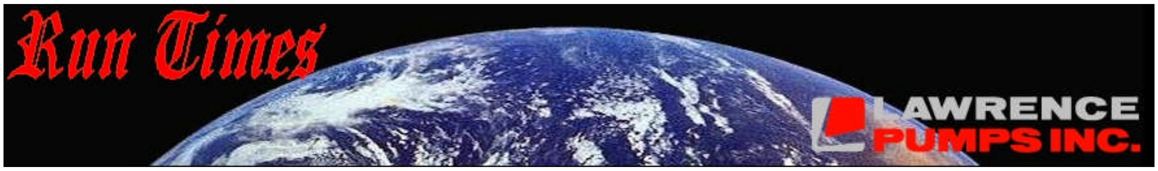


Aug 2006 *vol.3_iss 8*

Net positive suction head available (NPSHA) is the total suction head available at the eye of the first stage impeller expressed in terms of absolute pressure. Pump manufacturers use NPSHA to select a pump with a lower net positive suction head required (NPSHR) so as to avoid cavitation[1]. This issue covers how to determine NPSHA for a new or existing pump installation.

Dale B. Andrews – Editor

---

(1) $NPSHA = h_a - h_{vp} + h_s =$ where:

$\mathbf{h_a}$ = atmospheric head
$\mathbf{h_{vp}}$ = vapor pressure expressed as head
$\mathbf{h_s}$ = total suction head

Atmospheric Head (h_a)
Atmospheric pressure approximately equals 101.3 kPa.(14.7 psia) at sea level. The head associated with this pressure is dependent on the specific gravity of the fluid being pumped. The equation for determining head from any pressure reading is:

$$(2)\quad h = \frac{P_{kPa} \times 0.102}{Sp.Gr.} \text{ or } h = \frac{P_{psi} \times 2.31}{Sp.Gr.}$$

Vapor Pressure (h_{vp})
Vapor pressure is the absolute pressure at which a liquid will boil for any given temperature. For example, at sea level the boiling point of water is 100°C (212°F). 101.3 kPa is the vapor pressure of water at its sea level boiling point. Vapor pressure vs. temperature properties of fluids may be found in fluid property tables.

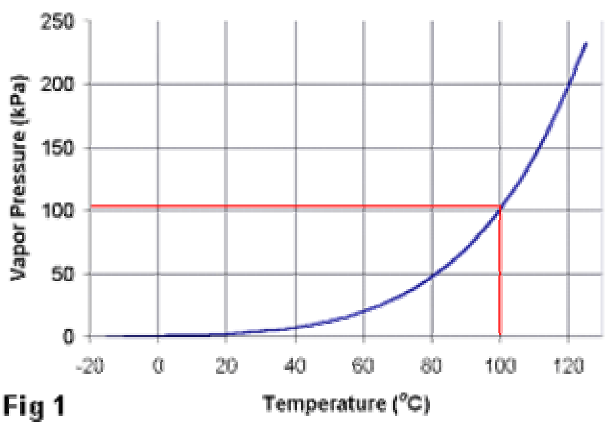


Fig 1

Notice that the equation for NPSHA has the term $\mathbf{h_a - h_{vp}}$. For any boiling liquid the resultant of this term is always zero. For boiling liquids the equation for NPSHA may be simplified to:

$$NPSHA = h_s$$

---

[1] For more information on cavitation see our Oct 2004 Issue.

