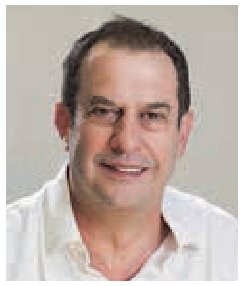
Pumping systems 101

What are pressure gauges actually telling us?



Harry Rosen discusses the very important role of pressure gauges: why they must to be accurate; the need to measure absolute pressure on the suction side, and how to determine what is happening to a pump from the suction and discharge pressure gauge readings.

In our pump training courses, trainers frequently harp on about the importance of installing pressure gauges on the pumps at factories or plants. One trainer compares pumps without gauges to driving a motor vehicle without an instrument panel – you have no idea how fast you are going, what revs the motor is doing, or whether the engine is running hot. Pressure gauges are inexpensive, generally easy to install if pressure tappings exist, and they are critical to understanding the operation of your pumps.

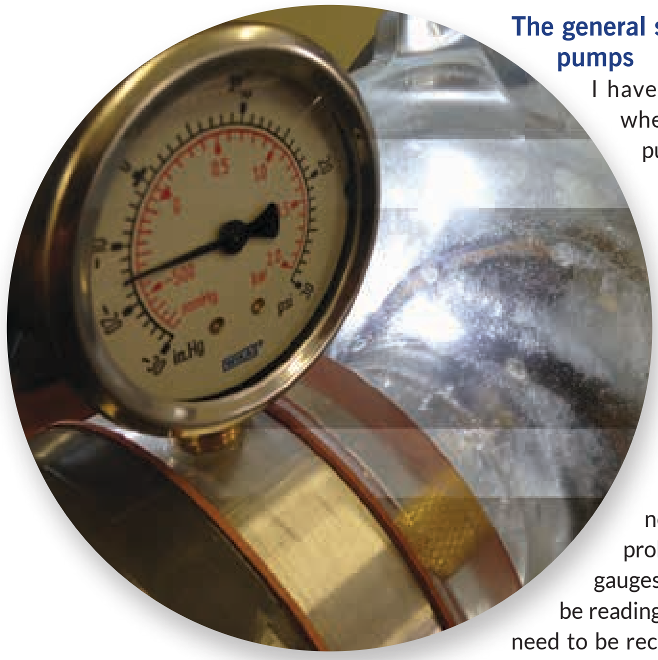


Figure 1: A compound pressure gauge showing the onset of cavitation only starting at gauge pressures below -40 kPa (-0.4 bar). A standard pressure gauge would still be showing 0 kPa and would be useless in this application.

Now that all the pumps in our plant have pressure gauges, on both the suction and discharge sides, what do we do with this information? How will it help us to operate our pumps more efficiently and reliably?

Once again, as with most questions related to pumping systems, the answers are not simple. Some of the uncertainties are:

- Are the gauges accurate?
- Is the suction gauge correct for the application?
- How do we interpret the discharge pressure reading?

The general state of gauges on our pumps

I have been in numerous plants where the gauges installed on pumps are in a very sorry state. Blocked pressure tappings, gauges filled with water, broken dials, and out of date or missing calibration certificates are just some of the obvious signs of dysfunctional instrument that cannot give an accurate reading.

Blockages in the reading pipe and isolation valves not fully open exacerbate the problem. Even brand new looking gauges with clear displays may not be reading accurately. Pressure gauges need to be recalibrated on a regular basis, at least once a year. This should be done by removing the gauge and sending it off for recalibration, but a pragmatic alternative is to install a calibrated gauge and take a snap shot reading while the pump is operating, and compare this with the reading off the installed gauge.

In principle, one needs to be able to trust the reading off the gauge.

What does the suction pressure actually mean?

The suction pressure, together with the discharge pressure, is required to calculate the total dynamic head of the pump. In most applications it will be significantly lower than the discharge pressure of the pump and so the accuracy of the measurement is not that important.

As an example, a typical cooling water pump has 20 kPa suction pressure and 600 kPa discharge pressure – do we really need to measure the suction pressure accurately? Even a 50% error in the suction pressure reading (10 kPa) will lead to less than 2% error in calculating the pump head. So why then is it so important to ensure our suction pressure gauges are accurate?

The most important function of the suction gauge is not to calculate the pump head, but to identify Net Positive Suction Head (NPSH) problems that could lead to the pump cavitating. We do not want cavitation in our pumps, as it tends to destroy their impellers, casings, bearings and mechanical seals within a very short period of time. To prevent pumps from cavitating, we need to ensure that the NPSH required by the pump, which is easily read off the pump curve, is lower than the NPSH available in the system.

