BUILDING PERFORMANCE EQUIPMENT, INC.®

Applying Energy Recovery Ventilation: Latent Only Application

Minimum Best Practices Guide

Printed in the U.S.A.

Building Performance Equipment, Inc. ®

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References:

ANSI/ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality, 2007

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Introduction

Latent only cooling is a method of utilizing the cooling energy of air leaving an existing or new construction fan coil air handler, to simultaneously pre-cool the air entering the air handler and reheat the air leaving the cooling coil. Installations and field tests have shown this can take an average fan coil either dx or chilled water and render the unit up to over 95% latent with very little temperature change.

On the cover is a photo graph of a 6,000 cfm latent only unit that not only saves energy but allows better humidity and moisture control in an industrial plant. located in a tropical jungle climate.

When the fan speed is adjusted we have found the leaving air temperature to approach within less than one degree Fahrenheit the entering temperature. Part of this is due to moisture or latent heat of condensation that has more effect on the air that has left the cooling coil to reheat this air to near the starting temperature or room temperature. This effectively allows very precise control of the moisture in the air without dropping the temperature.

Clients have used this for both outside air or for air recirculated from the space. We find recycling the air from the space allows the most efficient and precise control. A separate system can be used to bring in outside air and exhaust air from the space. A combination of recycled air and mixing this with pre-tempered fresh outdoor air can also be used. BPE energy recovery modules can be automatically, based on engineering design, track the interior space temperature, this is the engineering nature of a true direct counter flow heat exchanger.

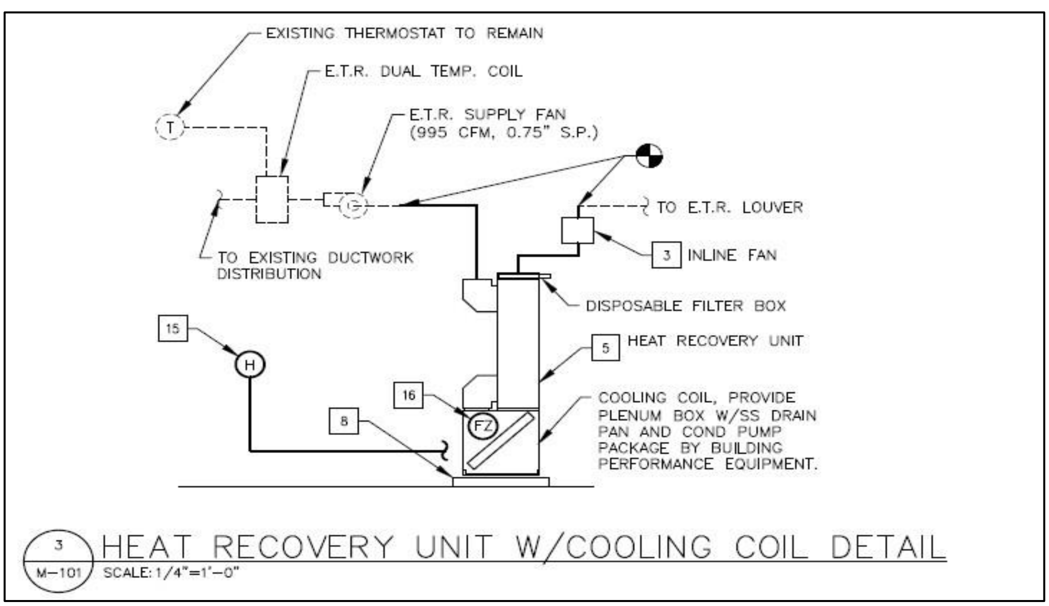


Figure 1- A detail of a 'latent cooling only loop' using a BPE ERV and a Cooling Coil

Figure 1 is a latent only device that uses a BPE unit and a chilled water coil as a run around loop to drastically reduce the required re-heating and cooling capacity. When in steady operation, return air from the space will be pre-cooled through the exhaust plenum of the heat exchanger by air leavings the cooling coil (supply air). By absorbing the heat of the return air, the supply air not only assists in pre- tempering the return air before the cooling coil, but in addition, reheats itself. It has been found through testing that this can reduce 80% of the sensible load and some of the latent load as well as greatly reduce the cooling tonnage needed to dehumidify air.

Latent only cooling systems have actually been shown to supply air within half of a degree of room temperature, effectively creating what we call a latent only device. This is useful in dealing with very moist locations or in climates where the humidity load can be excessive for a long period of time. Typically the unit is run off a humidistat and only operates when the relative humidity goes over a certain set- point. This can be done with any of the BPE Units and is relatively straight forward. The process can be summarized by the following steps:

1) The air comes in from the space and is pre-conditioned and cooled before it sees the coil

2) Pre-cooled air enters the coil and is supplied back to the heat exchanger around 50˚F

3) Supply air is reheated to 70-75˚F by the BPE ERM

4) The reheated air is then returned back to the space at nearly the same dry-bulb conditions, but much dryer. This is a huge step forward in handling relative humidity issues when there is no call for cooling.

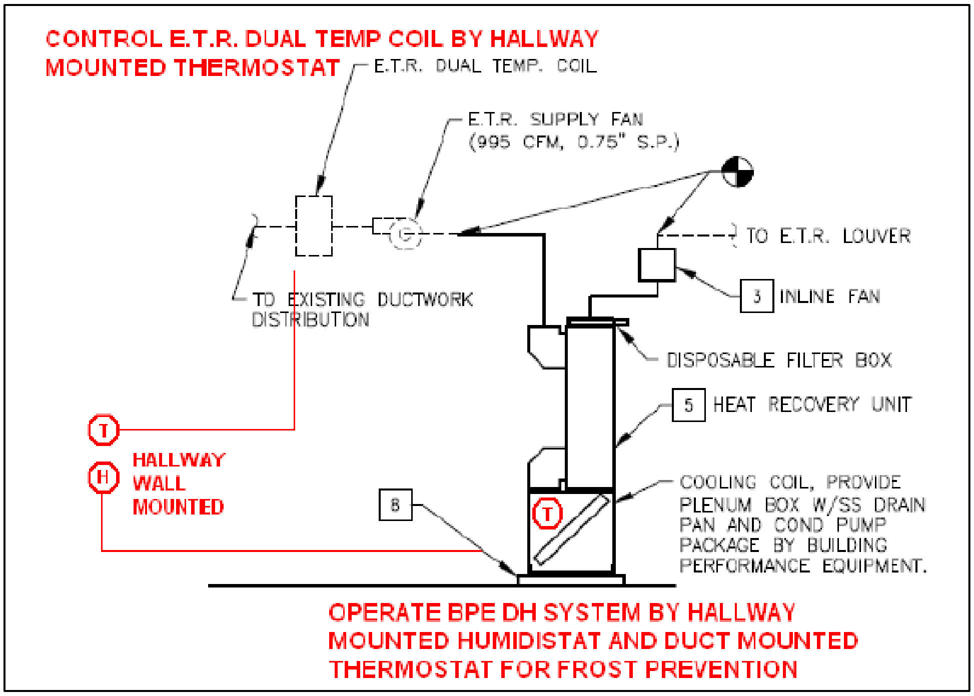


Figure 2 - A detail for the control modules of the latent only system to prevent frost

Figure 2 illustrates a detail of a run around latent only system with a direct expansion coil (DX), rather than a chilled water system for cooling. To solve this issue of coil freeze-up, BPE recommends installing a temperature loop which controls the operation of the refrigerant. When supply air falls below a certain temperature, refrigerant supply will terminate but airflow will continue. This process allows return air to warm up the coil thereby preventing any frost. This is engineered to provide latent only cooling – reduce relative humidity of air within a space without effecting temperature.

Tips:

- No. #3 – Inline Fan is before the BPE Energy Recovery Module (ERM), pushing air into the ERM.

- No. #5 – Heat Recovery Unit or ERM, is mounted vertically so the humid air condenses moisture and drips down into the air handler.

- No. #8 – Drip pan – In this configuration, there is a large volume of water generated. The Air Handler and drain pan need to be properly drained.

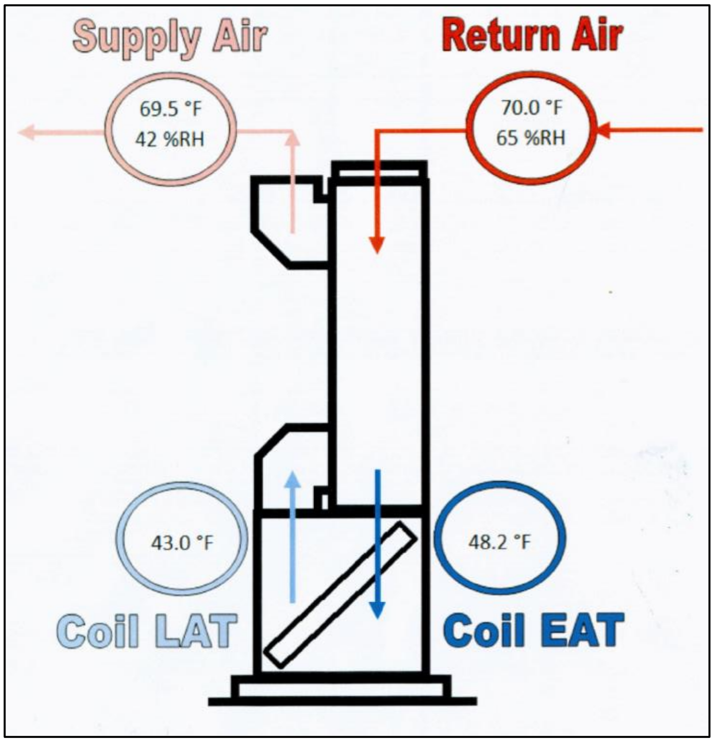


Figure 3 - Illustration of the effects of temperature and humidity in a latent only system

