Relative Calibration Functional Test

Instructions: For each system included on the checklist, verify the items indicated using **Yes** for acceptable, **No** for unacceptable, or **NA** for Not Applicable. For unacceptable items, identify what is required to correct the problem in the comments area provided. Use numbers to refer to comments. Identify the responsible contractor, if know, for any items requiring further action.

Equipment Required:

1. Field thermometer of some sort.
2. Lab grade thermometer (Optional, but highly desirable)
3. Minute by minute trending of points to be tested (Optional)
4. Shortridge meter with temperature probe (Optional but if available can be used as the field thermometer)

Acceptance Criteria: This test places the system in a steady state operating mode and then adjusts the return air temperature sensor, the mixed air temperature sensor, the warm-up coil discharge temperature sensor and the air handling unit discharge temperature sensor so that they read the same value when subjected to the same operating condition. Acceptance criteria are as follows:

1. With the system in a steady state condition, all sensors read the same value relative to a baseline, with-in their accuracy tolerance prior to adjustment.
2. With the system in a steady state condition, all sensors read the same value after adjustment.

The test will be performed at two different temperature levels in an effort to provide consistent readings from these sensors under all normally encountered operating conditions.

Date(s) of Test: _____

Time(s) of Test: _____

Test Technician _____

Item Number	Requirement	Initial and Date when Complete
Prerequisites		
1	Verify that all applicable prestart and start-up verification checks from the equipment manufacturer have been completed and that the system is fully functional.	
2	Verify that the sensors that are to be tested are certified and installed per the accuracy requirements of the specifications.	
3	Visually inspect the sensors that are to be tested to verify that they are installed in a manner that will allow them to measure the parameter intended and are free from influences due to mounting arrangement or configuration.	
4	Verify that the loads served by the system can tolerate the 15 to 60 minute period of operation with out active discharge temperature control that is required to perform this test.	
5	Target a day for the test when it is anticipated that the outdoor conditions will be in the mid 50°F range and suitable for operating on 100% outdoor air with out the need to heat or cool. This will allow calibration at two operating points. If the test cannot be scheduled for such a day prior to substantial completion, then proceed with the test in the full recirculation mode only.	
Preparation		

Item Number	Requirement		Initial and Date when Complete
1	Coordinate with the Owner and end-users served by the system for an appropriate test time. Note limits on deviations from set point that can be tolerated in the areas served during the test window and monitor these parameters during the test period. Terminate the test if they are about to be exceeded.		
	Area	*Criteria*	
	General office area (monitor return temperature)	75+/- 3°F	___ Verified
	Computer room	72+/- 3°F	___ Verified
	Return air CO_2 level	less than 750 ppm	___ Verified
2	Obtain copies of the specifications for accuracy for the sensors to be tested. Note the accuracy spec in the space provided below in step 10 of the procedure.		
3	Obtain copies of the factory calibration certificates for the sensors to be tested		
4	Place the following AHU01 points into trending or install data loggers.		
	Return air temperature AHU01RAT		___ In trend
	Mixed air temperature AHU01MAT		___ In trend
	Preheat coil discharge temperature AHU01PhT		___ In trend
	Supply fan discharge air temperature AHU01LAT		___ In trend
	The following system points will also be trended to document that the temperature in the area they serve did not exceed the limits requested by the Owner.		
	Computer room temperature 01VAV15SpT		___ In trend
	Return air CO_2 level AHU01RtCO2		___ In trend
Procedure			
1	With the system operating, document the supply and return fan heat by measuring the entering and leaving air temperature at each fan with the same thermometer and then subtracting the two readings[1].		
	Supply fan heat		
	Fan inlet temperature	_____ °F	
	Fan outlet temperature	_____ °F	
	Fan heat (outlet temperature - inlet temperature	_____ °F	
	Return fan heat		
	Fan inlet temperature	_____ °F	
	Fan outlet temperature	_____ °F	
	Fan heat (outlet temperature - inlet temperature)	_____ °F	

[1] This information will be used later in the test if a fan is located between two sensors under test. Thermometer accuracy for this measurement is not critical as long as the same thermometer is used for both readings since the readings are subtracted from each other, thus canceling any error.

