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White Paper
Pump Efficiency and Testing

Pump efficiency and testing considerations when selecting a pump for your hydronic application

In a world filled with so many choices, it isn't surprising that the decision on how to maximize energy savings on a new project or retrofit is not an easy one. This paper outlines important considerations in evaluating published pump performance and different testing options to achieve performance levels acceptable for an application.

Guarantee point efficiency, part load efficiencies, motor efficiencies, drive efficiencies and control strategies all come into play when determining the actual energy required to operate a system from a pumping standpoint. For the purposes of this paper the flow point that is most important in determining overall system efficiency will not be discussed. Instead, the potential differences between the performance of an installed pump and the published curve used to select that pump will be reviewed.

Just like the materials of construction, the seal type and the impeller trim have an impact on pump performance. Even if a performance test is requested in accordance with HI/ANSI 14.6 for a specified guarantee point, if the actual test grade is not specified in the order/quote the manufacturer will likely apply the default test grade for the intended service. It is important to review the current revision of HI/ANSI 14.6 to understand the default acceptance grades per application and shaft power along with the current grades and their associated test bands. It will be easier and more economical for the manufacturer to comply with requests that align with published standards as opposed to a custom specification developed for a specific project or customer.

A reasonable assumption is that a pump would perform closely to its currently published curve. But many curves, whether published in a booklet or displayed on selection software, do not specify the intended service or what grade they would certify to. Why is this important? Many factors influence how close to the published curve a pump will actually perform.

Variations in hydraulic performance are the result of manufacturing tolerances, testing instrument fluctuations and accuracy, driver (motor) variation, and the inherent instabilities in the pumped media near the pump suction and discharge. The magnitude of these variations will vary directly with the degree of precision applied to manufacturing processes, the test equipment, and test procedures. The higher the precision used in manufacturing and testing, the smaller the expected variations in test results…the published curve will likely represent an average of historical performance of similar units. (Hydraulic Institute, 2018)

If a pump is specified as requiring compliance to a grade higher than what the manufacturer assumed in their published curve, a quote from the manufacturer may come with a trim that is different from the published curve used to make the original selection. In fact, if the specified duty point falls on the maximum trim for a pump, the manufacturer's quote may come with a different pump or motor than originally specified in order to achieve the guarantee point at the tighter performance tolerance. This is very different from a scenario where no performance tolerance was specified and the pump was either not tested, or was tested to a general standard in the case that the manufacturer was not specifically informed about the type of application and therefore standard to apply.

Even if a performance test and grade are specified, it should be noted that may only ensure testing of head and flow to that grade at the specified guarantee point. The testing standard is specific and should be consulted to understand what will be included in a normal test and what must be additionally specified. Power or efficiency may not be guaranteed without being additionally specified. Another consideration is that some grades may have a bilateral (positive and negative) tolerance or a unilateral (positive only) tolerance for head and flow. It is important to understand what aspects of pump performance will be most critical for the application and match requirements accordingly. Will the pump be operated with a variable speed drive? Is maximum pressure or maximum horsepower a concern? Is the net positive suction head available a concern.

Here is an example to illustrate some of these points more clearly. Let's say that after determining the maximum load conditions for an application a need for a pump that produces 3,900 gpm at 60 ft of head is identified. The perfect 75 hp pump for the job is selected and an order is placed **(Figure 1)**. After installing the pump, it is noticed that at 3,900 gpm the pump is only generating 55 ft of head. In troubleshooting the issue the motor current is measured and the amps are higher than expected, considering the lower head. Using published motor efficiency it is possible to calculate shaft power and determine that the pump is drawing enough amps to equate to 67 hp at 3,900 gpm. Pump efficiency can be calculated from the calculated shaft power (unless of course you have a calibrated torque meter) and the pump's hydraulic power. The calculated result doesn't seem close to the expected pump efficiency of 87%.

