# NPSH – A DISCUSSION

**By**

**P.N. NARAYANA PILLAI**

## INTRODUCTION

The one hydraulic characteristic that is least understood by the people who maintain, or operate pumps is the Net Positive Suction Head (NPSH). Most of the literature available on this subject is complex in nature and tends to confuse those who have little experience in pumping technology. The purpose of this paper is to explain as simply as possible the many factors affecting NPSH.

## WHAT IS NPSH?

The NPSH required by a pump is the head of the liquid pumped, measured at the suction nozzle of the pump, necessary to overcome all energy requirements at the inlet of the pump (these included friction losses, acceleration, $\Delta$ P to lift values, heating effect of internally circulated liquid etc.) and thereby avoid any vaporization of liquid in the pump suction. The NPSH required is thus the head of the liquid required at the pump suction nozzle above the vapour pressure of the liquid at that point.

For any pump the NPSH required for a design performance is a function of the type of pump, the liquid characteristics, the system pressure-temperature conditions, the capacity and the operating speed.

## CENTRIFUGAL PLUMPS

**The NPSH** required is expressed in terms of head of liquid pumped, and not pressure. This means that for a pump which requires 5 meters head of water when pumping water requires 5 meter of head when pumping other liquid too at the same capacity and speed. Of course the effect of internal re circulation effect is neglected

**At** any fixed speed, the **NPSH** required by a centrifugal pump will increase with increase in flow from rated flow. At substantially increased flow from design flow the increase in **NPSH (R)** is very rapid. Enclosed Fig-8 will illustrate the matter further.

## POSITIVE DISPLACEMENT PUMPS

**NPSH** requirement of these types of pumps are not always expressed in terms of head of liquid. In some cases-as in the case of Reciprocation Pumps- NPSH is expressed as a pressure increment $\Delta$ P above the vapour pressure of the liquid.

For rotary gear or other type of positive displacement pumps NPSH ® is only a function of frictional losses plus the internal losses. However the viscosity of the fluid pumped has a significant effect i.e. because of slip due to low viscosity or increased suction losses for high viscosity.

For reciprocating pumps that are fitted with values substantial part of the NPSH (R) if for lifting the valves in the suction side. Hence for this type of pumps the NPSH (R)for a lighter fluid would be more than that required for a heavier liquid in terms of the head of liquid pumped.

**T**he flow to a reciprocating pump is cyclic then NPSH (R) shall be based on the 'maximum' or worst condition of acceleration and flow.

## NPSH AVAILABLE

NPSH (av) is the net head of liquid after all losses are considered at the pump suction nozzle. Above the vapour pressure of the liquid at the pump inlet conditions. NPSH (av) must always be above NPSH (R) of the pump for satisfactory performance of the pump.

For the computation of NPSH (av) the points to be considered are:-

**---** Datam Elevation
**---** Liquid head
**---** Operating conditions
**---** Type of pump

Illustrative examples 1 & 2 given in Fig-2 and Fig-3 will further illustrate the matter to aid computation of NPSH (av).

**NPSH-PROBLEMS**

**Centrifugal Pumps**

If the available NPSH is not greater than that required by the pump many serious problems can result.

The problems start with partial vaporization of the liquid at the leading edges of the vanes. This phenomenon is also called **CAVITATION**. The vapour formed as small bubbles at the suction side collapse more or less suddenly when the liquid moves through the impeller to a high-pressure region.

The formation of vapour has a marked reduction in total head and capacity of the pump. The loss in capacity is due to pumping a mixture of liquid & vapour. Water at $22^0$C increases in volume 54000 times when vapour. Thus slight cavitation will reduce duty. Under worse situation a complete failure of pump operation can result. Excessive noise & vibration can result when a section of the impeller handles vapour and the other section handling liquid.

Continued **CAVITATION** can result in a serious pitting and erosion of the pump parts leading to premature failure of impellers.

**Rotary Pumps**

These pumps are self priming type and therefore a certain amount of vapour can also be handled with liquid. However loss of suction have the following effects:

i) Suction loss can result in damage of pump due to overheating and loss of lubrication.

ii) Partial loss of suction can affect the process and create hydraulic shock due to vapour collapse as in the case of centrifugal pumps.

**Reciprocation Pumps**

These pumps are also self priming type and therefore certain amount of vapour can be handled. The effect of concentration are:

i) **A** loss of head can result in an increased speed of the pump. If the drive is steam turbine, unless extremely careful speed control systems are incorporated the increase in speed can damage the pump.

ii) **H**ydraulic shock is another effect of cavitation in these types of pumps.

**NPSH TESTS**

Pump NPSH requirement is established by tests with water. There are three methods available and they are:

i) Taking suction from an elevated tank with either the suction is throttled or the water is heated to vary the vapour pressure.

ii) For very large pumps the suction is taken from a suction sump with a suction lift such that the suction is throttled or the lift is increased to vary the vapour pressure.

iii) The third method is by creating a vacuum in the suction vessel and this method of suppression test is widely used for testing process pumps since pumps in process can also be used for vacuum services.

**NPSH MARGINS**

**Fr**om the above discussions it is clear that since a number of parameters are involved in the operation of pumps it is difficult to arrive at exact NPSH (R) and NPSH (av) relations and therefore there is a risk in selecting a pump NPSH (R) = NPSH (av). Normally it is a recognized fact that a margin is provided in the system above the NPSH (R) of pumps while there is no hard and fast rule or regulations regarding the margin to be provided, depending up on the criticality of services the margin of NPSH (av) over NPSH (R) will vary. It is suggested that there shall be a minimum of 0.6M margin for ordinary services and 1.5 to 2 M margin for critical services such as boiler feed pumps etc.