Item Number	Requirement	Initial and Date when Complete
2	Document the current software calibration and scaling factors for the sensors to be tested in the space below. *Point* — *Slope* — *Intercept* Return air temperature AHU01RAT _____ _____ Mixed air temperature AHU01MAT _____ _____ Preheat coil discharge temperature AHU01PhT _____ _____ Supply fan discharge air temperature AHU01LAT _____ _____	
3	Modify the software calibration and scaling factors to return them to the standard upon which the input is based. For example, if the sensor is a 4-20 ma sensor with a range of 0-100°F, then set the system up so that 4ma indicates 0°F and 20ma indicates 100°F[2]. Document these settings in the space provided. *Point* — *Slope* — *Intercept* Return air temperature AHU01RAT _____ _____ Mixed air temperature AHU01MAT _____ _____ Preheat coil discharge temperature AHU01PhT _____ _____ Supply fan discharge air temperature AHU01LAT _____ _____	
4	Disable alarms that could be triggered by the deviations from normal that will be seen during the test or coordinate with the operators to acknowledge them. Note all alarms that are disabled in the space provided for future reference when returning the system to normal operation. _____ _____ _____ _____ _____	
5	Place the system into steady state operation in the full recirculation mode via the following steps.	
	Close the manual isolation valves on the steam and condensate lines for the preheat coil.	___ Complete
	Place the preheat coil in full bypass.	___ Complete
	Close the manual isolation valves on the steam and condensate lines for the humidifier, including the jacket heater.	___ Complete
	Close the manual isolation valves on the chilled water supply and return connections.	___ Complete
	Shut down the exhaust systems associated with AHU01.	
	Toilet exhaust fan EF-1.	___ Complete
	Janitor's closet exhaust fan EF-2.	___ Complete

[2] You may discover that the system has already been set up to do this. However, it is not uncommon to adjust the software scaling and calibration factors to "tweak" a sensor to compensate for its certified accuracy limitations so that it reads closer to the true temperature. In fact, this is exactly what we will do later in the procedure to calibrate the sensors relative to each other. At this stage of the test, it is important that the system be set up to the sensor standards to allow a baseline to be established and evaluate if everything is reading with-in its certified accuracy specification.

Item Number	Requirement	Initial and Date when Complete
	Place the system in full recirculation (verify by visually checking the dampers).	
	Minimum outdoor air damper fully closed.	___ Verified
	Maximum outdoor air damper fully closed.	___ Verified
	Return air damper fully open.	___ Verified
	Relief damper fully closed.	___ Verified
6	While waiting for the system to stabilize, document any temperature change that is occurring through the mixing box due to damper leakage. Return air temperature ahead of the return damper. _____ °F Average mixed air temperature at the discharge of the mixed air plenum[3]. _____ °F Change (difference between the two readings). _____ °F	
7	Document the standard that will be used for comparison of all temperatures during the test. The allowable choices are listed below in the order of desirability. Use the most desirable option available at the time of the test. (Check off which will be used). Lab grade mercury thermometer ___ Field thermometer ___ Discharge temperature sensor ___ Location where the standard will be inserted into the system to take the baseline reading. _____	
8	Allow the system to stabilize in the full recirculation mode for 10-15 minutes.	
9	If the discharge sensor has been selected as the standard, evaluate its reading relative to other indicators like the apparent operating conditions and information from the other sensors taking fan heat into consideration. If the indication from the discharge sensor is significantly out of line from what would be anticipated based on the other available information, then it's accuracy may be out of spec and the test should be discontinued until the sensor's accuracy can be checked or a different standard becomes available. Indicate pass or fail in the check-off column.	___ **P**ass/**F**ail

[3] Take multiple readings - one at the center of each filter in the filter bank - and average them. Using the Shortridge meter in the automatic mode makes this very easy.

Item Number	Requirement	Initial and Date when Complete
10	At this point, all of the sensors should be reading nearly identical values since they are all being subjected to the same condition. The only difference between what the sensors indicate should be due to their accuracy tolerance and/or due to the effect of fan heat and damper leakage in the mixing plenum. Document the readings from the sensors and the deviation from the selected standard[4]. Compare the deviation from the selected standard to the accuracy specification to determine if the sensor passes this portion of the test or not (deviation from the standard outside the accuracy window fail). Include compensation for other offsets like fan heat and damper leakage in the mixing plenum where appropriate using the information gathered in steps 1 and 6[5]. Notes: _____ _____ _____	

Baseline reading from the standard _____ °F

Point	*Reading*	*Deviation*	*Accuracy Tolerance*	*Other Offsets*	*Allowable Deviation*	
Return air temperature AHU01RAT	_____	_____	_____	_____	_____	___ **P**ass/**F**ail
Mixed air temperature AHU01MAT	_____	_____	_____	_____	_____	___ **P**ass/**F**ail
Preheat discharge air temperature AHU01PhT	_____	_____	_____	_____	_____	___ **P**ass/**F**ail
Supply fan discharge temperature AHU01LAT	_____	_____	_____	_____	_____	___ **P**ass/**F**ail

11	Resolve all problems with sensors that fail the test in step 10 prior to proceeding. Notes: _____ _____ _____	

[4] At this point, if all of the sensors were identical and there was no such thing as calibration error, then all of the readings would be identical to each other and have the same deviation from the standard (probably none). But, this will very seldom be the case in the field due to manufacturing tolerances and other effects that combine to show up as the calibration tolerance for the sensors.

