Net Positive Suction Head

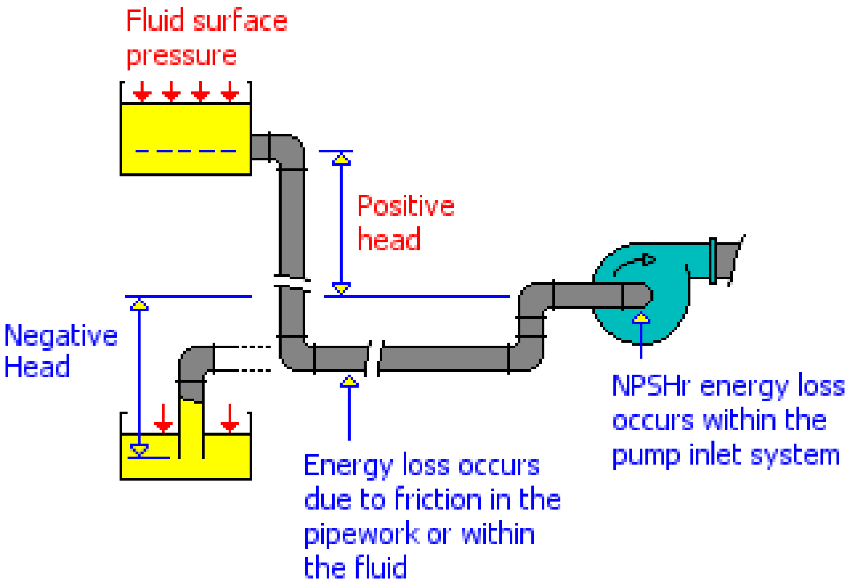
Net positive suction head is the term that is usually used to describe the absolute pressure of a fluid at the inlet to a pump minus the vapour pressure of the liquid.
The resultant value is known as the Net Positive Suction Head available.
The term is normally shortened to the acronym NPSHa, the ‘a’ denotes ‘available’.

A similar term is used by pump manufactures to describe the energy losses that occur within many pumps as the fluid volume is allowed to expand within the pump body. This energy loss is expressed as a head of fluid and is described as NPSHr (Net Positive Suction Head requirement) the ‘r’ suffix is used to denote the value is a requirement.

Different pumps will have different NPSH requirements dependant on the impellor design, impellor diameter, inlet type, flow rate, pump speed and other factors.
A pump performance curve will usually include a NPSH requirement graph expressed in metres or feet head so that the NPSHr for the operating condition can be established.

Pressure at the pump inlet

The fluid pressure at a pump inlet will be determined by the pressure on the fluid surface, the frictional losses in the suction pipework and any rises or falls within the suction pipework system.



NPSHa calculation

The elements used to calculate NPSHa are all expressed in absolute head units.
The NPSHa is calculated from:

Fluid surface pressure + positive head – pipework friction loss – fluid vapour pressure
or
Fluid surface pressure - negative head – pipework friction loss – fluid vapour pressure

Gas bubbles within the fluid (cavitation)

The 'Vapour pressure' of a fluid is the pressure at which the fluid will boil at ambient temperature.If the pressure within a fluid falls below the vapour pressure of the fluid, gas bubbles will form within the fluid (local boiling of the fluid will occur).

If a fluid which contains gas bubbles is allowed to move through a pump, it is likely that the pump will increase the pressure within the fluid so that the gas bubbles collapse. This will occur within the pump and reduce the flow of delivered fluid. The collapse of the gas bubbles may cause vibrations which could result in damage to the pipework system or the pump. This effect is known as cavitation.

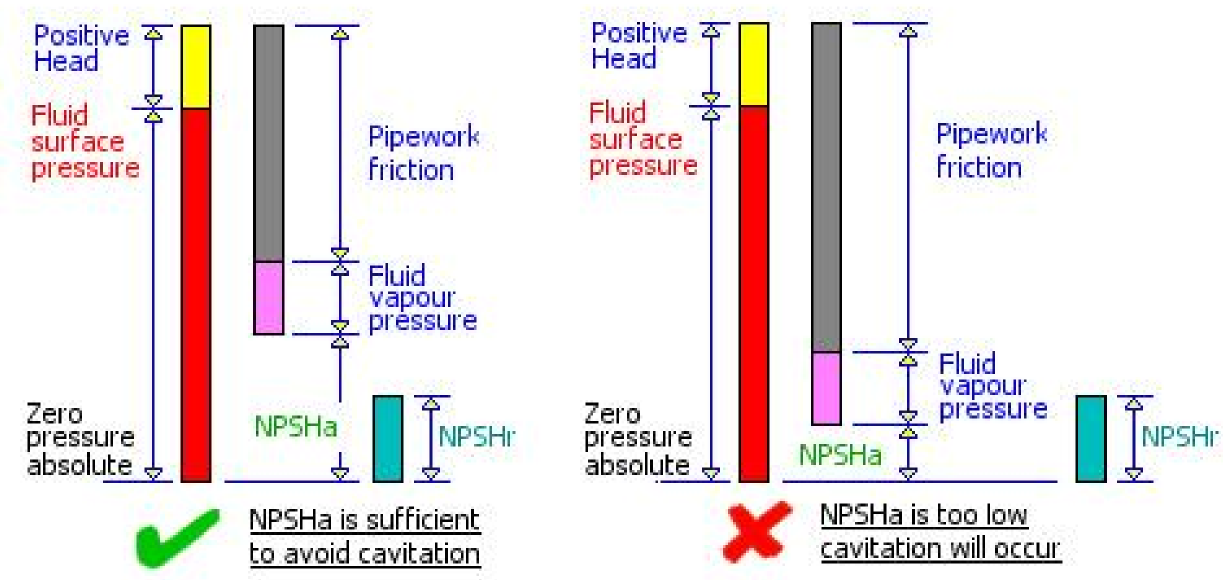
To avoid cavitation the pressure within the fluid must be higher than the fluid vapour pressure at all times.

