

While at the Houston pump symposium earlier this month, I attended a technical session where there was some confusion about how to treat NPSHR when changing pump speed. The effect of speed changes and, for that matter, impeller cuts on NPSHR is one where even the experts do not always agree. This month we'll discuss the ways in which pump speed and impeller trim affect NPSHR, and the most common methods for estimating the impact of those changes on NPSHR values.

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The net positive suction head required (NPSHR) of a pump is the minimum amount of suction head required at the inlet of the impeller to avoid cavitation levels that would seriously impair pump hydraulic performance<sup>1</sup>. A 3% drop in total dynamic head (TDH) at constant flow is the accepted standard for establishing NPSHR at test.

For any specific set of inlet conditions, the NPSH characteristics of a pump are driven by the geometry of the impeller inlet. Suction specific speed (N<sub>ss</sub>) is used to describe the relative NPSHR capabilities of pumps [1]. First presented by Karrasik, et al., in 1939, N<sub>ss</sub> is related directly to the geometry of the impeller inlet.

$$[1] \quad N_{ss} = \frac{RPM \otimes \sqrt{Flow_{BEP}}}{NPSHR^{3/4}}$$

### RPM Changes

Suction specific speed for any impeller is a constant. Holding N<sub>ss</sub> at a constant value, NPSHR will arithmetically vary as the square of the ratio of change to RPM [2]. There is some empirical evidence to suggest that NPSHR varies as the speed ratio to approximately the 1.5 power [3]. Different manufacturers use different exponents based on various products and individual test experience. There is no proven absolute predictive value for the exponent. The majority of authors agree that the NPSHR should behave according to equation 2, but that changes in the behavior of fluid within the inlet flow field, as the fluid nears its critical pressure, is responsible for differences between theoretical values and actual test results.

$$[2] \quad \left[ \frac{Rpm_2}{Rpm_1} \right]^2 = \frac{NPSHR_2}{NPSHR_1}$$

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<sup>1</sup> For a more detailed discussion of cavitation, see our [October 2004 newsletter](#)

[3]

$$\left[ \frac{Rpm_2}{Rpm_1} \right]^{1.5} = \frac{NPSHR_2}{NPSHR_1}$$

In practice the most conservative approach would be to conduct NPSHR tests at operating speed. Also, for estimating NPSHR in the absence of testing, use equation 2 when increasing the pump speed, and equation 3 when reducing the pump speed.

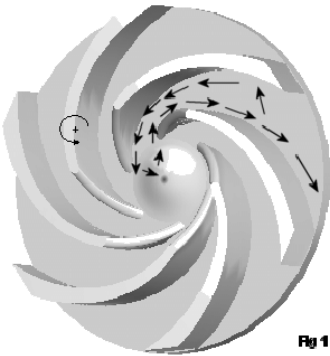


Fig 1

### Diameter Changes

For a specific inlet condition and rpm, flow into an impeller is controlled by the inlet area of the impeller eye and the inlet blade angle of the impeller vanes; both of which are fixed by design. For a specific flow rate and RPM, changes at the OD of the impeller should not impact the inlet of the impeller. When the impeller diameter changes, the cavitation characteristics of the impeller should remain unchanged unless discharge recirculation to the impeller eye occurs (Fig 1). Recirculation can be significant in a poorly designed impeller, an impeller operated off-design, or an impeller that has been trimmed excessively.

It should be noted that any change to impeller diameter will also result in a change in flowrate, and therefore NPSHR, unless there is also a change in the system curve<sup>2</sup>.

Some pump manufacturers display their curves holding NPSHR constant with flow changes (fig 2). Others show lines of varying NPSHR (Fig 3). The difference between the two curves is that the curve in fig. 3 has been drawn by applying the line of constant NPSHR using a 3% drop in TDH. Because TDH lowers as the impeller is cut, the 3% TDH drop criteria causes the NPSHR point to be defined at decreasing levels of TDH drop. Hence, the ISO lines of constant NPSHR are drawn across decreasing flows. The cavitation in the impeller is not changing. It is strictly a result of how NPSHR is defined. Fig. 3 is more conservative.

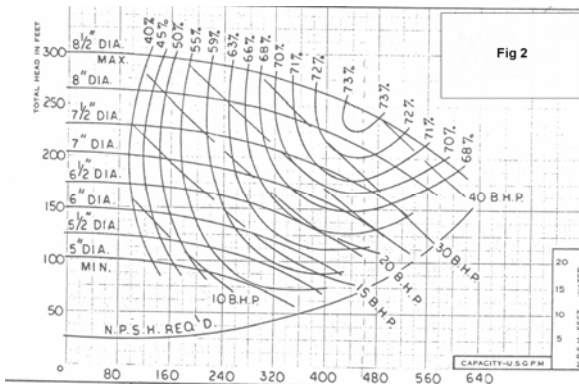


Fig 2

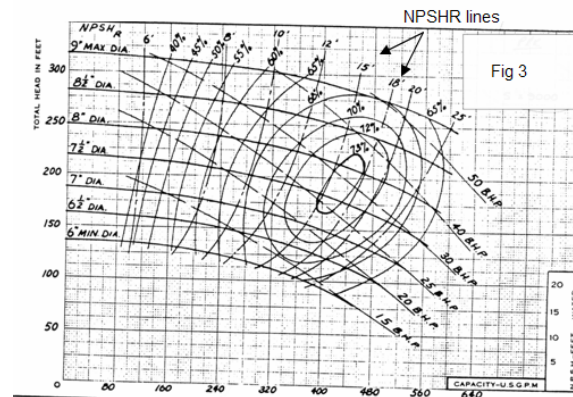


Fig 3

NPSHR is derived from test data and is specific for each individual set of pump and application conditions. Manufacturers provide data from water tests that provide a valuable baseline of a pump's NPSHR characteristics. The methods outlined above provide some estimating tools for dealing with changes to equipment and operating conditions. After any diameter or speed re-rate, a pump should be checked for signs of cavitation. Vibration and noise testing are probably the best tools for detecting cavitation outside of a test facility.

<sup>2</sup> For a discussion of system curves, please see our [November 2005 Newsletter](#).