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Saving with Variable Speed Kitchen Exhaust Fans and Make-Up Fans

Kitchen exhaust hoods having fans outfitted with variable speed motors are now offered by commercial kitchen equipment suppliers. Manufacturer's have claimed a payback period of approximately 1-2 years, maybe less. Of course, it all really depends upon the particular details for each project.

A good idea?

Well, there are many aspects to consider, including the following:

- Energy Savings Available
- Overall Safety/Compliance with Codes
- Installation Considerations
- Any Maintenance Concerns

In this article we explore the first of these – Energy $avings. In subsequent articles we will attempt to explore the others.

" $88.15 per month.
Now that's a nice savings."

Energy Savings $

First, there is a considerable savings realized from slowing down fan motors.

Fan Laws say it all. Consider the following:

1. Flow Rate (Q) is proportional to Fan Speed (RPM)
$$\frac{Q_1}{Q_2} = \frac{RPM_1}{RPM_2}$$
2. Fan Pressure induced is proportional to (Fan Speed) ^{2}
$$\frac{P_1}{P_2} = \left[\frac{\mathrm{RPM}_1}{\mathrm{RPM}_2}\right]^2$$
3. Fan Power required is proportional to (Fan Speed) ^{3}
$$\frac{BHP_1}{BHP_2} = \left[\frac{\mathrm{RPM}_1}{\mathrm{RPM}_2}\right]^3$$

For example, a fan that is slowed to ½ of its original speed, will require only $(1/2)^3 = 1/8$ of the original brake horsepower. Hence, a savings of 7/8 or 87.5% of the original power.

A savings in brake horsepower at the exhaust fan is a savings on the monthly power bill. Let's consider a fan that originally used 3.0 BHP that is slowed to half the original speed. Original power usage is 2,238 W of power:

(3.0 BHP)(746 W/BHP) = 2,238 W

The monthly cost, assuming 30 days operation @ 12 hour shifts is

2,238 W * 360 h = 805,680 W-h ~806 KWh

At .10 /KWh, this fan's cost is over $80/mo:

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0.10 /KWh * 806 KWh = $80.60

By slowing the fan down to ½, the cost is 1/8 or $80.60/8 = $10.08 per month.

The savings is therefore $70.52 per month.[1]

Now here's an added bonus to the savings: Make-Up Air.

The make-up air fan can also be reduced, or should I say, it MUST be reduced to maintain proper space pressure.[2]

Assuming the design included 100% make-up air (also referred to as *Replacement Air*), it is common for the total pressure required for the make-up air fan to be around 0.5 – 0.80 in WC, depending on what equipment is being used (evaporative cooling, direct expansion refrigeration (DX), chilled water air handler, etc.) Let's assume that the make-up air fan comes to ½ of the exhaust fan pressure. Recalling that fan pressure is proportional to the square of fan speed or flowrate, the power used is ¼ that of the exhaust fan. We can further save some calculations by including make-up air savings in the exhaust fan savings using this ¼ rule. So, the savings should be multiplied by 1.25 to include the make-up air fan. Again, we have made some assumptions that must be considered for each project before an accurate cost savings can be calculated.

Savings = 1.25 * $70.52 = $88.15 per month.

<u>Now that's a nice savings.</u>

So, what is the cost of implementing a variable speed system? The question was posed to one of the leading manufacturer's and the answer? "Around $1,500". At a savings of $88.15 per month, this comes to about 17 months.

In our next issue we discuss additional aspects of Variable Speed Kitchen Exhaust Fans and Make-Up Fans. ■

[1]Author's Note: We are not including all of the details needed to be exact, which include motor & drive efficiencies, motor loading factors, miscellaneous demand charges by the power purveyor, etc. but the foregoing will provide simplified theoretical savings. For a more in-depth analysis, the reader is referred to the *The Energy Management Handbook* by Wayne Turner, The Fairmont Press, 2001.

[2]The 2006 UMC maintains that air pressure between the kitchen area (the vicinity in which the hood is installed) and surrounding areas must not differ by more than 0.02" WC. Note that a difference in airflow rate is not provided, but the code goes right to the issue – pressure differential – and rightly so. We will explore more on this issue in later white papers and eNewsletters.