[5] Compensation for fan heat should be included for each fan that is between the baseline sensor and the sensor under consideration. For example if the fan heat were measured to be 1°F, and the discharge sensor is in the fan discharge and the baseline is a lab grade thermometer, also located in the fan discharge, then the only allowable deviation from the baseline for the discharge sensor will be its accuracy tolerance. But, the deviation from baseline allowable for the sensor in the preheat coil discharge would include the fan heat in addition to its accuracy tolerance. Similar considerations apply to the effects of damper leakage and the temperature change it creates across the mixed air plenum.

Item Number	Requirement	Initial and Date when Complete
12	Skip this step if all of the sensors passed step 10. Otherwise, retest and document the results below after completing step 11.	
	Baseline reading from the standard _____ °F	
	Point / *Reading* / *Deviation* / *Accuracy Tolerance* / *Other Offsets* / *Allowable Deviation*	
	Return air temperature AHU01RAT _____ _____ _____ _____ _____	___ **P**ass/**F**ail
	Mixed air temperature AHU01MAT _____ _____ _____ _____ _____	___ **P**ass/**F**ail
	Preheat discharge air temperature AHU01PhT _____ _____ _____ _____ _____	___ **P**ass/**F**ail
	Supply fan discharge temperature AHU01LAT _____ _____ _____ _____ _____	___ **P**ass/**F**ail
13	Modify the software calibration factors as required to cause all of the sensors to read the same value as the baseline sensor. Remember to compensate for the effects of fan heat and damper leakage in the mixing plenum. Document the results below.	
	Point / *Slope* / *Intercept* / *Final Value*	
	Return air temperature AHU01RAT _____ _____ _____	
	Mixed air temperature AHU01MAT _____ _____ _____	
	Preheat coil discharge temperature AHU01PhT _____ _____ _____	
	Supply fan discharge temperature AHU01LAT _____ _____ _____	
14	If time and outdoor conditions permit, perform the following additional steps to ensure the relative accuracy of the sensors over a range of operating conditions. Otherwise, proceed to the Follow-up/Return to Normal section of the procedure.	
15	Place the system in the 100% outdoor air mode to subject the sensors to a different operating condition (verify by visually checking the dampers).	
	Minimum outdoor air damper fully open.	___ Verified
	Maximum outdoor air damper fully open.	___ Verified
	Return air damper fully closed.	___ Verified
	Relief damper fully closed.	___ Verified
	Restart the exhaust systems associated with AHU01.	
	Toilet exhaust fan EF-1.	___ Complete
	Janitor's closet exhaust fan EF-2.	___ Complete
16	Allow the system to stabilize in the 100% outdoor air mode for 10-15 minutes.	

Item Number	Requirement	Initial and Date when Complete
17	Verify that the sensors are still reading the same or nearly the same values. (Note that the return air sensor cannot be tested in this mode.) If there are differences "tweak" the software calibration factors to eliminate them and/or provide a good compromise between the values indicated at this condition and the values indicated in the full recirculation condition. Remember to compensate for the effects of fan heat and damper leakage in the mixing plenum. It may be necessary to toggle back and forth between the recirculation mode and the 100% outdoor air mode to fine tune the settings. Document the final results below if they differ from the results on the full recirculation cycle.	

Point	*Slope*	*Intercept*	*Final Value 100% OA*	*Final Value Recirc.*
Return air temperature AHU01RAT	_____	_____	N/A	_____
Mixed air temperature AHU01MAT	_____	_____	_____	_____
Preheat coil discharge temperature AHU01PhT	_____	_____	_____	_____
Supply fan discharge temperature AHU01LAT	_____	_____	_____	_____

Follow-up/Return to Normal		
1	Return the system to normal operation via the following steps.	
	Open the manual isolation valves on the steam and condensate lines for the preheat coil.	___ Complete
	Return the preheat coil face and bypass dampers to automatic control.	___ Complete
	Open the manual isolation valves on the steam and condensate lines for the humidifier, including the jacket heater.	___ Complete
	Open the manual isolation valves on the chilled water supply and return connections.	___ Complete
	Return the economizer and minimum outdoor air control cycles to automatic (verify by visually checking the dampers).	
	Minimum outdoor air damper released to automatic control.	___ Verified
	Maximum outdoor air damper released to automatic control.	___ Verified
	Return air damper fully released to automatic control.	___ Verified
	Relief damper fully released to automatic control.	___ Verified
	Return the exhaust systems associated with AHU01 to automatic control.	
	Toilet exhaust fan EF-1.	___ Complete
	Janitor's closet exhaust fan EF-2.	___ Complete
2	Re-enable all alarms that were disabled previously. Use the items noted under step 4 of the procedure as a guide.	
3	Print trend reports from the trends that were running during the test and save the trend files to a floppy to document the test process and results.	

Item Number	Requirement	Initial and Date when Complete
4	Remove all trends that the Owner does not which to retain. Remove data loggers if they were installed in place of trending or to supplement trending.	
5	Back-up the controller database to ensure that the new calibration factors are saved to the system hard disk.	
6	Recommend that the Owner back up the system hard disk at the completion of the current commissioning process to ensure that the modifications and adjustments made can be recovered if the system hard disk fails.	

Comments: