Cavitation

What is Cavitation?

Cavitation is the formation of partial vacuums in a flowing liquid as a result of the separation of its parts.

Suction Side Cavitation

In its simplest terms, it is a restriction on the suction side of the pump, which does not allow enough fluid to enter the pump and be discharged. The pump resists back pressure on the discharge side and produces a higher flow of liquid than is available on the suction side. Restrictions on the suction side of the pump decrease the flow to the pump. This is particularly true for suction lift applications.

A common cause of suction side cavitation is related to the vapor pressure of the liquid. Liquid vapor pressure is shown on a graph, which shows the boiling point of a liquid at various elevations, such as sea level. For instance, we know that, at sea level, water will boil at 212° F; whereas, Carbon Tetrachloride will boil at 170°F. Other boiling points (of common liquids) may be seen on the chart below.

Product	Boiling Point at Atmospheric Pressure (14.7 PSIA or 1 Bar)			Product	Boiling Point at Atmospheric Pressure (14.7 PSIA or 1 Bar)	
	(°C)	(°F)			(°C)	(°F)
Acetone	50.5	133		Isopropyl Alchol	80.3	177
Ammonia	-35.5	-28.1		Jet fuel	163	325
Benzene	80.4	176		Kerosene	150 - 300	302 - 572
Butane-n	-0.5	31.1		Mercury	356.9	675.1
Carbon dioxide	-57	-70.6		Methanol	66	151
Carbon tetra-chloride	76.7	170		Nitrogen	-196	-320
Chloroform	62.2	142		Olive oil	300	570
Dowtherm	258	496		Oxygen	-183	-297
Ether	35	95		Petroleum	210	410
Glycerin	290	554		Propane	-43	-45
Ethanol	78.4	173		Sulphur	444.6	823
Ethylene Glycol	197	386		Sulphuric acid	310	590
Glycerine	290	554		Tar	300	572
Helium	-269	-452		Toluene	110.6	231
Hydrogen	-253	-423		Turpentine	160	320
Iodine	184.3	363.8		Water	100	212

The boiling point of a substance is the temperature at which it changes state from liquid to gas throughout the bulk of the liquid. At the boiling point molecules, anywhere in the liquid may be vaporized.

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When liquids turn to a gas (boil), they will cause cavitation in a pump. Other factors, such as restrictions of flow to the pump, often cause cavitation. As the liquid approaches its boiling point and the pathway to the pump becomes more restricted, cavitation is more likely to occur.

