Willard Says……

Vacuum

gauges are an absolute necessity on sand and gravel hydraulic dredges. There is no other way to determine what is going on in the dredge suction pipe.

What is vacuum? The technical explanation is that vacuum is the pressure in any enclosed space on earth that is less than atmospheric pressure. On a hullpump dredge, the running dredge pump (an enclosed space) reduces the pressure in its inlet port in an effort to cause liquid to flow into the impeller eye. We construct a dredge by connecting one end of an airtight suction pipe to the pump inlet and immersing the other end of the pipe beneath the surface of water. As long as air is not permitted to enter the suction pipe, the pump will reduce the pressure in its inlet to the extent necessary to cause sufficient water to flow into its suction inlet to satisfy its capacity to discharge it out of its discharge port.

The reduction in pressure in the dredge suction pipe is measured by extending a small tube from a tap in the suction pipe near the pump inlet port to a vacuum gauge located on the operator's console.

Vacuum Facts:

- Vacuum (absence of positive pressure) is measured as inches of mercury.
- Zero inches of vacuum equals zero psi on an air gauge.
- 30 inches of mercury—a perfect or complete vacuum—equals minus 14.7 psi air pressure.
- The above vacuum pressures are valid only at sea level. Atmospheric pressure—and a pump's ability to create vacuum—is reduced by about one inch of mercury per 1000 feet of altitude.
- *Clear water vacuum* is the vacuum created by a dredge pump while pumping clear water at target velocity.
- *Operating vacuum* is the vacuum created by a dredge pump while pumping a capacity load solids at target velocity.
- Maximum or cavitation vacuum is the highest vacuum that a dredge pump can develop. This depends upon operating conditions and pump design.
- Pipeline dredge pumps can create a vacuum of up to 25 inches of mercury.

- Dredge pumps that have a very low discharge head such as on a floatplant may develop nearly 30 inches of vacuum.
- *Effective vacuum*, the difference between maximum and clear water vacuums is the amount of vacuum that is available to raise solids into the pump inlet.
- Net Positive Suction Head Required (NPSHR) is the head (vacuum) that a particular pump requires to cause flow to enter the pump. NPSHR is a factor that is specific to each pump and is determined by the design of that pump and the rate of flow through it. NPSHR is the difference in between 30 inches of mercury vacuum and the vacuum at which the pump commences to cavitate.
- As the suction inlet is lowered into the solids bank vacuum increases somewhat in proportion to the amount of solids being taken into the suction pipe. This is the primary function of the vacuum gauge—to provide the operator with an indication of the rate at which solids are being taken into the dredge system.

Vacuum—A Guide Only

Many dredge operators depend entirely on the vacuum reading to guide them in the operation of their machines.

If the dredge IS suction-side limited the operator should always hold the vacuum as high as possible without cavitating.

If the dredge is NOT suction-side limited, there is no way these folks can realize the full potential of their dredge systems because vacuum is a flimsy indicator; it does not tell them all they need to know.

Let me explain. The vacuum reading observed on an operating dredge is the sum total of several variable factors or head losses that occur in the suction pipe and affect total dredge system performance.

- *Friction Head Loss* occurs because any flow of liquid up the suction pipe meets resistance called friction.

- *Entrance Head Loss* occurs because there is always some interference or restriction as slurry enters the suction inlet.

- *Velocity Head Loss* occurs because water and solids must be accelerated from zero at rest to 7 mph (10 fps) or more as they enter the suction inlet.

- *Static Head Loss* occurs due to the weight of the solids being raised to the pump inlet. If the pump inlet is above the water surface additional static head loss occurs to lift both water and solids from the water surface to the pump inlet.

Added together, these losses cause the vacuum reading to be what it is at any moment. If a dredge operator relies solely on the vacuum gauge for guidance to regulate the rate of production, he is leaning on a shifty indicator. Shifty, because there is no way to determine the affect of each loss on vacuum at any moment. Since vacuum is an unreliable indicator, he must allow a margin of safety—produce at a reduced rate—to avoid overloading the process plant or plugging the pipeline. That margin of safety represents lost production.

