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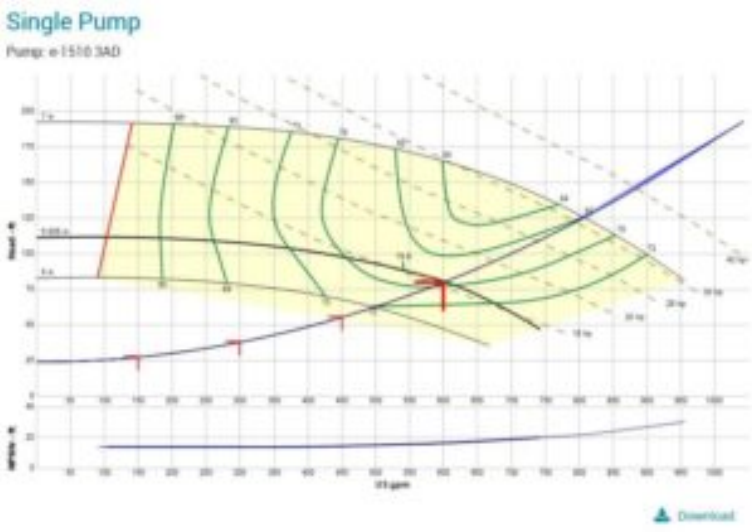
How to Pick an HVAC Centrifugal Pump Part 8: Motors for HVAC Centrifugal Pumps (continued)

Monday Morning Minutes | by Norm Hall, July 31, 2017

Motor speed for HVAC centrifugal pumps is a hot topic these days. Last week the R. L. Deppmann Monday Morning Minutes (MMM) began exploring motors and the normal speeds used for larger HVAC pumps. This week we look at the pump selection itself at 1800 RPM and 3600 RPM speeds.

HVAC Centrifugal Pump Selection at Different Speeds

I stated in the previous MMM that the standard for larger HVAC centrifugal pumps was 1800 RPM. What happens to the pump selection if we compare an 1800 RPM selection with a 3600 RPM selection? To illustrate, let's look at an example. Assume we have a closed chilled water system with a secondary pump requirement of 600 GPM at 80 feet of head. If we use the B&G ESP-SYSTEMWIZE selection program, and choose the superior *e*1510 style of pump, the first three choices are shown below.



The first choice has a very nice efficiency of 83.9% at design and a part load efficiency value or PLEV of 75.8%. The pump is an *e*1510-4BD with a 20 HP, 1770 RPM non-overloading motor. This pump has a 4" discharge and a 5" suction.

Now let's look at the 3600 RPM selection. This selection is an *e*1510-3AD with a 20 HP, 3550 RPM non-overloading motor. The efficiency at design is lower at 78.3% but the PLEV is 77% which is just above the 4BD selection. The selection is farther to the right than the 1770 RPM selection but it is still within 85% of the end of curve for protection from over headed design. In addition, this pump weighs less and is 20% less in first cost. Why not use the 3550 RPM pump?

Regarding the example shown above, what is the reason to spend 20% more for a pump just to get an 1800 RPM motor?

Motor Speed and Audible Noise

POINT 1: The first reason is noise. 3600 RPM motors are louder than 1800 RPM given the same manufacturer. When we are walking down the hallway in a school or hospital and hear the high pitched whine from a pump. We can guess that the pump is 3600 RPM. 1800 RPM motors are quieter. How much quieter? Obviously that depends on horsepower, manufacturer, frame, and construction but let's just pick one motor. This manufacturer publishes the 20 HP 1800 RPM motor at 64 dbA and the 3600 RPM motor at 70 dbA. Just to understand, 70 dbA is twice as loud as 60 dbA. A vacuum cleaner could be 70 dbA and background music is 60 dbA.