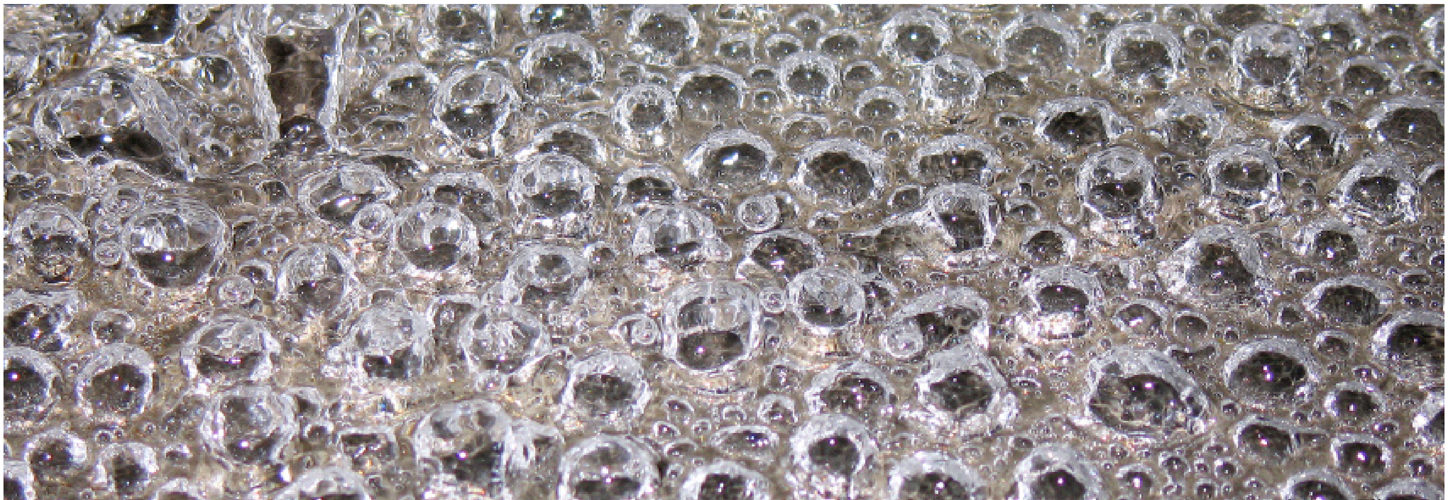

photo by Eli Ratner

How to Recognize Cavitation

Cavitation is relatively easy to recognize. In its mildest form, cavitation can be recognized as a sharp pinging noise that has often been described as pumping corn kernels or gravel through the pump. If you suspect cavitation in your pump system, but are not sure because you don't hear that noise, you can put a screwdriver onto the casing of the pump and the other end up to your ear. This will enhance your ability to hear the noise within the casing of the pump.

Another sure sign of cavitation is that your discharge pressure gauge on the pump system will fluctuate wildly. One must be careful to put a new gauge on the system and check the gauge tap opening so that you can be sure that the gauge is operating correctly. A properly operating system will give a steady pressure gauge reading with little or no variation during pump operation.

Cavitation causes many unwanted side effects. Because the pump is not operating in a hydraulically balanced manner, it can cause premature wear on the connecting rods, crankshaft and bearings. In addition, it often will cause pitting on valves and plungers (Fig. 1-1). Finally, the punger seals can degrade quickly and lose their ability to stop fluid from leaking (Fig. 1-2).

Fig. 1-1. Notice the pitting of the valve seat.

Fig. 1-2. Notice the uneven wear on seals from a cavitating pump.

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What Causes Cavitation?

One reason for cavitation is not enough fluid available on the suction side of the pump. If the Net Positive Suction Head Available (NPSHA) is less than the Net Positive Suction Head Required (NPSHR), cavitation will occur. There are many reasons for this: high fluid temperature, restrictions in the inlet line (such as clogged filters), hard piping in the inlet line, turbulent flow going into the pump, high speed of the pump to a point at which the flow demand exceeds the supply and leaks on the inlet side of the pump, which draws air into the pump.

How Do I Prove My Pump is Cavitating?

Beyond the obvious and characteristic noise, which was described above, and the erratic discharge pressure guage reading, an inspection of the valves and seals will always reveal the effects of cavitation. The most common characteristic is pitting on the sealing surfaces of the valve seat and valve plate. The seals often show abnormal or quick wear on the seal lips as well.

In a flowing liquid, cavitation is formed by a separation of its parts in a partial vacuum. The result of the implosion is damage to the metal surfaces or to the elastomeric surfaces of a pump. Cavitation affects every style of pump, such as centrifugal, progressing cavity, gear pumps, sliding vane pumps, air operated diaphragm pumps or any other style machine that applies energy to fluid. The laws of physics apply to all pumps and to all systems.

To show that caviation is occurring, install a combination pressure gauge (which indicates a vacuum as well as positive pressure) on the suction side of the pump and a discharge gauge on the discharge side of the pump and take the readings. The discharge pressure plus suction pressure (or vacuum) will be the operating pressure at which the pump is performing. As a simple calculation, assume the 1” of mercury on the vacuum gauge equeals 1 foot of head and remember that 1 PSI equals 2.31 feet of head.

To illustrate, if you have a suction lift and vacuum pressure of 5” of mercury on your suction combination gauge, convert that to 5 feet of head. If your discharge pressure gauge reads 1000 PSI, multiply that by 2.31 and your discharge pressure in feet of head is 2310. Add the 5 feet of suction head to 2310 and you will find that the pump is operating at 2315 feet of head (1002 PSI).

If you have a positive head condition and your suction gauge reads plus 10 PSI then multiply 10x2.31 which is 23.1 feet. Deduct that 23.10 from the discharge pressure of 2310 feet of head and yor net pump operating point is 2287 feet of head (990 PSI).

Compare the data found with the NPSHR curve for the pump. These curves show the point at which the pump begins to cavitate. The curve varies on the speed of the pump (at a particular pressure) and/or is dependent on the temperature (at a particular speed). See the NPSHR chart on the next page.

