Operation

Series fan terminals are arranged such that a constant quantity of air is delivered to the space from the terminal fan. As such, the fan must run continuously for both heating and cooling, to maintain space temperature set point. Typically, since the fan runs at a constant speed and essentially a constant air discharge rate, these types of fan terminals are often called constant volume fan terminals. The fan capacity is typically sized for 100% of the cooling load, with maximum primary airflow equal to or less than the fan flow to prevent spilling of primary air into the ceiling plenum. A diagrammatic plan view of the Anemostat QST and EST Series Fan Terminal is shown in figure 3 :

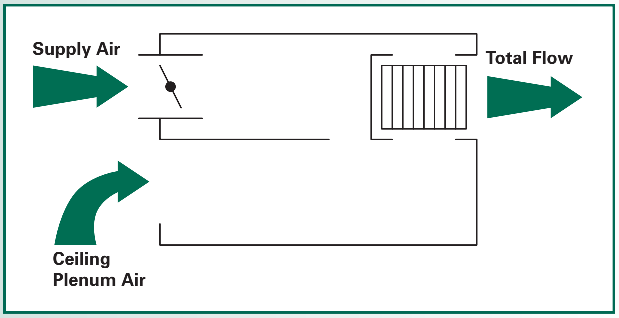

Figure 3: Model QST
Quiet Series Fan Terminal

The fan discharge air is composed of conditioned primary air, ceiling plenum air (induction air), or a mixture of both, providing variable discharge temperature:

Constant Fan Capacity = Primary Air + Induction Air

Conditioned, primary air is delivered to the terminal from a central system, through a duct, into the fan terminal cabinet. The quantity of primary air into the terminal is often regulated by a pressure independent control system responsive to the space thermostat (temperature) like conventional single duct control systems. The ceiling plenum air enters the fan terminal through an induction opening in the cabinet. With the fan operating at a constant air discharge rate to the space and the primary airflow into the cabinet varying (VAV) as demanded by the space thermostat and controls, induction air is drawn into the cabinet by fan suction as make-up air to maintain constant fan flow. With primary air at minimum, and induction air at maximum, supplemental heat is then added as required to meet heating loads. Often, series fan terminals are interlocked with the central system to operate simultaneously and prevent backward spinning of the unit fan.

System Operation

With the units fan providing the energy required to deliver the air from the terminal to the space, the central system only needs to provide the minimum terminal operating pressure at maximum design flow. The terminal fan is sized based on the maximum flow requirement at the downstream duct and diffuser pressure requirements.

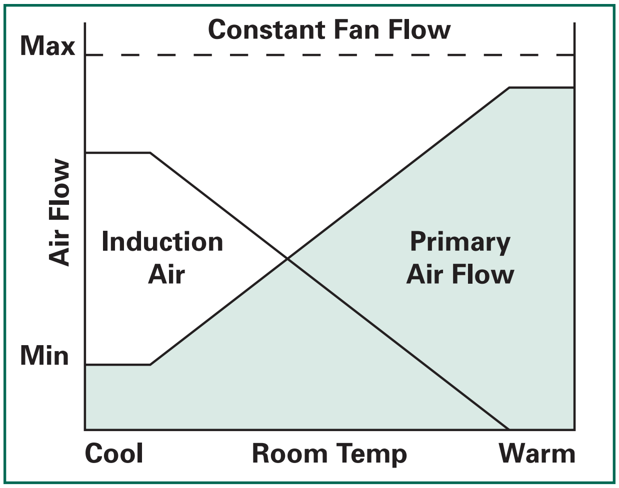

Diagram 4: Air Flow Diagram
Series Fan Terminal

Acoustics

Since the fan operates continuously, the sound levels from Series fan terminals are relatively constant during both heating and cooling modes. The radiated sound is often the dominant source to the space and requires sufficient analysis to ensure acceptable space sound pressure levels.

The Anemostat Model QST and EST - Quiet fan terminals have been specifically designed to abate radiated sound levels. Additionally, sound levels may be adequately controlled by selecting terminal fans operating at less than maximum RPM.

Selection Procedures for Series Fan Terminals

General

The specific selection examples given will provide the procedure required to properly select Series type fan terminals. Often, the selection process is iterative, requiring re-selection in order to meet all performance requirements.

Performance Criteria

The performance requirements of the fan terminals are predetermined by load calculations for both heating and cooling loads, supply air and ceiling plenum air temperatures, air change rates, acoustical requirements, etc. With these design criteria, fan terminals are selected for:

Fan Capacity Heating Coil Capacity Primary Inlet Capacity Acoustical Requirements

Fan Capacity

The fan capacity is typically sized for 100% of the cooling load handled by the conditioned primary air. In selecting the proper fan, the external or downstream static pressure (DSP) in the discharge duct must be determined. With the required fan capacity (CFM) and downstream static pressure known, refer to the fan curves to select a cabinet (fan) size that operates at this design point. The curve axes are Fan CFM vs. Downstream Static Pressure (DSP), and define the maximum to minimum operating range available for that unit size. The design operating point should fall between the maximum and minimum fan capacity curves. When a heating coil is used, the maximum capacity curve is shown with the coil.

