Pump Cavitation

Cavitation means different things to different people. It has been described as:

- A reduction in pump capacity.
- A reduction in the head of the pump.
- The formation of bubbles in a low pressure area of the pump volute.
- A noise that can be heard when the pump is running.
- Damaged that can be seen on the pump impeller and volute.

Just what then is this thing called cavitation? Actually it is all of the above. In another section of this series I described the several types of cavitation, so in this paper I want to talk about another side of cavitation and try to explain why the above happens.

Cavitation implies cavities or holes in the fluid we are pumping. These holes can also be described as bubbles, so cavitation is really about the formation of bubbles and their collapse. Bubbles form when ever liquid boils. Be careful not to associate boiling with hot to the touch. Liquid oxygen will boil and no one would ever call that hot.

Fluids boil when the temperature of the fluid gets too hot or the pressure on the fluid gets too low. At an ambient sea level pressure of 14.7 psia (one bar) water will boil at 212°F. (100°C) If you lower the pressure on the water it will boil at a much lower temperature and conversely if you raise the pressure the water will not boil until it gets to a higher temperature. There are charts available to give you the exact vapor pressure for any temperature of water. If you fall below this vapor pressure the water will boil. As an example:

Fahrenheit	Centigrade	Vapor pressure lb/in2 A	Vapor pressure (Bar) A
40	4.4	0.1217	0.00839
100	37.8	0.9492	0.06546
180	82.2	7.510	0.5179
212	100	14.696	1.0135
300	148.9	67.01	4.62

Please note that I am using absolute not gauge pressure. It is common when discussing the suction side of a pump to keep everything in absolute numbers to avoid the use of minus signs. So instead of calling atmospheric pressure zero, we say one atmosphere is 14.7 psia at seal level and in the metric system the term commonly used is one bar, or 100 kPa if you are more comfortable with those units.

Now we will go back to the first paragraph and see if we can clear up some of the confusion:

The capacity of the pump is reduced

- This happens because bubbles take up space and you cannot have bubbles and liquid in the same place at the same time.
- If the bubble gets big enough at the eye of the impeller, the pump will lose its suction and will require priming.

The head is often reduced

- Bubbles unlike liquid are compressible. It is this compression that can change the head.

The bubbles form in a lower pressure area because they cannot form in a high pressure area.

- You should keep in mind that as the velocity of a fluid increase, the pressure of the fluid decreases. This means that high velocity liquid is by definition a lower pressure area. This can be a problem any time a liquid flows through a restriction in the piping, volute, or changes direction suddenly. The fluid will accelerate as it changes direction. The same acceleration takes place as the fluid flows in the small area between the tip of the impeller and the volute cut water.

A noise is heard

- Any time a fluid moves faster than the speed of sound, in the medium you are pumping, a sonic boom will be heard. The speed of sound in water is 4800 feet per second (1480 meters/sec) or 3,273 miles per hour (5,267 kilometers per hour).

Pump parts show damage

- The bubble tries to collapse on its self. This is called imploding, the opposite of exploding. The bubble is trying to collapse from all sides, but if the bubble is laying against a piece of metal such as the impeller or volute it cannot collapse from that side, so the fluid comes in from the opposite side at this high velocity proceeded by a shock wave that can cause all kinds of damage. There is a very characteristic round shape to the liquid as it bangs against the metal creating the impression that the metal was hit with a "ball peen hammer".
- This damage would normally occur at right angles to the metal, but experience shows that the high velocity liquid seems to come at the metal from a variety of angles. This can be explained by the fact that dirt particles get stuck on the surface of the bubble and are held there by the surface tension of the fluid. Since the dirt particle has weakened the surface tension of the bubble it becomes the weakest part and the section where the collapse will probably take place.

The higher the capacity of the pump the more likely cavitation will occur. Some plants inject air into the suction of the pump to reduce this capacity and lower the possibility of cavitation. They choose this solution because they fear that throttling the discharge of a high temperature application will heat the fluid in the pump and almost guarantee the cavitation. In this case air injection is the better choice of two evils.

High specific speed pumps have a different impeller shape that allows them to run at high capacity with less power and less chance of cavitating. You normally find this impeller in a pipe shaped casing rather than the volute type of casing that you commonly see.

Source: McNally Institute