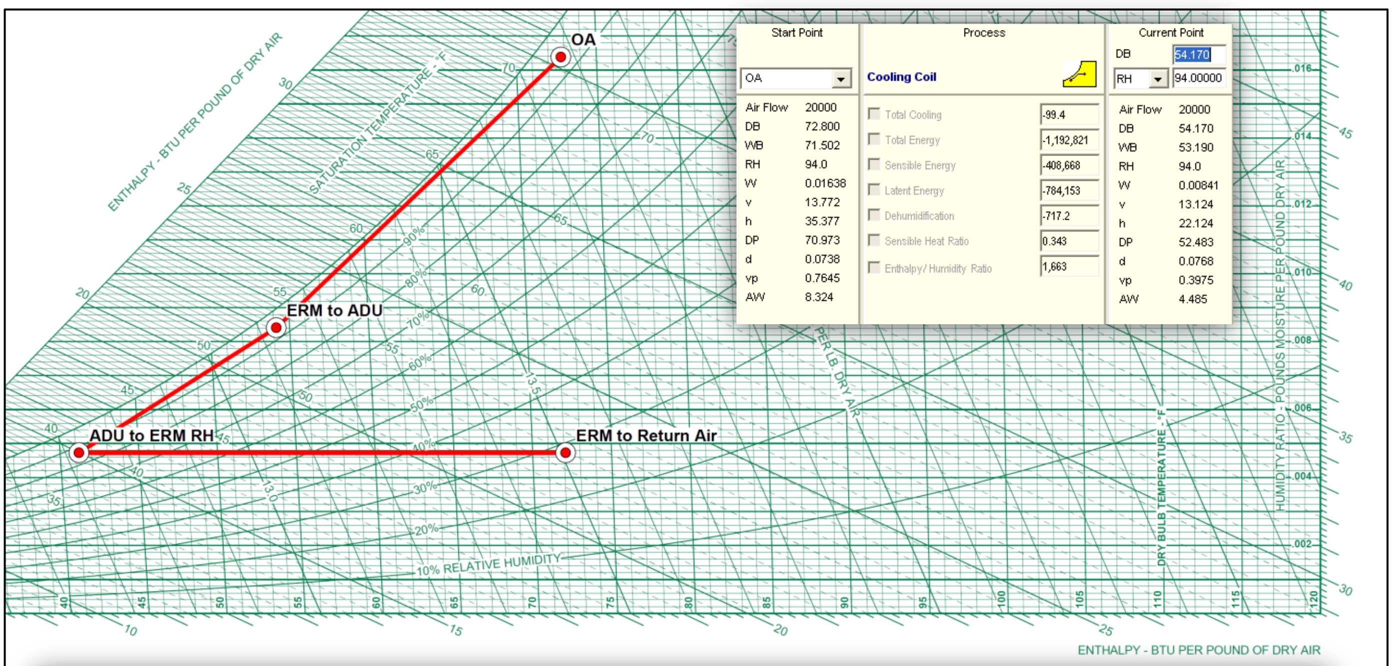
These temperatures in figure 3 are not theoretical, but were compiled through field testing. In this example the outdoor air is coming in at 70°F, so this is the worst case scenario for a traditional heating and air-conditioning system in which the air is very humid, but no actual cooling is needed. That is specifically what a latent only system is engineered to solve by figuring out how to wring out the moisture without adding expensive re-heat.

For most buildings the re-heat would involve electric resistive heating that is actually more expensive than the cooling needed to reduce the temperature for this loop. An interesting side note is that with a direct counter-flow heat exchanger, the pre-cooled air actually wants to track the temperature that you are coming off of. An automatic feature of this type of equipment is that it does not want to change the temperature of the air, but rather it uses the air that has been cooled to pre-cool the air coming in. Then the air that is coming into this device is ultimately the temperature that the air wants to seek after it has been pre-heated with the air that has been pre-cooled before it goes to the cooling coil.

The return air comes in relatively humid at room temperature. There is no need to cool the air, it is simply wringing out the moisture. The air that had already been cooled by the coil, which in this example is now down in the low 40°F, is used to pre-cool the 70°F air to the point where it is already wringing out moisture and the temperature of this air is typically in the low 50s°F and upper 40s°F and in this example it is 48.2°F. At that temperature there is very little sensible cooling that needs to be done. 43°F is the temperature of the air leaving the coiling and now the wet bulb is below 43°F, so it is relatively dry air. As this approaches the 70°C direct counter-flow air coming down into the core it will reheat the 43°F air.

In this test case we found that the resulting temperature actually approached the return air degrees within half a degree. This eliminates the comfort problems with introducing 43°F air to a room. It also helps the dry the air out and reduces the relative humidity by increasing the temperature of the air.

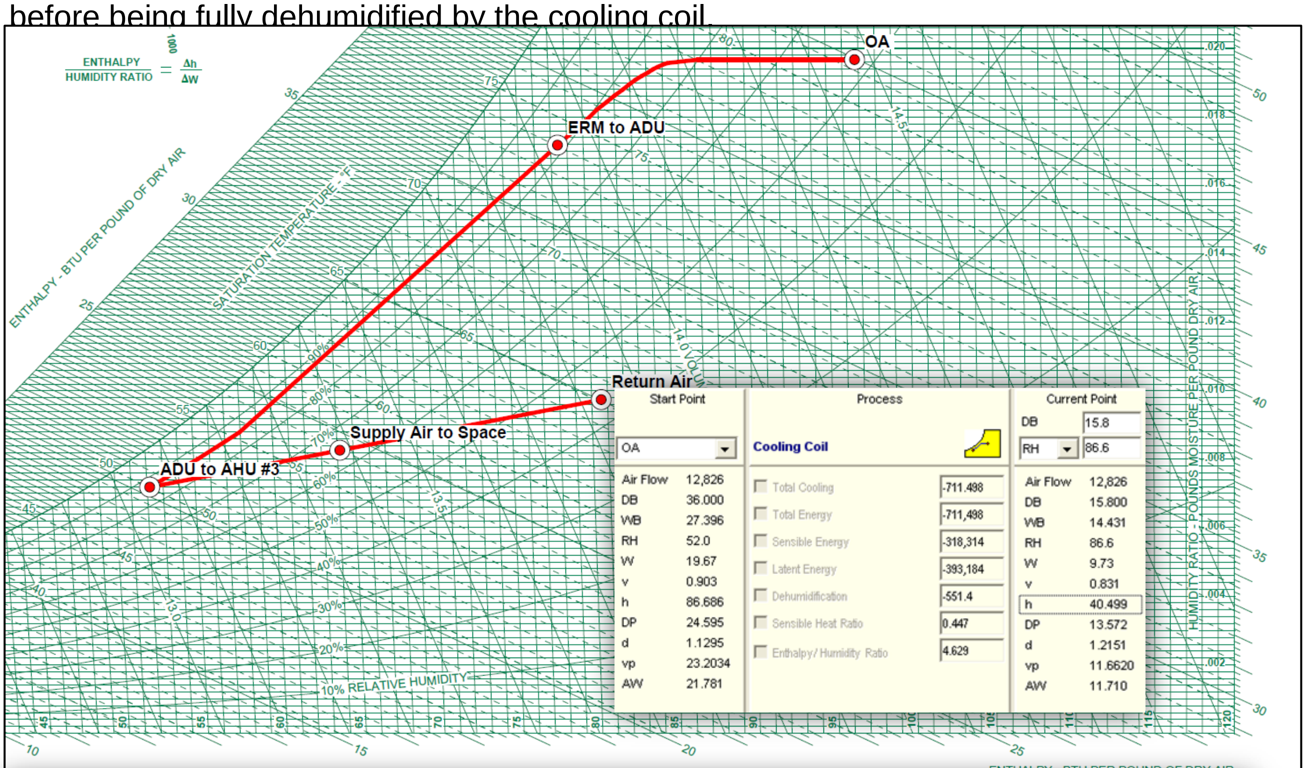
In this particular application the primary comfort cooling for the space would control the temperature and this unit would be strictly driven off a humidity stat that would come on when the relative humidity went above a pre-set point, typically at 50% to 55% relative humidity.



POINT	LABEL	AIR FLOW	UOM	PROCESS	GIVEN	DB	WB	RH	W	v	h	DP	d
OA	AR	20000	STD CFM	Add State Point	POINT	72.8	71.5	94.0	0.0164	13.77	35.38	71.0	0.0738
ERM to ADU	AR	20000	STD CFM	Cooling Coil	POINT	54.2	53.2	94.0	0.0084	13.12	22.12	52.5	0.0768
ADU to ERM RH	AR	20000	STD CFM	Cooling Coil	POINT	41.2	39.5	86.6	0.0047	12.72	14.99	37.5	0.0790
ERM to Return Air	AR	20000	STD CFM	Sensible Heating	POINT	72.1	53.9	28.3	0.0047	13.50	22.47	37.5	0.0744

Figure 4 - Psychrometric chart illustrating the behavior of the air-vapor mixture through a latent only system

The Diagram above, in Figure 4 is called a Psychrometric Chart, which plots the characteristics of water vapor and air mixture. The red lines demonstrate the behavior of the air when interacting with the BPE Latent Cooling Loop in a humid application. In this example a 20,000 cfm air flow is able to reduce cooling load by 1,192,821 btu/hr or 99.4017 tons of chilled water per hour. This allows older air handlers and equipment that is not functioning properly to work in very humid and challenging situations that traditional equipment would not be able to dehumidify without over cooling or using typically very expensive reheat. In this example the reheat is free byproduct of pre-cooling to return air before being fully dehumidified by the cooling coil.



POINT	LABEL	AIR FLOW	UOM	PROCESS	GIVEN	DB	WB	RH	W	v	h	DP	d
OA	AR	27177	STD CFM	Add State Point	POINT	96.8	81.3	52.0	0.0197	14.47	44.95	76.3	0.0705
ERM to ADU	AR	27177	STD CFM	Cooling Coil	POINT	78.4	74.0	81.6	0.0172	13.93	37.65	72.3	0.0730
ADU to AHU #3	AR	27177	STD CFM	Cooling Coil	POINT	52.2	50.0	86.6	0.0072	13.05	20.30	48.3	0.0772
Return Air	AR	19858	STD CFM	Add State Point	POINT	80.6	65.1	43.6	0.0097	13.83	30.02	56.4	0.0730
Supply Air to Space	AR	47035	STD CFM	Air Mixing	POINT	64.2	56.9	64.6	0.0083	13.38	24.40	52.0	0.0754

Figure 5 - Psychrometric Analysis of a project in Malaysia

Figure 5 are the results from a project in Malaysia. We were asked to engineer a 100% outdoor air flow of 27,177 cfm at 96.8 F and a wet bulb of 81.3 F qb, with 137.9 grains of water. This was difficult for the existing air handlers to dehumidify. With the use of BPE energy recovery modules, the 137.9 grains of moisture in the outdoor air was reduced to 58.1 grains of water per pound of air, in a single pass.

Figure 6 - a photograph of a 6000 CFM latent only system in an industrial facility

Figure 6 is a 6,000 cfm industrial latent only device that uses a BPE unit and a chilled water coil as a run around loop to drastically reduce the required re-heating and cooling capacity. When in steady operation, return air from the space will be pre-cooled through the exhaust plenum of the heat exchanger by air leaving the cooling coil (supply air). By absorbing the heat of the return air, the supply air not only assists in pre-tempering the return air before the cooling coil, but in addition, reheats itself. It has been found through testing that this can reduce 80% of the sensible load and some of the latent load as well as greatly reduce the cooling tonnage needed to dehumidify air.