Heating Coil Capacity

The space-heating load is calculated for MBH (thousands of BTU/hr), at winter indoor design temperature. From this, the coil leaving air temperature (LAT), at the design airflow rate (fan capacity) is determined. This is the heating supply air temperature to the space. The heat output from the coil can then be determined giving the air temperature rise required to bring the coil entering air temperature (EAT) up to the required coil LAT. During heating, the coil entering air is typically a mixture of both ceiling plenum air and minimum primary air and the mixed temperature can be calculated for the coil EAT. Coil heat transfer equations are given in the examples to follow.

Primary Inlet Capacity

The inlet size selected is based on both the maximum and minimum primary airflow rates. The maximum primary airflow rate determines the minimum operating pressure requirement for the terminal. This is the pressure required in the inlet supply duct for the maximum primary airflow rate with the damper in the full-open position. Minimum operating pressure requirements are provided for each inlet size in tables 38 and 52 (pages D-16, 47). For flow control, both the maximum and minimum primary airflow rates must fall within the Primary CFM Ranges as shown in charts 1, 2 and 3 (pages D-12, 30, 46). The primary ranges shown represent limitations of the controlling devices.

Acoustical Requirements

For series type fan terminals, the maximum sound levels occur during full cooling with maximum primary airflow at system static pressure. The radiated sound levels typically dictate the space sound pressure levels. A space NC level is easiest to specify, but attenuation assumptions for the path should be carefully verified. A detailed analysis using AHRI Std 885 in predicting space sound pressure levels, to determine the maximum permissible octave band sound power levels of the fan terminal is preferred.

Example 1

Model QST Series Fan Terminal with Hot Water Heat

Select Cabinet for Fan Capacity

Required information:

Design airflow	1300 CFM
Downstream Static Pressure (DSP) at design airflow	0.25" wg
Fan Motor Voltage	277 volts

From the fan curves on pages D-14, 15, select QST Unit size 50 (QST-50). This fan terminal is capable of delivering the design flow by adjusting the fan speed with the manual SCR speed controller, and/or by changing the motor HP taps. The fan curves represent the upper and lower operating limits of the fan terminal. The desired operating point must fall below the appropriate high-speed curve (basic assembly, 1 row, 2 row hot water coil) and above the minimum speed curve.

Select Hot Water Coil

Required information:

Winter indoor design temp.	70° F
Entering Water Temp. (EWT)	180° F
Space heating load	24000 Btu/Hr
Minimum primary CFM	300 CFM
Primary air temperature	55° F
Ceiling plenum temperature	73° F

The space-heating load is the heat loss rate of the space, and therefore, the heat added to the space by the supply air must be 24,000 Btu/Hr (or 24 MBH). The discharge air temperature required from the fan terminal to the space may be calculated from equation (1):

Equation 1

$$Q = CFM \times \varnothing T \times 1.08$$

Where,
Q is energy rate in Btu/hr
CFM is volumetric airflow rate
ØT is (Supply Air Temp – Space Temp)

24,000 Btu/Hr =
1300 CFM x (Supply air temp - 70°F) x 1.08

or, Supply air temp = 87°F

The hot water coil must provide a discharge temperature or leaving air temperature (LAT) of 87°F at an airflow rate of 1300 CFM (a blend of 300 CFM minimum primary air + 1000 CFM of ceiling plenum air) to maintain the space temperature of 70°F. The hot water coil entering air temperature (EAT) is calculated from the mixture of primary and ceiling plenum air, equation (2):

Equation 2

Design Flow x Coil EAT =
(Primary Flow x Primary Temp) +
(Plenum Air x Plenum Temp)

1300 CFM x Coil EAT =
(300 CFM x 55°F) + (1000 CFM x 73°F)

or, Hot Water Coil EAT = 69°F

Since the air temperature entering the coil is less than the space temperature, the coil heat output is greater than the space-heating load. The hot water coil heat output, Q, is calculated in Btu/hr using equation (1):

Q = CFM x ØT x 1.08

Q = 1300 x (87°F - 69°F) x 1.08

Q = 25,272 Btu/Hr

Where ØT is the temperature rise of the air across the coil (LAT-EAT).

Refer to the QST-50, 1 row hot water coil performance data table 31, page D-9. The data tables are based on a coil EWT-EAT of 125°F, as noted at the bottom of the page. For this example, the EWT-EAT is 180°F - 69°F = 111°F. By interpolation, the adjustment factor is .89. At 2 GPM, for 1300 CFM, find 37.2 MBH (table 31) x .89 (factor) = 33.1 MBH, which meets the minimum requirement of 25.3 MBH, as calculated above.

Select Primary Inlet Size:

Required information:
Maximum primary airflow 1300 CFM
Minimum primary airflow 300 CFM

Refer to the primary airflow capacity tables on page D-12, select the inlet size for the 1300-300 CFM operating range of this fan terminal. If the design flow rates do not fall within range, the minimum primary flow rate must be increased as required. The heating coil selection must be repeated if the minimum primary airflow is changed.

