Zone T-stat Check

HAP users are occasionally puzzled by two outputs located on the Air System Sizing Summary in the Central Cooling Coil Sizing Data area. These outputs are **Zone T-stat Check and Max Zone Temperature Deviation** (see Figure 1). This Article will define these outputs and provide troubleshooting for common issues.

Please refer to HAP e-Help 004 - Transfer Function Methodology (TFM) for a description of the dynamic nature of cooling loads. The ASHRAE design procedure requires a two-stage calculation, a sizing stage, and a simulation stage. In the sizing stage zone sensible loads are computed assuming the zone is held exactly at the cooling thermostat setpoint 24 hours per day. The results are used to determine peak zone and central coil airflow rates. HAP then simulates the system operation using these airflow rates. The zone loads are then corrected for the actual system operating conditions. The simulation accounts for the use of different setpoints during the occupied and unoccupied times or the shutdown of cooling during the unoccupied period and the existence of a throttling range for the thermostats. Considering these real life operating factors changes the thermal dynamics of the system, causing zone temperatures to vary within the throttling range and introducing pull-down load components during the course of the day. In some cases, the sizing used is inadequate to maintain a zone temperature during the simulation stage.

The Zone T-stat Check describes the status of zone air temperatures for the month and hour when the maximum cooling coil load occurs. In this case, it is July 1400. This item is only provided for cooling control. The first value listed is the number of zones with zone air temperatures that lie below the upper limit of the cooling thermostat throttling range. The second number is the total number of zones in the system.

Air System Sizing Summary for A09 - Project 2 - Wing D PFPMXB

Project Name: Zone Tstat Check article — 11/04/2005
Prepared by: — 02:31PM

Air System Information

Air System Name	A09 - Project 2 - Wing D PFPMXB		Number of zones	7	
Equipment Class	CW AHU		Floor Area	4433.0	ft²
Air System Type	VAV		Location	St. Louis IAP, Missouri	

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	Peak zone sensible load	Calculation Months	Jan to Dec
Space CFM	Coincident space loads	Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	28.4	Tons	Load occurs at	Jul 1400	
Total coil load	341.1	MBH	OA DB / WB	93.0 / 75.5	°F
Sensible coil load	272.0	MBH	Entering DB / WB	85.7 / 66.9	°F
Coil CFM at Jul 1400	7792	CFM	Leaving DB / WB	52.7 / 51.9	°F
Max block CFM at Jul 1700	7870	CFM	Coil ADP	50.9	°F
Sum of peak zone CFM	7979	CFM	Bypass Factor	0.050	
Sensible heat ratio	0.798		Resulting RH	38	%
ft²/Ton	156.0		Design supply temp.	55.0	°F
BTU/(hr-ft²)	76.9		Zone T-stat Check	2 of 7	OK
Water flow @ 14.0 °F rise	48.75	gpm	Max zone temperature deviation	10.1	°F

Figure 1 – Zone T-Stat Check

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Zone T-stat Check

Example: The sample-cooling coil sizing table shown in Figure 1 is for a VAV system that serves seven zones. The zone cooling thermostat setpoint is 72° F with a throttling range of 3° F. For July 1400, when the maximum cooling coil load occurs, the air temperature in two of the zones is at or below 75° F. Therefore, the output states "2 of 7 OK;" the numbers are highlighted in red to bring it to the users' attention.

This item is a useful check figure for confirming that the system is maintaining desired comfort conditions in the zones for the hour when the maximum coil load occurs. When one or more zones are warmer than the upper limit of the thermostat throttling range, it is often due to system operating problems in dealing with very large pull-down loads. These problems can be investigated further by generating the Hourly Zone Design Day Cooling Loads and the System Psychrometrics reports.

Max Zone Temperature Deviation is used in conjunction with the Zone T-stat Check. It indicates the largest difference between a zone air temperature and the upper limit of the cooling thermostat control range. When zone temperature problems occur, it is used to judge the severity of the problem. If there are no zone temperature problems, this item will be displayed as 0. In our sample case, it is 10.1. There is at least one zone with a temperature of 85.1 (72.0 + 3.0 + 10.1), therefore further investigation is required.

