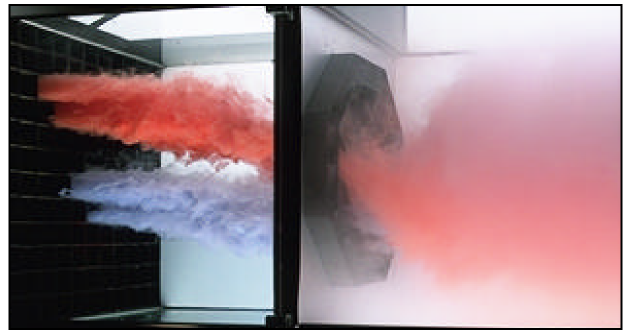
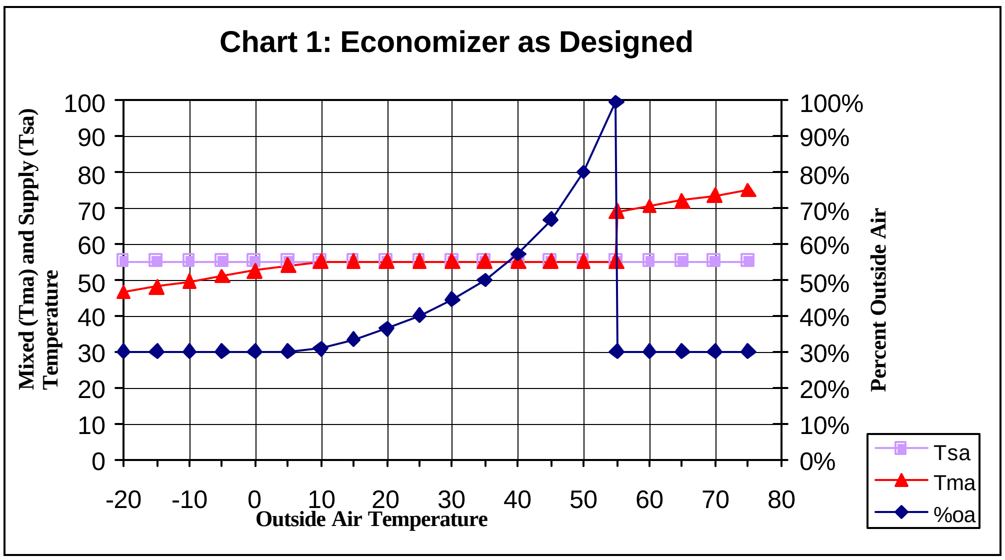
Blender Products, Inc.

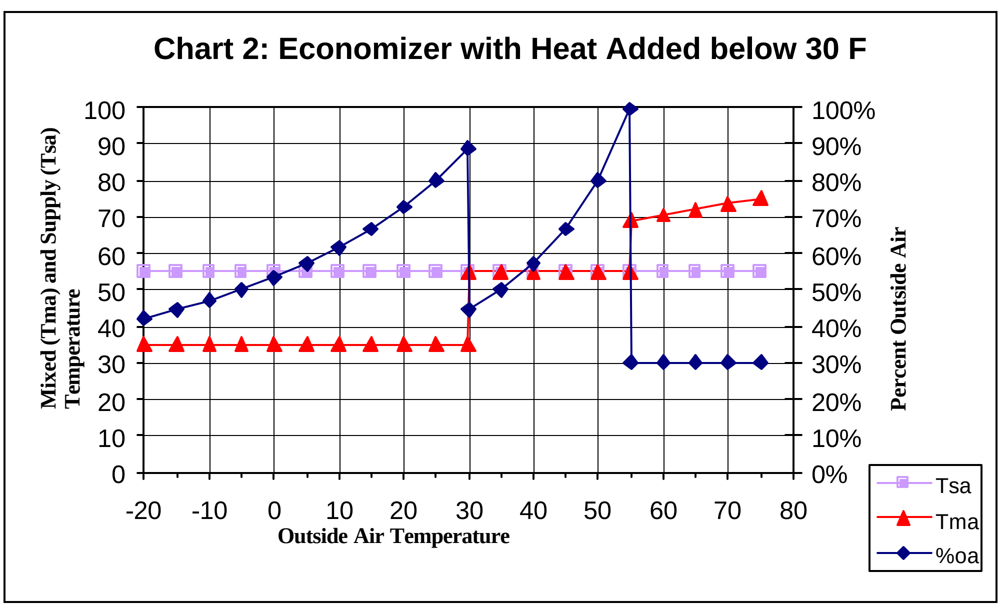
HVAC Mixing Update



Freeze Protection and Economizer Operation: An Energy Study

Over the past several years rising energy demand has forced energy companies to charge peak demand charges during the summer cooling season. This in turn has forced engineers and building owners/operators to resort to a variety of techniques to avoid going over the peak and paying premium charges in the summer. For the most part these strategies are effective during summer months because the techniques can be applied without negatively impacting to system reliability. However, as energy consumption and heating costs continue to rise, engineers and owners are looking to create energy savings strategies for wintertime as well. Unfortunately, these strategies are often limited because of the freeze protection required to protect an air handling unit.





Significant energy savings during the winter are achievable if the Air Handling Unit can run in economizer mode as much as possible. Graph 1 shows the ideal economizer operation where outdoor air is mixed with return air to maintain supply air set point until the point where economizer must be abandoned to maintain minimum outdoor air standards.

However, in most real world scenarios, due to the effects of stratification the freeze stat will trip long before the minimum outdoor air changeover point. Consequently this becomes the determining factor as to if the unit can run on economizer vs. switching over to heating mode. As shown in Graph 2, in order to protect the unit from tripping out at 30°F the heating coil is turned on. Consequently, more outside air is introduced into the system to maintain the desired 55°F supply temp. The result is an inefficient control system resulting in significant energy usage.

