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Achieving Lower Ultimate Pressure in Production Systems

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Vacuum systems that are used in production often have performance requirements that would seem to be at odds in terms of a solution. Production throughput goals can mandate the need for a faster pumpdown while process quality goals can mandate a lower process pressure. The most common culprit in either case is water vapor desorbing from the process chamber's internal surfaces. Slow desorption can extend pumpdown time to a given process pressure, and continued desorption at a fairly steady rate can limit a system's ultimate pressure. In both cases, enhanced UV initiated desorption from a Phototron source can be the answer.

FASTER PUMPDOWN

If a process has a specified process pressure that the system is capable of meeting, but the pumpdown time to that pressure needs to be reduced; the Phototron can be used to reduce that time. Unless the chamber is provided with a very low pumping speed, additional pumping speed probably won't accomplish very much in terms of pumpdown time.[1] Since the heaviest desorption occurs during the first part of the pumpdown, the technique of increasing the desorption rate during this period will allow a low enough desorption rate in a shorter time has been previously described.[2] Power levels to reduce pumpdown time to 1/3 or 1/2 of the time previously encountered are also described.[2]

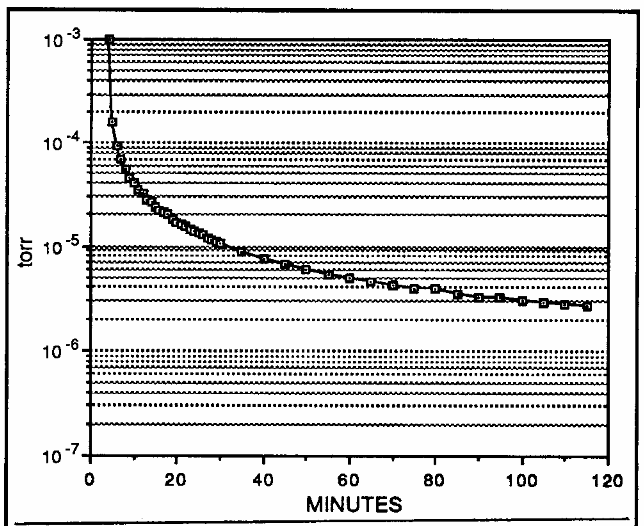

Figure 1. Preliminary Pumpdown Curve for Setting a Performance Goal

ACHIEVING A LOWER PRESSURE

The technique for achieving a lower pressure is essentially the same as for achieving a faster pumpdown. The idea is merely to provide a lower water vapor desorption rate. Since the bed of sorbed water molecules has water-to-water bonds that increase as the bed is eroded,[3] enough weakly bound water needs to be desorbed to reach a low enough point in the bed where the desorption rate is low enough to satisfy the performance goals.

EVALUATING THE SYSTEM PRIOR TO SETTING A GOAL

If you want to improve the ultimate pressure that you can achieve in a given pumpdown time that is probably dictated by the process cycle requirements, you have to be certain that you know where you are starting. This would appear to be overly obvious, but you need to understand the pumpdown performance in more detail than just how far it pumps down in so much time. This means a pumpdown curve with enough detail to show the curve's shape.

Figure 1 shows what is probably a typical pumpdown curve. This curve is typical in that it shows a fairly rapid pressure reduction early in the pumpdown where desorption is high and then begins to flatten out when the desorption rate of the chamber's inner surfaces becomes lower. This makes the system a good candidate for achieving a lower ultimate pressure within the specified pumpdown time if UV energy from a Phototron is correctly applied.

SETTING THE PERFORMANCE GOAL

Lower Pressure in the Same Time

If we look at Figure 1, we can see that we reached a pressure of about 3 x 10^{-6} torr in 120 minutes. If we then set a goal of reaching a pressure one decade lower (3 x 10^{-7} torr) in the same time period, we could choose a Phototron power level and exposure time that would allow that goal to reached. Or, we could choose to reach a goal pressure 1.5 decades lower (8 x 10^{-8} torr) and choose a higher power level.

MEETING THE GOAL

Once a goal is decided upon, the next question to consider is what you have to do to meet that goal and whether or not it can be met within the constraints of system and available time. In general, it's only necessary to apply enough Phototron UV power and provide enough pumping speed. That's where the compromises start.

If you're using an existing system, you probably have to look at the pumping speed you've got available for starters. You can only pump what you desorb, but you've got to consider that you've also got to desorb what you pump. In other words, if you desorb water vapor at a higher rate than you can efficiently pump it, the extra power you applied to provide a really high desorption rate will be partially wasted.

RULES OF THUMB

Figure 2 shows pumpdown curves that meet proven and reasonable goals by using the appropriate power levels and with ON times relating to the evaluation curve (Figure 1) with rules that follow:

1. At 2.5 mw/in.,[2] we can reach a decade lower in pressure by running the Phototron for 1/2 the time. (1/2 Rule)
2. At 5 mw/in.,[2] we can reach a decade and a half lower in pressure by running the Phototron for 1/3 the time. (1/3 Rule)

Both the 1/2 and 1/3 rules can be met with a critical pumping speed[1] of about 0.11 liters/sec./in.[2] or lower,[2] but higher speeds are required for higher power levels than that specified for the 1/2 and 1/3 rules.

Lower and Faster

A compromise goal might be needed to meet production requirements that indicates that a slightly lower pressure is required, but that that pressure needs to be reached faster. An almost endless series of combinations can be provided to use both varying power and time.

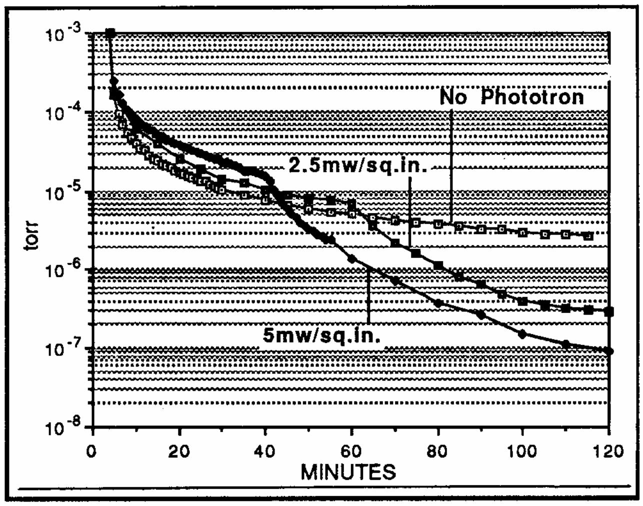

Figure 2. Pumpdown Performance Goals Using the 1/3 and 1/2 Rules

The best way of planning these relationships is to work out the 1/2 and 1/3 rule possibilities based on the suggestions above and to accept a compromise solution that you can live with. Use as much power as you can sensibly provide since you can always turn the Phototron source OFF earlier. It's always best to err on the high power side, but don't lose your head by doubling or tripling what you think you might need.

REFERENCES

1 "Critical Pumping Speed and Water Vapor in Production Systems," *The Vacuum Chronicles*, Vol 4, No. 9

2 "Phototron Power an Performance Relationships," *The Vacuum Chronicles*, Vol 4, No. 11

3 "Understanding Water Desorption," *The Vacuum Chronicles*, Vol 4, No. 12

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