Total Suction Head (h_s)

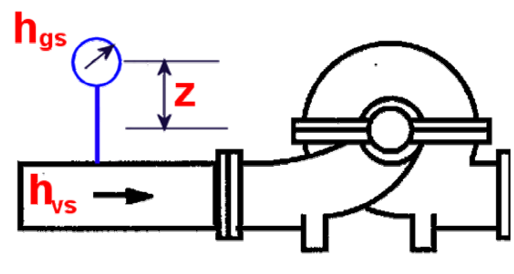
Total suction head is the total fluid head available to the eye of the first stage impeller. It is the combination of static and dynamic heads corrected for losses and gauge location. The equation for $\mathbf{h_s}$ is:

$$(3) \quad h_s = +/-h_{gs} + h_{vs} +/-z - h_f$$

Where:

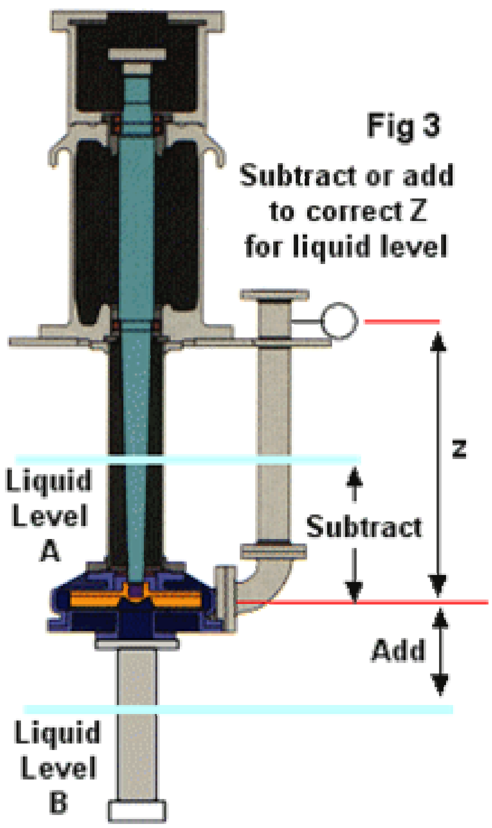
$\mathbf{h_{gs}}$ is the suction gage reading converted to meters or feet of head. It is positive if it is above atmospheric pressure and negative if it is a vacuum gage reading[2].

$\mathbf{h_{vs}}$ is velocity head. Velocity head is the head associated with the kinetic energy of the fluid moving at some velocity(V) in the suction pipe, toward the impeller eye. Velocity head is calculated from the equation:



$$(4) \quad h_{vs} = V^2/2g$$

Where g is the acceleration due to gravity, 9.81 m/sec^2 or 32.2 ft/sec^2



The velocity through the standard piping for a given flowrate may be found in most hydraulic tables or calculated by dividing the flowrate by the cross sectional area of the piping.[3]

z is a correction for the vertical distance between the center of the suction gage and the centerline of the 1st stage impeller. The value of z is expressed in either meters or feet. It is positive if the gage is located above the impeller centerline and negative if located below the impeller centerline.

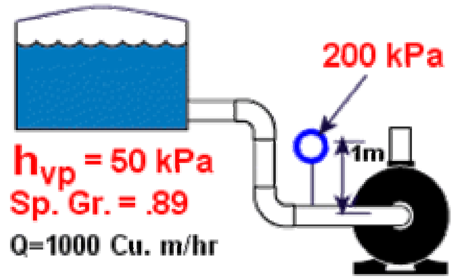
Note: For a vertical pump with no suction gage, z is the distance from the centerline of the impeller to the fluid free surface. It is negative if the fluid surface is below the impeller centerline and positive if the fluid surface is above the impeller centerline.

$\mathbf{h_f}$ represents friction and other losses associated with the piping and fittings located between the suction gage pressure tap and the pump inlet or, in the case of vertical pumps with tailpipes, losses between the suction inlet and the impeller. $\mathbf{h_f}$ for standard pipe, valves, and fittings can be found in most fluid tables. *However, for most pumps, $\mathbf{h_f}$ is a relatively small number and can be ignored if the pressure taps are within a few feet of the pump and the piping is relatively straight.*

[2] For conversion of vacuum readings to head: 1 mm hg = 0.0133 m (H_2O) , 1 in. hg = 1.13 ft (H2O)

[3] See our July 2006 newsletter for more information on velocity head.

