Pump ED 101

Suction Specific Speed and Wastewater Pumps

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In the February 2010 issue of Pumps & Systems I wrote an article on my Excel based Suction Specific Speed and Suction Energy calculators and how they can be used to predict the onset of suction recirculation. Over the past year, I have received several requests to revisit this topic and its application to wastewater pumps.

Clear water impellers are usually designed for high efficiency but, they can also be designed for low NPSHr. Increasing the eye diameter decreases the inlet velocity and thus reduces the NPSH required to maintain uniform flow. It is this reduction in inlet velocity that causes NPSHr to drop as flow moves to the left of a typical H/Q curve and when the rotational speed of the same pump is reduced. These impeller designs can work well as long as flow remains at or near BEP. If flow moves to far to the left of BEP, the increased peripheral velocity of the larger eye distorts the flow into the inlet and directs a portion of the flow back out of the impeller (suction recirculation). During recirculation, intense vortices arise and cause low pressure areas that will lead to cavitation and severe pressure pulsations. The effect of impeller eye diameter on potential suction recirculation can be evaluated using Suction Specific Speed (S or Nss).

Igor Karassik and two of his associates, G.F. Wislicenus and R.M. Watson developed Suction Specific Speed (S) in 1937 during their tenure at Worthington Pump. It is a dimensionless number that describes the suction conditions that occur due to the relationship of rotational speed, flow and NPSHr. Its development overcame the limitations of Thoma-Moody constant which attempted to describe suction conditions by relating head to NPSHr. S can range from about 5,000 to over 20,000 and is computed by the equation $S = N\sqrt{Q}/NPSHr^{3/4}$ where N is the rotational speed, Q is BEP flow and NPSHr is the NPSHr at BEP. Several pump organizations including HI and API recommend an S of under 10,000 in order to maintain a reasonable range of flows without the potential for suction recirculation.

Wastewater pump impellers are not intentionally designed for low NPSHr but the relatively large eye required to pass solids can often lower their NPSHr and increase the value of S. The H/Q curves for some higher flow wastewater pumps show a continuous increase in NPSHr as flow moves to the left of BEP. This is exactly opposite to the NPSHr versus flow for clear water pumps with normal eye diameters. In the case of wastewater pumps, discharge recirculation at the vane exits can also increase the possibility of suction recirculation. This is due to the lack of any vane overlap on most wastewater impellers which results in the onset of discharge recirculation at higher flows than expected. For more information on suction and discharge recirculation, see Igor Karassik's three part series "Centrifugal Pump Operation at Off-Design Conditions. It is available on the "Other Pump Topics" page of PumpEd101.com.

Suction Specific Speed (S or Nss)

$S = N\sqrt{Q} / NPSHr^{0.75}$

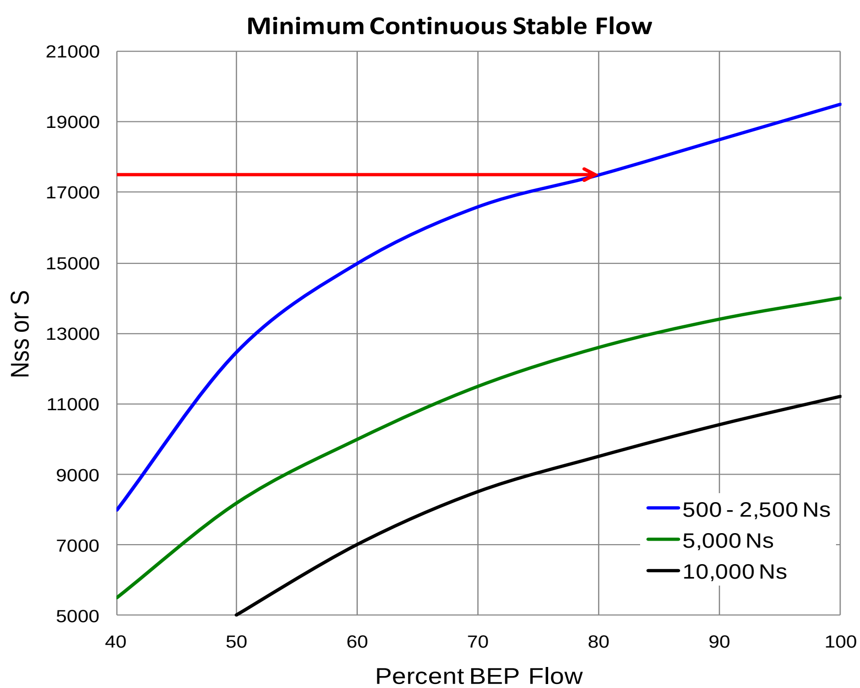
Enter the required data in the highlighted cells

