Sensible Equipment Company, Inc.

PO Box 669 Goldenrod Florida 32733
Phone: 407 296-8068 Fax: 407 296-7420
E-mail kle@tricoil.com Web Site www.tricoil.com

TRICOIL® Variable Air Volume (VAV) Application

An important negative aspect of using VAV systems is the reduction of latent cooling capacity at part load cooling operation. This can have a serious negative impact on the indoor air quality, particularly with moderate to high occupancy applications such as dining rooms, meeting rooms, theaters and auditoriums.

The primary benefit of using a variable air volume (VAV) system is that one air conditioning unit can be used to satisfy the temperature control requirements in multiple zones. This is accomplished by modulating the air flow to any one of the various temperature control zones in response to changes in the room air temperature within the zone. As the air temperature in the room increases a damper in a VAV Box modulates opens to allow more cooling air flow into the room. Conversely, as the temperature in the room drops the VAV Box damper modulates closed to reduce the amount of supply air. With this continuous modulation of the air flow to the room maintains at the room temperature at the thermostat cooling set point.

The supply air volume delivered to the room provides three functions; 1) sensible room cooling, 2) latent room cooling, and 3) outside air for ventilation purposes. This points out a major problem with VAV systems. One controlled variable (the supply air volume) is responsible for 3 resultant outcomes. As the air volume is reduced to satisfy a reduction in the room sensible cooling load the room latent cooling and the outside air delivered to the room also decreases. The reduced latent cooling capacity will cause the room relative humidity to increase. The reduced ventilation air will cause the room CO2 level to increase. Both of these items, room humidity and room CO2, are affected to various degree depending on such factors as how many people are in the room, the activity level of the occupants, infiltration of outside air into the space, and other items of concern such as cooking, dishwashing, etc. However, typically the room occupancy, and the resulting latent heat gain and CO2, will remain fairly constant while the room sensible heat gain varies considerably.

The TRICOIL® method will mitigate the negative effects of the traditional VAV system by resetting the supply air temperature and the supply air dew point as a function of the reduction in the supply air volume. The supply air temperature is increased and the leaving chilled water coil temperature is decreases as the supply air volume decreases. Conversely, the supply air temperature decreases and the leaving chilled water coil increases as the supply air volume increases. This operation provides for an increase latent cooling effect per unit air volume delivered to the space. Also, this operation reduces the sensible cooling effect per unit air volume. The result is the room relative humidity can be maintained at the desired level and the supply air volume can be maintained at a higher level to improve the effectiveness of delivering the ventilation air to the room.

Table 1; TRICOIL® VAV Reset Schedule Example: This table indicates a typical reset schedule and the resulting performance of the air handling system.

VAV Reset Values			EXAMPLE PERFORMANCE (based on 10,000 cfm supply air and 75 deg F room air temperature)				
% Air Volume	*Supply Air Temperature*	*Leaving Primary Coil*	Room Sensible Cooling, mbh		Room Latent Cooling, mbh		RSHF
	Deg F	Deg F	mbh	% of Full Load	mbh	% of Full Load	
100%	55.0	53.0	217.0	100%	33.9	100%	0.86
70%	59.2	52.0	120.0	55%	33.9	100%	0.78
50%	62.0	50.5	70.5	33%	33.9	100%	0.68

Table 1 Notes:

- The reset schedule calls for the *Supply Air Temperature* to increase as the *Supply Air Volume* decreases. The result is a greater supply air volume is used to provide the part load room sensible cooling. For instance, 50% of the room supply air is used to satisfy a 33% room cooling load
- The reset schedule calls for a reduction in the *Leaving Primary Coil Temperature* as the *Supply Air Volume* decreases. With this strategy a greater amount of latent cooling is provided per unit air volume delivered to the room at partial cooling conditions. The result is the room latent cooling available does not decline with a reduction in the supply air volume.
- The room latent cooling provided remains constant during the operation of the reset schedule. At the peak sensible cooling load (indicated by the 100% supply air volume value) the room latent cooling available is 33.9 mbh. At 70% supply air volume as well as the 50% air volume, the room latent cooling remains 33.9 mbh. This constant 100% dehumidification is available even though the room sensible cooling is reduced to 33% of the maximum.

<u>Psychrometric Chart 1:</u> This chart indicates the change in performance of the air handling system when operating under the control of the TRICOIL® VAV reset schedule.