Figure 7 - A photo of a BPE ERV installed vertically in a latent only system

Figure 7 is a photograph of an actual installation of a latent only system. You can see the direct counter-flow heat exchanger with the air coming in on the left hand side in the straight part and in the opened plenum part, where the air after traveling through the coil with the air returning from the top in on the right hand side. This was relatively easy to install and was control at a simple binary point off a humidity sensor.

Figure 8 - DX Expansion valve

Figure 8 is an image of the expansion valve for the DX refrigerant unit that is going directly into the coil. This is an extra deep coil that is designed to wring out moisture and provide latent cooling. If the flow is relatively low there can be a concern with freezing. This can be controlled with cycling. Some of the DX units also have the ability to detect freeze up or low temperatures on the coil with an infrared sensor. For our purpose we found that this DX unit, which had a variable speed drive on the compressor, did not need any adjustment at all, it was put in place and run off the humidity stat. It was a very simple install and commissioning.

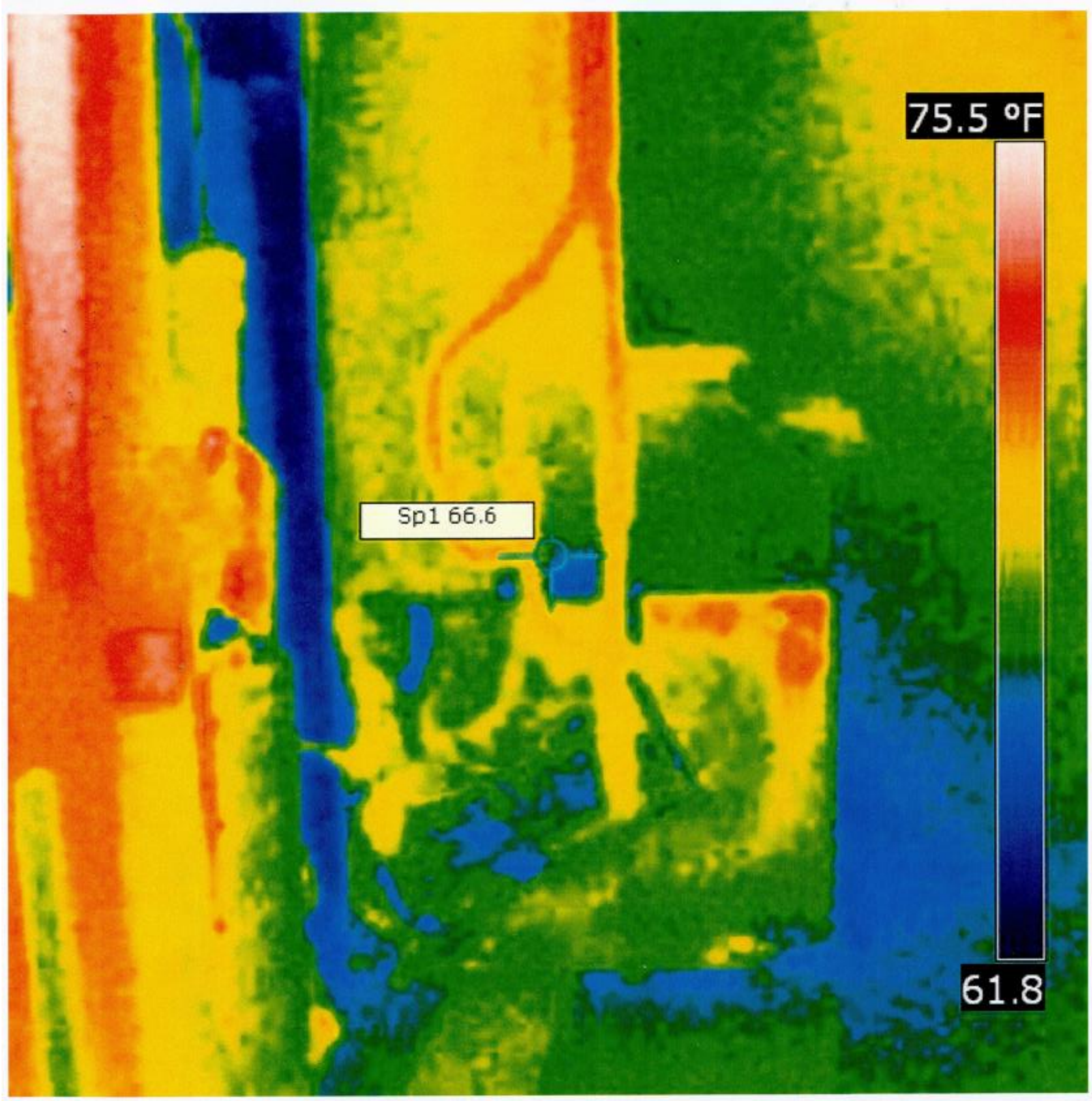


Figure 9 Thermal image of the BPE ERV from Figure 5

This shows a detailed thermograph image of the temperature changes of the air as it moves through this unit. It shows that the relatively warm air starts out in the 70s°F range and gets cooled down into the low 50s°F and the outside skin goes down into the low 60s°F. This shows the thermal energy of the air being pre-cooled and then reheated as it comes back up.

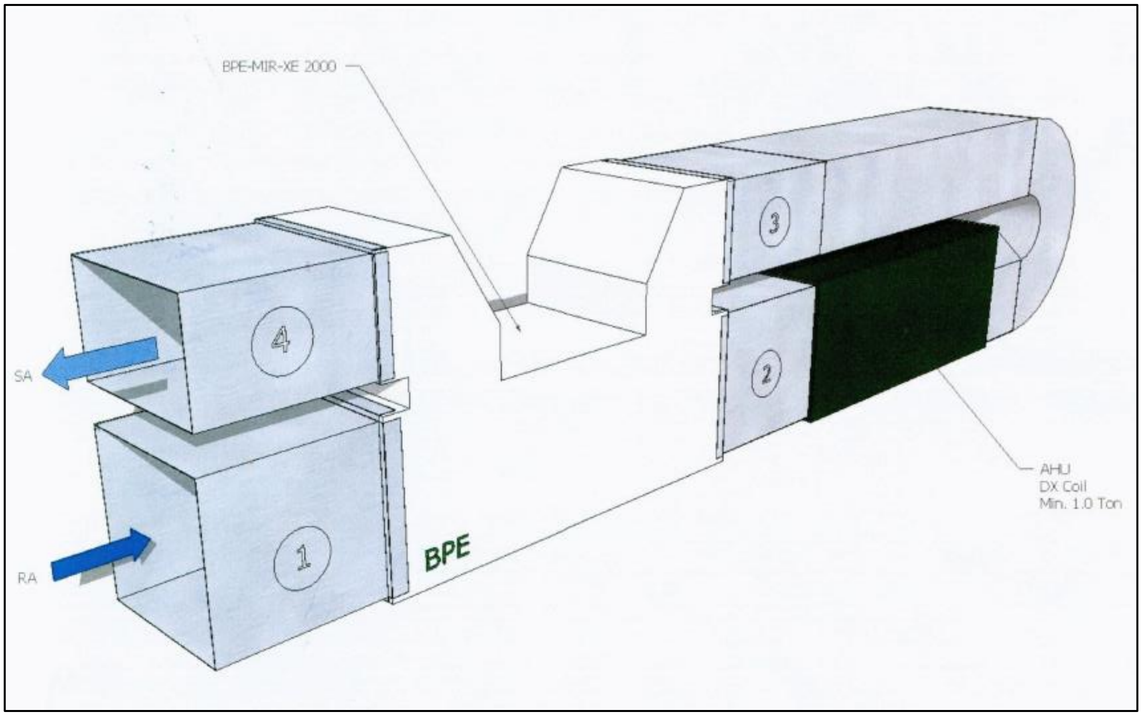


Figure 10 Typical design of a latent only system using a BPE ERV and a DX coil

As an alternative for large industrial applications, we have seen that several BPE units can be stacked side to side with the air handler in line. If this is done in a humid climate such as Latin America or Malaysia or in the southeastern part of the United States such as Georgia or Florida, it is highly recommend having a drip tray under both the air handler and the BPE unit, as even with the tightest connections there can be some seepage. The amount of water that an industrial scale unit, on the order of 10,000 cfm will be pulled out of the air per hour can be measured in terms of gallons per hour.

Figure 11 Image of a 6000 CFM BPE ERV hung from ceiling

The photo in Figure 11, above shows a 6,000 cfm Latent Only BPE energy recovery module that greatly reduces cooling coil load and also off loads. The fresh outdoor is pre-cooled by the air that has already traveled through the chilled water coil and is reheated to a comfortable temperature. The three main benefits are better thermal comfort, increased dehumidification and energy savings. This process also reduced control issues and is more stable with less temperature swings that typical reheat with a hot water or steam coil.

This was installed in a mechanical room in Puerto Rico for a large pharmaceutical facility. Three units have been placed side by side where they provide enhanced dehumidification without the need for elaborate temperature controls or reheat systems. This was brought in through a standard thirty-six inch wide door in an existing mechanical room where traditional equipment would have been impossible to bring in without structural modifications to the building itself. The units are functioning better than expected and have helped to reduce energy consumption and has alleviated comfort complaints and concerns.

