

Willard Says.....

Cavitation

is a common, destructive, little-understood problem that can seriously interfere with dredge pump operation. Most dredge operators recognize the obvious symptoms of cavitation and know that the main cause is suction inlet choke-off or vacuum that is too high as a result of a cave-in. There are other, more subtle, causes of cavitation.

We will share with you the one, foolproof way to tell when dredge pump cavitation is occurring whatever the cause.

What is Cavitation?

Willard Says..... **Vacuum** details the head losses that occur on the inlet side of a dredge pump. Effective vacuum—the difference between clear water and the maximum or cavitation vacuum—is all that is available to lift solids into the pump inlet. Many hull pump dredge operators, trying to maintain maximum production, tiptoe right along the edge of cavitation. Often they get too close and operate with a slight case of continuous cavitation. When this is brought to their attention, they say, “That sound is just rock going through the pump.”

Cavitation occurs when the pressure in the dredge pump inlet is lower than vapor pressure of the water entering the pump. Vapor pressure refers to the pressure at which water will turn to vapor. Water turns to vapor (vaporizes) when it boils. Sealed in a container such as a dredge pump case, water will vaporize (boil) at ambient temperatures if the pressure in the container is reduced far enough.

This is often the situation in the impeller eye area/suction inlet when slurry enters a dredge pump; a sealed container. The vacuum reading indicates the pressure (vacuum) in the inlet of a working dredge pump and when the vacuum reading reaches about 25" of mercury, cavitation is likely to occur. When cavitation does occur, the operator must promptly reduce the vacuum by raising the suction or, if he has one, rely on a suction relief valve to open. To attempt to continue operation while cavitating is to suffer reduced production and invite serious consequences.

Pump Curves

Reputable manufacturers actually test each model and size pump they build and record the results on a paper called a pump curve. The curves for a specific pump model and size should show the horsepower required, efficiency, speed and NPSHR at various combinations of flow and total dynamic head. The curves always measure performance while pumping water. Correction factors must be applied to data derived from pump curves to estimate performance when pumping slurry.

Net Positive Suction Head (NPSHR)

is the amount of vacuum (head) that a pump must develop to cause water to enter its suction inlet. NPSHR can never be zero because every pump has some inefficiency. Every pump designer seeks to meet the needs of a variety of customers and at the same time build the most efficient pump he can. All pumps represent a compromise between several desirable features such as high efficiency, low NPSHR, high resistance to wear, large particle passage, high head capacity and low cost. Water pumps and dredge pumps are in the same family, however, their specifications are quite different. The high efficiency of a water pump must be compromised if it has to pump chunks and make like a dredge pump.

One of the factors that can be adjusted by a pump designer is NPSHR. The NPSHR for a hull pump is a factor that affects the productive capability of the dredge in which it is installed. Not all dredge pumps are created equal. Note that low NPSHR is only one feature to consider when shopping for a dredge pump. See *Willard Says.....Dredge Pumps*.

Factors That Affect Cavitation

The vacuum pressure at which a given pump starts to cavitate depends on several factors:

- Net Positive Suction Head Required.
 - Increases as the rate of flow through the pump increases.
 - Increases with the pump operating speed.
 - Increases with increased Total Dynamic Head (TDH).
- The operating height above sea level.
 - Effective vacuum decreases as elevation increases.
- The amount of effective vacuum used to satisfy production requirements.
- Air leaks in the suction pipe.
- Air leaks through the packing gland.
- Gases in the solids deposit.

What Happens when a Pump Cavitates.

Cavitation occurs when a shape (impeller vane) passes through a liquid so fast that the liquid can not flow back into the void that is created by the passing shape.

Picture the leading edge of the impeller vanes rotating about its eye with slurry flowing out into each of the 3 or 4 passages between the vanes. The vanes are shapes passing through the slurry of water and solids. If the vanes move too fast or if the resistance to flow (vacuum) in the suction pipe is too great, the slurry cannot flow to fill the voids left by the passage of the vanes. The formation of these voids is called cavitation.