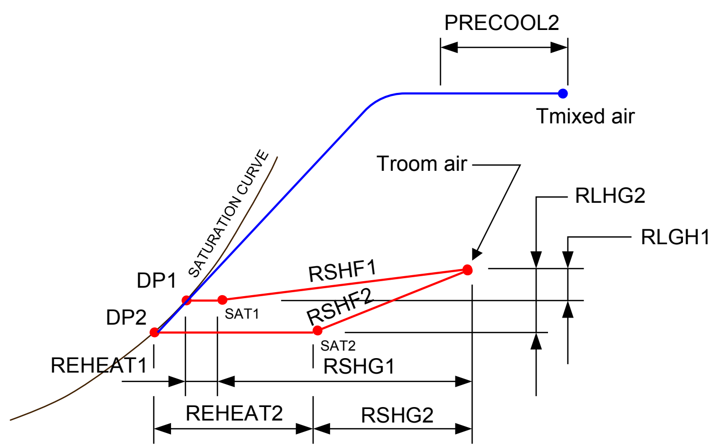


Chart 1 Notes:

- SAT1 is the supply air temperature at 100% supply air volume. DP1 is the leaving primary cooling coil air temperature and in most applications is very close to the supply air dew point temperature.
- SAT2 is the supply air temperature at 50% air volume and DP2 is the leaving primary coil temperature at the 50% air volume. Again, this value is typically close to the supply air dew point temperature.
- The supply air condition, defined by the supply air dry bulb temperature and supply air dew point, provides the room sensible and latent cooling; RSHG1 is the room sensible cooling at 100% air volume, RSHG2 is the room sensible cooling at 50% air volume (representative of a part load cooling condition).
- Reheat is the amount of heat that is added to the air stream to provide the supply air condition (SAT1 or 2). The reheat required for SAT1 is typically provided by the heat of compression for the supply air fan. The reheat required for SAT2 is provided by the heat extracted from the mixed outside air and return air stream and the heat of compression for the supply air fan.
- The RSHF (Room Sensible Heat Factor) is an indication of the amount of room sensible cooling required as a fraction of the total room cooling required. The total room cooling is the sum of all the

room sensible cooling loads plus the sum of all the room latent cooling loads. Therefore, a RSHF of 1 would be 100% sensible room cooling. Values less then 1 would have some amount of room latent cooling. Decreasing RSHF indicate an increase in the room latent cooling requirement.

- RSHF2 line is steeper indicating that this particular condition requires more latent cooling per unit air volume than the condition indicated by RSHF1.
  - RSHF1: 10,000 cfm is used to provide 33.9 mbh of latent cooling.
  - RSHF2: 5,000 cfm is used to provide 33.9 mbh of latent cooling.
  - RSHF2 indicates the same amount of latent cooling provided as RSHF1 even though only 50% of the air volume is provided. Therefore, twice as much latent cooling is provided per unit air volume when comparing condition 2 to condition 1.
- RLHG1 and RLHG2 indicate the amount of room latent cooling provided at 100% air volume (condition 1, full load) and 50% air volume (condition 2, part load). RLHG2 appears to be twice as much as RLHG1 on the chart. This is indeed the case. However, since condition 2 has 50% air flow as condition 1 the resultant latent cooling available is the same for both condition 1 and condition 2. Refer again to the table of example 2.

Condition	1	2
Supply Air, cfm	10,000	5,000
Room Latent Cooling, mbh	33.9	33.9

<u>Coil Selection Criteria</u>

More often than not, the coil manufacturer is presented with a single set of criteria for coil performance. This is criteria is presumed to identify the peak requirements. However, the engineer should specify that the coils used on the project must satisfy both the full load criteria and all reasonably expected part load coil criteria. In fact, often a presumed part load condition will form the worst case for the coil selection criteria. This often is the case for variable air volume applications where typically reheat required at the partial room air conditioning load is greater then the reheat required at room full load condition. Consider the coil criteria for the example project conditions.