Pump RPM (N)	1780
BEP Flow (Q)*	3000
NPSHr @ BEP	10

S = 17,337

Figure 1 shows the S calculation for an 8", 1780 RPM wastewater pump with a BEP flow and head of 3000 GPM @ 135' and a Specific Speed (Ns) of 2450. BEP efficiency and NPSHr are 82% and 10'. The calculated value for S is 17,337.

Figure 2 shows the minimum continuous stable flow (MCSF) for pumps with a given Ns and S. MCSF is the flow at which the onset of suction recirculation can begin. The Y axis is S and the X axis is percent of BEP flow. The three curves represent various pump Specific Speeds (Ns). You will note that MCSF is dependent upon both Ns and S. Our example has an Ns of 2450 so we will use the upper curve. The red horizontal line at Y = 17,337 intersects the curve at X = 80%. Therefore this pump could potentially begin suction recirculation when flow drops to just 80% of BEP flow. If you evaluate the suction energy ratio (2/10 P&S) of this pump you will find that an NPSHa to NPSHr margin of 4.0 could be



required to provide stable operation at or below 80% of BEP flow.

Many higher flow pumps with relatively low values of S can still exhibit an increase in NPSHr as flow is reduced. For example the performance curve for an 18"X16" wastewater pump (Ns = 2735) with a BEP flow of 16,000 GPM @200' shows an NPSHr of 31 feet. The calculated value of S is 11,072 which predicts an MCSF of approximately 50%. But at 13,000 GPM (a flow reduction of just 19%) NPSHr, as shown on the curve, increases to 44 feet.

Submersible wastewater pumps can be especially problematic. Although some undergo comprehensive NPSHr testing, many are not tested at all. Others are tested at BEP only and NPSHr values are calculated at other flow points. Often it is assumed that the additional inlet pressure provided by submersion will provide adequate NPSH. Actually submersion offers no NPSH advantage since pumps installed in dry pits also have a similar level of "submersion" due to the water level in the wet well. Submersibles do have one advantage and that is lower inlet losses due to no inlet piping and fittings. This, of course, goes away when they are installed as a "dry pit submersible".

So, if the manufacturer does not provide us with NPSHr data, how can we identify potentially problematic submersible pumps? There is no perfect way but, what I do is to compare untested pumps with similar ones from other manufacturer's that have been tested at multiple flow points. To get a good comparison, you need to compute the Ns of the untested pump and compare it to tested pumps with the same or similar Ns, rotational speed, hydraulic efficiency, eye diameter ratio, flow and head.

Here are some rules of thumb. S is directly proportional to rotational speed and the square root of flow. Therefore, higher speed and higher flow pumps will more likely have higher values of S. I have found that most 1750 RPM pumps with 4" discharges and flows under 800 GPM will have an S under 10,000. 1750 RPM pumps with 6" discharges and flows under 1750 GPM have similar values of S. However, as the eye diameter ratio of either approaches 0.6, S can exceed 13,000. If you plan to run a wastewater pump to the left of BEP and NPSHr is not part of the test curve, get the manufacturer to sign off on the application.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pumps & packaged systems manufacturer & distributor with branches throughout the Pacific Northwest. He can be reached via his website www.PumpEd101.com. If there are topics that you would like to see discussed in future columns, drop him an email.