Avoiding cavitation

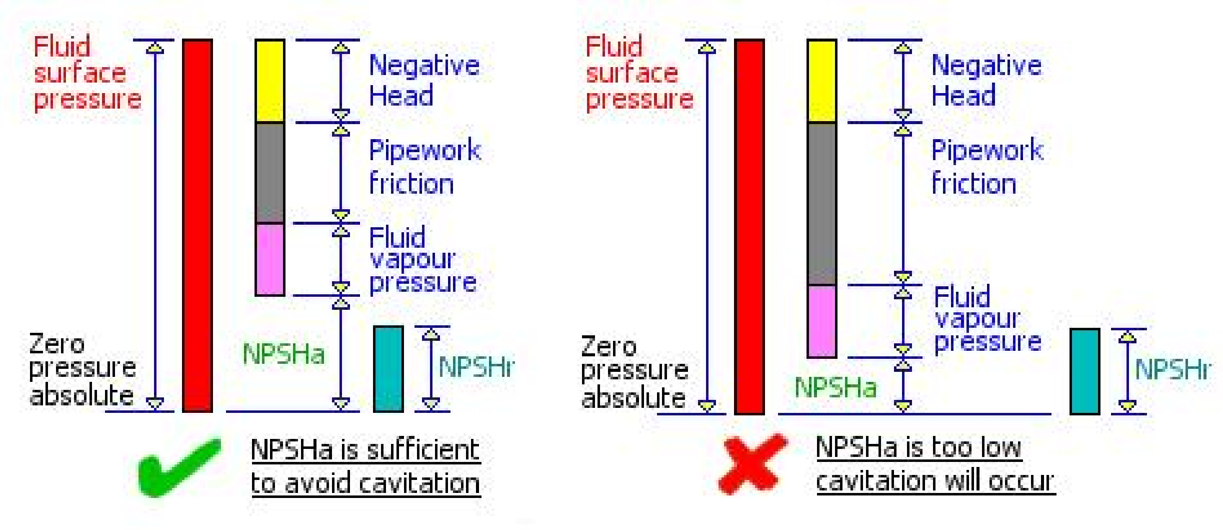
In a system where the pipe work layout provides a positive head, the motive force to move the fluid to the pump will be the fluid surface pressure plus the positive head.

Incorrect sizing of the supply pipe work and isolating valves may result in high frictional losses which can still lead to situations where the NPSHa is still too low to prevent cavitation.

Understanding NPSHa and NPSHr



In a system where the fluid needs to be lifted to the pump inlet , the negative head reduces the motive force to move the fluid to the pump.
In these instances it is essential to size the supply pipe work and isolating valves generously so that high frictional losses do not reduce the NPSHa below the NPSHr.



Comparison of NPSHa and NPSHr

All calculated values must be in the same units either m hd or ft hd.

If the NPSHa is greater than the NPSHr cavitation should not occur.

If the NPSHr is lower than the NPSHr then gas bubbles will form in the fluid and caviation will occur.

Increasing the NPSH available

Many systems suffer from initial poor design considerations.

To increase the NPSHa consider the following:

a. Increase the suction pipe work size to give a fluid velocity of about 1 m/sec or 3 ft/sec
b. Redesign the suction pipework to eliminate bends, valves and fittings where possible.
c. Raise the height of the fluid container.
d. Pressurise the fluid container, but ensure that the pressure in the container is maintained as the fluid level is lowered.

High Fluid temperature

If the temperature of the fluid to be pumped is higher than normal the relative density of the fluid will reduce. This may result in a reduction in pipe work friction losses, but this reduction may be offset (or exceeded) by an increase in Fluid Vapour Pressure.

An example:

Water at 20°C (68°F) has a density of 998 kg/m^3 (62.303 lbs/ft^3) the vapour pressure of the fluid is 2.339 kPa.a (0.339 psi.a).
Water at 60°C (140°F) has a density of 984 kg/m^3 (61.429 lbs/ft^3) the vapour pressure of the fluid is 19.946 kPa.a (2.893 psi.a).

A comparison of the system with the two fluid temperatures:
The frictional resistance of the pipe work will reduce by about 10% due to the reduced density and viscsoity of the fluid, but the vapour pressure of the fluid will increase by about 1.8 m head (5.9 ft head).
It will be normally necessary to check the NPSHa for a normal ambient fluid temperature and the higher fluid temperature under these circumstances.