Note that Net Positive Suction Head Required is not listed with the other head losses that comprise the vacuum reading. NPSHR is the vacuum you do not see—it is the difference between the maximum operating vacuum and perfect vacuum; 30 inches of mercury.

The reader could get the idea that vacuum is not very important. *Au contraire!* Tain't so. It is just that vacuum alone cannot provide a complete picture of how a dredge is performing. The vacuum gauge needs a playmate—a velocity meter—so that the operator has enough information to maximize production and efficiency.

The Dynamic Duo

A vacuum gauge and a velocity meter make up a team that provides the operator with all the information needed to maintain full production and efficiency. See *Willard Says…***Use a Velocity Meter**.

Maximum dredge production and efficiency is best accomplished by adjusting the vacuum as required to maintain a target velocity. Pump speed should be changed only to adjust the rate of production or to maintain adequate velocity during an emergency.

Even with an effective digger fitted to the suction inlet to loosen solids continuously at a rate sufficient to support production, there is always the problem of interruptions caused by cave-ins. Normal, frequent, small cave-ins usually require the operator to react promptly to lift the ladder to prevent cavitation or choke off. Each of those episodes constitutes an interruption in production. Missed production is production lost forever.

The Tremendous Trio

The many benefits that flow from the use of a vacuum gauge and velocity meter can be compounded with the addition of a CONVAC modulating bypass valve to the system. This unit prevents interruptions caused by cave-ins. It automatically maintains vacuum at a selected value. It intervenes to prevent problems before the operator is aware that they exist. It is constantly on guard to prevent pipeline plugging. *The Tremendous Trio* will enable the operator to produce at a continuous, regulated rate! All the operator has to do is keep the suction inlet immersed in an ample supply of pumpable solids. Life does not get much better than this for a dredge operator!

Conservation of Vacuum

Because e*ffective vacuum*, the difference between maximum and clear water vacuum, is the entire vacuum available to raise solids into the pump inlet, it is prudent to practice conservation of vacuum to maximize effective vacuum.

Conservation measures include:

- Maintaining the operating pipeline velocity at the target velocity—no more than 20 percent above the critical velocity.
- Locate the hullpump dredge pump inlet at or very near the surface of the water.
- Use a suction pipe that is one size larger than the discharge pipe on hullpump dredges. Note that there are rare situations where the pipes should be the same size.
- Use a CONVAC modulating bypass valve system so that the intake of solids into the dredge system can be maintained at a continuous and uniform rate.

Vacuum Indicators

Always provide the operator with an ANALOG indication of vacuum. That means either a dial with a needle or a bar graph display.

Never provide a digital (numbers only) readout for use as an operating instrument.

Vacuum is a critical operating factor. The operator should be constantly aware not only of the vacuum reading, but whether it is changing and at what rate. He can glance at an analog display and easily determine whether vacuum is steady, increasing or decreasing without performing any calculation. Not so with a digital display.

Digital is currently a popular buzzword. Almost anything digital is better than whatever it was before. This is not true when it comes to operating indicators such as the vacuum gauge. Digital readouts require the operator to mentally calculate if or how much the indicated value differs from the desired value each time he refers to it. It requires repeated mental calculation to determine whether there has been a change in vacuum, if so which direction and at what rate. That takes way too much thinkin'.

Do not burden the operator with a digital vacuum display. And that goes for the velocity indicator as well. Provide him with good old-fashioned analog indicators or if it has to be cutting edge, shell out for electronic LED bargraphs.

Did I mention that operating meters should always be the analog type? How else can I stamp out all those stupid digital displays I see out there if I don't pound on their lack of suitablility?

Comment, questions, criticism or information on products mentioned? Contact willard@willardsays.com.