ENGINEERING UPDATE

OCTOBER 2015 - **VOLUME 19**

THIS PACKAGE INCLUDES A COLLECTION OF ARTICLES FROM VOLUME 19 OF THE OCTOBER 2015 ENGINEERING UPDATE.

TABLE OF CONTENTS:

Reducing Energy Costs for Make-Up Air Units.. 2

Product Feature: Price Critical Controls Launches Innovative Touchscreen Room Pressure Monitor.. 4

Tech Tip: Zone Level Moisture Load... 5

ENGINEERING UPDATE

October 2015 | **Vol. 19**

REDUCING ENERGY COSTS FOR MAKE-UP AIR UNITS

By Wade Link – Custom Air Handling Units Product Manager, Price Mechanical

Gas Fired Make-Up Air units (GFMUA) play an integral role in providing tempered fresh air to occupied spaces during North American winters. Typical GFMUA applications include garages, warehouses, labs, and kitchens or any space that has a specific requirement for exhausting air.

GFMUA units are traditionally inexpensive to purchase, yet can consume large amounts of energy via natural gas and electricity. When integrated with an energy recovery (ER) device such as a heat recovery plate (HRP) or energy recovery wheel, significant operational cost savings are available, as well as opportunities to attain LEED Green Building points and tax incentives. To showcase these benefits this article reviews two systems requiring 10,000 CFM of make-up air utilizing drum and tube indirect gas fired heat in Winnipeg, MB, and Milwaukee, WI. This analysis is only reviewing winter operation, so a sensible only heat recovery plate was chosen as the ideal energy recovery device for this application.

The heat recovery plate transfers thermal energy from the waste exhaust air stream to the colder outside airstream. In many applications such as garages and labs, the exhaust air is contaminated and zero infiltration into the supply air stream is permitted. For these applications, the heat recovery plate is the ideal solution.

MUA units are also required for locations and systems that require cooling. A total energy recovery device

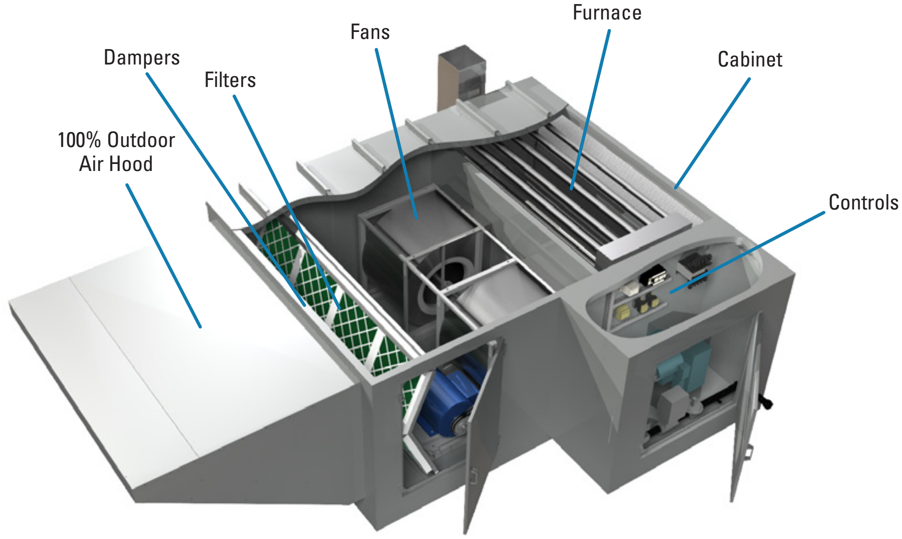


Figure 1: Example of a gas fired make-up air unit

like a wheel and energy recovery plate should be used. Adding these devices will only increase the amount of energy saved throughout the year and increase the return on investment (ROI).

For severe winter applications, frost build-up on the heat recovery plate may be of concern as warm and humid return air passes through the HRP and can condense and freeze up. In this model, face and bypass dampers are designed into the GFMUA unit to allow cold outside air to temporarily bypass the heat recovery plate, thus preventing freeze-up. By design, the furnaces or other heat source should be sized in order to handle the demand of heating the air in bypass mode with enough turndown to handle the lower heat demand when the plate is in use. This is important as maximum efficiency from a furnace occurs between 75%-

Figure 2: Example of a typical gas fired make-up air unit with HRP

100% of full fire. For the locations selected, the design conditions are listed in **Table 1**.

