

Application Note 2009: Outside Air

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Introduction

This Application Note provides an overview related to introducing outside air into a VRF system with either commercial or residential style indoor units.

Outside Air (OA)

Outdoor air (OA) introduced into an indoor unit constitutes a large part of the total indoor systems load, which is one reason to limit air exchange rates into the VRF indoor unit, as this will increase the load on the selected indoor unit.

As air exchange is increased to the indoor unit, its load is affected in several ways. First, incoming air must be heated or cooled from the outdoor air temperature to the indoor temperature. The rate of energy consumption by this sensible heating or cooling is given by

$$q_s = 60Q\rho c_p \Delta t$$

where

q_s = sensible heat load, Btu/h

Q = airflow rate, cfm

ρ = air density, lb. /ft.³ (about 0.075 at or near sea level)

c_p = specific heat of air, Btu/lb.·°F (about 0.24)

Δt = temperature difference between indoors and outdoors, °F

and at or near sea-level air density, with an adjustment for typical room air humidity, this equation is commonly presented for design use as

$$q_s = 1.1Q\Delta t$$

This equation is known as the **sensible heat equation**. HVAC designers typically assume sea-level air pressure for locations with altitudes of 2000 ft. or lower.

Air exchange also modifies the moisture content of the air. The rate of energy consumption associated with these latent loads is given by

$$q_l = 60Q\rho\Delta W (1061 + 0.444t)$$

where

q_l = latent heat load, Btu/h

ΔW = humidity ratio difference between indoors and outdoors,

gr_m water/gr_m dry air

t = average of indoor and outdoor temperatures, °F

This equation is known as the **latent heat equation**. When at or near sea level, and for common comfort air temperatures, the right-hand side of Equation is approximately $0.68Q\Delta W$.

Example

A 30 MBH VRF indoor unit is supplied with 100 cfm of OA for a building in Atlanta, Georgia. If the air is to be delivered directly to the indoor unit, how much sensible and latent heat will be added to the indoor unit coil load by the OA at summer/winter design conditions provide below.

- Loads (no OA) for the zone: 28,000 Btu Total / 18,000 btu Sensible cooling
20,600 Btu Sensible heating
- Selected unit is a PEFY-P30: 30,000 Btu Total / 19,700 btu Sensible cooling
24,600 Btu Sensible heating
- OA conditions: Summer – 94°F DB / 74°F WB
Winter – 24°F DBVR
- Return air conditions: Summer – 80°F DB / 67°F WB
Winter – 70°F DB

Solution

From the weather data tables from ASHRAE, Atlanta is at an elevation of about 1000 ft. Because this is below the rule-of-thumb cutoff of 2000 ft. for assuming sea-level conditions, air density is assumed to be 0.075 lb._m/ft.³. First from the Atlanta data table, the winter 99% design dry-bulb (dB) temperature is 23.9°F, rounded to 24°F for winter. Second from the Atlanta data table the summer 0.4% dry-bulb temperature is 93.8°F, rounded to 94°F and the wet-bulb (wb) is 74.3°F, rounded to 74°F

From ASHRAE's sea-level psychometric chart and the summer/winter design conditions, the desired humidity ratio W of the 70°F, 56 wet-bulb (wb) return air in the winter is about 55.76 gr_mw/gr_mda, as this will be of little concern for this example as we will only be concerned with the dry-bulb (dB) temperature difference. The desired humidity ratio W of the 80°F, 67 wet-bulb (wb) return air in the summer is about 78.55 gr_mw/gr_mda. The desired humidity ratio W of the 94°F, 74 wet-bulb (wb) outside air in the summer is about 94.55 gr_mw/gr_mda. With 100 cfm of outdoor air to be conditioned, and using the sensible and latent heat equations for sea level, the energy needed to condition this outdoor air is

WINTER:

$$\begin{aligned}q_s &= 1.1Q\Delta T = 1.1 \times 100 \text{ cfm} (70 - 24^\circ\text{F}) \\&= 5060 \text{ Btu/h}\end{aligned}$$

SUMMER:

$$\begin{aligned}q_s &= 1.1Q\Delta T = 1.1 \times 100 \text{ cfm} (94 - 80^\circ\text{F}) \\&= 1540 \text{ Btu/h}\end{aligned}$$

$$\begin{aligned}q_l &= 0.68Q\Delta W = 0.68 \times 100 \text{ cfm} (94.55 - 78.55 \Delta W) \\&= 1088 \text{ Btu/h}\end{aligned}$$

Conclusion

The VRF indoor unit coil will need to be sized to provide at least 5,060 Btu/h of sensible heat loss in the winter in addition to the space load required of 20,600 Btu/h. The indoor unit coil will also need to be sized to provide at least 1,540 Btu/h of sensible heat gain, and 1,088 Btu/h of latent heat gain in the summer in addition to the space load required of 18,000 Btu/h. The capacity tables in the engineering manual illustrate that the additional sensible and latent load of the outside air requires that a 36 MBH indoor unit should be selected instead of a 30 MBH indoor unit.

A much higher OA flow rate can be utilized if pre-treated with a ventilation unit such as an ERV or DOAS ventilation system. This will allow OA to be supplied at room neutral conditions.

In addition, the ceiling-recessed indoor units have a maximum ventilation flow rate of about 550 FPM (It is recommended to use a duct-u-lator and have the air enter at a low velocity) due to the additional sound associated with the airflow through the ventilation air input opening near the grill. The maximum flow rate for these units before the sound level gets too high is generally about 50-80 CFM.

Finally, to ensure all indoor units are properly selected, include the ventilation air conditions (output from a ventilation unit if one will be utilized) and flow rates in the load calculations whenever possible, prior to selecting the indoor units.