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Example

To demonstrate this problem consider a sample unit operating under the following conditions:

Unit capacity: 40,000 CFM	Min OA Percentage: 30%
Supply Air Temperature: 55°F	Return Air Temperature: 72°F
Freeze Stat Set point: 38°F	Heating system efficiency: 80%

Generally, a standard mixing box without an Air Blender mixer provides 25 percent mixing effectiveness when 30 percent outside air is being introduced into the system. Given this level of mixing, as the outdoor air approaches 30°F, the minimum temperature in the mixing plenum starts approaching the freeze stat trip point because there is limited mixing taking place. Therefore, in order to keep the freeze stat from tripping, the DDC system program will have to be modified so the heating coil valve will modulate open any time the outdoor air temperature falls below 30°F. Table 1 shows the 2000 ASHRAE BIN data for Denver[i] and the associated cost breakdown for the number of hours the outdoor air temp is below the freeze stat tripping point.

OAT Range	**Bin Data hours**	**MMBTU Required**	**Efficiency adjustment**	**$6.57/ MMBTU**
29 to 25	565	208.82	261.03	$1,714.97
24 to 20	399	173.80	217.26	$1,427.37
19 to 15	164	82.26	102.83	$675.58
14 to 10	106	60.17	75.21	$494.11
9 to 5	65	41.18	51.48	$338.22
4 to 0	80	55.97	69.96	$459.64
-1 to -5	22	16.55	20.69	$135.94
Total Hours	**1401**		**Total Cost**	**$5,245.83**

Table 1: Heating Costs to Avoid Freeze Stat Trips in Denver[i]

Since the Winter Design Temperature in Denver is –3°F, a facility operating 24 hours per day faces an annual heating cost of $5,245.83. Also worth mentioning is that as soon as the heating coil valve is opened, the Supply Air Temperature as a whole will rise. Since the typical DDC system isn't looking at max and min temperatures in the mixing box, but instead uses an averaging bulb, the computer assumes the Mixed Air Temperature (Tma), needs to be cooled down by either bringing on mechanical cooling or inducing more outside air. The result is the system "hunting" without stabilizing, an unsolvable problem that drives DC programmers and building owners crazy.

Now consider the addition of a Series IV Air Blender mixer, which can be purchased and installed for approximately $0.10 per CFM. A standard installation with one Air Blender diameter of downstream distance available will have a mixing effectiveness of 68% at 30% outdoor air ratio. Given the addition of this product, the lowest temperature value of the mixed air temperature doesn't approach the freeze stat trip point until the outside air temperature falls below 0°F. In Denver, this means a drastic reduction in the number of heating hours required, down from 1401 to 22. This translates into a heating savings of $5,110 ($5,245 - $135 , per Table 1). An additional benefit is that the Mixed Air Temperature average remains at 55°F. Therefore the control system has the ability to stabilize.

It should be pointed out that there is the operating cost for the mixer. Since the typical Air Blender mixer selected during the project design phase will have a pressure drop in the neighborhood of 0.15" w.c. This will require an additional 1.35 BHP of the fan. At $0.06 per kWh, this requirement translates into a yearly operating cost of around $528/year.

Cost breakdown	**Equipment cost (installed)**	**1st year total cost**	**2nd year cost**	**Total Cost over 5 years**
System w/o Air Blender	$0.00	$5,245.83	$5,245.83	$26,229.15
System with Air Blender	$4,000.00	$4,664.00	$664.00	$7,320.00

Table 2: Energy Heating Cost Comparison to Avoid Freeze Stat Trips

Table 2 shows a cost breakdown for a system without an Air Blender utilizing heating cost from Table 1. Further, Table 2 shows a system with an Air Blender combining the heating cost from Table 1 with the Air Blender equipment and operating costs. The 1st year total cost for the system including the Air Blender mixer is$4,664 ($4,000 equipment cost + $528 operating cost + $136 heating cost). As you can see, even with the $4,000 "up-front" equipment cost, the Air Blender pays for itself during the first year.

Design vs. Retrofit Option

While Blender Products has had many successful retrofits using Air Blender mixers, the product should not be treated with a "wait and see" approach. The majority of retrofits have less than ideal space for the Air Blender, resulting in lower mixing effectiveness and higher pressure drop. "Squeezing" an Air Blender into a unit often solves a freeze stat trip problem for mildly cold days, but often the system still has to utilize heating on single digit cold days.

The main benefit to including Series IV Air Blender mixer in the design phase is that the required mixing effectiveness can be achieved. Therefore the installation can be custom arranged based on climate and building requirements. For example, in Denver, increasing the downstream distance to 1.25 diameters raises the mixing effectiveness to 73%, which will allow the unit to run down to -5°F outside air temperature before needing to add heat to avoid tripping the freeze stat. Since the temperature in Denver does not typically dip below -5°F, the heating time and the heating cost is minimized.

Conclusion

To realize maximum system performance, the Air Blender mixer needs to be considered in the design phase because this will ensure that the mixer is applied correctly, thereby maximizing the associated benefits. One extremely effective way to reduce energy costs is to maximize economizer operation. Applying the Air Blender mixer to these economizer systems allows this to happen. Blender Products provides tools to achieve this benefit simple. Our tools consider what the design conditions are and we have a vast array of product sizes designed for the highest performance and lowest operating cost for the system. A few minutes used up front could prove to be a very wise decision down the road.

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[i] Equation (26), found in AHRAE Fundamentals chapter 26: Ventilation and Infiltration, can be used to estimate the energy required and associated cost of using the heating coil to raise the mixed air temperature in order to eliminate the freeze stat from tripping.