For this study there is a 41.9% and 38.9% increase in energy efficiency in Winnipeg and Milwaukee respectively when adding a HRP over a standard GFMUA as per winter design day conditions. For Winnipeg, the design with the HRP allowed for a reduction in size for the standard unit from a furnace sized for 125 MBH, down to a furnace sized for 75 MBH. For Milwaukee, the unit size dropped from 100 MBH to a furnace sized for 65 MBH. This decrease in heat exchanger size will help offset the increased unit size and costs. The annual energy savings are listed in **Table 2**, and the unit differences are explained in **Table 3**.

With the energy savings from the HRP, the ROI provides a payback period of approximately 3 years in Winnipeg and 2.5 years in Milwaukee. These savings are derived from the added cost of the plate, filters, return fan/motor, and increased cabinet size, and balanced with the savings in gas energy. While the initial cost increase to add energy recovery appears high on paper, it is offset by the energy savings. The average cost of the GFMUA increases by approximately 50% when an HRP is included in the design. The primary driver for the difference in payback periods between locations is the cost of energy. In Milwaukee, natural gas was priced at $0.75/therm and electricity at $0.12/kWh, and in Winnipeg, natural gas was priced at $0.335/therm and electricity at $0.05/kWh. The cost for energy in Winnipeg is much lower in this example and therefore the payback period is longer, yet there are more energy savings. As energy costs are a significant factor in lifecycle cost and savings, careful consideration for the current and future costs of energy in the local area are required.

Beyond the ROI presented, the energy recovery device provides LEED points and potential tax incentives that would only decrease the payback period.

Table 1: Design conditions used for locations selected

Location	Airflow [CFM]	Outside Air DB [°F]	Discharge Air Set Point [°F]
Winnipeg, MB	10,000	-23	72
Milwaukee, WI	10,000	-2	72

The units were to run at constant volume for 24 hours, 7 days a week and the model used incorporated a frost protection that begins to modulate at 40°F.

Table 2: Annual energy savings

Location	Savings in Gas Energy [MMBtu]	Added electrical power [Amps] / KWH	Net total savings [KWH]
Winnipeg, MB	1,809	[7.88] / 39,692	490,473
Milwaukee, WI	1,500	[7.88] / 39,692	399,915

Table 3: Unit differences

Location	Standard GFMUA footprint [L x W in"]	ERV Footprint [L x W in"]	Standard GFMUA weight [lbs]	ERV weight [lbs]
Winnipeg, MB	205 x 92	260 x 100	5,800	10,800
Milwaukee, WI	167 x 91	200 x 100	4,610	9,600

Design considerations to take into account with an ER device on a GFMUA include:

- Amp draw will increase due to the added static pressure of the device and necessity for a return fan, thus larger field wiring may be required
- Quality of air being discharged should be assessed, return air filtration will be required and coatings of interior components may be required
- Size and weight of unit will increase to accommodate energy recovery device, fan, and other components
- Furnace size decreases
- Frost protection with face and bypass dampers
- Cost of local energy and potential future costs

The benefits of including an energy recovery device into a simple GFMUA are lowering operating costs, reducing energy consumption and gaining valuable LEED points. Depending on the geographical location and application, these devices may be required by ASHRAE 90.1. By incorporating energy recovery directly into the GFMUA unit, the total HVAC system efficiency is increased, and the need for multiple run around loops is removed. When designing your GFMUA system, several design considerations should be taken into account, but overall, adding energy recovery to a simple system can have significant benefits.

ENGINEERING UPDATE

October 2015 | **Vol. 19**

PRODUCT FEATURE: PRICE CRITICAL CONTROLS LAUNCHES INNOVATIVE TOUCHSCREEN ROOM PRESSURE MONITOR

By Jarvis Penner
– Product Manager, Critical Controls

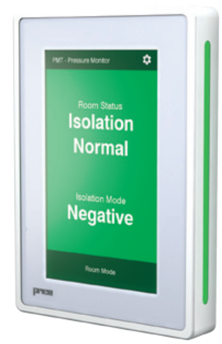
Price Critical Controls has designed a new Touchscreen Room Pressure Monitor (PMT) with the industry's highest resolution screen combined with a maintenance free pressure sensor. The PMT will be released on November 16, 2015, and will be fully supported by Price Critical Controls' experienced application engineering team and global representation.