Inlet size / range selected 10" ø
Minimum operating total
Pressure required (table 38, pg D-16) 10" = .14" w.g.

Verify Acoustical Acceptance:

The terminal radiated sound levels typically dictate the room sound pressure level, and therefore, are evaluated at maximum cooling capacity and system inlet static pressure. An acoustical analysis of a typical zone using AHRI Std 885 for predicting space sound pressure levels determines the allowable sound power levels of the fan terminal to meet NC levels. From the typical NC design values in table 3, page D-71, for an open office space:

Required information:
Design inlet static pressure 1.0" w.g.
Noise Criteria NC-37
Max radiated sound power levels, Lw. by octave band, Fan = 100% Primary Flow as determined by AHRI 885 Calculations:

Octave Band	2	3	4	5	6	7
Sound Power	72	66	62	64	67	71

Refer to table 39 page D-17 for Model QST-5010 radiated sound power data with Fan CFM = Primary CFM, at 1.00" Inlet Ps, 1300 CFM, .25" downstream static pressure.

Octave Band	2	3	4	5	6	7
Sound Power	70	66	58	52	48	47

The sound power levels for this terminal are below the maximum allowable as determined by AHRI 885 prediction methods. If fan terminal sound power or NC levels are too high, re-select a larger cabinet (fan) at reduced operating speeds, and recheck performance criteria.

Example 2

Model QST Series Fan Terminal with Electric Heat

Select Cabinet for Fan Capacity

Required information:
Design airflow 650 CFM
Downstream Static Pressure
(DSP) at design airflow .30" wg
Fan Motor Voltage 277 volts
Electric Heat Voltage 277 volts

From the fan curves on page D-13, select QST cabinet size 17 (QST-17xx).

Select Electric Heating Coil

Required information:
Winter indoor design temp. 72°F
Space heating load 16,000 Btu/Hr
Minimum primary CFM 150 CFM
Primary air temperature 58°F
Ceiling plenum temperature 75°F

The discharge air temperature required from the fan terminal to the space may be calculated from equation (1):

Equation 1

Q = CFM x ØT x 1.08

Where,
Q is energy rate in Btu/hr
CFM is volumetric airflow rate
ØT is (Supply Air Temp – Space Temp)

16,000 Btu/Hr =
650 CFM x (Supply air temp - 72°F) x 1.08

or, Supply air temp = 95°F

The electric coil must provide a discharge temperature or leaving air temperature (LAT) of 95°F at an airflow rate of 650 CFM (a blend of 150 CFM minimum primary air + 500 CFM of ceiling plenum air) to maintain the space temperature of 72°F. The coil entering air temperature (EAT) is calculated from the mixture of primary and ceiling plenum air:

Design Flow x Coil EAT =
(Primary Flow x Primary Temp) +
(Plenum Air x Plenum Temp)

650 CFM x Coil EAT =
(150 CFM x 58°F) + (500 CFM x 75°F)

or, Electric Coil EAT = 71°F

Since the air temperature entering the coil is less than the space temperature, the coil heat output is greater than the space-heating load. The electric coil heat output, Q, is calculated, in Btu/hr by:

Q = CFM x ∆T x 1.08

Q = 650 x (95°F - 71°F) x 1.08 = 16,848 Btu/Hr

where ∆T is the temperature rise of the air across the coil (LAT-EAT).

Converting to Kilowatts

16,848 Btu/Hr x 1 Kw / 3,412 Btu/Hr) = 5.0 Kw

Refer to table 32 page D-11 to see that a 5.7 KW Electric Heater is available for a QST-17XX unit at 120 volts.

The heating coil selection must be repeated if the minimum primary airflow is changed.

Select Primary Inlet Size

Required information:
Maximum primary airflow 650 CFM
Minimum primary airflow 150 CFM

Refer to the primary airflow capacity tables on page D-12, select the inlet size for the 650-150 CFM operating range of this fan terminal. If the design flow rates do not fall within the range, the minimum primary flow rate must be increased as required.

Inlet size selected: 8” ø
Minimum operating total
Pressure required .11” w.g.
(page D-16 table 38)

Verify Acoustical Acceptance

The terminal radiated sound levels typically dictate the room sound pressure level, and therefore, are evaluated at maximum cooling capacity. An acoustical analysis of a typical zone using AHRI Std 885 for predicting space sound pressure levels determines the allowable sound power level of the fan terminal to meet required room NC levels.

Required information:
Design inlet static pressure 1.0” w.g.
Max radiated sound power levels, Lw by octave band, Fan = 100% Primary Flow: NC = 32

Octave Band	2	3	4	5	6	7
Sound Power	72	66	57	59	62	66

Referencing table 39 page D-17 for Model QST-17, and interpolating for Radiated sound power levels at 1.0” Ps, 650 CFM:

Octave Band	2	3	4	5	6	7
Sound Power	71	65	53	48	46	44

The sound power levels for this terminal are below the maximum allowable as determined by AHRI 885 prediction methods. Sound power or NC level may be reduced by selecting a large cabinet (fan) at reduced operating speeds.