Application Note 2009: Outside Air

Author **James Brackett** | Mechanical Engineer

Contributors **Joe Vaughan** | Manager, Application Support and Development
Yvette Daniel | Document Program Manager

Reference Documents
Engineering Manual | PLFY
Engineering Manual | PEFY
Engineering Manual | PCFY
Engineering Manual | PMFY
Engineering Manual | PVFY
Engineering Manual | PEAD
Engineering Manual | PEA
Engineering Manual | PLA
Engineering Manual | PVA
Engineering Manual | MVZ

Table of Contents

Introduction

This Application Note provides an overview related to the application of outside air being supplied to system with CITY MULTI® and M- and P-Series indoor units.

Outside air can be connected to the following CITY MULTI® PLFY, PEFY, PCFY, PMFY, PVFY, PEA, PEAD, and M- and P-Series PLA, PVA, MVZ, SLZ, and SEZ indoor units.

Outside Air

Outdoor air introduced into an indoor unit constitutes a large part of the total load, which is one reason to limit air exchange rates into the 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

$$q_S = 1.1Q\Delta t$$

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

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

An indoor unit (PEFY-P30NMHU-E2) is supply with 100 CFM of outdoor air 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 outside air at summer/winter design conditions provide below.

- Load calculations (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 DB
- 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 psychrometric 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_m w/gr_m da, 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_m w/gr_m da. 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:

$q_S = 1.1Q\Delta T = 1.1 \times 100$ CFM (70 – 24° F)

$= 5060$ Btu/h

SUMMER:

$q_S = 1.1Q\Delta T = 1.1 \times 100$ CFM (94 – 80° F)

$= 1540$ Btu/h

$q_l = 0.68Q\Delta W = 0.68 \times 100$ CFM $(94.55 – 78.55\ \Delta W)$

$= 1088$ Btu/h

Conclusion

Thus, the 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. Thus, 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 PEFY-P36NMHU-E2 should be selected instead of the PEFY-P30NMHU-E2.

A couple items to take into consideration, a much higher OA flow rate can be utilized if pre-treated with a ventilation unit such as a Dedicated Outside Air System (DOAS), Lossnay ERV or PremiSys® ventilation system. Also, the ceiling-recessed (PLFY, PLA, SLZ) units have a maximum ventilation flow rate of about 550 FPM (It is recommended to use a ductulator and have the air enter at a low velocity) due to the additional noise associated with the air flow through the ventilation air input opening near the grill.

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.