Example 1 – Horizontal Pump (300 mm Suction)
Flow (Q) = 1000 m^3/hr
Suction Pressure h_{gs} = 200 kPa
Fluid vapor pressure h_{vp} = 50 kPa
Sp.gr. = .89
Suction gage elevation z = 1 m above the pump centerline
Suction gage tap location 1 m from the pump inlet



From equation (1): NPSHA = $h_a - h_{vp} + h_s$

$$h_a - h_{vp} = \frac{(101.3kPa - 50kPa)\times 0.102}{0.89} = (+)5.9m$$

From Equation (3)
$h_s = +/-h_{gs} + h_{vs} +/-z - h_f$

$$h_{gs} = \frac{200kPa \times 0.102}{0.89} = (+)22.9 \text{ m}$$

Velocity = 3.9 m/sec

$$h_v \text{ from equation (4)} = \frac{(3.9m/\sec)^2}{(2)(9.81m/\sec\cdot\sec)} = (+)0.8 \text{ m}$$

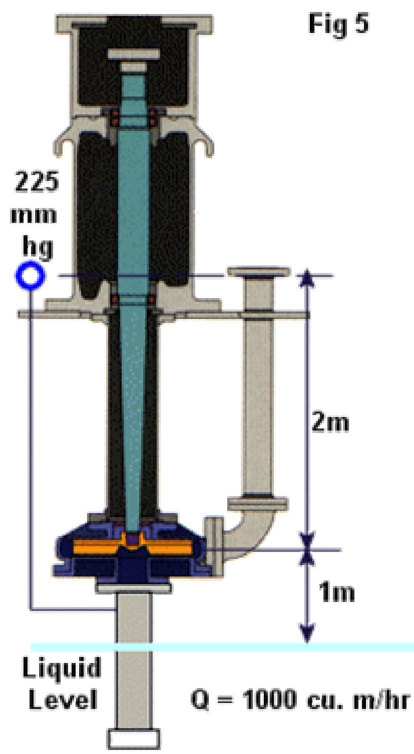
z = (+)1 m

h_f may be disregarded due to the close proximity to the pump inlet.

h_s = (+)22.9m + (+)0.8m + (+)1 m = (+)24.7m
Adding in the result from $h_a - h_{vp}$ yields

NPSHA = (+)5.9 m + (+)24.7 m = 30.6 m

Example 2 – Vertical Pump (300 mm Suction) - open sump
Fluid level = 1 m below impeller
Flow (Q) = 1000 m^3/hr
Suction Pressure h_{gs} = (-)225 mm hg
Suction velocity = 3.9 m/sec
Fluid vapor pressure h_{vp} = 50 kPa
Sp.gr. = .89
Suction gage elevation z = 2 m above the impeller centerline, located at the coverplate



From equation (1): NPSHA = $h_a - h_{vp} + h_s$

$$h_a - h_{vp} = \frac{(101.3kPa - 50kPa)\times 0.102}{0.89} = (+)5.9m$$

From Equation (3)
$h_s = +/-h_{gs} + h_{vs} +/-z - h_f$

h_{gs} = (-)225 mm hg * 0.0133 m (H_2O)/mm hg = (-)3 m

h_{vs} from equation (4) = $\frac{(3.9 m/\sec)^2}{(2)(9.81 m/\sec\cdot\sec)}$ = (+)0.8 m

z = (+)2 m

h_f may be disregarded due to the close proximity to the pump inlet.

h_s = (-)3m + (+)0.8m + (+) 2m = -0.2 m

Adding in the result from $h_a - h_{vp}$ yields

NPSHA = (+)5.9 m + (-)0.2 m = 5.7 m

For existing installations, investigating NPSHA is one of the first steps in investigating a cavitation problem. In a new installation, designing a system with sufficient NPSHA so as to accommodate a pump with a reasonable suction specific speed (S)[4] will significantly lower the life cycle cost of the installed equipment.

[4] Refer to our Oct 2004 newsletter for a discussion of NPSH margin, cavitation and suction specific speed.