THE VACUUM CHRONICLES

Volume 2, Number 5/1991

Sorbodyn[tm] Getter Lifetime

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Getter pumping is based on the premise that the gases being pumped will react with the getter material to produce chemical compounds that have negligible vapor pressures. This means that pumping will only occur if there is unreacted getter material available for further reaction. Since the getter material is being continually consumed by chemical reaction, it follows that a given amount of getter material will have a certain finite lifetime before it is totally consumed by reaction with pumped gases. Understanding of the getter lifetime and its determination is the key to understanding and using Sorbodyn getter pumps.

Sorbodyn pumps use a unique design based on a large amount of steady state getter pellets contained in a heated bed. This means that the getter material does not require dispensing by evaporation, sublimation, or sputtering as is required by existing getter concepts. The available getter material can then be viewed as a whole without need to consider its rate of production from a source along with the rate of consumption of a deposited film as is required for a titanium sublimation pump.

PUMP CAPACITY

The capacity of any capture pump is the amount of gas it will hold before pumping action declines or ceases. The pumping speed of the pump and the pump's capacity depend upon the gases being pumped. Although capacity is traditionally stated in torr liters, it is often clearer to think in terms of number of molecules that require pumping in a given pumpdown and in a given getter lifetime. The Sorbodyn-20 can be used as an example.

Gas	Capacity *torr liters*	Capacity *molecules*
CO	720	2.52×10^{22}
CO_2	720	2.52×10^{22}
N_2	720	2.52×10^{22}
O_2	3200	1.12×10^{23}
H_2	1600	5.60×10^{22}
H_2O	6400	2.24×10^{23}

CAPACITY IN NUMBER OF PUMPDOWNS

Although a typical chamber pumpdown must deal with a gas mixture, it is useful to consider a pumpdown of a pure gas as an example. Nitrogen gas provides a good example because systems are often flushed or backfilled with nitrogen before pumpdown and because it has a lower total capacity than some other common gases and can be considered as a "worst case."

Conditions: Sorbodyn-20 — Crossover at 10^{-4} torr
50-liter chamber — Ultimate at 10^{-7} torr
N_2 gas

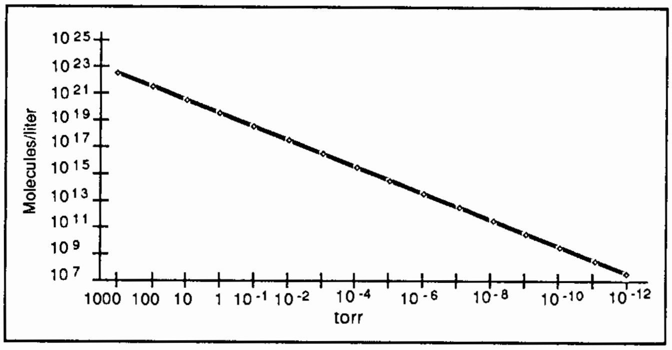

Figure 1. Molecules/liter vs. Pressure.

Figure 1 shows the number of molecules/liter at various pressures.

10^{-4} torr -- 3×10^{15} molecules/liter
10^{-7} torr -- 3×10^{12} molecules/liter

The Sorbodyn-20 then will be required to pump approximately 3×10^{15} molecules/liter for each pumpdown. Since a 50-liter chamber will contain 50 times as many molecules, pumpdown of a 50-liter chamber will require 150×10^{15} or 1.5×10^{17} molecules pumped for each pumpdown.

Since Sorbodyn-20's total capacity for N_2 is 2.5×10^{22} molecules, the number of pumpdowns that can be achieved before saturation can be easily calculated as follows:

$$\frac{\text{Total capacity in molecules}}{\text{Number of molecules per pumpdown}} = \text{Number of pumpdowns before saturation}$$

OR,

$$\frac{2.5 \times 10^{22}}{1.5 \times 10^{17}} = 1.7 \times 10^{5} \text{ pumpdowns before pump is saturated}$$

The determination of the number of pumpdowns possible before saturation is an oversimplification that is intended to provide only a beginning understanding of the performance of getters. However, a pump is required to do more than just pump a chamber down to a specific pressure. It has to maintain pumping for extended periods at the chamber's ultimate pressure.