**NPSH (R) CORRECTIONS**

The NPSH requirement of centrifugal pumps are normally established by tests with water under room temperature. Operating experience in the field has indicated and based on a limited number of carefully conducted laboratory tests have confirmed that pumps handling certain hydrocarbons fluids or water at significantly higher temperature will operate satisfactorily with less available NPSH than would be required for cold water

Hydraulic Institute Standards have thus come out with a chart for certain fluids with NPSH correction factors, However the institute have cautioned the use of these correction factors since an incorrect use of the charts can create problems of severe cavitation in pumps.

While this aspect was mentioned only for completeness of this discussion it is to be noted that while designing the system the best practice is to go with the NPSH (R) value with cold water without any correction applied.

EXAMPLE-1

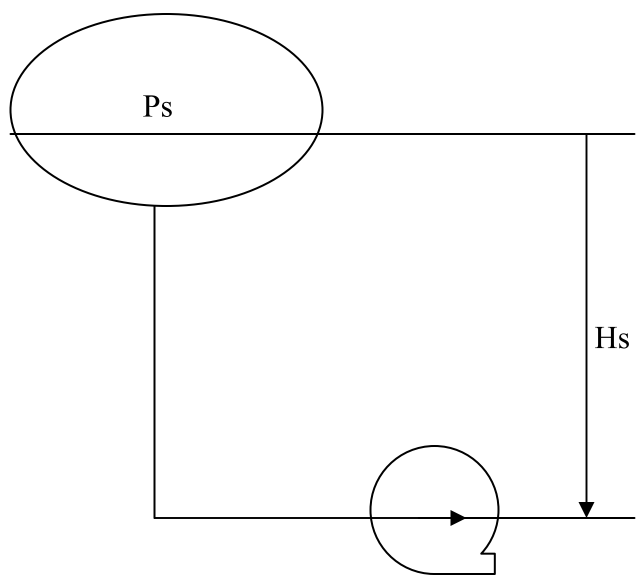


FIG-2

NPSH(av) = Ps+Hs-Vp-Fs

EXAMPLE-2

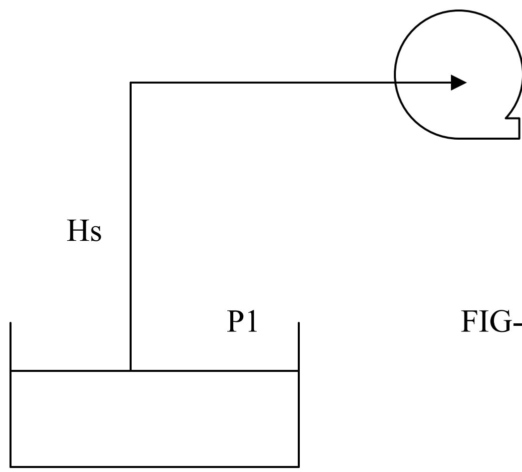


FIG-3

NPSH(AV) =P1-Hs-Vp-Fs

PERFORMANCE CURVE

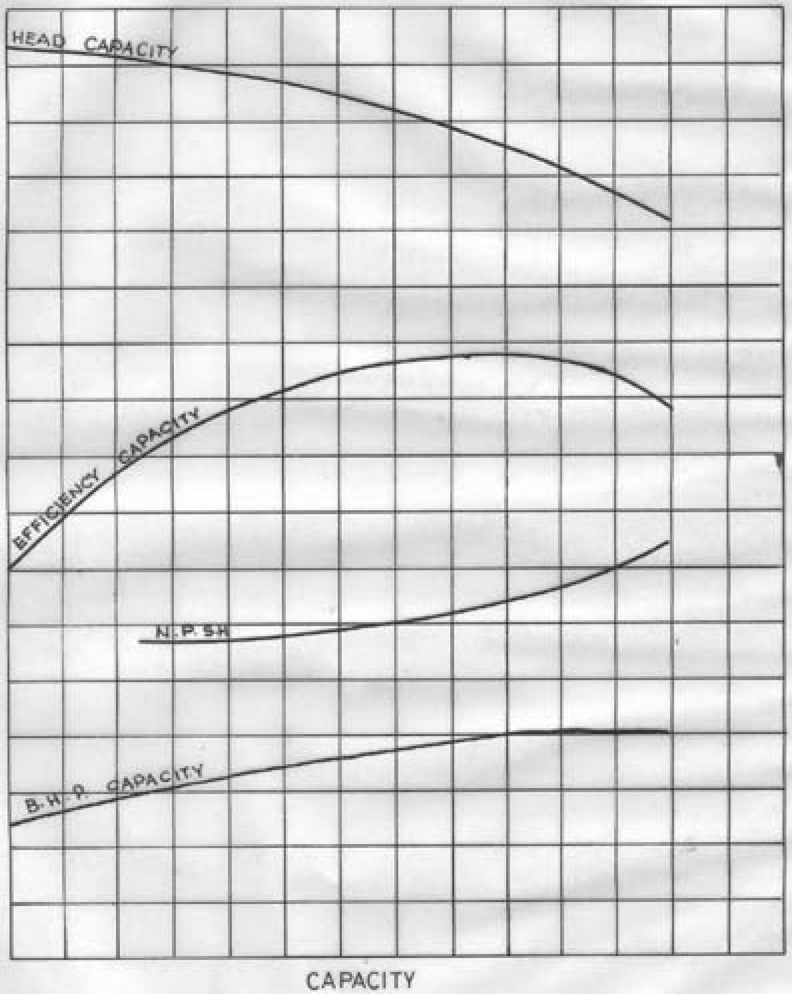


Fig. 8