ENGINEERING WHITE PAPER

Internal use only

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Fan Motor Heat Gain

When calculating the net capacity of an air handling unit, it is sometimes important to calculate the impact of fan motor heat gain. When working with an engineer who as asked for AHU cooling coil performance, first clarify if their leaving coil condition takes into account fan motor heat gain. If not, you'll need to calculate it.

The equation to calculate the heat gain is: **BTUH = (BHP x 2545) / Motor Efficiency.** This is a sensible only heat load. To convert this heat load into temperature gain, use the sensible heat equation: **BTUH = 1.09 x CFM x ΔT.** There is a spreadsheet in the H:\Engineering folder that will help you make this calculation. There is a tab for draw-through and blow-through coils, as each of these is treated differently.

Please Note: The sensible heat constant 1.09 will vary with the air temperature as warmer air is less dense than colder air. You may recall the equation $Q = \dot{m} \times Cp \times \Delta T$ from your college heat transfer course. The factor Cp is the specific heat which is 0.24 BTU/Lb-°F for air. The sensible heat constant is calculated as (60 min/hr x 0.24) / Specific Volume. Hence, the factor 1.09 assumes a specific density of 13.2 FT3/Lb.

In the spreadsheet, I calculated this factor for draw-through and blow-through assuming 55°Fdb/54°Fwb conditions in draw-through (13.16 FT3/Lb and a constant of 1.094) and 80°Fdb/67°Fwb for blow-through applications (13.85 FT3/Lb and a constant of 1.040). For a 20,000 CFM unit at 14 BHP with a 91% motor, the result is a 1.79°F rise for the draw-through case and 1.88°F rise for the blow-through case. This is a delta of only 0.09°F. Obviously if your conditions are slightly different than 55/54 or 80/67, it will not have a serious impact on the calculation.

Let us look at draw-through and blow-through in more detail.

Draw-Through

Referring to Figure 1, the entering coil temperature is position 1. The leaving air temperature off the coil is position 2 and the air temperature leaving the unit is position 3. We normally know the entering coil condition (1) and select a coil for a leaving air condition (2).

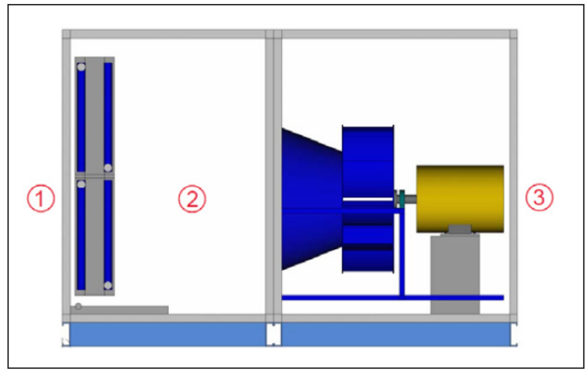

Figure 1 Draw-Through

For this example, the unit is selected at 20,000 CFM. The total static pressure on the fan is 6" and the BHP is 26.4. The motor efficiency is 93.6%. Therefore, the fan motor heat gain is equal to (26.4 x 2545)/0.936 = 71,782 Btuh. The temperature gain across the fan is calculated by the sensible heat equation; 71,782 = 1.09 x 20,000 x ΔT whereas the ΔT is equal to 3.3°F.

In this case, the entering coil temperature was 80.0°Fdb/67.0°Fwb and the leaving coil condition was 54.2°Fdb/53.6°Fwb. The dry bulb temperature at the fan outlet is 54.2°F + 3.3°F = 57.5°F. If, on the other hand, we know we need 55°F at the unit outlet, then the temperature off the coil must be 55.0°F – 3.3F = 51.7°F. Using 45/55°F water, this would result in an 8-Row / 11 FPI coil

Blow-Through

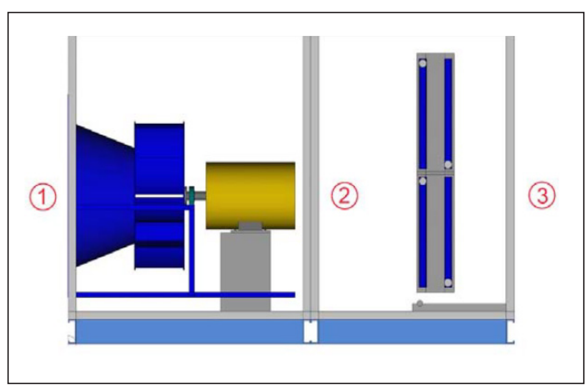

Figure 2 Blow-Through

Referring to Figure 2, we normally know the return air temperature (1) and a desired leaving coil condition (3). But need to calculate the entering coil air temperature (2).

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For our same 20,000 CFM example, if the return air temperature is 80.0°Fdb/67.0°Fwb and the fan heat gain is 3.3°F, then the entering coil dry bulb temperature will be 80.0°F + 3.3°F = 83.3°F. Using a psych chart or smartphone app we can calculate the entering wet bulb temperature at the same dew point as 80/67. In this case, the entering wet bulb temperature would be 68.0°Fwb.

If we need to provide 55°Fdb leaving this unit, we would select a coil to cool 83.3°Fdb/68.0°Fwb air to 55.0°Fdb. Using the same 45/55°F water, the resulting coil would be 6-Row / 9 FPI.

It is important to note that blow-through coils will normally have fewer rows and/or fewer fins per inch with a lower pressure drop than coils in a draw-through position. This is due to the simple fact that it's easier to cool air from 83.3°F to 80.0°F than it is to cool air from 55.0°F to 51.7°F with whatever chilled water temperatures you're working with.

So, you may ask why blow-through coils are not used more often? The historical answer is that prior to direct drive fan arrays, it was harder to assure even airflow across a coil downstream of a DWDI fan. Some manufacturers used diversion plates (large plate with holes) to even out the airflow, but this added pressure drop and increased the brake HP.

Now that fan arrays are common, blow through coils should be considered more often. If there is one possible drawback it's that the air tunnel can increase in length if there is a heating coil upstream of the fan that would otherwise be installed in a preheat position adjacent to a draw-through chilled water coil. In addition, on outdoor units with coil connection housings, it is often more convenient to have all the piping contained in a single housing. In each case, there is often little reason why the heating coil cannot go downstream of the fan as well. The fan heat gain would reduce the boiler load during heating months. The exception to this would be on 100% outside air units where some engineers prefer to have the heat source upstream of the fan.

If there are any questions or concerns, please feel free to contact the engineering department.

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