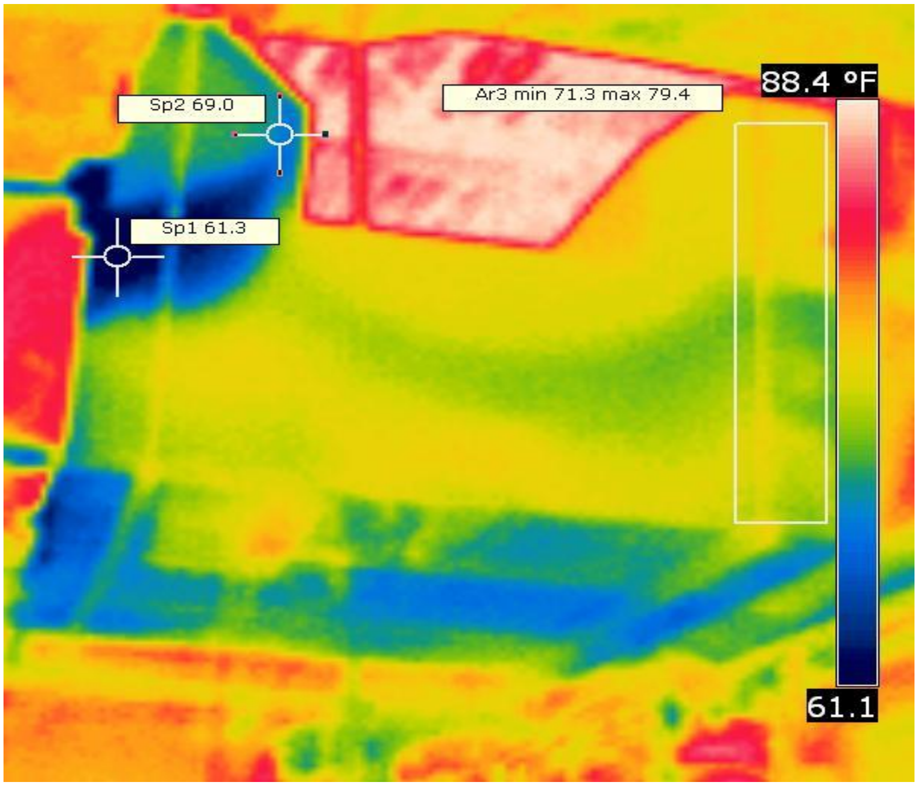


Figure 12 Thermal image of the BPE ERV ranging from temperatures 88.4F to 61.1F

The above photograph is a thermal image of the previous photograph, where we can see that the air handler side is extremely cold represented by the blue area, and that the outdoor air coming in and going out is warm. This shows that the energy recovery module is able to keep the cold air in and affectively recycle the cooling energy where the air leaving the unit is basically back up to the temperature where it started.

The cool air on the bottom of this shows condensation and the piping that pulls this away from the air handler. This unit is dehumidifying in the energy recovery core the air handler itself also does additional cooling. This is a very good graphic representation of the recycling process of the cooling energy and preheating the supply air with the outdoor return air being brought into this AHU 1500.

Airflow Measuring

Balancing is measuring air volumes and adjusting volume control devices to get the desired airflow. Fan speeds may also need adjusting. Unless otherwise specified, it's generally considered there's an adequate balance when the air quantities measured on the job are within plus or minus 10% of the desired quantities. The first step in balancing the air distribution or exhaust system is to determine the total air volume. This is accomplished by the Pitot tube traverse or vane anemometer.

If the velocity of the air stream in a duct were uniform, only one reading at any point in the duct would be enough to determine volume of flow. However, this isn't the case. Generally, velocity, because of friction, is the lowest near the sides of the duct, and greatest at or near the center. Therefore, a Pitot tube traverse or vane anemometer is needed to determine the average velocity in the duct at the point of traverse.

In most situations, a Pitot tube traverse will not be readily available, and in the interest of time and efficiency, a vane anemometer should be used. Just as you would do with a Pitot traverse, several points of the duct work should be measured for flow. In most instances, feet per second (ft/s) or feet per minute (fpm) should be used. Typically, desired flow rates are specified in cubic feet per minute, or cfm. Measuring the flows in standard, English units will make calculations much simpler in the future. A minimum of 12 points should be measured for ducts larger than 10" (round). For smaller ducts, such as 4-6" round, only 1-4 measurements should be used. Smaller ducts will be closer to the actual size of the vane used to measure the flow, so fewer measurements are required.

To determine the equivalent duct diameter of a rectangular duct use the following equation:

Equation 1: $$d = \sqrt{\frac{4ab}{\pi}}$$

where: d = equivalent diameter in inches
a = length of one side of rectangular duct in inches
b = length of adjacent side of rectangular duct in inches
π = 3.14

If a Pitot tube traverse is used, additional calculations will be required. Since the readings from the manometer are velocity pressure (VP) and not velocity (V), it's necessary to convert VP to V using Equation 2.

Equation 2: $$V = 4005\sqrt{VP}$$

Note: Air is less dense as temperature and altitude increase. Therefore, if the air in a duct is different from standard conditions (70F and 0.075 lb/cf at 29.92 inHg barometric pressure), then the density has also changed. In these instances, adjustments will be required to get accurate results. These corrections can be made by the Technical Support division of Building Performance Equipment, Inc. ®.

Using the previous equations, determine the average velocity (V_{avg}). This value will then be multiplied by the inner duct areas (A), or free-velocity inlet/exhaust area, to calculate flow rate. Equation 3 below demonstrates this process.

Equation 3: $Q = AV_{avg}$

Where: Q = volumetric flowrate in cubic feet per minute (cfm)
A = free velocity area of duct or louvre (ft^2)
V_{avg} = average velocity of air (ft/min)

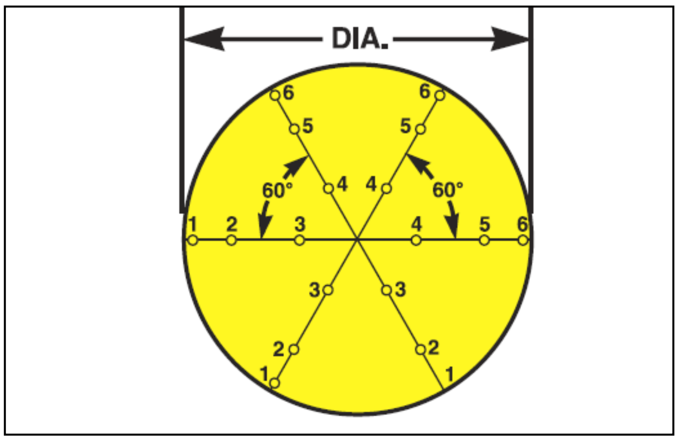


Figure 14 - Example of Flow Readings for Round Duct

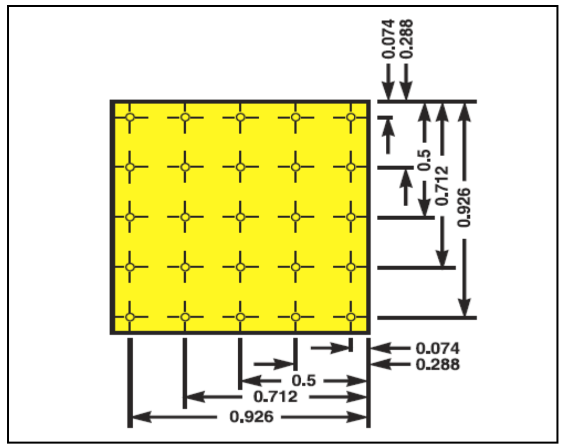


Figure 13 - Example for flow readings of a rectangular duct

Figures 13 and 14 demonstrate how flow measurements are taken for round and circular duct.

<u>Controls</u>

Typically larger industrial project will have very well maintained and engineered control systems that typically control most AHU and fan motors. By simply modifying the control program or algorithm the latent only BPE energy recovery modules can be used to pre-cool the air to be dehumidified with the air that needs to be reheated.

BPE can also provide additional controls, variable speed drive for standard applications. Many of these latent only projects are tied into a humidity sensor that is simply an on/off binary point that turns on the cooling coil and starts the dehumidification process. Once the humidity is brought down to the desired humidity level the cooling coil shuts down along with the air handler fans. The moisture is more effectively drained with the air flow shut off. If the process needs continuous air flow than the fans can be left on as needed to service the process needs.

Choosing the right size ERV for your building

Ventilation is one of the most influential aspects of a building. Not only does ventilation affect a substantial part of O&M costs, but more importantly, it affects system performance. Students occupying classrooms with ample ventilation typically score better on standardized testing and have higher attendance rates. In combination, all of these benefits contribute to increased state funding, reduced expenses, and increased budgets for improving the quality of education.

Latent only applications can be used for 100% outdoor air or as a dedicated dehumidification system tied to humidity sensor, to control humidity to a precise predetermined point. In Industrial setting, standard 2,000 to 20,000 cfm modules have been used to control humidity for pharmaceutical applications, in Latin America, Malaysia, Southern States in the United States such as Alabama and Georgia.

Calculations of Minimum Ventilation Rates

Minimum Ventilation rates should always be the sum of each zone's requirements. With respect to a room application, typically one zone will exist. Other zones will exist within the building, such as locker rooms, offices, auditoriums, and hallways. However, for the purpose of this analysis, ventilation will be calculated on a per classroom basis. This approach allows for optimal control and energy efficiency as ventilation is provided when required, and in the amount required.
The following is a step-by-step process to calculate minimum ventilation rates:

1. Calculate the **Breathing Zone Outdoor Airflow –** the design outdoor airflow required in the breathing zone of the occupiable space or spaces in a zone.

   Equation 6-1: $$V_{bz} = R_p \cdot P_z + R_a \cdot A_z$$

   Where

   V_{bz} = breathing zone outdoor airflow

   R_p = outdoor airflow rate required per person as determined from *Table 6-1*

   P_z = zone population: the largest number of people expected to occupy the zone during typical usage

   R_a = outdoor airflow rate required per unit area as determined from *Table 6-1*

   A_z = zone floor area: the net occupiable floor area of the zone in ft^2

   Note: Use Table 6-4 on the next page to calculate Breathing Zone Outdoor Airflow based on the space use and age of students.

Table 6-4 MINIMUM VENTILATION RATES IN THE BREATHING ZONE	
Occupancy Category	R[
Ceiling Supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air at 15°F (8°C) or more above space temperatures	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperatures and ceiling return provided that the 150 fpm(0.8 m/s) supply jet reaches to within 4.5 ft (1.4 m) of the floor level. ***Note:*** *For lower velocity supply air, Ez = 0.8*	1.0
Floor supply of cool air and ceiling return provided that the150 fpm (0.8 m/s) supply jet reaches to within 4.5 ft (1.4 m) of the floor level. ***Note:*** *Most under-floor air distribution system comply with this proviso*	1.0
Floor supply of cool air and ceiling return, provided low- velocity displacement ventilation achieves unidirectional flow and thermal stratification	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return	0.8
Makeup supply drawn in near to the exhaust and/or return location	0.5

2. Calculate the **Zone Outdoor Airflow** – the outdoor airflow that must be provided to the zone by the supply air distribution system.

Equation 6-2: $V_{oz} = V_{bz} / E_z$

where

V_{oz} = zone outdoor airflow

E_z = zone air distribution effectiveness determined from Table 6-2 (shown below)

a) "Cool air" is air cooler than space temperature.
b) "Warm air" is air warmer than space temperature.
c) "Ceiling" includes any point above the breathing zone.
d) "Floor" includes any point below the breathing zone.

e) As an alternative to using the above values, E_Z may be regarded as equal to air change effectiveness determined in accordance with ANSI/ SHRAE Standard 129[16] for all air distribution configurations except unidirectional flow.