To determine which zones are outside the control range, the System Psychrometric Report should be examined (see Figure 2, Table 2).

System Psychrometrics for A09 - Project 2 - Wing D PFPMXB

Project Name: Zone Tstat Check article 11/04/2005

Prepared by: 02:54PM

July DESIGN COOLING DAY, 1400

TABLE 1: SYSTEM DATA

Component	Location	Dry-Bulb Temp (°F)	Specific Humidity (lb/lb)	Airflow (CFM)	CO2 Level (ppm)	Sensible Heat (BTU/hr)	Latent Heat (BTU/hr)
Ventilation Air	Inlet	93.0	0.01534	1756	400	17580	55608
Vent - Return Mixing	Outlet	85.7	0.01007	7792	833	-	-
Preheat Coil	Outlet	85.7	0.01007	7792	833	0	-
Central Cooling Coil	Outlet	52.7	0.00816	7792	833	272007	69052
Supply Fan	Outlet	55.0	0.00816	7792	833	19238	-
Cold Supply Duct	Outlet	55.0	0.00816	7792	833	-	-
Zone Air	-	80.0	0.00853	7792	959	205910	13440
Return Plenum	Outlet	83.5	0.00853	7792	959	29279	-

Air Density x Heat Capacity x Conversion Factor: At sea level = 1.080; At site altitude = 1.058 BTU/(hr-CFM-F)
Air Density x Heat of Vaporization x Conversion Factor: At sea level = 4746.6; At site altitude = 4650.7 BTU/(hr-CFM)
Site Altitude = 564.0 ft

TABLE 2: ZONE DATA

Zone Name	Zone Sensible Load (BTU/hr)	T-stat Mode	Zone Cond (BTU/hr)	Zone Temp (°F)	Zone Airflow (CFM)	CO2 Level (ppm)	Terminal Heating Coil (BTU/hr)	Zone Heating Unit (BTU/hr)
D100-Computer Closet	7735	Cooling	6656	74.1	329	881	0	0
D101-Classroom	25090	Cooling	38636	80.4	1440	986	0	0
D102-Classroom	25090	Cooling	38636	80.4	1440	986	0	0
D103-Classroom	25090	Cooling	38636	80.4	1440	986	0	0
D104-Classroom	29423	Cooling	41465	77.6	1731	959	0	0
D105-South Vestibule	4303	Cooling	5401	74.1	267	894	0	0
D114-Corridor	20576	Cooling	36481	85.1	1146	890	0	0

Figure 2 – Zone Temperatures

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Zone T-stat Check

Inspect the values in the Zone Temp column to identify the zones that are out of range. Next, examine the tabular and graph data from the Hourly Zone Loads Reports (see Figures 3 and 4).

It can be seen from Figure 3 that the Hourly Zone temperatures for the design day in July are out of range for all hours of the day. The graph helps to visualize the load profile.

Internal loads commonly dominate zones that are out of range. The graph in Figure 4 shows that the Zone Sensible load is rather constant 24 hours a day. However, the Zone Conditioning indicates an 11-hour on-cycle for zone temperature control.