COIL SCHEDULE

SYSTEM OPERATION LOAD	COIL FUNCTION	AIR VOLUME	ENT AIR		LVG AIR		CAPACITY	EWT	LWT	WATER FLOW
		CFM	DB °F	WB °F	DB °F	WB °F	TOTAL MBH	°F	°F	GPM
FULL LOAD	PRECOOLING	10000	80	66.3	-	-	-	-	-	-
	CHILLED WATER		80	66.3	53	53	401.8	44	58	57.4
	REHEAT		53	53	-	-	-	-	-	-
PART LOAD 70% AIR FLOW	PRECOOLING	7000	82.1	67.8	76.9	66.2	39.5	64.5	69.65	15.2
	CHILLED WATER		76.9	66.2	52	52	297.8	44		57.4
	REHEAT		52	52	57.2		39.5	69.65	64.45	15.2
PART LOAD 50% AIR FLOW	PRECOOLING	5000	85	69.8	73.5	66.3	62.4	62.0	73.5	10.9
	CHILLED WATER		89	80	50.5	50.5		44		57.4
	REHEAT		50.5	50.5	62		62.4	73.5	62	10.9

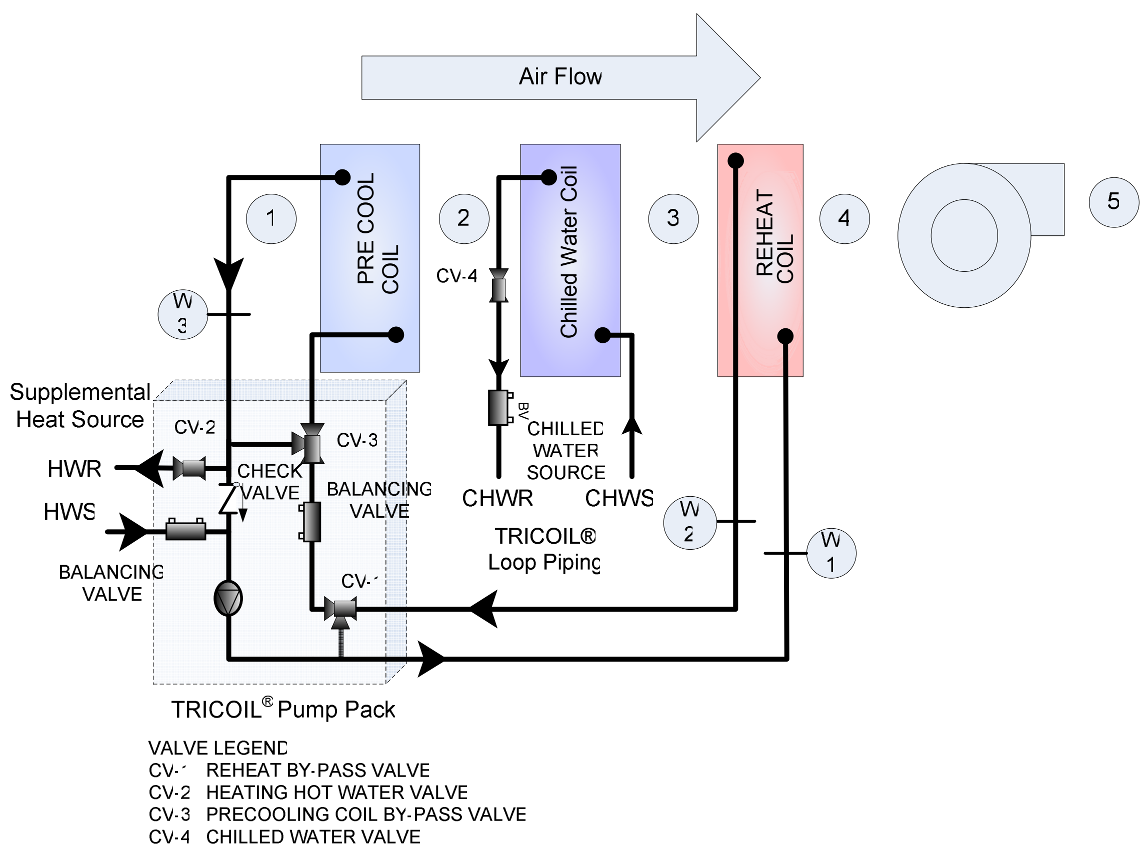
The coil manufacturer's selection and rating programs are used to determine which set of criteria represents the worst case coil criteria. Note that the chilled water flow rate is based on the full cooling load criteria. Full load criteria are used to establish the peak chilled water flow rate. At the part load conditions the chilled water flow volume is used as a maximum value for re-rating the chilled water for the part load conditions. Also note that the full load criteria for this application does not require reheat. When reheat is not required there will be no precooling, therefore the entering chilled water coil criteria is the same as the entering precooling coil criteria for this particular application. In many applications there will be a demand for reheat at peak cooling load. Care should be taken in establishing the peak load criteria as well as the part load criteria.