Table 6-2 Zone Air Distribution Effectiveness	
Air Distribution Configuration	E_Z
Ceiling Supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperatures and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperatures and ceiling return provided that the 150 fpm (0.8 m/s) supply jet reaches to within 4.5 ft (1.4 m) of the floor level. ***Note:*** *For lower velocity supply air, Ez = 0.8*	1.0
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Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return	0.8
Makeup supply drawn in near to the exhaust and/or return location	0.5

Note: Zone Air Distribution Effectiveness is based on the air distribution configuration. Depending on supply and return air positions, air may or may not be effectively introduced into the breathing zone. For example, ceiling supply of warm air 15°F or more above space temperature with a ceiling return will not effectively provide outdoor air into the breathing zone. Because of its lower density, warm air will remain closer to the ceiling and not completely mix with the air in the space, especially if there is a ceiling return.

3. Depending on the type of system, use the equation below to calculate **Outdoor Air Intake Flow** and verify that the systems dedicated to those zones comply.

Single Zone Systems
(Recommended for Classrooms)

Equation 6-3: $V_{ot} = V_{oz}$

100% Outdoor Air Systems
(*Recommended for Classrooms) Equation 6-*

Equation 6-4: $V_{ot} = S_{all\ zones} V_{oz}$

Multiple Zone Recirculating Systems
(Not recommended for Classroom Applications)

Equation 6-5: $Z_p = V_{oz} / V_{pz}$
Equation 6-6: $V_{ou} = D S_{all\ zones} (R_p \cdot P_z) + S_{all\ zones} (R_a \cdot A_z)$
Equation 6-7: $D = P_s / S_{all\ zones} P_z$
Equation 6-8: $V_{ot} = V_{ou} / E_v$

Where

V_{ot} = outdoor air intake flow: the outdoor airflow that must be provided to the zone or zones by the supply air distribution system
Z_p = zone primary outdoor air fraction
V_{pz} = zone primary airflow, i.e. the primary airflow to the zone from the air handler including outdoor air and recirculated air
V_{ou} = uncorrected outdoor air intake
D = occupant diversity which may be used to account for variations in occupancy
P_s = total population in the area served by the system
E_v = ventilation efficiency determined from Table 6-3 (next page)

Table 6-3 System Ventilation Efficiency	
Max (Zp)	Ev
≤ 0.15	1.0
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
> 0.55	Use appendix A ANSI/ASHRAE 62.1 - 2007

a) "Max Z_p" refers to the largest value Z_p calculated using Equation 6-5, among all the zones served by the system

b) For values of Z_p between 0.15 and 0.55, one may determine the corresponding value of E_v by interpolating the value in the table.

c) The values of E_v in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the uncorrected outdoor air intake V_{ou} to the total zone primary airflow for all the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table may result in unrealistically low values of E_v and the use of Appendix A may yield more practical results.

Ventilation System Hardware/Equipment Specifications and guidelines

Fan Configuration

When used in a comfort-to-comfort or process-to-comfort application, it is essential that the fans are placed in the proper configuration to prevent cross contamination and for optimization of the Regenerative Condensate Return® (patented latent effect technology). Fans should be installed so that they produce the following effect: AIRFLOW 1 (or Outdoor Air) is positively pressurized, and AIRFLOW 2 (Return/Exhaust Air) is negatively pressurized (suction side of fan). For installations applicable to Figure 15, the AIRFLOW 1 fan would be located on the inlet (left side); AIRFLOW 2 fan would be located after the outlet (left side). *NOTE: For all counter-flow, comfort-to-comfort or process-to-comfort applications, supply and exhaust fans will always be located on the same side of the heat exchanger with airflows traveling in opposite directions (see Figure 15).*

BPE heat exchangers are not provided as a packaged ventilation system. Fans, when included in the purchase of BPE units, are typically provided as loose items. BPE recommends installing fans that are high-efficiency, type D – ducted inlet, ducted outlet, mixed flow impeller, and 100% speed controllable fans suitable for temperatures up to 140°F and accompanied by a minimum three year factory warranty. All fans, no matter the installation method, should be installed with vibration isolation damper as per manufacturers recommendation or local code, whichever is more stringent.

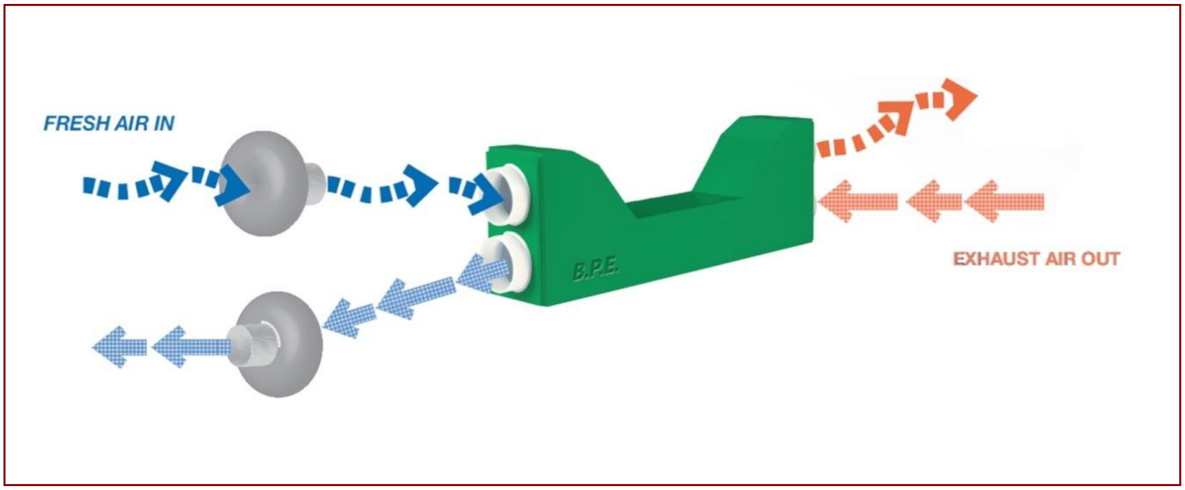

Figure 15- Typical fan configuration for comfort-to-comfort and process-to-comfort applications

Ductwork, Louvers, and Filtration Sizing

Ductwork connected to the BPE heat exchangers should follow the following guidelines:

- With the exception of fan and heat exchanger connections and inlet/outlet, all ductwork within the system should be sized for providing air velocities of less than 500 linear feet per minute (fpm).
- For fans intended for ducted systems, the duct, including transition and any flex duct, should meet the requirements for 100% effective duct length, L_e (*ASHRAE Handbook – Fundamentals*, Chapter 35: Duct Design, 2005). Effective length is the minimum recommended distance of ductwork from a fan inlet or outlet for prevention of fan system effects and establishment of a uniform velocity profile.

ERV Inlet and Outlet Connections

All connections to the ERV inlet and outlets of both airflows should be completed in the following manner:

1. Fabricate Z-Clips (typical) for sliding over the inlet/outlet edges of the ERV (see example on next page) below for BPE-XE-MIR 2000 and 1000. Z-Clips are not required for the BPE-XE-MIR 200 and 500 as these models are manufactured with round collars.
2. Slide Z-Clips onto all four sides of the ERV inlet/outlet and fasten to the ERV surface with sheet metal screw of the appropriate length.
3. Slide flanges of connecting duct into the Z-Clip.
4. Fasten connecting ductwork to Z-Clip with sheet metal screw spaced 6" O.C. Repeat for all sides.
5. Seal all seams between Z-Clip and ERV surface as well as Z-Clip and connecting ductwork.

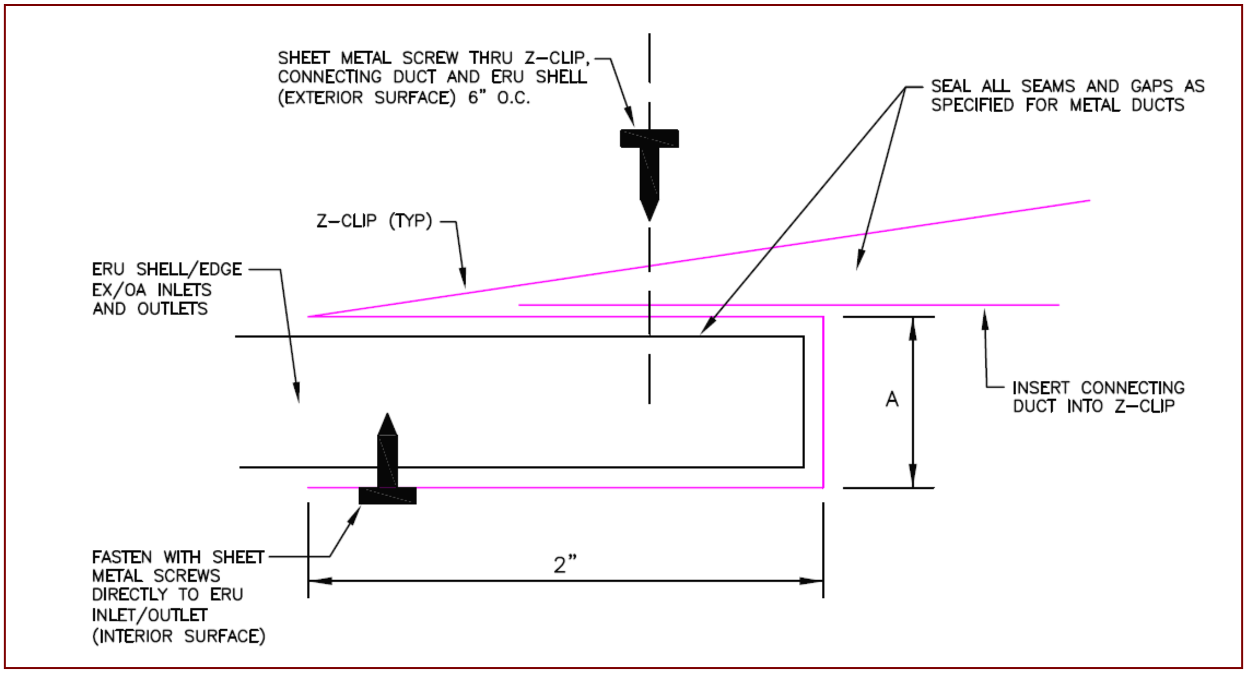

Figure 16- Z-clip configuration

Note: Dimension "A" will vary depending on the Airflow. Airflow 1 (supply air) connections will be 3/8 in. whereas Airflow 2 (exhaust air) connections will be 3/4 in. Z-Clip length should be determined based upon model size and airflow.

