Suction Specific Speed & Wastewater Pumps

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In the February, 2010 edition of P&S, I discussed my Suction Specific Speed (S) calculator and its ability to predict the stable range of flow for a particular centrifugal pump. In November of 2011, I did a follow up that addressed the S value of wastewater pumps. Recently I have seen some engineering specifications that limit S to a maximum of 11,000 for any wastewater pump. I disagree with this across the board limit for several reasons that I will address in this column.

In case you did not read my previous columns, I will start with a brief overview of Suction Specific Speed. In the early 1960's many pump users began to encourage their manufacturers to provide pump designs that reduced the required net positive suction head (NPSHr). The NPSHr at BEP flow is a function of the impeller design and, a major design characteristic is the ratio of the impeller eye diameter to its overall diameter. As this ratio increases, the entrance velocity decreases and NPSHr is reduced. These "large eye" impellers allowed pumps to operate satisfactorily in applications with low NPSHa (available). There was, however, a down side. The peripheral velocity of the large eye also increased and, at some capacity, flow into the entrance was distorted due to the high peripheral speed. This caused some of the flow to reverse direction and begin recirculation at the entrance of the eye (suction recirculation). This recirculation can give rise to intense vortices that cause cavitation and pressure pulsations.

The flow at which suction recirculation begins depends upon the impeller design but, as the eye diameter ratio increases so does the recirculation point as a percent of BEP flow. The calculation for Suction Specific Speed was developed to help predict the point at which suction recirculation could begin. As the value of S increases, the flow at which recirculation can begin moves closer to BEP flow. Guidelines were established that suggested that S values not exceed a range of 8500 to 9500 for pumps that could potentially operate at flows that were significantly below BEP flow. Lower flows could be caused by dynamic changes in system conditions or by a throttle valve at the discharge.

Suction Specific Speed is calculated by the equation below. S is directly

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

proportional to the pump speed in RPM (N) and the square root of pump flow in

GPM (Q). It is inversely proportional to NPSHr to the three quarter power. Therefore S will increase with an increase in speed and/or flow. It will also increase with a decrease in NPSHr.

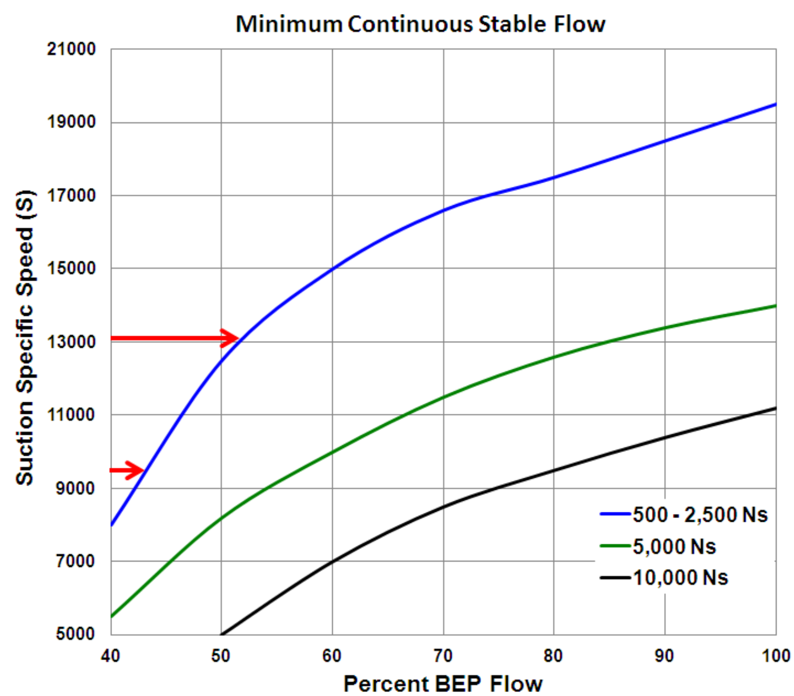
Wastewater pumps are not designed for low NPSHr but, the large eye that is required for solids passage can reduce NPSHr and thus increase the value of S in certain designs. Let's take a look at a couple of examples. The two pumps below have a 6" suction and are designed for a BEP flow of 1500 GPM at a TDH of 80'.

Pump A - 6" Suction, 10" Impeller, 1750 RPM, NPSHr = 9

Pump B - 6" Suction, 14" Impeller, 1150 RPM, NPSHr = 8

NPSHr is very similar for both but, Pump A operates at 1750 RPM while Pump B operates at 1150 RPM. Both have a Specific Speed (Ns) at or below 2500. Pump A has a relatively high eye diameter ratio (0.54) which accounts for its low NPSHr. Pump B has a lower eye diameter ratio (0.38) but since it operates at a lower speed its NPSHr is also low. Calculations for S are 13044 for Pump A and 9363 for Pump B. Based on the engineering specification I mentioned earlier (S max = 11000) Pump A would not be an acceptable option.

Figure 1 compares values of S with the percent of BEP flow at which recirculation can begin. Since Ns is at or under 2500 for both of the examples, we can use the blue curve for our comparisons. The lower, red arrow shows that Pump B could begin recirculation at about 43% of BEP flow. The upper, red arrow shows that Pump A could begin recirculation at about 52% of BEP flow.



The reason I disagree with the S max = 11000 specification is that no wastewater pump should ever be operated anywhere near the two recirculation points shown in Figure 1. The reasons they should not have nothing to do with recirculation. The first is the cost of pumping and once you drop below about 85% of BEP flow, the cost per 1000 gallons pumped goes up substantially for most pumps. The second reason is pump life. Once you drop below 75% of BEP flow, higher head wastewater pumps will generate increased radial forces that will cause vibration and shorten the life of seals, bearings and wear rings. So why debate this? Why not just follow the engineer's recommendation and select Pump B? Well, you certainly can if you want to. The pump I used in my example is a high quality unit but, so is Pump A. The reason Pump A should be allowed is because its cost is about 40% lower due to its higher rotational speed. There are many applications where 1750 RPM pumps will have life span that is very similar to their lower speed cousins thus making first cost a significant factor in the equation.

Let's close with one more example. A higher head, higher flow pump is designed for 12,000 GPM @ 140'. It has a 16" suction and a 22" impeller that rotates at 1170 RPM. Ns is 3250 and the NPSHr is 21'. The calculated S is 13065 which is about the same as Pump A in the previous example. Although the curve for Ns = 3500 is not shown in Figure 1, the S value of 13065 would intersect the curve at about 60% of BEP flow. Once again, this is well below where any wastewater pump should run. Remember also that NPSH margin plays a role in the S predicted point at which recirculation can begin. Most wastewater applications are flooded suction and can take advantage of 100% of atmospheric pressure. Also, suction submergence is typically high. At sea level the pump in this example could experience an NPSHa : NPSHr margin of 2:1. In the previous examples it could be almost 5:1.

In my opinion there is nothing wrong with high S value wastewater pumps as long as they are sized correctly for the application. After all, Suction Specific Speed was developed to identify pumps that could undergo recirculation at "significantly" reduced flows when running at full speed. It should not be used as a fudge factor for poor pump selection or system design.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pump & 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.