The coil schedule can be condensed into a single set of criteria. The rows and fins per inch of each coil are selected based on the worst case criteria for the respective coil. Inspection of the coil manufacturer's rating program output sheets is required for this step. Typically the Full Load criteria establishes the chilled water coil requirements and a Part Load criteria establishes the precool coil and reheat coil requirements.

COIL SCHEDULE															
AHU TAG	COIL FUNCTION	AIR VOLUME	ENT AIR		LVG AIR		CAPACITY	EWT	LWT	WATER FLOW	FACE AREA	ROWS	FINS PER FOOT	MAX PRESSURE DROP	
		CFM	DB °F	WB °F	DB °F	WB °F	TOTAL MBH	°F	°F	GPM	SQ.FT.			AIR IN. W.C.	WATER FT. W.C
EXAMPLE	PRECOOLING	5000	85	69.8	73.5	66.3	62.4	62	73.5	10.9	18.6	3	8	0.17	4.2
	CHILLED WATER	10000	80	66.3	53	53	401.8	44	58	57.4	18.6	8	9	0.85	12.0
	REHEAT	5000	50.5	50.5	62	-	62.4	73.5	62	10.9	18.6	3	8	0.17	4.2

Note (1): The precooling coil and the reheat coil selection criteria, for this VAV application are based on the reduced air volume of 5000 cfm. However, the fan and motor must be selected for 100% air volume (10,000 cfm). Use the air side pressure drop through these coils based on 100% air volume.

TRICOIL® PIPING DIAGRAM



OPERATING SEQUENCE: The following notes are intended to provide a brief over-view of the operating sequence for the TRICOIL® VAV control.

Pump control: The pump runs continuously when there is a demand for reheat or preheat.

CV-4 The chilled water control valve, CV-4, modulates to maintain the air temperature leaving the chilled water coil (point 3) at set point.

The set point is reset based on the supply air volume. As the volume is reduced the leaving air temperature is reduced to enhance dehumidification. Alternately, a critical zone can be used to provide the input to the reset.

CV-1 The reheat coil by-pass valve, CV-1, modulates to maintain the supply air temperature (point 4) at set point.

The set point is reset based on the supply air volume. As the volume is reduced the supply air temperature is increased to enhance dehumidification and zone air circulation.

CV-2 The heating hot water valve, CV-2, is used to provide supplemental reheat from a hot water source.

This is used when precise control is required. For example, if the minimum circulation rate is required or precise humidity control is required CV-3 will modulate to maintain the supply air at set point if there is insufficient heat available in the precooling process. For most systems supplemental heat will not be used when the chilled water valve is actively controlling to maintain the leaving chilled water coil temperature set point.

CV-3 The precooling coil by-pass valve, CV-3, is a two position control valve and it used as follows.

Precool By-pass: CV-3 is used to by-pass water around the precooling coil to preclude preheating the air if the leaving reheat coil water temperature is above the entering precooling coil air temperature. For example, if CV-2 is modulating to actively maintain the supply air temperature at set point (for instance when active humidity control is required) there could be operating conditions when the outside air temperature drops such that the mixed air temperature is lower than the entering coil water temperature. To prevent a preheating effect when in the cooling mode CV-3 would be positioned to the by-pass position.

Heating/Preheat: If the mixed air temperature drops below a minimum set point the precooling coil by-pass valve, CV-3, is positioned for 100% water flow through the coil. The hot water valve, CV-2, modulates to maintain the leaving precooling coil air temperature at the minimum desired temperature.

Freeze Protection: There are various methods available to the designer to provide coil freeze protection. Where appropriate a freeze-stat can be used to override the temperature controls and position CV-1 and CV-3 to the coil flow position and open CV-2 to provide hot water flow through the coils and the TRICOIL® loop.

With a slight variation to the above controls the TRICOIL® method can be applied to a single zone VAV control system where the room temperature is controlled directly by modulating the air flow at the air handling unit.