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# Phototron Power and Pumping Speed Relationships

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In any vacuum system, there's a relationship between pumping speed and pumpdown performance. It would seem to be obvious that there would be limits that could be characterized as too little or too much pumping speed. These limits do exist, but only in terms of meeting a certain performance specification. Barring leaks, there is no such thing as too little pumping speed in an absolute sense. It'll pump down, but it might well take a ve-e-e-ry long time.

The concept of too much pumping speed is also suspect. Even if your system is provided with pumping speed that is much higher than the critical pumping speed,[1] extra speed will help. It just might not buy you as much as you'd like in terms of pumpdown performance. Pumping Speed is often whatever sized pump you have installed on your system already, so how do you estimate the gains when Phototron desorption is added to your system?

First, though, consider the conditions where a Phototron might not help much:

1. Chamber liners that might block UV radiation,
2. Large number of virtual leaks that would also block UV radiation, or
3. Water sources that hold water in the bulk such as spongy deposits or gassy plastics.

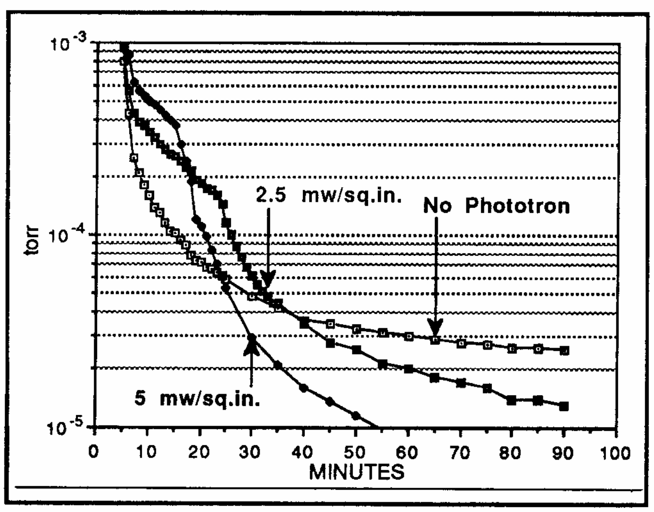


*Figure 1. 1/3 and 1/2 Rule Pumpdown at 0.022 liters/sec/sq.in.*

## LOW PUMPING SPEED

The idea of low pumping speed is misleading at best in that the best you can pin it down to is that it's lower than high. It is what it is, and what it often is the biggest pump you can afford in terms of budget or physical room on your chamber. The only question is this. Does it pump down? If it pumps down, a Phototron will help you improve pumpdown performance.

If your system pumps down under "natural" desorption conditions, what can you expect under conditions of enhanced desorption when you use a Phototron? That all depends upon matching the power of the Phototron to the pumping speed. If your system has a pumping speed below the critical pumping speed[1] of about 0.049 liters/sec./in.$^2$ you can depend upon improving the pumpdown performance according to the 1/2 Rule[2,3] which states:

At 2.5 mw/in.$^2$ of Phototron power you can, based on a time chosen from a "natural" desorption rate curve,[2]

1. Cut the pumpdown to 1/2 by turning the Phototron ON for 1/2 of the time goal, or
2. Pump down to a level one decade lower by turning the Phototron ON for 1/2 of that time.

### *Low Critical Pumping Speed*

The 1/2 Rule will also work out at what can be considered the Low Critical Pumping Speed of 0.022 liters/sec./in.$^2$ Figure 1 shows pumpdown performance with this power level in terms of faster pumpdown. Note that the 1/2 Rule as stated above is met exactly at these power levels even though the pumping speed is below the Critical point. The key to understanding this is that the pumping speed is setting the proportionality in that desorbing water molecules are being pumped at whatever rate they can statistically enter the pump. This holds for both "natural" and enhanced desorption rates.

Figure 1 also shows the same proportionality for a higher Phototron power level. This is for 5 mw/in.$^2$ as is given in the 1/3 Rule which states that performance much like the 1/2 Rule can be achieved, but in 1/3 the time and at a higher power level.

In both the 1/2 Rule and 1/3 Rule cases, the low pumping speed is still fast enough to handle the higher desorption rate provided by the Phototron even though the desorption rate is higher at 5 mw/in.$^2$ Desorbed water vapor molecules that aren't pumped away quickly are kept energized by the Phototron's UV to keep them from resorbing as completely and with as much binding energy

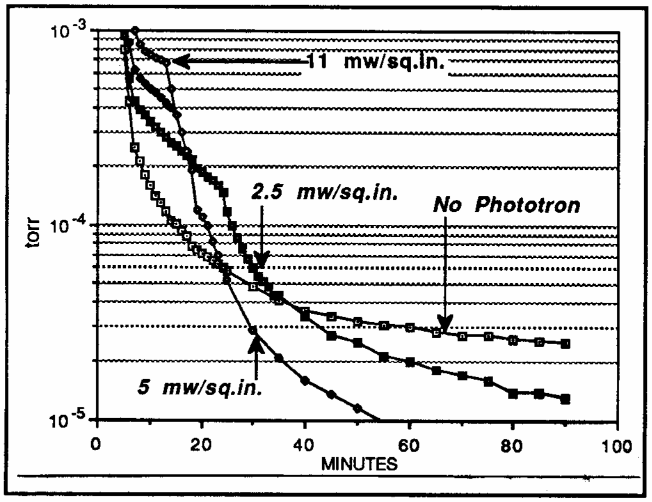


*Figure 2. Phototron with Additional Power Above Critical.*

as is found in the original sorbed bed. Under these conditions, the pumpdown performance will remain proportional to the "natural" desorption rate pumpdown.

### *Critical Power Levels at Low Critical Pumping Speed*

Figure 1 shows pumpdown performance levels that meet the 1/3 and 1/2 Rule expectations where the enhanced desorption rates are within the pump's ability to deal with the rates. If, however, we raise the power level again to 11 mw/in.[2], we see the pumpdown performance as shown in Figure 2 where we see the results of the higher power level as well as the lower power levels we'd already seen in Figure 1.

In Figure 1, the Phototron has caused enhanced desorption at a rate that puts enough water molecules into play and keeps them in play long enough for the low pumping speed to statistically pump them away. A higher power level, though, will raise the desorption rate so high that even though there are more water molecules in play and statistically able to enter the pump, the low pumping speed will not allow the molecules to be removed at a high enough rate to gain in pumpdown performance by adding additional Phototron power. This effect can be clearly seen in Figure 2 where no gain in pumpdown performance is seen above 5 mw/in.[2]

## LOW CRITICAL PUMPING SPEED DEFINED

A low critical pumping speed, then, can only be defined by its relationship with the Phototron power level. In the case described above, a pumping speed of 0.022 liters/sec./in.[2] can be defined as low critical pumping speed since it will allow both the 1/3 and 1/2 rule power levels to be applied efficiently but will not react efficiently to any higher power.

### REFERENCES


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

2 "Achieving Lower Ultimate Pressure in Production Systems," *The Vacuum Chronicles*, Vol. 5, No. 4

3 "Phototron Power and Performance Relationships," *The Vacuum Chronicles*, Vol. 4, No. 11





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