Hourly Zone Loads for A09 - Project 2 - Wing D PFPMXB

Project Name: Zone Tstat Check article 01/04/2006
Prepared by: 12:19PM

ZONE: D102-Classroom
DESIGN MONTH: JULY

Hour	OA TEMP (°F)	ZONE TEMP (°F)	RH (%)	ZONE AIRFLOW (CFM)	ZONE SENSIBLE LOAD (BTU/hr)	ZONE COND (BTU/hr)	TERMINAL COOLING COIL (BTU/hr)	TERMINAL HEATING COIL (BTU/hr)	ZONE HEATING UNIT (BTU/hr)
0000	81.1	109.1	-	0.0	22229.8	0.0	0.0	0.0	0.0
0100	80.0	110.1	-	0.0	21925.7	0.0	0.0	0.0	0.0
0200	79.1	111.2	-	0.0	21654.0	0.0	0.0	0.0	0.0
0300	78.2	112.2	-	0.0	21394.3	0.0	0.0	0.0	0.0
0400	77.4	113.2	-	0.0	21163.4	0.0	0.0	0.0	0.0
0500	76.9	114.2	-	0.0	20960.9	0.0	0.0	0.0	0.0
0600	76.7	86.8	32	1439.9	21167.6	48460.9	0.0	0.0	0.0
0700	77.1	85.6	33	1439.9	23102.7	46667.2	0.0	0.0	0.0
0800	78.0	85.0	34	1439.9	24430.5	45660.6	0.0	0.0	0.0
0900	79.6	84.3	35	1439.9	25323.1	44615.4	0.0	0.0	0.0
1000	82.0	83.5	35	1439.9	25573.0	43391.9	0.0	0.0	0.0
1100	84.8	82.6	36	1439.9	25439.3	42082.6	0.0	0.0	0.0
1200	87.9	81.7	37	1439.9	25066.8	40740.1	0.0	0.0	0.0
1300	90.8	81.0	38	1439.9	25065.7	39641.9	0.0	0.0	0.0
1400	93.0	80.4	38	1439.9	25089.6	38635.8	0.0	0.0	0.0
1500	94.5	79.7	39	1439.9	25033.8	37664.6	0.0	0.0	0.0
1600	95.0	79.1	40	1439.9	24865.3	36704.0	0.0	0.0	0.0
1700	94.5	100.3	-	0.0	25901.5	0.0	0.0	0.0	0.0
1800	93.2	102.5	-	0.0	25413.9	0.0	0.0	0.0	0.0
1900	91.2	103.7	-	0.0	24748.7	0.0	0.0	0.0	0.0
2000	88.8	104.8	-	0.0	24054.7	0.0	0.0	0.0	0.0
2100	86.4	105.9	-	0.0	23477.2	0.0	0.0	0.0	0.0
2200	84.4	107.0	-	0.0	23002.7	0.0	0.0	0.0	0.0
2300	82.6	108.1	-	0.0	22587.2	0.0	0.0	0.0	0.0

Figure 3 – Hourly Zone Loads Report

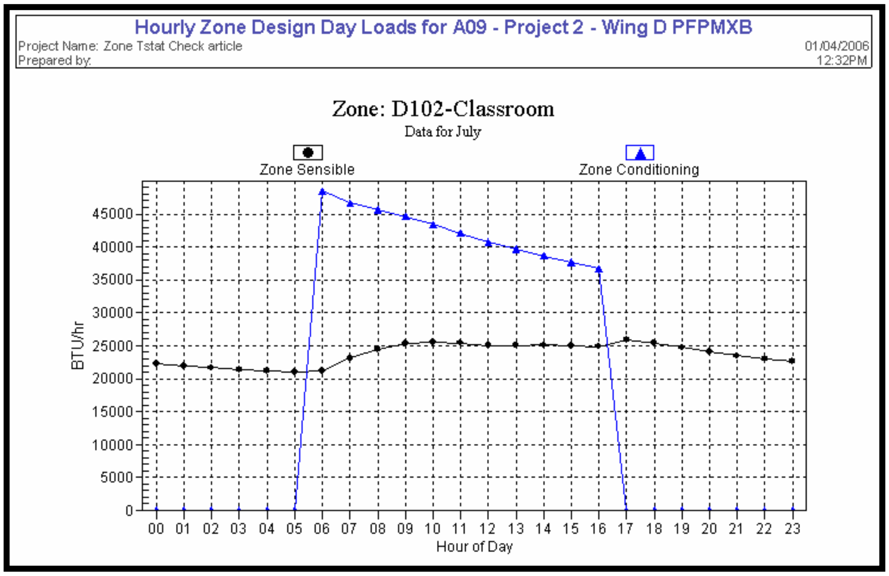

Figure 4 – Hourly Zone Design Day Loads

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Zone T-stat Check

Examination of the internal load schedule shows that these loads are constant over time as indicated in Figure 5. A more realistic schedule should be considered as shown in Figure 6.

If the internal loads are constant for a long period of time, the on-cycle for cooling should be extended. In HAP, this is the Fan and Thermostat schedule used with the Air System.