In addition to the motor noise, we must also consider velocity noise. In the 1800 RPM example, the pump has a 4" discharge and a 5" suction. The exit velocity through the 4" discharge nozzle is 15.12 FPS in schedule 40 pipe. The exit velocity through the 3" discharge of the 3600 RPM pump is 26.05 FPS or almost double. Even at a reduced speed in variable speed applications, the noise will always be more excessive with the 3600 RPM motor.

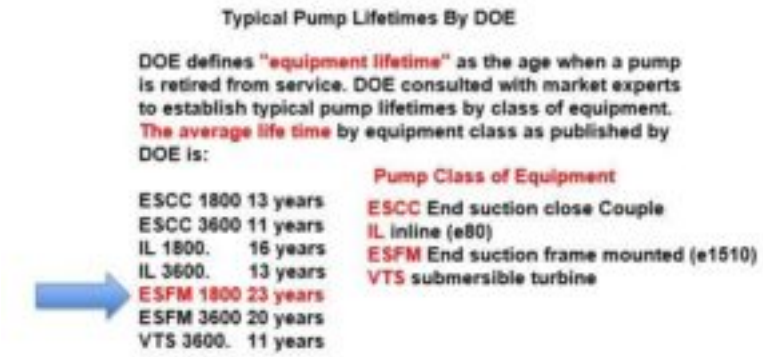
Motor Speed and Energy Cost

POINT 2: The second reason is about energy. The efficiency of the pump has less to do with the speed than the selection. For any given set of capacities, I may find an 1800 RPM selection better than a 3600 RPM selection or vice versa. But when we look at the piping, things can change. The velocities mentioned above also come with a friction loss penalty. The friction loss of the 3" pipe at 3600 RPM is 74.5 Ft/100 while the 4" in the 1800 RPM pump is 18.5 Ft/100. Assuming this is a variable speed chilled water system operating over 50% of the year, ASHRAE 90.1-2013 recommends 6" pipe.

How does the contractor get from 3” to 6” pipe? Is the discharge flexible connector 3” or 6”? If we simply look at the suction diffuser selection for the two pumps, we can see the penalty for the smaller pump. The 3600 RPM pump with the 4” suction will require a 6”x 4” suction diffuser while the 1800 RPM selection will require a 6” x 5” suction diffuser. The 3600 RPM fitting has a pressure drop 300% higher than the 1800 RPM fitting. At 600 GPM this will cost ¾ HP or 5% of the brake horsepower.

Motor Speed and the Life of the Pump

POINT 3: The third reason is pump repair cost and life of the pump, let’s just think about automobiles. If one car runs at 6000 RPM and another runs at 3000 RPM, which will need more maintenance and repair? Which engine might last longer? 3600 RPM pumps require more repair. The seal surfaces are turning at a higher speed and require more lubrication and produce more heat. If dirt gets in the bearings or the seal, the additional speed will cause damage at a faster rate.



The NPSH required by the pump is higher at 3600 RPM than at 1800 RPM. The examples above show the properly selected 3600 RPM pump has 2-1/2 times more net positive suction pressure required. Failure to account for this will result in a host of issues.

In addition to repair, the actual life of the pump is less at 3600 RPM vs. 1800 RPM. The United States Department of Energy recently published the 2020 pump efficiency standard and in it they published the expected life of pumps. Take a look at the numbers below from the DOE standard. Most engineers choose the 1800 RPM model *e*1510 (labeled ESFM style) pump over the 1800 RPM model *e*80 inline or (labeled IL style) pump to enjoy the 143% difference in pump life. But if we then accept a 3600 RPM (ESFM), that lifetime advantage drops to 125%.

So the reason most engineers choose 1800 RPM pumps vs. 3600 RPM pumps is not just from habit. There are times when the 3600 RPM pump selection makes better sense, but as a rule of thumb, select 1800 RPM HVAC centrifugal pumps and, better yet, make them Bell & Gossett.

Next week the R L Deppmann Monday Morning Minutes will explore the over-speeding of 1800 RPM pumps.