

## Suction Calculators

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<http://www.pumped101.com>

Last month I reviewed an excel based Radial Thrust Calculator and showed how it can predict the magnitude of unbalanced radial thrust when a centrifugal pump is operated to the left of BEP. This month we will explore another calculator that can help identify pumps that may be problematic when operated on either side of BEP.

I suspect that most readers will agree that Terry Henshaw's year-long series on NPSH has been extremely useful and informative. His September, October and November 2009 columns addressed an NPSH topic that may have been new to many of us. Suction Specific Speed (S or Nss) and its effect on NPSH margin can be a very useful parameter in identifying pumps that could have a high potential for suction recirculation induced cavitation. As Terry said, S is an indication of the aggressiveness of an impeller eye design. As the ratio of eye diameter to peripheral diameter increases, NPSHr typically decreases but, an unexpected byproduct can be a reduction in a pump's stable window of operation.

As shown below, the equation for S is very similar to the equation for Pump Specific Speed (Ns). The only difference is that Head (H) is replaced with NPSHr.

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

S is directly 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 and decrease with an increase in NPSHr. NPSHr is also an indication of the aggressiveness of the impeller eye design. Lower values of NPSHr usually indicate a larger eye diameter ratio. As Terry mentioned in his September article, a flow reduction at the entrance of a large eye can result in a partial reversal of flow towards the suction pipe. The vortices that are created by such a reversal can lead to the onset of cavitation.

An excel based Suction Specific Speed calculator is shown to the left of Figure 1

and is available for download from my web site ([www.PumpEd101.com](http://www.PumpEd101.com)). Entering the required data in the three yellow cells will result in the calculation of S. The chart below the calculator shows the stable window of operation for several values of S. Normally, suction recirculation occurs at low flows but, with increasing values of S, suction recirculation will begin at higher than expected flow rates. Many experts specify that pumps with a value of S greater than 9000 may require a sizeable increase in NPSH margin if they are to maintain a stable window of operation.

Suction Calculators		Joe Evans <a href="http://www.PumpEd101.com">www.PumpEd101.com</a>																
<b>Suction Specific Speed (S or Nss)</b>		<b>Suction Energy (SE)</b>																
$S = N \sqrt{Q} / \text{NPSHr}^{0.75}$		$SE = De \times N \times S \times SG$																
Enter the required data in the highlighted cells		Enter the required data in the highlighted cells																
Pump RPM (N)	1185	Impeller Eye Diameter " (De)	10															
BEP Flow (Q)	5000	Pump RPM (N)	1185															
NPSHr @ BEP	10	Suction Specific Speed (Nss)	14901															
		Specific Gravity (SG)	1															
<b>S =</b>	<b>14,901</b>	<b>SE =</b>	<b>176,576,850</b>															
Values of S greater than 9,000 may require a greater NPSH margin. Refer to the chart below for acceptable operating ranges.																		
		<table border="1"> <thead> <tr> <th>Pump Type</th> <th>High Suction Energy</th> <th>Very High Suction Energy</th> </tr> </thead> <tbody> <tr> <td>2- Vane Sewage</td> <td>100,000,000</td> <td>150,000,000</td> </tr> <tr> <td>End Suction</td> <td>160,000,000</td> <td>240,000,000</td> </tr> <tr> <td>Double Suction</td> <td>120,000,000</td> <td>180,000,000</td> </tr> <tr> <td>Vertical Turbine</td> <td>200,000,000</td> <td>300,000,000</td> </tr> </tbody> </table>		Pump Type	High Suction Energy	Very High Suction Energy	2- Vane Sewage	100,000,000	150,000,000	End Suction	160,000,000	240,000,000	Double Suction	120,000,000	180,000,000	Vertical Turbine	200,000,000	300,000,000
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<p><b>Instructions:</b></p> <p>If the impeller eye diameter is not known it can be approximated as follows:            End Suction Pump - Suction nozzle diameter x 0.90            Horizontal Split Case Pump - Suction nozzle x 0.75</p>																		

Another indicator of potential suction recirculation is a quantity known as Suction Energy (SE). (Reference: H.P. Bloch, A.R. Budris - Pump Users Handbook - Life Extension / Fairmont Press). SE is an indication of a liquid's momentum at the impeller eye and takes S a step further. As shown in the equation below, it is the product of the eye diameter (De), pump RPM (N), suction specific speed (S) and specific gravity (SG).

$$SE = De \times N \times S \times SG$$

The SE calculator appears to the right of Figure 1. Entering the required data in

the highlighted cells will result in the calculation on SE. The table below the calculator shows the values for the start of high and very high suction energy for several pump designs. Pumps that exhibit a high SE can experience vibration, noise and minor cavitation damage. Those with a very high SE can experience much more severe erosion due to cavitation.

The example used in both calculators is a dry pit non-clog with a 12" suction and a two vane, 18.5" impeller. BEP flow is 5000 gpm @ 105 ft. and requires a NPSH of 10 feet. Both calculators confirm very high values of S and SE which indicates that a large NPSH margin is required for this pump to operate at off BEP flows.

Igor Karassik was the major force behind the development of suction specific speed. In the mid eighties he wrote a three article series titled "Centrifugal Pump Operation at Off Design Conditions". They are written in a simple Pump Ed 101 style and are available on my web site under the "Other Pump Topics" tab. They are definitely worth reading.

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