STEADY GAS LOADS

Once a chamber has been evacuated, the pump must maintain a given pressure for a period of time dictated by the application. If we look at the same 50-liter chamber

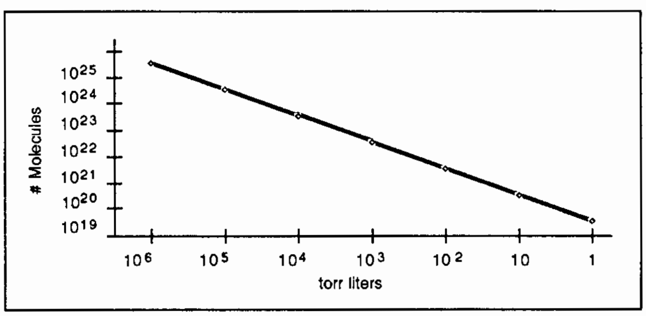

Figure 2. Torr Liters vs. Number of Molecules.

we discussed above and assume that the gas load at its ultimate of 10^{-7} torr is pure N_2, we can calculate the gas load the Sorbodyn-20 will have to deal with at its rated speed of 15 liters/sec for N_2.

Q=SP

GAS LOAD= PUMPING SPEED x PRESSURE

torr liters/sec. = liters/sec. x torr

torr liters/sec. = 15 liters/sec. x 10^{-7} torr
= 1.5×10^{-6} torr liters/sec.

If we refer to Figure 2, we see that 1.5×10^{-6} torr liters = 5.3×10^{13} molecules. This means that the pump would be pumping 5.3×10^{13} molecules/sec. Or:

5.3×10^{13} molecules/sec.	4.6×10^{18} molecules/day
3.2×10^{15} molecules/min.	3.2×10^{19} molecules/wk.
1.9×10^{17} molecules/hr.	9.6×10^{20} molecules/mo.
1.2×10^{22} molecules/yr.	

Since the total capacity of the Sorbodyn-20 for N_2 is 2.5×10^{22} molecules, the getter charge would last for one year before it required replacing if it were pumping at 10^{-7} torr of N_2 constantly.

PRACTICAL APPLICATION PUMPING

In most practical pumping applications, the high vacuum pump is required to both pump chambers down continually and to maintain an ultimate pressure by meeting a steady gas load. Although the mixture is likely to be erratic, it is still possible to calculate an approximate getter lifetime. In this case, using the number of molecules concept makes it possible to easily estimate lifetime.

We can use the same system we have described above for simplicity and assume the following operational parameters for an 8-hour working day's operation plus overnight pumping.

Pumpdown Capacity

4 pumpdowns/day
Pumpdown from 10^{-4} torr to 10^{-7} torr
Pumpdown time of 1 hour

Steady Gas Load

1×10^{-7} torr
1/2 hour system loading time with pump valved off
18-hour total pumping time at 1×10^{-7} torr

Determining Number of Molecules Pumped

Each pumpdown requires that 1.5×10^{17} molecules be pumped for each pumpdown (from above).

4 pumpdowns = 1.5×10^{17} molecules x 4
= 6×10^{17} molecules pumped during four pumpdowns

One hour of pumping at 10^{-7} torr requires that 1.9×10^{17} molecules be pumped (from above).

$$\left[\begin{array}{l}\text{18 hours of}\\ \text{pumping steady}\\ \text{gas loads}\\ \text{at } 1 \times 10^{-7} \text{ torr}\end{array}\right] = \left[\begin{array}{l}1.9 \times 10^{17}\\ \text{molecules}\\ \times\ 18\end{array}\right] = \left[\begin{array}{l}34 \times 10^{17}\\ \text{molecules}\end{array}\right]$$

Total number of molecules pumped / 24 hour day is,

$$\left[\begin{array}{c}6 \times 10^{17} \text{ molecules}\\ +\\ 34 \times 10^{17} \text{ molecules}\end{array}\right] = 4 \times 10^{18} \text{ molecules}$$

Getter Lifetime

We can repeat the same calculations for lifetime we used above to determine the lifetime under these conditions.

Total Capacity = 2.5×10^{22} molecules
Molecules pumped = 4×10^{18} molecules

$$\frac{\text{Capacity in molecules}}{\text{molecules pumped per day}} = \text{number of days before saturation}$$

$$\frac{2.5 \times 10^{22} \text{ molecules}}{4 \times 10^{18} \text{ molecules}} = 6.3 \times 10^{4} \text{ days}$$

CONCLUSIONS

The method of calculation shown here is not intended to be a fully accurate determination of actual lifetime. It is intended to help in an understanding of how the Sorbodyn getter pumps work and what can be expected of them. In actual pumpdowns from air or maintaining an ultimate pressure under continuous gas load, the gases making up the gas load will be mixtures of gases and the mixtures will be changing during the process. Nitrogen pumping was used as a simplified concept to help gain understanding. Other variations such as leaks, contamination, etc., will also have an effect on actual lifetime. It is, however, expected that these kinds of calculations will produce lifetime expectations in the same order of magnitude as will be found in an actual system.

Vol. 2, #5/91, "Sorbodyn Getter Lifetime"

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