The PMT is designed to provide intelligent room pressure monitoring of critical environments with BACnet communication (BTL Certified) to the building management system. The touchscreen display features visual and audible alarms signaling unsafe conditions with illuminating sidebars providing 180 degree visual status from anywhere in the corridor. Using the latest in microcontroller and sensor technologies, the PMT can measure extremely small pressures and display the readings on the local high-resolution display. The touchscreen interface of the PMT provides a sleek, modern design that allows for rapid set up and ease of use.

For more information please view our PMT product page at pricecriticalcontrols.com/PMT or contact criticalcontrols@priceindustries.com.

KEY PRODUCT FEATURES:

- Elegantly designed with the industry's highest resolution
- Innovative side bar room status indicator
- Advanced contamination resistant sensor
- BTL Certified for reliable network integration



Touchscreen Room Pressure Monitor (PMT)

Touchscreen Room Pressure Monitors (PMT) mounted in hospital patient/isolation rooms

TECH TIP: ZONE LEVEL MOISTURE LOAD

By Jerry Sipes, Ph.D., P.E.
– Vice President of Engineering

Moisture analysis in occupied building spaces is becoming more important as HVAC designers move toward minimal outdoor air volume designs. One common question is "How dry must the supply air be?"

When designing a traditional overhead mixing system, the volume of supply air is often fairly large and our spaces typically end up with humidity levels around 50% RH due to the large volume of supply air having enough drying effect to absorb the moisture in the occupied space. No moisture analysis is typically performed except in spaces of concern such as atria, kitchens, swimming pools, etc.

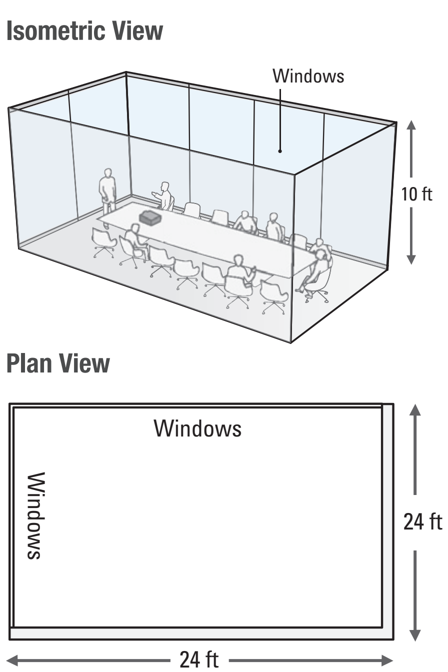


Figure 1: Private Boardroom, Example 12.4 Price Engineer's HVAC Handbook

Since codes and design practices are shifting toward minimizing outdoor air in an effort to lower operating energy costs, an analysis of the zone humidity levels has become more important than ever. This is particularly true when using chilled surfaces such as radiant cooling panels, passive beams and active beams to provide sensible cooling.

To analyze the moisture levels in a zone, one must understand the typical sources and types of moisture additions to the occupied space for the worst case scenario.

There are eight types of moisture gains to the occupied space:

1. Ventilation load: this is typically the largest source of moisture load since the ventilation air is from outdoors. The moisture content in the ventilation air depends on the outdoor conditions and will vary over the year as the climatic conditions change.
2. Infiltration load: this is moisture that is transported through the building façade into the occupied space through wall materials, windows and imperfections in the construction. This load is often magnified by wind driven pressure differentials. The age of the building may impact the amount of infiltration with older construction practices and materials having a higher potential for moisture and air movement across the building façade.
3. Occupant generated load: occupants continually give off moisture through respiration and evaporation. Additionally, their clothing may transport moisture into the occupied space due to weather events such as rain.
4. Diffusion load: moisture is transported through the building material due to the porosity in the material and is separate from the moisture movement due to moist air infiltration. A gauge of the potential for diffusion load is referred to as material permeance.
5. Internal load: building features such as fountains, swimming pools, kitchens, etc.
6. Windows and doors: doors and operable windows can add significant moisture loads depending on the occupants' behavior (i.e. leaving windows open at night).
7. Wet surfaces: cleaning tables in dining areas, mopping hard surfaces, etc.
8. Other sources: carpet cleaning, products or materials delivery (i.e. cartons) that have absorbed moisture content.