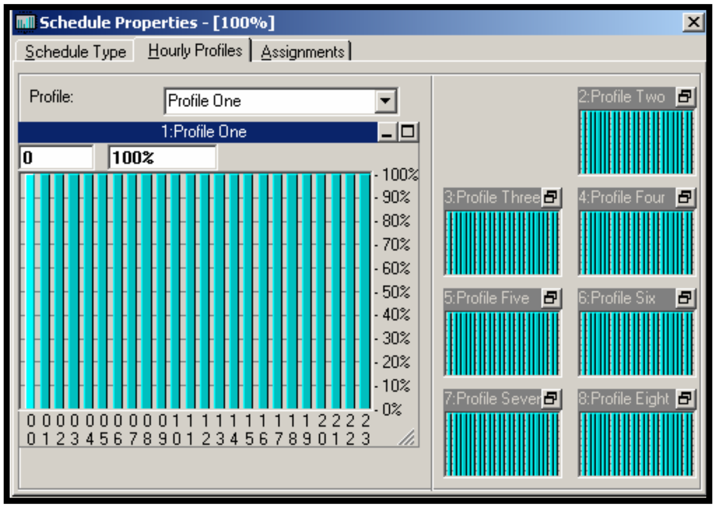

Figure 5 – Schedule Properties – 100%

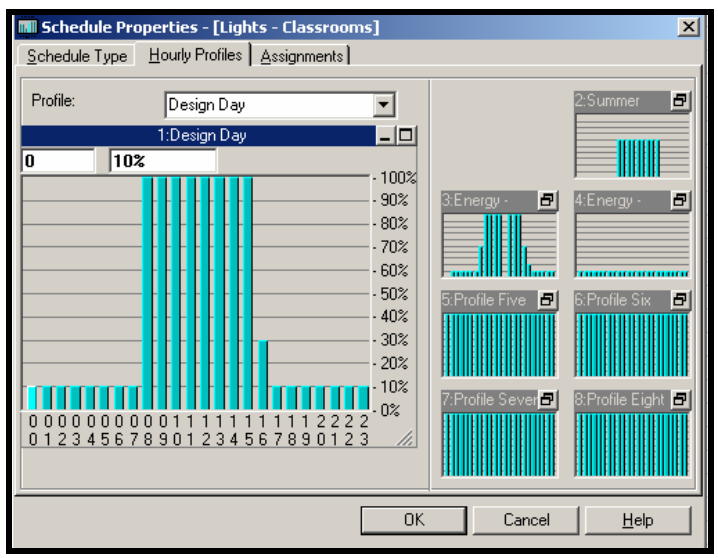

Figure 6 – Schedule Properties, Lights - Classrooms

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Zone T-stat Check

Another way to diagnose this problem is to approach it as if it were a problem at job start-up. The first thing to try would be to start the system up earlier in the day to see if a longer run-time will bring the temperature under control. Adjust the Fan and Thermostat schedule, re-run the calculations, and check the results.

Another possible solution would be to cool with a set-up temperature during the unoccupied period. Adjust the unoccupied setpoint values in the Air System input, make Unoccupied Cooling Available, and re-run the calculations and check the results (see Figure 7).