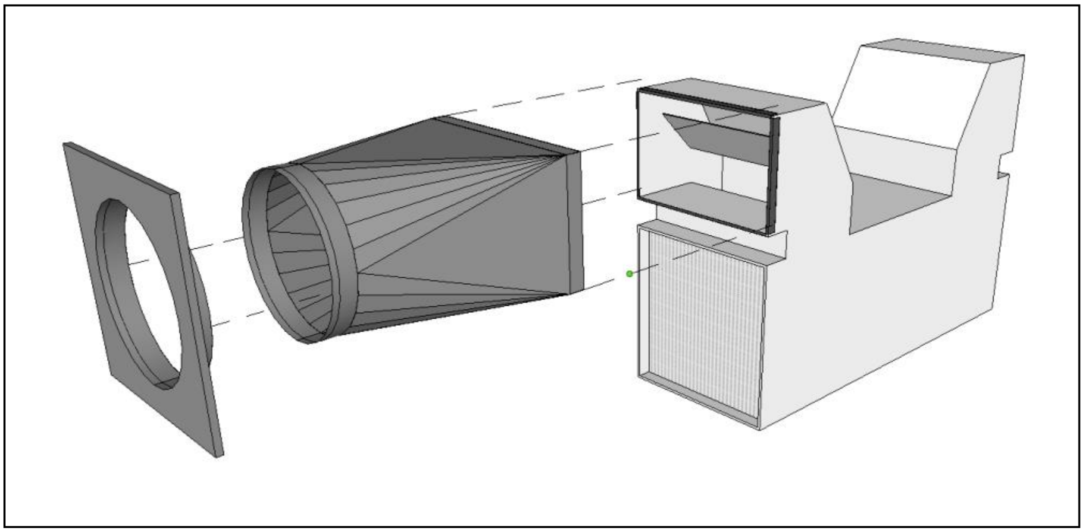

Figure 17 Exploded view of airflow 1 connection assembly (from left to right: Faceplate/Collar, Round-to-Square Transition, Z-Clips, ERV)

Outdoor Air Louvers, Screens, and Filtration

Figure 18 shows the side view of the louvered intake connected to the fresh air intake duct. There should be a flow of less than 500 fpm, or the maximum amount of air flow needed to eliminate water droplets being pulled in through the fresh air intake. See manufacturer's instructions for specific installation guidelines. *Note: Clips, fasteners, and additional hardware must be supplied by your local contractor.*

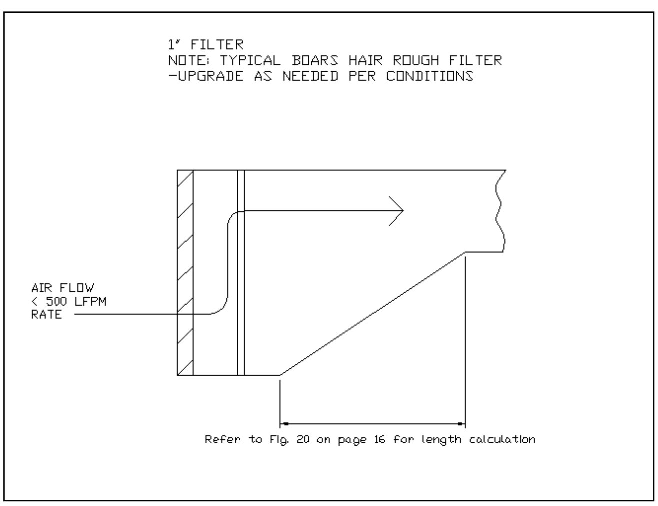

Figure 18 Recommended Louver Dimensions and Characteristics (side view)

System and Equipment Specifications of ASHRAE *Standard 62.1* – 2007

Plenum Systems: When the ceiling or floor plenum is used both to recirculate return air and distribute ventilation air to ceiling-mounted or floor-mounted terminal units, the system shall be engineered such that each space is provided with its required minimum ventilation airflow.

Designing for Air Balancing: The ventilation air distribution system shall be provided with mean to adjust the system to achieve at least the minimum ventilation airflow as required by ASHRAE Standard 62.1-2007 or local code, whichever is more stringent.

Exhaust Duct Location: Exhaust ducts that convey potentially harmful contaminant shall be negatively pressurized relative to spaces through which they pass, so that exhaust air cannot leak into occupied space; supply, return, or outdoor air ducts; or plenums.

Ventilation System Controls: Mechanical ventilation systems shall include controls, manual or automatic, that enable the fan system to operate whenever the spaces served are occupied. The system shall be designed to maintain the minimum outdoor airflow as required by Section 6 of ASHRAE Standard 62.1 – 2007 or local code, whichever is more stringent.

Airstream Surfaces: All airstream surfaces in equipment and duct in the heating, ventilating, and air-conditioning system shall be designed and constructed to be resistant to erosion.

Outdoor Air Intakes: Ventilation system outdoor air intakes shall be designed in accordance with the following:

> **Location:** Outdoor Air intakes, including doors and windows, shall be located such that the shortest distance from the intake to any specific potential outdoor contaminant source shall be equal to or greater than the separation distance listed in Table 5-1, Air Intake Minimum Separation Distance, of ASHRAE Standard 62.1 – 2007.
>
> **Rain Entrainment:** Outdoor air intakes that are part of the mechanical ventilation system shall be designed to manage rain entrainment. Outdoor air intakes should be designed for 400 fpm for flows of 7,000 cfm or greater and 300 fpm for flows below that range. FPM shall refer to the face velocity of outdoor air into the intake or louver in feet per minute.

Rain Intrusion: Air-handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow.

Snow Entrainment: Where climate dictates, outdoor air intakes that are part of the mechanical ventilation system shall be designed to manage melted snow blown or drawn into the system.

Bird Screens: All outdoor air intakes shall include a screening device designed to prevent penetration by a 0.5 in. diameter probe. The screening device material shall be corrosion resistance. The screening device shall be located, or other measures shall be taken to prevent bird nesting within the outdoor air intake.

Maintenance: Suitable access door should be provided to filters and equipment to permit cleaning.

Drainage: Outdoor air ductwork or plenums shall pitch to drains designed in accordance with the requirements of Section 5.11 of ASHRAE Standard 62.1 – 2007.

Installing Ducts, Registers, and Diffusers

CAUTION

If ducts have to go through an unconditioned space, always use insulated ducts (purchase separately).

HINT: When penetrating a roof, coordinate with existing roofer to keep entire roof under roof warranty whenever possible. Coordinating Trades to maintain any existing roof warranty is good practice.

Stale Air Exhaust Ductwork

WARNING !!!

Never install a stale air exhaust register in a room where a combustion device operates, such as a gas water heater, a gas furnace or a fireplace.

1. Install the stale air exhaust register(s) in the main area where the contaminants are produced. Position the register(s) as far from the stairway as possible and in such a way that the air circulates in all the frequently occupied spaces in the building.

2. Install the register(s) 6 to 12 inches (152 to 305 mm) from the ceiling on an interior wall OR install it in the ceiling.

3. Attach one end of the flexible duct to the fresh air distribution register, and the other end to the unit's "Return Air In" port, using tie wrap and duct tape.

Fresh Air Distribution Ductwork

1. Install the fresh air distribution register(s) in a large open area in the lowest level to ensure the greatest possible air circulation. Keep in mind that the fresh air register(s) must be located as far as possible from the stale air register(s).

2. Install the register(s) in the ceiling OR 6 to 12 inches (152 to 305 mm) from the ceiling on an interior wall. The duct length should be at least 15' (4.6 m). (The cooler air will then cross the upper part of the room and mix with the room air before descending to occupant level.)

Exterior Opening(s) Installation - Locating 2 Soffits or Wall Grills

If this unit is installed in the attic, choose an appropriate location for installing the Soffit grills.

WARNING !!!

Make sure the fresh air intake grille is at least 10 feet away from any of the following:

- **High efficiency furnace vent.**
- **Gas meter exhaust, gas barbecue-grill.**
- **Any exhaust from a combustion source.**
- **Garbage bin and any other source of contamination.**

- The prevailing winds should not blow the stale air towards the fresh air intake grill.
- There must be a minimum distance of 10 feet (3.048 m) between the grills to avoid cross-contamination. (See Fig 4).

CAUTION

Make sure the insulated ductwork vapor barrier does not tear during installation.

- For each exterior hole, using a jig saw, cut the proper diameter hole in the soffit or wall. Pull back the insulation to expose the flexible duct. Run each flexible duct through its respective hole.
- Using provided screws, attach the flexible duct to the ring of the grill. Carefully seat with duct tape. Assemble the grills to the Soffit or wall.

Receiving

All BPE heat exchangers are packaged at the factory. Upon arrival, remove the scratch prevention covering and inspect the units. Report any damage immediately to the transportation company. Also, check to insure that the model numbers are as ordered. Alert your local sales representative or Building Performance Equipment, Inc. ® at (201) 722-1414 to report any discrepancies.

Mounting and Hanging

Consult your local engineer or architect for specific standards and code appliances. Locate the BPE air-to-air heat exchanger (AAHX) in close proximity to a fused power source. If the unit is installed independent of a forced air system, locate the ductwork near the center of the air distribution system. If the ERM is installed in conjunction with a forced air system, mount the unit near the indoor or outdoor equipment. It is recommended that the AAHX be installed on the rooftop of the building or within a mechanical room where the equipment is located. Make sure that the equipment is correctly sized to take into account the load reduction of the AAHX. In order to connect to an existing A/C unit, the system must have adjustable balancing dampers installed. Also be sure to provide easy access to the ERM to allow for cleaning and inspecting. The preferred method of installation is by mounting and fastening the unit to a set of suitable mounting stanchions or by hanging the unit(s) from threaded rod.