ESTIMATE DEHUMIDIFICATION LOADS

This procedure is similar to the one outlined in Chapter 11 of the *ASHRAE Humidity Control Design Guide for Commercial and Institutional Buildings*, 2001. This analysis is only for one zone, not the entire building. I will be using Example 12.4 from the *Price Engineer's HVAC Handbook* to explain the zone load and characteristics.

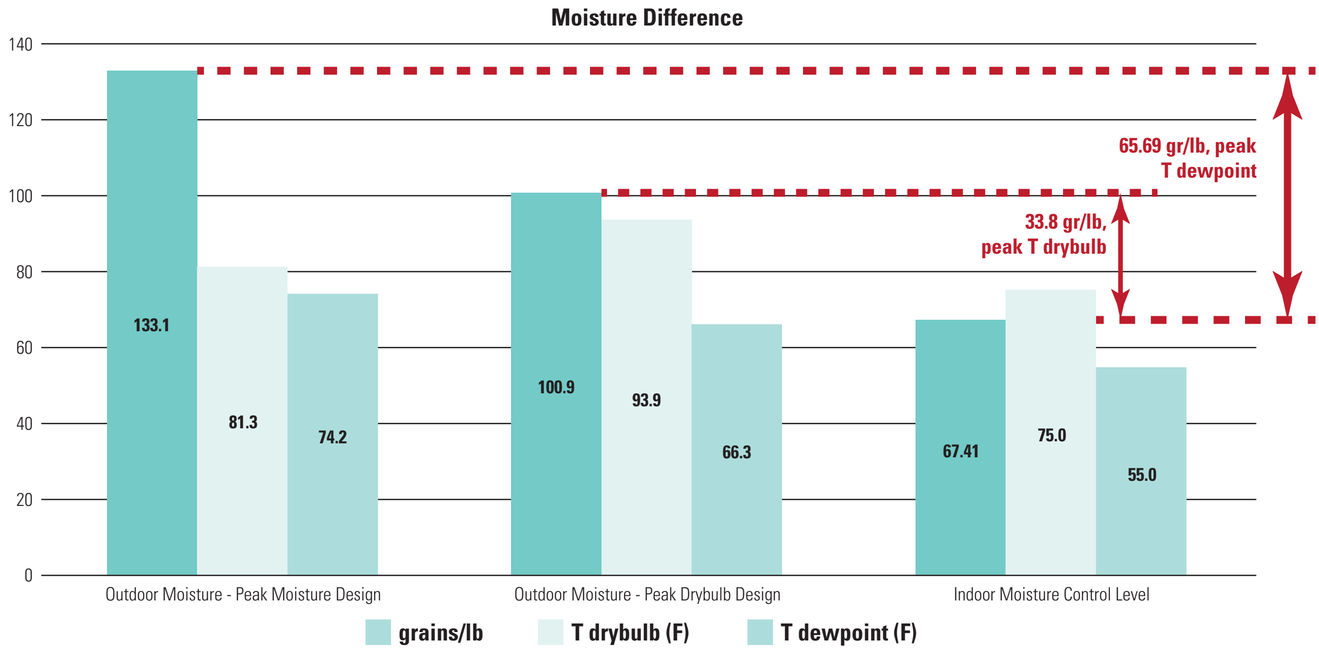


Figure 2: Atlanta Outdoor Design Conditions (ASHRAE 2013 Handbook of Fundamentals, Chapter 14)

Step 1: Select Design Conditions

To determine the zone of dehumidification load, it is important to understand the exterior air conditions at both the extreme moisture content and extreme dry bulb temperature, and to establish how many hours the building can risk being above the humidity set point. Chapter 14 in the 2013 *ASHRAE Handbook of Fundamentals* covers this topic, and for this example the Atlanta 0.4% percentile design conditions will be used (please see **Figure 2**).