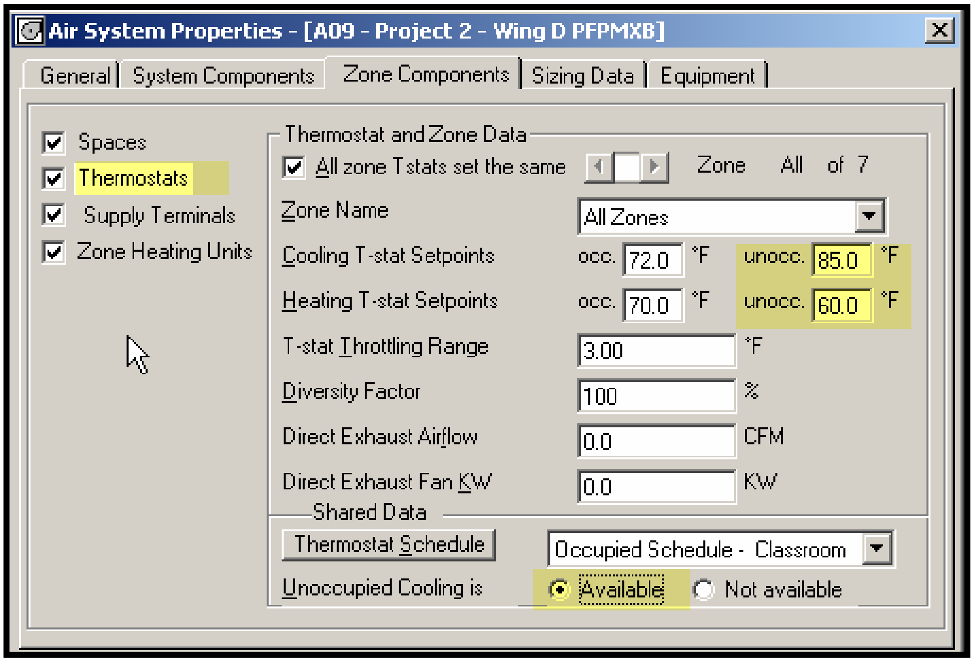

Figure 7 – Air System Properties – Zone Components

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Zone T-stat Check

The last possible solution is to put more air into the problem zones by using the User-Defined sizing option in the Air System Sizing Data tab and re-run the calculation (see Figure 8).

This error and the possible solutions to correct this situation are due to inherent characteristics of the Transfer Function Methodology. See HAP e-Help 004 - Transfer Function Methodology (TFM). Stage-one sizing is performed with the system held at a constant temperature for 24 hours. Stage-two then simulates the system operation using the stage-one sizing. If there are any problems, the Zone T-stat Check will alert the designer that changes to the model should be considered.

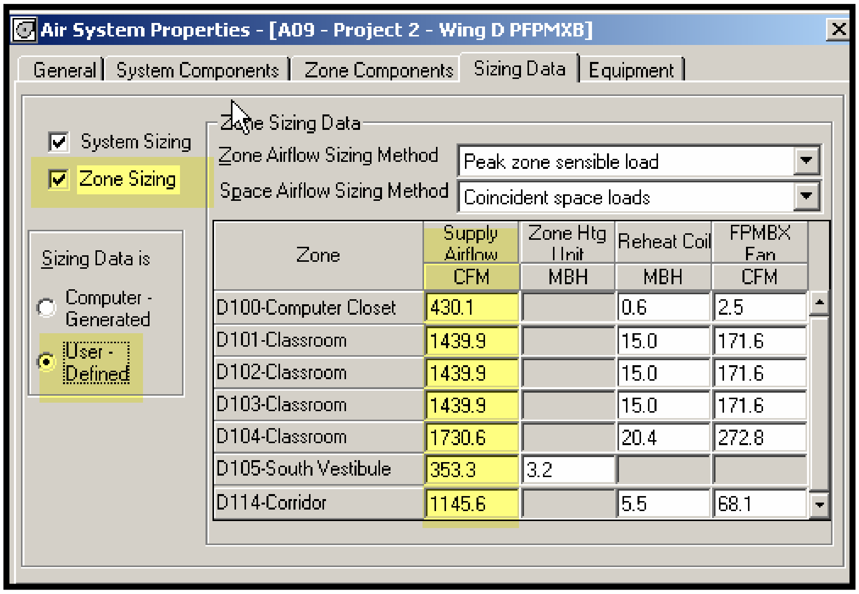

Figure 8 – Air System Properties – Sizing Data

At this time, HAP does not have a warning indication to check for zone heating temperatures out of range. To check for heating temperatures out of range, look at the System Psychometric Report for winter and inspect the zone temperatures. This would be similar to Figure 2, Table 2 but for heating.

This concludes the explanation of the "Zone T-stat Check" and how to troubleshoot and remedy this problem should it occur. The HAP program is a true HVAC system simulation tool, not just a load calculation program and as such can often be used to troubleshoot system design or operational problems.

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