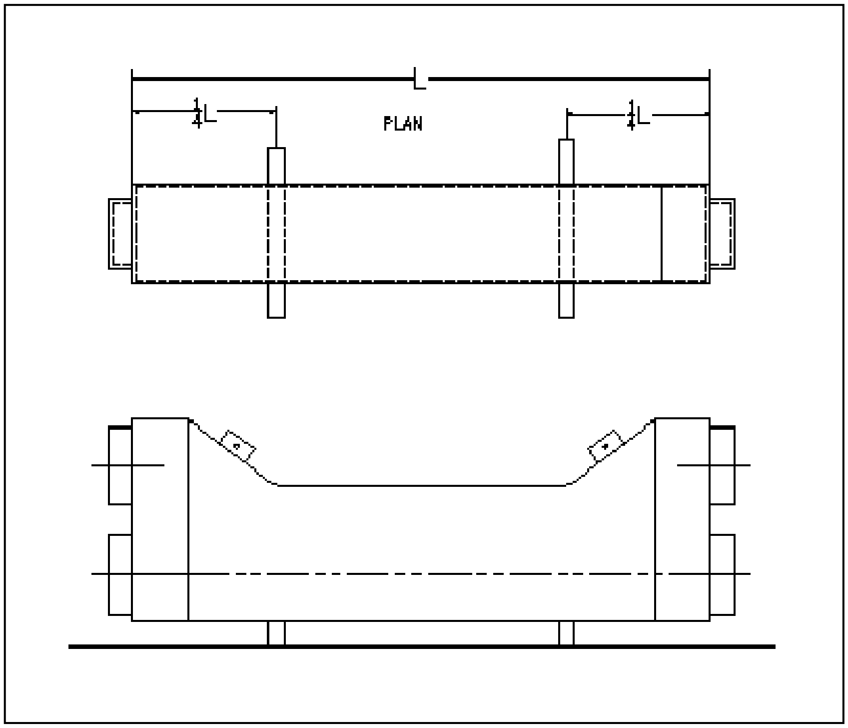

Figure 19 Mounting and hanging positions (Top: Bird's eye | Bottom: Side view)

<u>Note</u>: Be sure to apply vibration isolation and ensure all fastening provides enough structural integrity to meet local code requirements. Consult with your engineer or architect for details and instructions.

Basic Installation Parameters

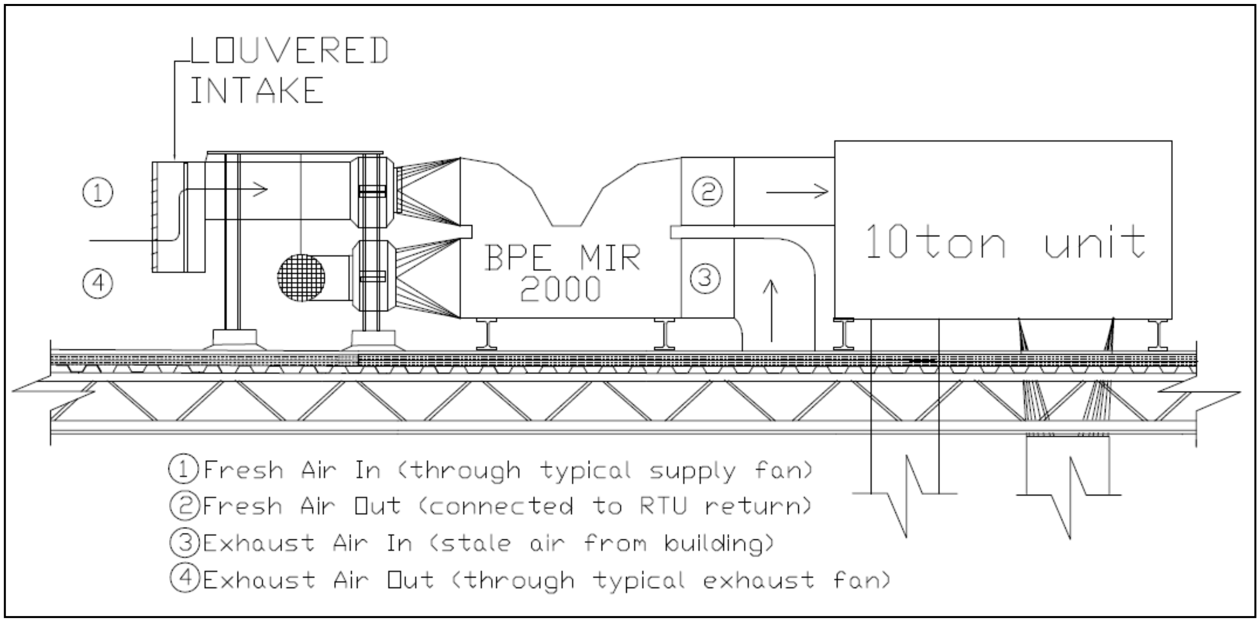

Figure 20 Typical RTU Installation, side view

Note: It is recommended that there be a minimum of 10 feet of separation, or the minimum required by code (whichever is higher), between points 1-(Fresh Air In) and 4-(Exhaust Air Out) in order to prevent cross contamination between the air streams. Installing hoods and/or an inlet screen are necessary to protect the duct openings from rain and animals. See Figure 18 for a detailed drawing of the louvered intake.

OPERATION

Industrial Settings

Though BPE's air-to-air heat exchangers can withstand many different contaminants, make sure to consult with the manufacturer if a proposed application contains harmful chemicals and contaminants unsuitable for the units. The ERM can also endure a great amount of chlorine in pool applications, though an installation for a pool environment should be handled strictly. Take into account that for a pool application, fans for the ERMs should be installed on opposite sides of the units (as opposed to on the same side as seen in Fig. 2).

Safety Considerations

Installation and servicing of this equipment can be hazardous due to mechanical and electrical components. Only trained and qualified personnel should install, repair, or service this equipment.

Untrained personnel can perform basic maintenance functions such as cleaning and replacing filters. All other operations must be performed by trained service personnel. When working on this equipment, observe precautions in the literature, on tags, and on labels attached to or shipped with the unit and other safety precautions that may apply.

Follow all safety codes. Installation must be in compliance with local and national building codes. Wear safety glasses, protective clothing, and work gloves. Have a fire extinguisher available. Read these instructions thoroughly and follow all warnings or cautions included in literature and attached to the unit.

Recognize safety information. This is the safety-alert symbol ⚠. When you see this symbol on the unit and in instructions or manuals, be alert to the potential for personal injury. Understand these signal words; DANGER, WARNING, and CAUTION. These words are used with the safety-alert symbol. DANGER identifies the most serious hazards which **will** result in severe personal injury or death. WARNING signifies hazards which **could** result in personal injury or death. CAUTION is used to identify unsafe practices which **may** result in minor personal injury or product and property damages. NOTE: This is used to highlight suggestions which **will** result in enhanced installation, reliability, or operation.

MAINTENANCE

WARNING!!!

ELECTRIC SHOCK HAZARD

Failure to follow this warning could result in personal injury or death.

Before installing or servicing system, always turn off main power to system. There may be more than one disconnect switch.

CAUTION

CUT HAZARD

Failure to follow this caution may result in personal injury.

Sheet metal parts may have sharp edges or burrs. Use care and wear appropriate protective clothing and gloves when handling parts.

The BPE ERV requires little to no maintenance because it is constructed of polypropylene – classified as a “non-stick” plastic due to its very low surface energy. Because of its “non-stick” material construction and high airflow design makes it extremely resistant to fouling.

Polypropylene’s low surface energy also renders it relatively chemically inert and resistant to a wide range of corrosive substances.

The hydrophobic quality of the polypropylene core and shell makes the ERV far less susceptible to fouling, increases energy transfer and makes the ERV more effective in dehumidification and condensation applications.

Due to the low surface tension and inert characteristics of the heat exchanger material (polypropylene), small particles and dust can easily pass through the core without clogging or fouling the unit. However for non-traditional applications such as dust collectors, metal shops, or greasy (oil, fuels, cooking) environments, BPE recommends cleaning the unit as often as necessary. BPE recommends cleaning the unit when performance (flow and/or effectiveness) has been altered by 10%.

With a bird screen, appropriate filtration and condensate drainage, the ERV can operate virtually maintenance free in many applications.

Where maintenance is required, simply hosing out or vacuuming out the unit is sufficient. The most important item is to ensure that any condensate drainage system employed be kept clean, just as with any device removing moisture from the air.

Preventative maintenance for all BPE air-to-air heat exchangers requires careful observation over the following aspects:

- Bird Screens
- Filtration (Outdoor and Return/Exhaust Air)
- Flow and/or Effectiveness

INSPECTING:
We recommend inspecting the unit about once a year for any filter changing needs.

A handheld telescopic mirror and flashlight would be sufficient and will simplify and accelerate the process.

To inspect the ERV unit, access the unit through the door in the ductwork. If using a mirror and flashlight, follow the same steps above inspecting each section of the core for fouling.

Be sure to inspect both the Exhaust Air and Outdoor Air sections of the heat exchanger core.

For typical school or office environments, changing filters is the only needed maintenance. If longer intervals are desired, insect screen along with Hepa Vacuum can be used every 5 years or so depending on the amount of lint and material in the air.

Be sure to close each section and duct work when complete.

CLEANING:

When cleaning the BPE heat exchanger core, the only things that are required are a water supply and a power washer or a HEPA vacuum.

1. Access the unit through access door in the ductwork.

2. When using the HEPA vacuum, be sure to thoroughly clean the interior of both airflow paths.

3. When using a power washer, be sure to thoroughly clean the interior of both airflow paths and take proper steps to contain the water draining from the ERV unit.

4. For smaller ERVs, it may be most convenient to remove the ERV to an outside location for power washing. It is easiest to dry the ERV unit by placing it in a vertical position. Reinstall the heat exchanger in its same position and close all duct work that has been opened.