As you can see in the moisture difference chart, if the designer selected peak outdoor dry-bulb temperature conditions for the design, there would be a significant chance that at peak outdoor moisture levels, the building occupancy would have higher than desired humidity. This is, of course, also related to how much infiltration exists into the occupied space being analyzed. This is a zone level analysis so I am making the assumption that the central conditioning system can handle both the peak dry-bulb and peak moisture conditions, and still provide the necessary supply temperature and moisture levels to control the zone.

Step 2: Define Building and Occupants

To give you a feel for the impact of moisture on different types of air distribution for the same space, I will select an overhead mixing diffuser and determine the supply air maximum moisture content for a private boardroom (zone level analysis). The values for this example are taken from the *Price Engineer's HVAC Handbook*, Example 12.4.

Step 3: Estimate the Dehumidification Loads

There are two types of people loads – respiration/perspiration and moisture from clothing.

Parameter	Value
# Occupants	30
Room Set-point (cooling)	75F
Floor Area	576 SF
External Wall Area (floor to floor)	672 SF
Internal Wall Area (floor to floor)	672 SF
Occupant Sensible Load	7996 BTUH
Lighting Sensible Load	3928 BTUH
Shell Gain (cooling mode)	5040 BTUH
Total Sensible Cooling Load	16,964 BTUH (29.5 BTUH/SF)
Mixing air flow volume to meet cooling load	785 CFM
Ventilation air flow volume to meet ASHRAE 62.1	185 CFM
Supply Air Temperature (cooling)	55F
Supply Air moisture content	tbd
Desired Maximum Zone Moisture Content	67.4 grains/lb

Table 1: Zone Parameters

Activity	Typical of	lb/h moisture
Seated, at rest	Theatre patron	0.10
Seated, light work	Hotel or restaurant patron	0.15
Seated, moderately active	Offices, retail cashier	0.19
Standing, light work, walking	Offices, retail floor patron	0.19
Walking, standing	Offices, retail floor clerk	0.24
Seated, light work	Electronics assemblers	0.45
Moderate dancing	Dancing, nursing care	0.52
Walking briskly with loads	Restaurant servers	0.60
Light exercise	Bowling, slow treadmill	0.83
Heavy work with lifting	Factory, health club machines	0.92
Athletics	Basketball, heavy exercise	1.04
Source: ASHRAE Humidity Control Design Guide, Figure 11.5		

Table 2: Respiration and Perspiration Moisture Loads

Respiration and Perspiration

With every breath, people release water vapor and they also evaporate moisture from their skin. Every exhale releases a lung full of moisture air at nearly saturated conditions at body temperature (98.6F, 283 grains/lb). The number of breaths per hour is dependent on the occupant activity level. Please see **Table 2** for examples.

To determine the amount of moisture generated by the occupants, please see **Equation 1** (Page 8).

MOISTURE DESORBED FROM CLOTHING

In spaces such as theatres, retail spaces, etc. with a large number of people who enter the space from the outdoors, the moisture released from the clothing can be significant. Since the analyzed space is interior and would not see a significant number of occupants directly enter from the outdoor conditions, I will not be taking this into account. As an aside, most of the moisture released from clothing occurs in the first 10 minutes of occupancy[1]. For more information on this please see either the *ASHRAE Humidity Control Design Guide*, or reference 1.

[1]Jones, B. Sipes, J., Quinn, H. McCollough E., The Transient Nature of Thermal Loads Generated by People, Final Report of ASHRAE 619-RP, ASHRAE Transactions, 1994, V. 100, Pt. 2.

INFILTRATION MOISTURE LOAD

It is very difficult to make a building envelope that is perfectly sealed. Any air penetrating the building's envelope will transport moisture and the higher the leakage, the higher the moisture that must be controlled. The air leakage is pressure dependent and as the wind pressure ebbs and wanes, the leakage will change. This means that infiltration is very difficult to predict with any accuracy. Often designers will provide positive pressurization of the building to the outdoors in an effort to minimize the infiltration. Any penetrations such as doors and windows will be a continual source of air infiltration that may become worse as the seals age. Since this example doesn't have operable windows or exterior doors, the only leakage I will anticipate is through the building façade.