If water cannot fill the voids, does that mean there are holes in the water? Yes. What is in the holes? Water vapor. Swarms of tiny bubbles (voids or holes) filled with water vapor. This phenomenon occurs near the eye of the impeller because that is the area where the highest reduction of pressure (vacuum) exists in a centrifugal pump. The bubbles cease to exist as they move away from the high-vacuum, impeller eye area and flow outward toward areas where the pressure is higher.

What does “cease to exist” mean? It means that the water vapor that was occupying the hole reverts to water and the holes fill with water. What is more, the collapse of each void is so fast—so violent—that it is called an implosion. Each implosion is minute—very small—because the voids are not much bigger than a grain of sand. They can be seen in a glass laboratory pump and there are millions of them; they look like clouds, clouds that can be made to come and go by changing the vacuum. The severity of the consequences of cavitation is related to the number of little implosions and that, in turn, depends upon how high the vacuum goes.

Symptoms of Cavitation

Symptoms of cavitation are caused both by the presence of these bubbles as well as by their subsequent collapse or implosion. Symptoms include:

- A. A sudden drop in the discharge line pressure.
- B. High vacuum reading.
- C. Popcorn popping sound.
- D. Vibration, sometimes violent.
- E. A rumbling noise.
- F. Loss of prime.
- G. A fish-scale-like wear pattern on the backside of the impeller vanes.
- H. Frequent need to adjust shaft packing.

A Sure Sign of Cavitation

A drop in the discharge pressure.

Discharge pressure goes down when the pump slows down or when cavitation is occurring. Either of these conditions causes a reduction in the rate at which slurry is being forced into the discharge pipe. Cavitation is the villain when the pressure drops suddenly during normal constant-speed pump operation.

Usually the drop will be 10 to 20 percent of the normal pump pressure if cavitation occurs rapidly due to a cave-in or choke-off.

Fluctuating or fluttery discharge pressure is almost always a sign that pump performance is being affected by cavitation. This usually occurs when the operator carries too high a vacuum and the solution is to reduce the operating vacuum until the discharge pressure steadies. If lowering the vacuum does not calm a fluttery discharge pressure, the cause may be a chunk missing from an impeller vane.

Consequences of Frequent or Prolonged Cavitation

- A. Pipeline plugging.
- B. Broken pump shaft.
- C. Damaged pump packing gland.
- D. Erosion of impeller metal.
- E. Reduced production.
- F. Loss of prime.

Ways to Avoid Cavitation

- A. Operate at a lower vacuum.
- B. Dredge at a shallower depth so effective vacuum can raise more solids.
- C. Keep the dredge pump in good condition and adjustment.
- D. Lower the hullpump to water level to increase effective vacuum.
- E. Install a suction jet assist to increase effective vacuum.
- F. Install a ladderpump to totally eliminate the suction-side limitation.
- G. Maintain the target pipeline velocity to better utilize effective vacuum.
- H. Eliminate air leaks on the suction side of the pump. A little air can seriously impair centrifugal pump function; a little more air will cause pumping to cease.
- I. Keep the packing gland adjusted to prevent air from entering the pump.
- J. Assure an adequate supply of service water supply to the packing gland to keep air out of the pump.
- K. Keep the surface speed per minute of the impeller eye below 3000 feet per minute.
- L. Install the CONVAC modulating bypass valve. This unit prevents high vacuum and enables uninterrupted, controlled production at a selected vacuum.

FALLACY ALERT!! FALLACY ALERT!!

Fallacy, i. e., a false or mistaken idea.

A noted dredging authority states in his book that ladderpumps cannot cavitate! This is a fallacy!

Absolutely not true. Ladderpumps are *less likely* to cavitate than hullpumps, however, if the suction inlet of a ladder pump is restricted too much, it *will* cavitate. A dredge pump does not know and does not care where it is located in the world—it must have sufficient liquid available to satisfy its flow requirements. If it is starved, it **will** cavitate.

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