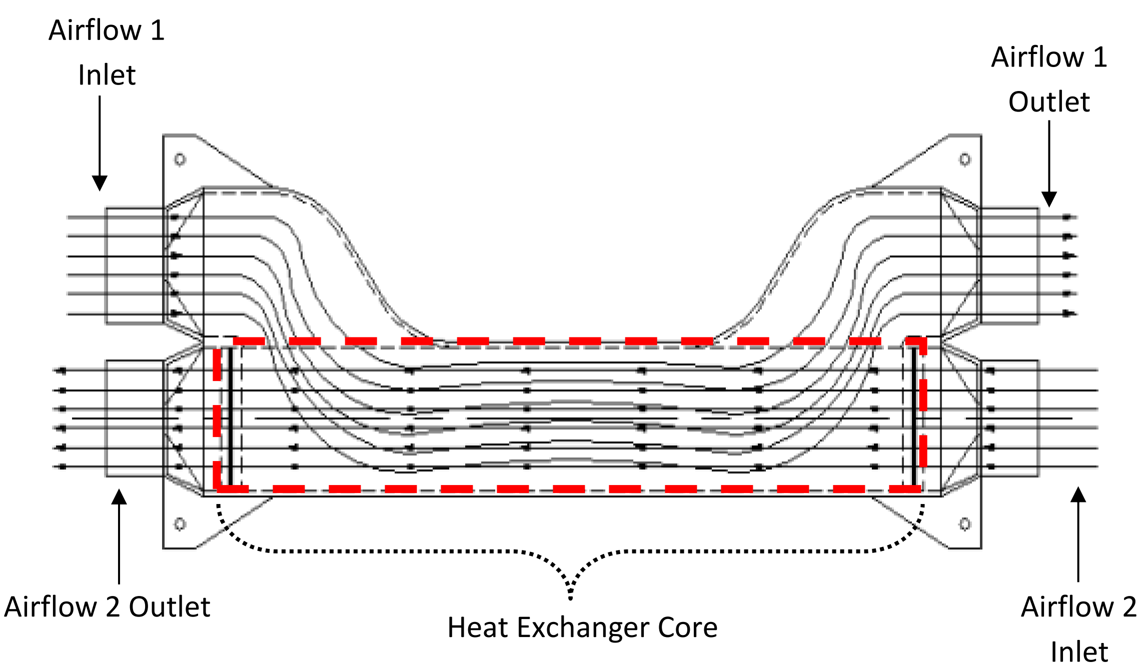

Figure 21- Typical ERV inside structure

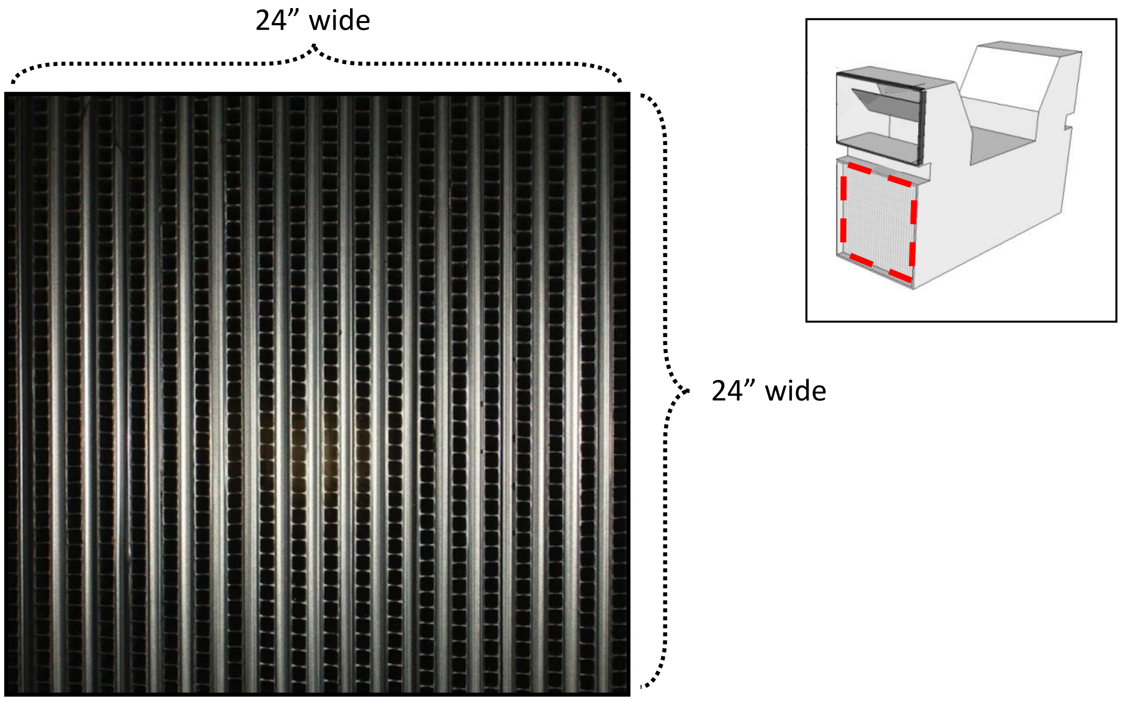

Figure 22- Front view of BPE-XE-MIR 2000 ERV heat exchanger core

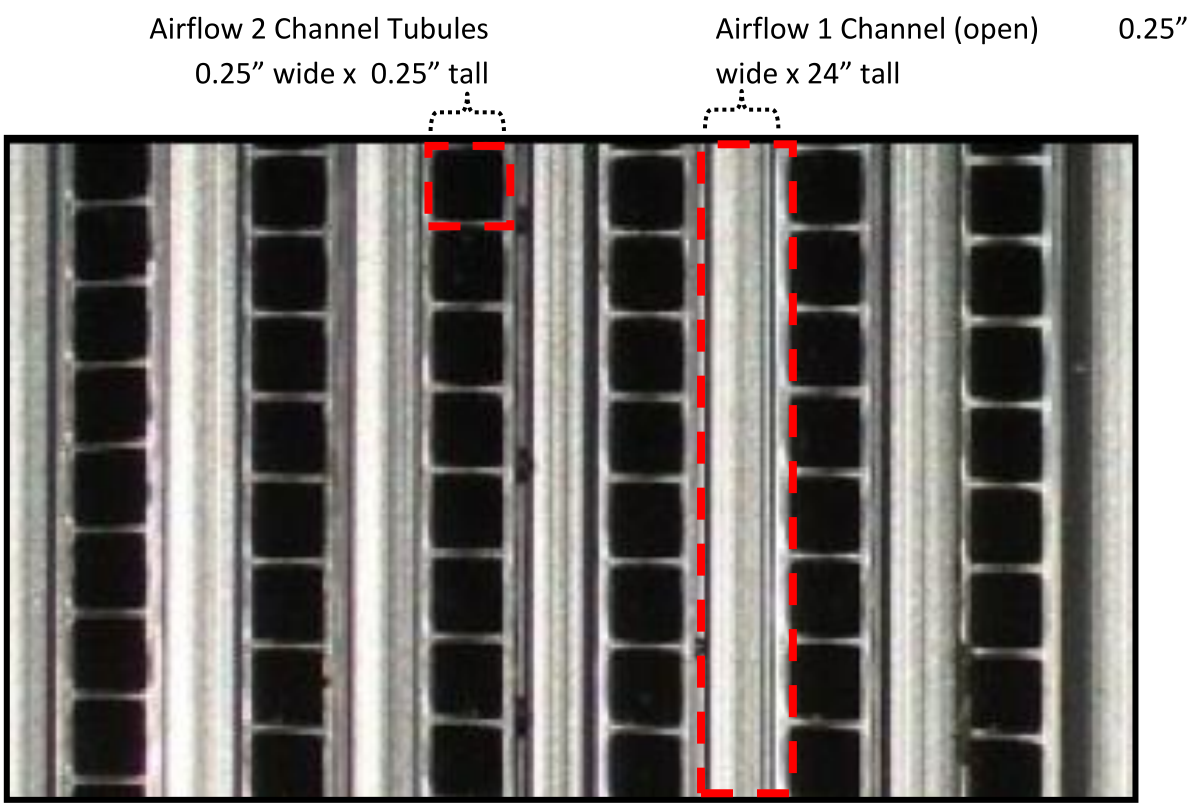

Figure 23- Close up view of ERV heat exchanger core showing dimensions

GLOSSARY OF TERMS

Hours of operation:
The hours during the day when the building is ventilated with outdoor air—typically the time when the building is occupied.

Days per week:
Days per week that the building is ventilated with outdoor air.

CFM of outdoor air:
The rate of outdoor air ventilation during the hours of operation.

Electric Rate:
Expected cost for electricity in $/kWh. (Default $.09/kWh)

Peak Demand Charge:
Expected electric demand charge in $/kW. (Default: $10/kW)

Months of Peak Demand Charge:
The number of months the utility assesses a demand charge during the year. (Default: 6 months)

Gas rate:
Expected cost for gas in $/therm. (Default: $1.20/therm)

Heating Efficiency:
The heating efficiency for the heating system. (Default: 81%)

Cooling Efficiency:
The cooling efficiency rating for the HVAC system. (Default is 10 EER.)

BPE ERM Total Effectiveness:
BPE total energy recovery wheels generally recover over 80% of the difference in sensible and can recover over 34% of the latent energy (total energy) between the building exhaust and incoming ventilation air streams. This effectiveness can vary depending on the system. People are more sensitive to thermal effectiveness, BPE ERM properly sized can be stand-alone without additional coils in line, as long as the space is conditioned by standard HVAC systems.

HVAC Fan Power (% of Total System):
In most DX systems, fan power represents approximately 15% of total energy consumption. Energy Recovery ventilation enables a smaller DX system to be installed. As a result, significant operating savings can be attributed to operating a smaller fan in the smaller system.

Installed Cost per Ton:
Estimated installed cost for the HVAC system on a per ton basis.

Installed Cost per cfm for ERM:
The installed cost for the energy recovery system. This number will vary depending on size and system design. $4 per cfm is a general average but may vary between $2 and $6 per cfm.

BPE ERM Cooling Capacity:
BPE energy recovery ventilators provide significant cooling capacity. Consequently, a system with energy recovery will require less mechanical tonnage than one without.

BPE ERM Heating Capacity:
BPE energy recovery ventilators provide significant heating capacity. Consequently, a system with energy recovery will require less mechanical mbh capacity than one without.

Peak Demand Reduction:
The cooling capacity reduction also translates into reduced peak demand (kW), which in turn reduces operating cost and may qualify for utility rebates.

Annual Cooling Energy Saved:
Estimate of savings in kWh of using a system with energy recovery versus one without.

Annual Heating Energy Saved:
Estimate of savings in Mbtu of using a system with energy recovery versus one without.

Cooling Operating Cost (Savings):
Estimated net change in annual operating cost that energy recovery contributes during the cooling season.

Heating Operating Cost (Savings):
Estimated net change in annual operating cost that energy recovery contributes during the heating season.

Cost (Savings) to operate smaller unit fan:
When a DX/ERM system is properly right sized, there are operating savings for the resulting smaller system fan. The system fan generally represents 15% of the total system energy consumption. This variable can be adjusted in the input section.

Cost (Savings) to run ERM fan:
An energy recovery wheel increases static pressure on the HVAC system. Fan power is necessary to overcome this static pressure. The program estimates the cost to operate those fans with approximately 0.8 inches of pressure drop across the BPE energy recovery core. In many applications with lower flow velocities this can be well under ½" of water column.

Cost of HVAC Unit:
An HVAC unit with energy recovery will have smaller mechanical capacity than one without energy recovery. This field estimates the incremental first cost reduction from installing this smaller mechanical system. It is critical that systems be right sized with energy recovery in order to maximize payback as well as overall performance.

Cost of ERM:
Estimated incremental cost to add energy recovery ventilation to the system.

Net Capital Expenditure:
Cost of HVAC added with Cost of ERM

Payback Period:
Net Capital Expenditure divided by Annual Operating Savings.

Annual ROI:
Operating Savings divided by Net Capital Expenditure

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