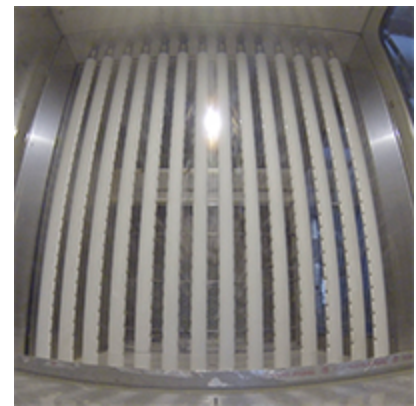


Monday, October 3, 2016

Calculating Humidification Loads for Economizer Cycle Systems: Humidification Basics (Part 5)

Now that we've learned [how to calculate a basic humidification load](#), we need to understand how to do the same when an economizer cycle is part of our design.

Why is that so important? Because nearly every commercial building in the continental United States is required (per DOE) to incorporate either an air- or water-side economizer. If your state hasn't already incorporated the ruling into its commercial building code, it's just a matter of time before it does. And that's a good thing, because using cool outside air to maintain building temperature is an excellent way to reduce cooling costs.



Proportioning Return and Outside Air

Airside economizers work by mixing outdoor air with building return air in order to maintain the supply temperature to the space – typically about 55°F. Proportions of indoor and outdoor air will vary, of course, depending on what the outdoor air temperature is. The table below from the [Dristeem Design Guide](#) shows the percentages of outside air that can be mixed with return air to maintain a 70°F space using one of three mixed-air temperatures.

Outside air percentages with 70 °F return air and various mixed air temperatures			
Outside temp (°F)	Outside air percentage		
	of 50 °F mixed air	of 55 °F mixed air	of 60 °F mixed air
-20	22	17	11
-10	25	19	13
0	29	21	15
10	33	25	17
20	40	30	20
30	50	38	25
40	67	50	34
50	100	75	50
55	—	100	67
60	—	—	100

Determining Outside Air Quantity

As with natural and mechanical ventilation, we must first determine the quantity of outside air in order to calculate what our humidification load will be. Again, there are excellent programs out there that do all the legwork for us, but to impart true understanding, we're going to work through an example as if such aids don't exist.

Let's say we're calculating humidification loads for a non-critical application with an economizer cycle, using the following parameters:

Desired Space conditions

Space temperature	70°F
Relative Humidity (RH)	35%
Mixed Air temperature	55°F
Total CFM	12,000 cfm
Design Outdoor Temperature	20°F

The formula for determining the quantity of outside air in an economizer cycle is:

$$V_2 = V_{AH} \div ([A \div B] + 1)$$

where:

$$V_{AH} = V_1 + V_2$$

V_1 = volume of return air (cubic feet per minute)

V_2 = volume of outside air (cubic feet per minute)

A = temperature difference between mixed air and outside air

B = temperature difference between return air and mixed air

Plugging our numbers in, this is what we get:

$$V_2 = 12,000 \text{ cfm} \div ([35^\circ\text{F} \div 15^\circ\text{F}] + 1) = 3,600 \text{ cfm of outside air}$$

Determining Maximum Humidification Load

Next, using a psychrometric chart or table [as demonstrated in the previous blogs](#), we can determine that the moisture content of the desired conditions of 70°F and 35-percent RH is 2.40 lb per hour per 100 cfm. We need to determine the worst-case

moisture content of the outside air for the specific location to calculate the maximum humidification load.

Table 11-1 in the DriSteem Design guide shows the values for various cities. If we're calculating the load for a non-critical application, we can use the daily minimum % RH. However, if the application is critical, the recommendation is to use the extreme minimum daily % RH for the year. For example, in Minneapolis, MN, the average daily minimum RH for the year is 51% and the extreme daily minimum RH is 20% for the year. Knowing this, we can determine the maximum load for this system by using the following formula:

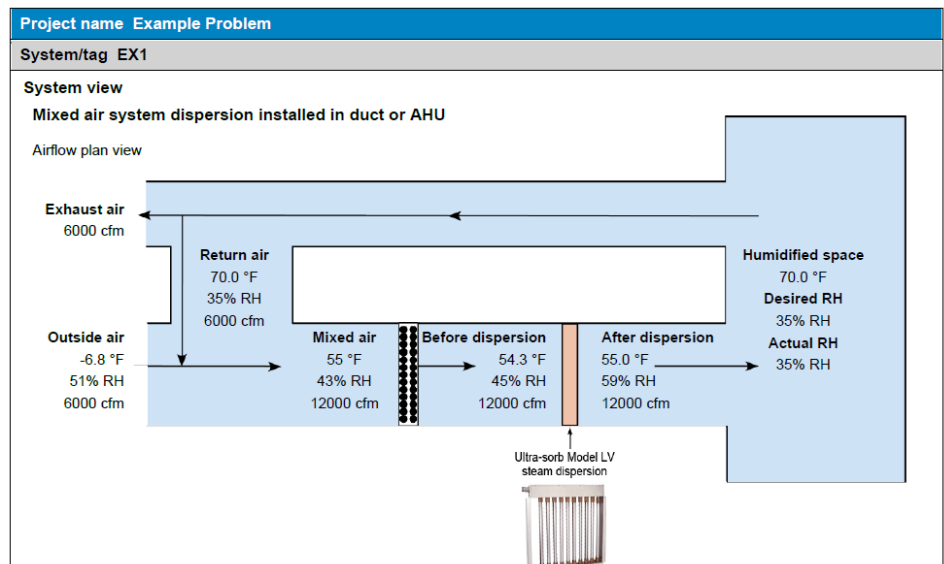
$$(H [\text{space}] - H [\text{outside air}]) \times \text{percentage of outside air} \times (\text{cubic feet per minute [total air]} \div 100 \text{ cfm}) = \text{pounds per hour (load)}.$$

Calculation table from economizer cycle method													
Outside temp.	H (space)	-	H (outside air)	=	Subtotal	x	% of outside air	x	Total air	÷	100	=	Load
°F	lbs/hr/100 cfm		lbs/hr/100 cfm		lbs/hr/100 cfm		%		cfm		cfm		lbs/hr
-20	2.4	-	0.072	=	2.328	x	17	x	12,000	÷	100	=	47.49
-10	2.4	-	0.124	=	2.276	x	19	x	12,000	÷	100	=	51.89
0	2.4	-	0.208	=	2.192	x	21	x	12,000	÷	100	=	55.24
10	2.4	-	0.338	=	2.062	x	25	x	12,000	÷	100	=	61.86
20	2.4	-	0.545	=	1.855	x	30	x	12,000	÷	100	=	66.78
30	2.4	-	0.856	=	1.544	x	38	x	12,000	÷	100	=	70.41
40	2.4	-	1.222	=	1.178	x	50	x	12,000	÷	100	=	70.68
50	2.4	-	1.794	=	0.606	x	75	x	12,000	÷	100	=	54.54
55	2.4	-	2.140	=	0.260	x	100	x	12,000	÷	100	=	31.20

The table below shows the data created from this formula in 10-degree increments of outside air for Minneapolis:

The maximum humidification load for this application is 70.68 lb per hour, which occurs when the outdoor temperature is 40°F.

Of course, it's a lot easier to simply use a program like [DriSteem's DriCalc tool](#). You'll still need to know your Total CFM and your mixed-air temperature, but the program will do the rest of the heavy lifting. Keep in mind that you'll still have to specify the outdoor RH either as the Daily Extreme Minimum or the Average



Outside Conditions. After that, it's smooth sailing. DriCalc provides several handy printouts, including this installation diagram with all of the pertinent data and selection.