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Sizing and Selecting the Proper Pump

Like most activities in HVAC design, selecting a pump involves many variables—and, sometimes, tradeoffs among those variables. A designer must consider the pump's intended service, the space available for installing and maintaining the pump, and the costs associated with procuring, installing, and then operating the pump over the lifetime of a project.

Pump Construction

In HVAC service, we're usually pumping water, so exotic alloys for handling abrasive fluids rarely are required. Typical HVAC pumps are "bronze-fitted" using a cast-iron volute and cast-bronze impeller. All bronze or stainless-steel pumps are required for systems in which high temperatures and high oxygen concentrations are encountered.

Pump Curves

Pumps should be selected by consulting the pump curve published by the manufacturer. This curve is based on tests that are conducted in accordance with procedures published by the Hydraulic Institute. Figure 1 shows an example of a typical HVAC pump curve. If glycol or anything else that increases viscosity above the usual range for water is going to be used, special calculations will be required. Viscous fluids distort the pump curve as published for water—decreasing the efficiency of the pump and requiring a larger motor.

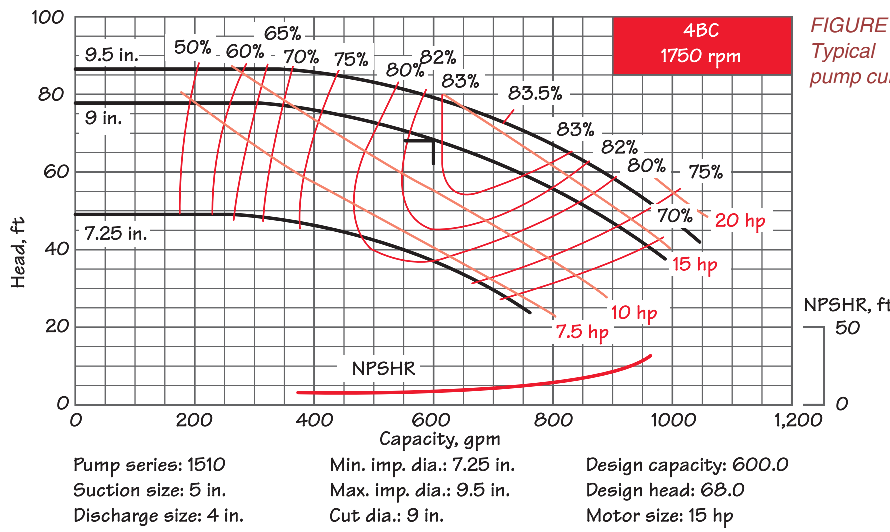

FIGURE 1. Typical pump curve.

The "duty point," as represented by the bracket in Figure 1, is the combination of head and flow required in the application. The flow required usually is calculated by considering the required heat-transfer rate and the temperature change in the pumped fluid. Because these variables are at least reasonably well known, we can be pretty sure about the flow requirement. Determining the required pump head often is more uncertain. It may be that important components, such as coils or control valves, have not been selected, but the pump procurement lead times demand that the pump be ordered immediately. Many designers react to this situation by picking a reasonable amount of head, then adding an arbitrary, large safety factor to cover any possible contingency. Over-head pumps selected in this way are prime candidates for causing operating problems and needlessly increasing costs as they run out on their curves—increasing flow and drawing more horsepower until they achieve a balance between the excess head being provided and the actual system head requirement.

Total head, the ordinate on a pump curve, is the increase in mechanical energy being provided by the pump to the fluid. This energy is used entirely by the system in elevating the fluid, overcoming pressure or velocity differences from source to destination, and overcoming friction effects in the pipes, fittings, and other components. The published sources for calculating friction loss generally are conservative. If extra safety factors are included, the result is a pump that provides more flow than required with noise and inefficient operation as the result. For these reasons, resist the temptation to specify unnecessary head.

Pump Types

Although many pump types are available to the HVAC designer, most applications are well-served by centrifugal pumps. Among centrifugal pumps, there are many styles: single- or double-suction, in-line- or base-mounted, and close- or flexibly coupled. All have their specific uses and a wide overlap. So, in many

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B&G pump configurations engineered for ease of installation and valuable space savings.

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applications, more than one pump style could be used. There are exceptions to this. For example, a vertical turbine pump is particularly well-suited to applications such as a cooling tower in which water from a tower basin must be elevated to the condenser and then to the tower. Using a vertical turbine pump is a way to avoid a "suction-lift" situation that can be difficult for a standard centrifugal pump. Higher flow rates might be better-served by a double-suction pump in which axial forces tend to balance one another. In a large single-suction pump there will always be some net axial force acting on the shaft: the product of pressure differences between the suction eye and the back of the impeller acting over the area of the suction eye. In-line-mounted pumps range from very small, fractional horsepower circulators to large pumps capable of handling several thousand gpm. Close-coupled pumps are more compact than flexibly coupled pumps, but they require motors with special faces that can be bolted up to the pump-mounting bracket and longer shafts for mounting the impeller. Another important consideration is the space available for installation. Designers must consider the installation footprint plus the access space required to service the pump properly. In this light, vertical split-case, double-suction pumps might serve best.