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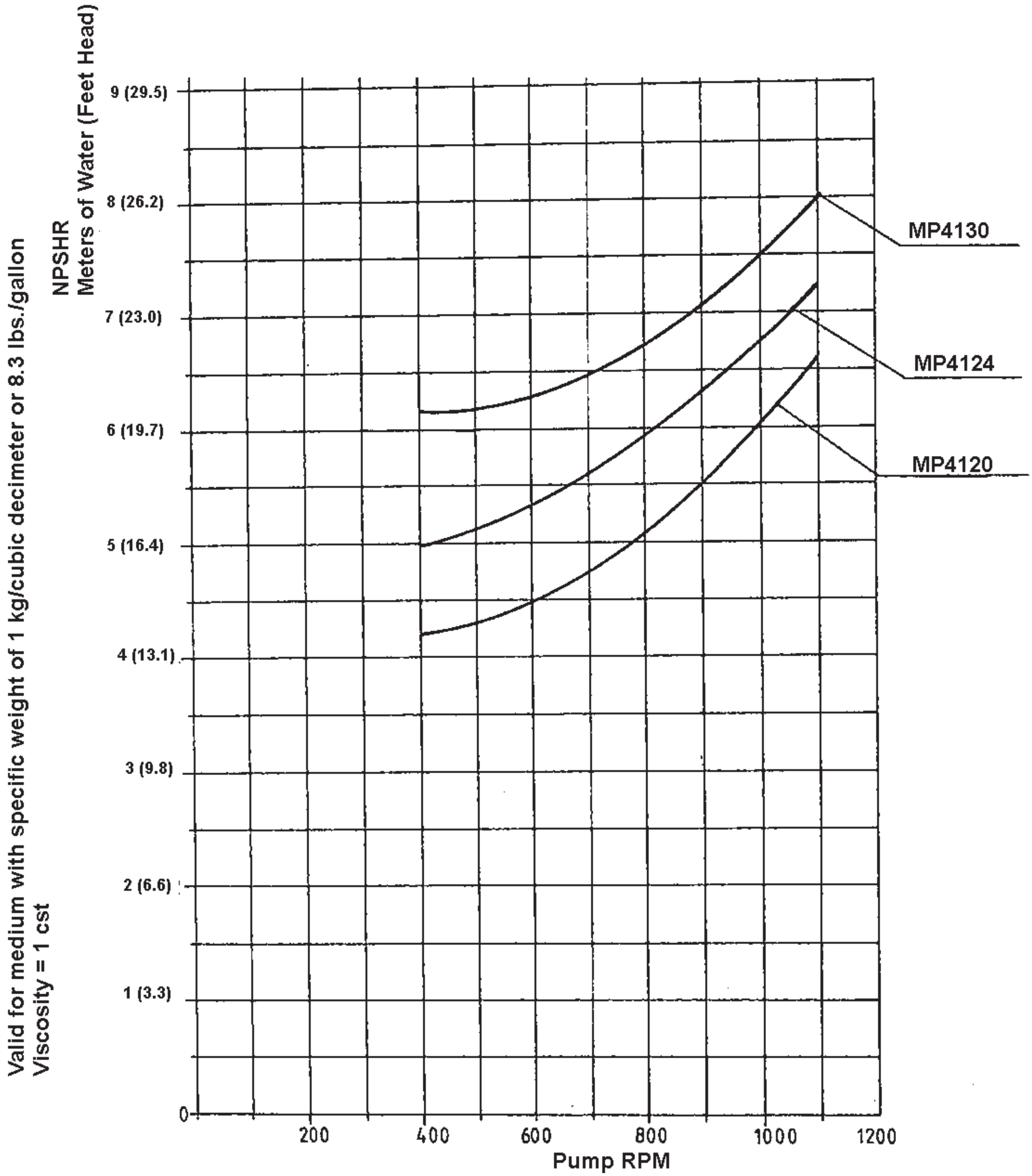

Valid for medium with specific weight of 1 kg/cubic decimeter or 8.3 lbs./gallon
Viscosity = 1 cst
NPSHR
Meters of Water (Feet Head)
9 (29.5)
8 (26.2)
7 (23.0)
6 (19.7)
5 (16.4)
4 (13.1)
3 (9.8)
2 (6.6)
1 (3.3)
0
200
400
600
800
1000
1200
Pump RPM
MP4130
MP4124
MP4120