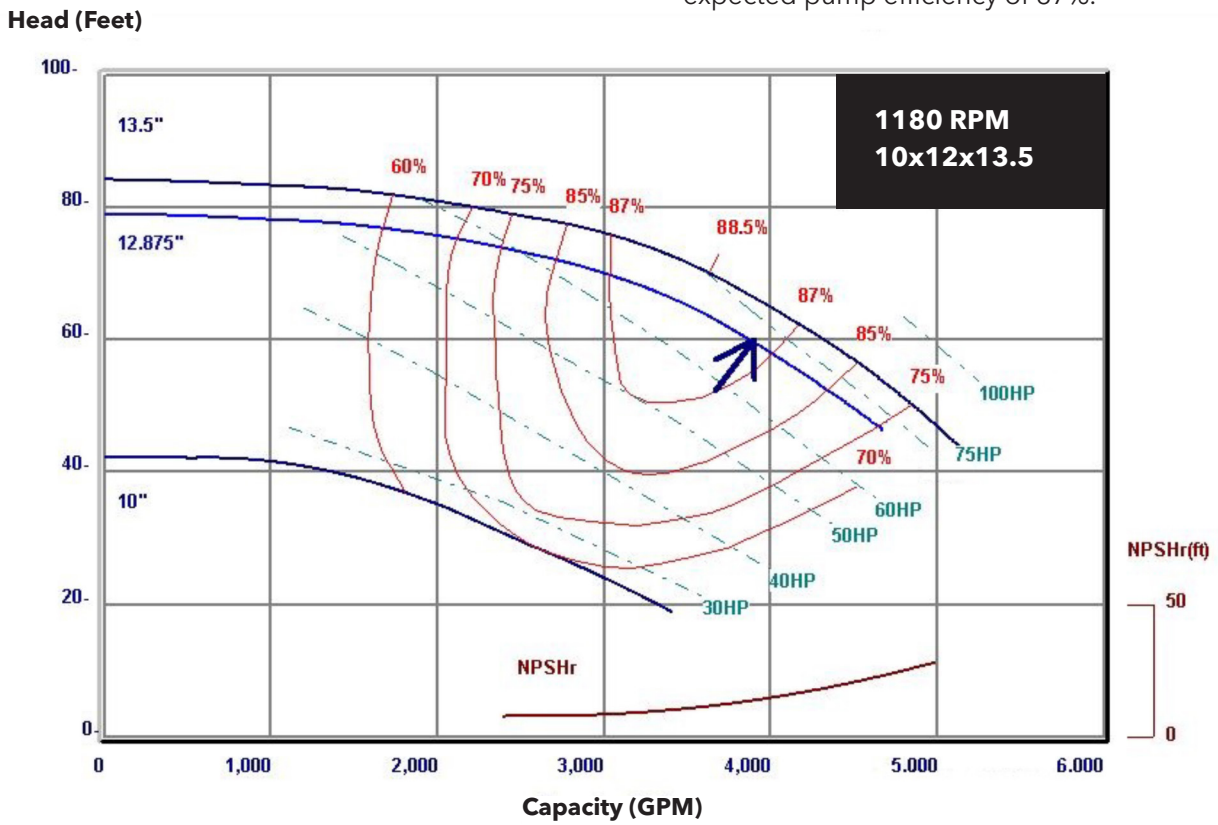

Figure 1. Expected performance based on published curve

Surprised by this revelation the pump manufacturer is contacted to determine if there is a potential problem with the pump. After reviewing the information, the manufacturer responds that the pump seems to be operating within the expected standard tolerances (pump actual performance represented in **Figure 2**). You explain that the application's head requirements are critical and that an 8% reduction is detrimental. The pump manufacturer understands the dilemma but responds that this important requirement should have been provided at the time of the order. The options to correct the problem include purchasing a larger impeller or to utilize a variable speed drive to over speed the impeller to gain the additional head. Of course this does mean more money and lost time, not to mention the fact that the lower efficiency will mean higher long term operating costs. You find yourself wondering if all pump curves are created equal, and what can be done differently in the future.