How do we find the NPSH available in the system? We read it off the suction pressure gauge. However, we know that NPSH is measured in absolute pressure so the suction pressure gauge must be capable of measuring this.

To illustrate the above, assume our pump has an NPSHr of 5.0 m (as read off the pump curve). There is an installed gauge just before the suction of the pump and we will look at two different operating conditions with two different types of gauges. Let us assume we are at sea level where the atmospheric pressure is 101 kPa. Table 1 below shows two scenarios.

We know that available NPSH must be higher than the NPSH required by the pump to ensure the pump does not cavitate. It is clear from the example in Table 1 that going to the trouble of fitting a standard pressure gauge on the suction of the pump is a waste of time, as it does not show us when there is a problem. Either a compound pressure gauge – that can go negative – or an absolute pressure gauge must be used.

No	Type of gauge	Gauge Pressure	Absolute pressure	Is the pump cavitating?
1	Normal pressure gauge	0 kPa	0-101 kPa	We don't know
	Compound pressure gauge	-32 kPa	69 kPa (7.0 m)	No. We have a margin of 2.0 m available between NPSHa and NPSHr
2	Normal pressure gauge	0 kPa	0-101 kPa	We don't know
	Compound pressure gauge	-62 kPa	39 kPa (4.0 m)	YES. NPSHa in the system is less than that required by the pump

Table 1: Two scenarios for determining whether a pump is cavitating due to insufficient NPSH.

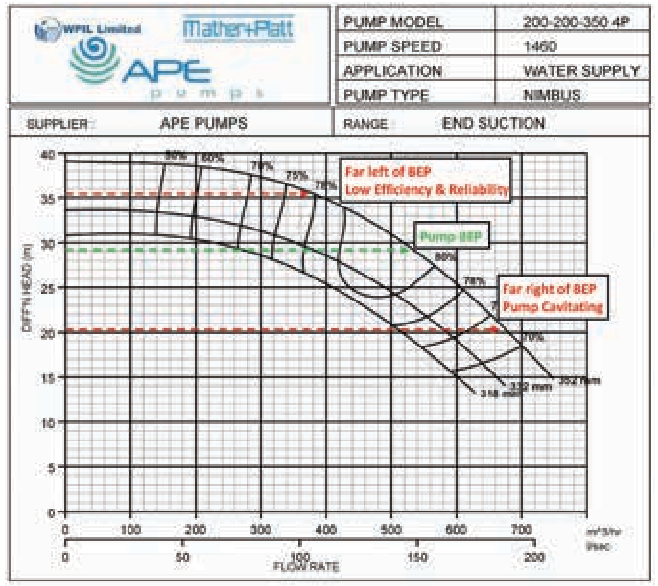


Figure 2: A pump curve showing different measured operating points, and their effect on the pump efficiency and reliability.

What does the discharge pressure actually mean?

Now that we have ensured the gauges are the correct type, and recently calibrated so we are confident of their accuracy, what exactly are we measuring? We have seen how to use the suction pressure gauge to check on NPSHa and whether the pump is cavitating. But what about the discharge pressure?

For the same pump above, we measure a discharge pressure of 550 kPa. Is the pump OK? Is it running efficiently and reliably? What happens if the pressure rises to 650 kPa or drops to 400 kPa? Does that mean there is a problem?

Unfortunately we are used to standalone instrumentation in the field, which tells us all we need to know, based on the single value being read. A vibration sensor reads 3.5 mm/s, and we know that anything less than 6.0 mm/s is OK and, if it is above 10 mm/s, then we should immediately do something. Monitoring the temperature of bearings or the cooling water to the mechanical seals quickly identifies a problem when the temperature rises above a preset alarm level.

There is however no rule of thumb that states that if the discharge pressure of a pump is less than a certain value, then everything is OK. Some pumps have a discharge pressure of 8 000 kPa, which for a 10-stage mine dewatering pump is normal. Some pumps have discharge pressures of 80 kPa, a high flow axial flow pump as an example. The problem with measuring the pump's discharge pressure is that the reading on its own is insufficient. We need to relate it back to the specific pump curve – and for that we not only need the discharge pressure, but also the suction pressure.

It is the total dynamic head developed by the pump that is important, because this will tell us where the pump is operating on its performance curve, and how far away it is from the Best Efficiency Point (BEP). The pump could be running far to the right of BEP, and suffering from cavitation. Or the pump could be running far left of BEP, in an area of high recirculation leading to lower efficiency, increased wear on the impeller and casing, and reduced bearing and mechanical seal life.

Measuring suction and discharge pressure is only the first step towards improving the operation of the pump. In my next Pumps 101 column, I will discuss what to do with this information. ❑