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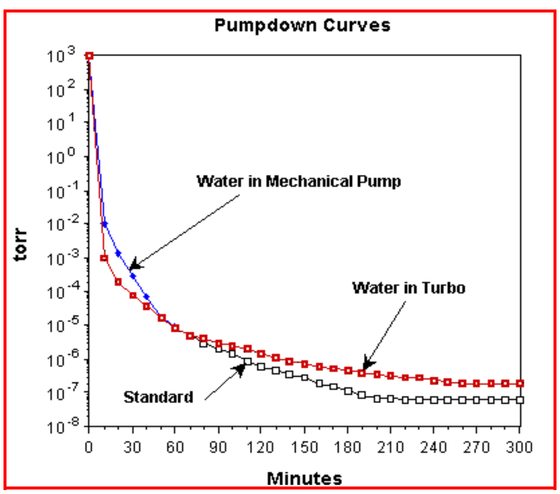
PUMPDOWN CURVES AS A DIAGNOSTIC TOOL

Vacuum technology, like all technical pursuits, requires a toolkit. In addition to the obvious physical tools such as wrenches, a number of procedural tools are required in order to understand, monitor, and troubleshoot a vacuum system or process. One of the most powerful tools you can use in vacuum technology is also one of the simplest to obtain. It's nothing more than a simple pumpdown curve. That is to say, a pressure vs. time plot. When confronted with some kind of vacuum problem, you need to have a starting point to focus on— something that helps you narrow your thinking toward the possible cause of the problem or problems. You've got to start somewhere. You also need a means of sorting symptoms from the real problem, and that's not always immediately obvious.

The usual trigger for suspecting that a problem might exist with the vacuum system is an uneasy feeling that it's pumping down slower than usual or it isn't pumping down quite as far as it used to. Something along those lines. If you've kept any kind of a system log, you can at least check the time-to-pressure numbers at the system's ultimate to see if you're anywhere near on track, but it doesn't give you much more information than the simple go-no-go of 'it's working the same as always' or 'it isn't.' So where do you start?

Chart Your Standard Curve

If you've got a "standard" pumpdown curve, you can begin to eliminate a lot of possible problems quickly and easily. Let's say that you've already taken a detailed set of data when you were certain that the system was operating right on spec. If you've taken enough data points to establish the shape of the pumpdown curve in some detail to firmly define a "standard" curve, you now have the ability to compare a curve taken during a new pumpdown to see if they match the "standard" exactly or just sort of. Then again, if you've only got a vague feeling that there might be a problem, you might just spot check with a few readings and compare it to the "standard" curve. If a simple spot check shows almost no deviation along the curve, you've already accomplished something of value with the peace of mind situation in that you don't really have a problem.



The first question that always arises is why should there have to be a detailed "standard" curve? Isn't it good enough to know whether it changed from yesterday or last week? The answer is that it's seldom that the performance of a system changes suddenly. If it does, you've usually got a good idea of what just happened. It's the slow and incremental changes that will get you. Contamination could be building up or a pump's performance could be falling slowly off. Your process could be in trouble before you knew it.

Compare Curve To Curve As You Go

If you had a good "standard" curve, you could probably catch a problem early on before the problem got severe enough to attract your attention in a passing fashion. Comparing today's pumpdown curve with a "standard" can give you a real heads up. Let's say, for example, that you've got a system where the time-to-ultimate is pretty consistent and you decide that everything's just fine. You might be living in a fool's paradise. Then again, you might compare the shape of today's curve with the "standard" and find out that the upper part of the curve where you're roughing might be slowing up even though the time to ultimate is okay. Is that important?

It might well be. The figure shows a set of common variations. Let's say that the humidity has slowly increased and you're rough pumping efficiency is falling off due to a slow buildup of condensed water vapor in the roughing pump. If it's an oil-sealed mechanical pump and a quick look through the oil reservoir's sight glass shows that it's milky looking, it's probably time to gas ballast the pump to remove the condensed water before you overwhelm the high vacuum pump's gas handling ability. As the water builds up in the mechanical pump, the pressure in the pump's inlet line will also rise above the usual ultimate due to the vapor pressure of the water.

Let's also say you're using a turbopump and it's still able to handle the water load and produce an acceptable time-to-ultimate performance. The higher foreline pressure resulting from the effects of the condensed water vapor in the mechanical pump will limit the turbo's pumping efficiency because the compression ratio of the turbo will falter. Additionally, if the water load in the foreline increases just a little bit more, you'll start to lose performance due to too much water vapor being sorbed on the inner surfaces of the turbo itself near the exhaust or actual liquid condensation in the final stages. According to Murphy's law, that will happen right in the middle of your process. This could have been avoided by reacting to the early warning that would have come from a simple and routine curve comparison.

Okay, so we've seen a simple problem with a simple fix. Is that worth a lot of trouble and oversight? Maybe. Let's say that you're using an oil-sealed mechanical roughing pump with a foreline trap and you've got a process that's sensitive to oil contamination. A variation in part of the roughing cycle's pumpdown curve shape might just as easily been caused by the foreline trap's either becoming saturated with oil or water or losing its effectiveness for some other reason. The variation that you might detect in a pumpdown curve could have been caused by a slow buildup of oil vapor in the chamber resulting from a problem with the foreline trap. That condition could be a big problem. Certainly larger than just a drop-off of the efficiency of the mechanical pump.

Then again, a small change in the curve at a lower pressure might indicate a problem with the turbo pump. If, as we stated earlier, the humidity was getting higher than previously noted, the turbo might be losing efficiency due to a build up of water inside the turbo itself. Remember that the cool surfaces within a turbo can sorb water easily and affect the pump's compression ratio. This would easily cause a slowdown in pumpdown time in the area of the curve where the turbo is the main pump. It might be necessary to warm the turbo during high humidity operation to maintain process production throughput.

The point here is not to try to show all the problems that can be avoided by constant comparison of pumpdown curves but to begin the show the advantages that can be gained by their use. In terms of overall hassle, the small amount of energy that goes into checking curve against curve can be easily offset by the avoidance of being forced to deal with a problem after the fact instead of heading it off before it becomes a real problem.

Another consideration is that you can avoid a lengthy trouble shooting process to discover what the problem is when a system isn't performing to specification. The first reaction to a problem is a suspected leak that too many times results in a time consuming and fruitless search for a leak that doesn't exist. There are too many other things that might result in a variation from spec to always assume a leak or even contamination when the cause of the problem could actually be simple and easy to fix.

An additional advantage of having a good "standard " curve is having a basis for comparison following any change in the system such as cleaning or the replacement of some component part. You can use the curve you obtained earlier to benchmark the new performance.

The advantages of using pumpdown curves on a routine basis far outweigh the efforts required to obtain and use them.

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