Series 1510 End Suction Pump with ANSI and OSHA-Compliant Coupling Guard

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Pump-Selection Tips

Always select a pump at, or close to, its "best efficiency point" ("BEP"). The Hydraulic Institute gives some guidelines for the "preferred operating region" based on pump-specific speed.[1] Many designers prefer even narrower regions around the BEP. The BEP represents a combination of head and flow produced by the pump where efficiency is at its highest. All other things being equal, high efficiency also represents the minimum horsepower for that head-and-flow combination. Because it is rare that an application duty point will just happen to land on the BEP, there are guidelines to help you make the best choice. Because head calculations are more uncertain than flow calculations, and because designers are likely to add safety factors, it makes sense to pick a constant-speed pump with the required duty point to the left of the BEP. By doing that, the pump will move toward higher efficiency as it reacts to lower-system head loss. By selecting pumps that operate in the center or high efficiency part of the curve most of the time, we can lower operating costs and lengthen the life of pump seals and bearings. This is because the pump impeller generates increasingly high radial loads as its point of operation moves away from BEP toward lower efficiency points. The pump net positive suction head required (NPSHR) usually is low in the higher efficiency part of the curve. For open systems in which net positive suction head available (NPSHA) may be limited, it is very important to select the pump for high efficiency and low NPSHR so that it will not cavitate.

Larger pumps can be equipped with a range of impeller diameters. It is not good practice to choose a pump with either the largest or the smallest impeller. In doing this, you will limit your ability to fine-tune the pump's performance after it is installed. Once installed, you can measure the pressure difference across the pump and convert it to the head being produced by the pump (and demanded by the system). If an impeller is larger than required for the system, it can be "trimmed" by putting it on a lathe, reducing the diameter, and rechecking the balance. Trimming an impeller is easy and inexpensive. It is an excellent way to counteract the oversizing that might have resulted because of errors in early calculations. If a pump was selected with the smallest diameter impeller and it is still too large, it cannot be trimmed. A similar situation exists if the largest diameter impeller has been selected. If the pump is undersized, there is no way to install a larger impeller and increase capacity. This situation is seldom encountered, but it could happen. And, the solution probably is pretty expensive.

There are a couple of other tips that you might consider: multiple pumps and variable speed pumps. "Multiple pumps" means any application that uses several smaller pumps in series or parallel, or any of several possible primary-secondary pumping situations. These applications offer a great deal of flexibility, redundancy, and possible cost savings if the flow requirement varies with time.

The practices used in selecting pumps for series or parallel operation are roughly similar to those discussed above, but there are some important differences. The motors provided for parallel pumps must be chosen for the single-pump operating mode because the single pump will run out on its curve and draw more horsepower than when both pumps are operating together. Motors for pumps in series must be selected to handle the horsepower requirements when both pumps are running.

Variable speed pumping, by the use of variable speed drives (VSDs), has grown common in recent years as people have become more familiar with the technology and as costs for VSDs have gone down. With a VSD, pump head as well as flow are reduced to handle part-load situations. In the right kind of application, this can result in large savings in operating costs.

[1]Hydraulic Institute, ANSI/HI 9.6.3-1997, American National Standard for Centrifugal/Vertical Pumps, Allowable Operating Region.

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Pump Selection

Once you've made these initial decisions, you can turn to printed catalogs or computer software to help in narrowing down the selection. In a catalog, "range charts" show the head and flow envelope for each size of a particular pump style. Range charts can help you focus on the few pumps that would meet the application requirement, but they should not actually be used to select the pump. Always look at the specific curve that describes the pump's performance. Computer-selection programs also can help narrow the search. You can set defaults to tailor the search to your specific needs. For example, you could define a motor speed, a minimum efficiency, or some portion of the pump curve to limit the number of choices the computer will present to you. Remember, that's all that the computer is doing—presenting you with a list of possible selections. It's still up to you to select the pump.

On the pump curve, you can determine if the pump is a "flat-curve" or "steep-curve" pump. The shape of the curve is determined by factors such as the number of impeller vanes, the curvature of those vanes, and the width of the impeller. The difference is more than an academic detail. By definition, a flat-curve pump will increase in head less than 25 percent as it moves from the best efficiency point toward shut-off head or no flow. Both flat- and steep-curve pumps have their applications: flat-curve pumps are preferred in multi-circuit systems having many control valves. In this kind of system, large flow-rate changes should be expected, but the flat-curve pump will not greatly increase the amount of differential head provided at low flow. A steep-curve pump might be just the thing for a boiler-feed system in which the flow rate is not expected to change and a lot of head is required to feed the boiler.

Conclusion

Well-designed and carefully manufactured pumps often command a price premium, but this initial cost is small compared to operating costs in most areas. Good selection practices can ensure that the pump will last a long time while minimizing operating costs. Considering these reduced operating costs over the life of the project often will yield a very attractive return on the initial pump investment.

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