VAPOR PERMEANCE

Water molecules migrate by diffusion through solid materials due to the difference in water vapor pressure on both sides of the material and the porosity of the material. For most buildings being dehumidified, the load from the permeance is very small. Moisture gain from infiltration is significantly larger and as a result, vapor diffusion is typically not estimated. However, if the building is being humidified, then an analysis should be performed. Please note that this was a very simple analysis; a complete building analysis would need to address many other factors. Please see the *ASHRAE Humidity Control Design Guide* for further guidance.

ANALYSIS

Using **Equation 1**, there will be an addition of 5.7 pounds of water per hour to the occupied zone from occupant respiration and perspiration using seated, moderately active generation rate shown in **Table 2**.

$$W_{rp} = \sum_{1}^{np}\left(n_i \times rp_i\right) = 30 * 0.19 = 5.7\frac{lb_W}{h}$$

Using **Equation 2**, there will be an addition of 2.8 pounds of water per hour to the occupied zone from infiltration using an average exterior wall construction leakage rate, shown in **Table 3**.

volume of air that infiltrates is small compared to the supply, the above equations can be used to determine the supply air enthalpy and moisture content as shown in **Table 4**.

$$W_i = A \times I_r \times (60 \times d) \times (M_1 - M_2) = 672 \times 0.1 \times (60 \times 0.075) \times \left(\frac{133.1 - 67.41}{7000}\right) = 2.8\frac{lb_W}{h}$$

Please note that the air density as defined for Standard Air is used.

Total amount of water added to space is 5.7+2.8=8.6 lbW/h. Knowing the amount of water being added to the space, the desired zone conditions of 75F, 50%RH and the supply air volume and supply air temperature will allow us to determine the supply air moisture content needed to absorb the added 8.6 lbW/h water. For a more complete description, please see Chapter 5, page 153 of the *Price Engineer's HVAC Handbook*.

$$\dot{m}_{SA}h_{SA} + \sum \dot{q}_z + \sum(\dot{m}_w h_w) = \dot{m}_{RA}h_{RA}$$

$$\dot{m}_{SA}W_{SA} + \sum \dot{m}_W = \dot{m}_{RA}W_{RA}$$

$$\dot{m}_{RA} = \dot{m}_{SA} + \dot{m}_{IA}$$

Using the 785 cfm calculated to handle the thermal load and assuming the

The analysis represented above shows that this is a very dense occupancy and that the occupants, which are the primary source of moisture in the space, roughly double the infiltration. Please see future Tech Tips where I will show examples of different space with different occupancy types and air distribution such as chilled beams.

Exterior Wall Construction	Probable Leak Rate, cfm/ft²
Tight	0.1
Average	0.3
Loose	0.6
Leakage rates are based on field measurements for North American commercial buildings at a pressure difference of 0.3"	
Source: ASHRAE Humidity Control Design Guide, Figure 11.5	

Table 3: Typical Leakage Rates for Commercial Buildings

Equation 2: Infiltration Load per Hour (lb)

$$W_i = A \times I_r \times (60 \times d) \times (M_1 - M_2)$$

$where:$ W_i is the Infiltration Load per Hour (lb)

A is wall surface exposed to wind (ft²)

I_r is the Infiltration rate (cfm/ft²)

d is air density (lb/ft³)

M_1 is the Outdoor humidity ratio (lb/lb)

M_2 is the Indoor humidity ratio (lb/lb)

Equation 1: Respiration & Perspiration Load per Hour (lb)

$$W_{rp} = \sum_{1}^{np}(n_i \times rp_i)$$

$where:$ W_{rp} is Respiration & Perspiration Load per Hour (lb)

np is # of people

n_i is the number of people in group i @ activity level i

rp_i is the moisture release per person (grains)

Parameter	Zone / Return Air	Supply Air	Outside Air
Tdrybulb	75	55	81.3
Gr/lb	67.4	66.5	133.1
Enthalpy	28.5	23.5	40.4
RH%	50	99.1	79

Table 4: Psychrometric Parameters

Private boardroom using chilled beams at the HMFH Architects, Inc. offices in Cambridge, MA