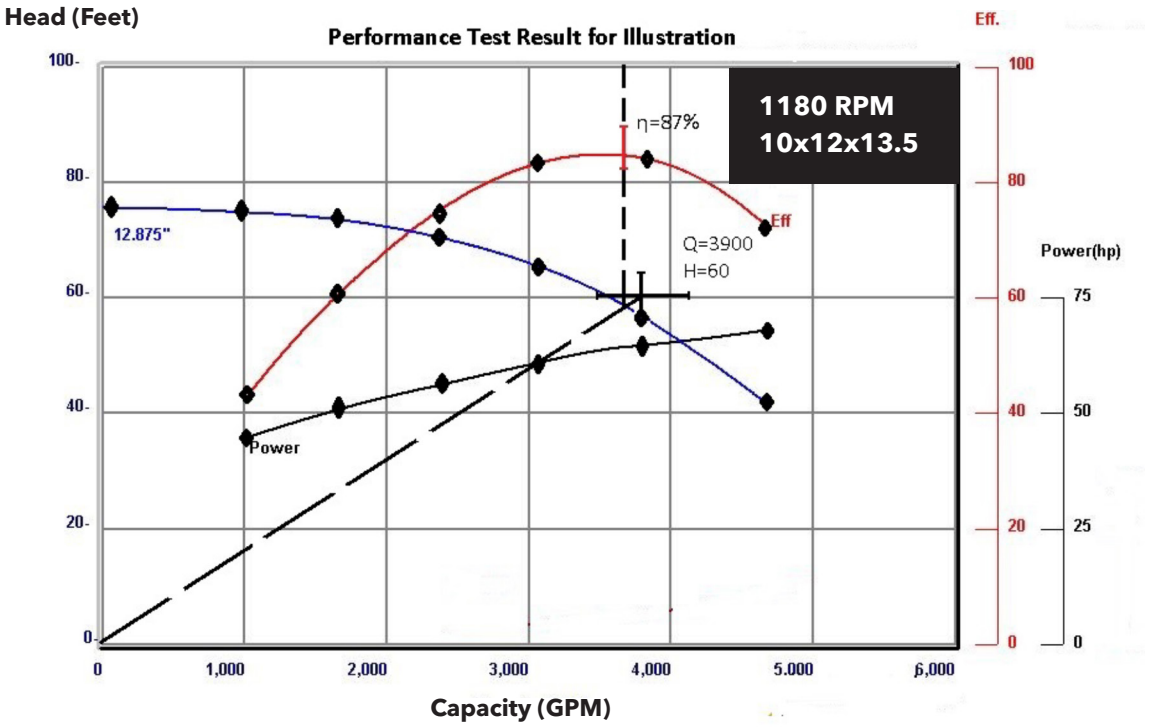

Figure 2. Here the actual performance curve is passed through the tolerance cross hairs of the guarantee point. Efficiency is measured at the intersection of the curve with a straight line from the origin through the guarantee point.

The good news is that there are steps that can be taken to ensure future pumps satisfy requirements. While every project cannot justify the additional cost of certified performance test to the tightest tolerance band on pump flow, head, and efficiency, it doesn't mean that you can't ensure that the application requirements are met. When creating a pump specification make sure to include the fact that the pump must perform to a specified grade at a minimum and all submittals should include a curve to meet that grade. If the order contains a certified test requirement, be explicit in the test specification for head, flow and/or efficiency. It is up to you as the specifier to include this information in the specification. As an alternative, a tighter tolerance for head and flow can be specified, with a lower tolerance for efficiency.

If you are concerned about overloading the motor, you might consider specifying a maximum horsepower and flow range to be evaluated. If you are going to be operating the pump with a variable speed drive, the duty point may be achieved at other than the typical motor test speed. Remember to either specify the reduced test speed, or provide a guarantee point that will fall on the constant speed curve of the pump.

These are all important agreements to have up front. It will be difficult to start adding or changing criteria once you have a completed test report and the manufacturer is waiting for approval to ship. A tighter performance specification or additional test requirements typically equate to additional costs for the pump. It can also extend lead times as the manufacturer takes additional steps to ensure compliance and schedule the testing. Balance these short term issues with the longer term issues of pump performance. Understand exactly what is needed to make the project successful, and then specify the requirements precisely.

A good specification maximizes project outcome and provides clear guidance on expectations to the manufacturer. A cut and paste of old specifications risks disappointment and a last minute scramble to make system adjustments at commissioning.

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