override Control. a. Verify the unoccupied schedule. b. Change the room schedule to be unoccupied. c. Engage the override button. Return the schedule to original.	a. Specified: _____ Found: [_____] b. Observe the new space temp setpoint and cfm in the BAS. Specified _____F; _____cfm. Found: [_____F; _____cfm]. c. Observe the system go to occupied values. Specified _____F; _____cfm. Found: [_____F; _____cfm].	
37.		Unoccupied Night Low Limit. Put in UO mode. Change space UO Sp to 5F above space temp. UO SP = _____ Space temp = _____ Lower SP to be satisfied.	TU fan starts after a call for heating [_____]. AHU stays OFF and OA dampers closed [____]. Heating pump starts [____]. HCV modulates to meet space UO SP [_____]. All above turn OFF.	
38.		Unoccupied Night High Limit. Put in UO mode. Change spec UO SP to be 5F below space temp. UO SP = _____ Space temp = _____ Raise SP to be satisfied.	TU fan starts [_____]. AHU fan starts [_____]. TU and AHU OA dampers modulate to meet space set point. All above go OFF.	
39.		Normal Operation--Heating. Lower space setpoint (SP) 5F below space temp. Let it go into cooling mode with HCV shut. Raise SP 5F above space temp.	TU primary air cfm goes to minimum [_____]. TU RA damper modulates to maintain SP [_____]. If it can't do it, HCV modulates to meet space SP [_____].	
40.		Normal Operation--Cooling. Lower SP 5F below space temp.	TU primary air cfm modulates up [_____]. RA damper modulates to min. [___]. HCV closes [____]. SP is met [_____].	

Notes:

IV. Trend Logs

Proced. No.	Seq. ID[1]	Test Procedure (including special conditions)	Expected and Actual Response[2] [Write ACTUAL response or finding in brackets or circle]	Pass Y/N & Note #
41.		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.	
42.		*(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.	
43.	**--**	**Return all changed control parameters and conditions to their pre-test values[5]**	**Check off in program printout when completed**	

MONITORING AND TREND LOGGING Format

Monitoring via BAS trend logs are required for test procedures 40; 41. 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 or specifications attached to this test.

[2]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.

A SUMMARY OF DEFICIENCIES IDENTIFIED DURING TESTING IS ATTACHED

-- END OF TEST --

Notes: