THE VACUUM CHRONICLES

Volume 5, Number 6

Phototron Operating Pressures: Part 1 *Turning It On*

by Phil Danielson

Since the Phototron is often used to provide a faster pumpdown to some specified ultimate pressure, it's vital that it be operated such that the maximum effect be obtained in the shortest amount of time. This means desorbing the maximum amount of water the pumping system can handle in the shortest time. There are a couple of simple techniques to accomplish this.

WHEN TO TURN THE SOURCE ON

There seems to be a tendency to think about turning the Phototron source ON at about the same time you'd turn an ion gauge ON during the initial pumpdown cycle. There appears to be some sort of psychological connection between the two. In fact, the best time to turn it ON is at the start of the roughing cycle. You don't have to worry about either burning out or damaging the source by operating it at atmospheric pressure.

If the source is turned ON at atmospheric pressure, there will be so much water vapor in the air filling the chamber that no UV will reach the internal surfaces of the chamber. The water vapor in the air will absorb all the UV energy, but as the pressure falls and water vapor is pumped away by the roughing pump, a point is reached where the UV can reach the walls. At this point, the UV begins to desorb water vapor from the internal surfaces rapidly. This generally occurs at about the point where the pressure is low enough to enter the molecular flow regime.

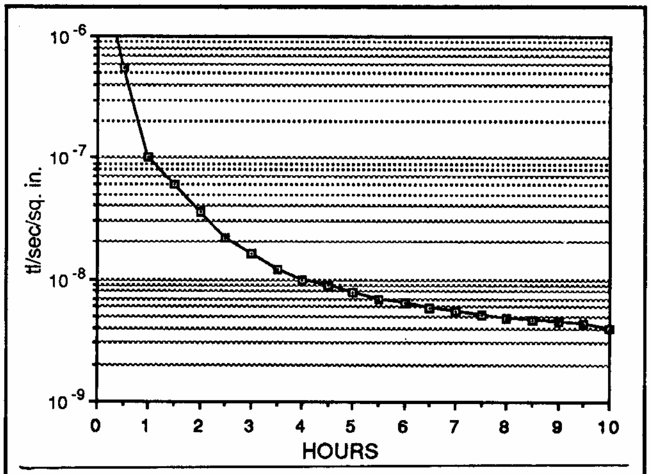

Figure 1. Natural Desorption Rate of Water.

Figure 1 shows the "natural" desorption rate of water vapor, and you can see that the desorption rate is very high at this point in the pumpdown. The sorbed bed of water vapor is very disordered[1,2] at this point, and the water vapor desorbs with little energy. As the Phototron's UV energy reaches this loosely bound water, the desorption rate goes up dramatically.

As the desorption rate climbs, some entrainment of desorbed water into the roughing line will occur even though the pressure is edging around molecular flow conditions. This entrainment efficiently helps sweep desorbed water into the roughing pump so it won't need to be dealt with by the high vacuum pump later in the pumpdown cycle.

The point is to remove as much of the loosely bound water as quickly as possible early on in the roughing cycle. When the loosely bound water is removed, the more tightly bound water that's deeper in the bed is exposed[2] so that the Phototron will be able to pump desorption energy into that part of the bed.

Getting the more tightly bound water desorbed will move you to a part of Figure 1, in terms of desorption rate, where the total desorption rate is low enough to meet whatever your target ultimate pressure specification might be. You can't pump it until you desorb it.

What's Happening?

If the Phototron is turned ON at high pressure, you are already seeing the high "natural" desorption rate put a lot of previously sorbed water into the chamber's volume. The UV energy from the Phototron adds to the desorption rate. A high percentage of the desorbed water molecules will impact another surface and tend to stick. The energy from the Phototron negates this effect to some extent by continuously pumping energy into the molecules as they impact and as they move through the chamber's volume and this tends to make any sojourn on another surface extremely short.[2] This will keep the molecules in play until they can be pumped away and removed from the quasi-equilibrium within the chamber.

Pressure Readings

When the Phototron is in use during the roughing cycle, it is extremely difficult to detect just what the effects might be in terms of desorption by attempting to monitor the roughing gauge. For one thing, the sheer number of molecules involved at these pressures makes it hard to

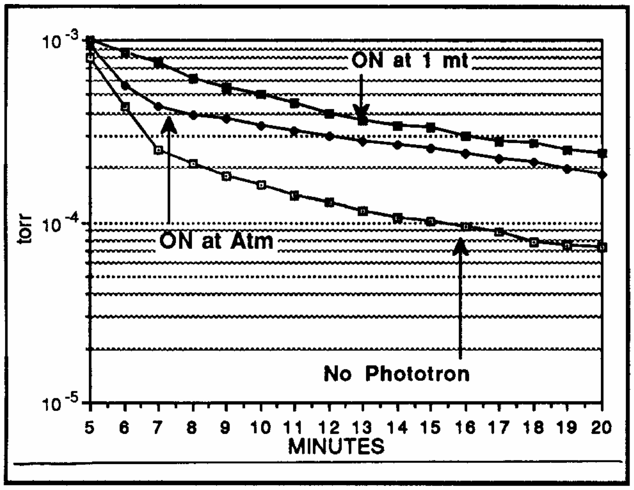

Figure 2. Pumpdown performance with Phototron ON at atmospheric pressure and 1 mt, at 1/2 rule power of 2.5 mw/in.[2]

separate out the effects of the increased desorption rate over the already chaotic conditions shown by the gauge. Things are just happening too fast and in too complex a fashion to allow you to sort it out.

The difference can only be detected after the fact by comparing a series of pumpdown curves[3] such as can be seen in Figure 2 where we can see the difference in pumpdown performance between "natural" desorption with no Phototron, turning the Phototron ON at 1 x 10^{-3} (1 micron or millitorr), and turning the Phototron ON at atmospheric pressure. Note that the pressure as evidenced by the ion gauge reading is lower when the gauge is turned on at atmospheric pressure. The pressure reading is lower because the desorption rate is lower at this point in the pumpdown curve.

Pumping Speed

The pumpdown curves will also need to take into account the type of roughing pump in use when the Phototron is used during the roughing cycle. It will obviously help in shortening the pumpdown time no matter what kind of roughing pump is used, but different results will be obtained with with different pumps.

For example, an oil-sealed mechanical pump will have its highest speed near atmospheric pressure. That allows it to easily deal with the volume gases in the chamber following air release, but its speed will fall off rapidly as the pressure drops. Its pumping speed, then, will be at its lowest when the water vapor gas load is increasing due to Phototron induced enhanced desorption. Keeping the desorbed water energized as discussed above will allow the pump to do its best in dealing with the water vapor load even though its pumping speed is at its lowest.

This effect will be in place for any of the other "trapped volume" type pumps such as diaphragm, piston, or scroll pumps. Totally different results will be seen for pumps that reach their highest pumping speed at low pressures such as Tribodyn pumps that utilize continuous inletting into the molecular drag module.

CONCLUSIONS

There is no reason to delay turning ON the Phototron until the roughing cycle is over. Indeed, the results that can be gained by turning it ON at the onset of roughing should not be thrown away since water desorption during the roughing cycle can be a very effective means of reaching a low total desorption rate quickly. Desorbing a little more water than you can pump easily certainly causes no problems.

The Phototron can be turned ON either manually at the onset of roughing or from the system's control system by sending either an AC or DC signal to the remote operation input on the Phototron's Universal Power Supply.

SAFETY WARNING, OZONE ALERT

The Phototron should never be operated for more than a few minutes at atmospheric pressure. The UV from the source will start to produce ozone from the oxygen in the atmosphere. The ozone can be pumped through the roughing pump into the atmosphere and cause operator irritation.

A greater potential for safety problems, though, is if ozone is pumped into a pump containing hot hydrocarbons since rapid oxidation or detonation of the oil can result.

The tiny amounts of ozone formed during roughing are too negligible to be considered any sort of safety problem.

REFERENCES

1 "How the Phototron Works," *The Vacuum Chronicles*, Vol 4, No. 10

2 "Understanding Water Desorption," *The Vacuum Chronicles*, Vol. 4, No. 11

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