HARRICK Scientific Products
Solutions in Optical Spectroscopy

How can I calculate the maximum pressure for my gas, liquid or solid cell with FT-IR or UV-VIS windows?

Only cells with metal bodies should be pressurized. Those with plastic bodies should not be used for high pressure applications. Be sure to review the specification for the particular device. If the pressure rating given in the specification is lower than that calculated below, then use the lower figure as the maximum pressure.

All cells are capable of operation from vacuum to ambient pressure. The question is, how high above ambient pressure can any particular cell configuration tolerate. The maximum operating pressure, psi (in pounds per square inch, psi) for a gas, liquid or solid cell is given by:

$$p_{psi} = \frac{1.333t^2m}{d^2} \tag{1}$$

where t is the thickness of the window in mm, m is the modulus of rupture in pounds per square inch (psi), and d is the unsupported diameter of the window, also in mm. From this formula, it can be seen that increasing t or decreasing d will have a great effect on increasing p and that the pressure is directly proportional to m.

The quantity t is dictated by the windows and d is governed by the accessory design. The modulus of rupture is based on the material used for the window and can be found in Table 1 and in Harrick's Optical Materials Table. For Harrick accessories, the window thickness, diameter and unsupported diameter are shown in Table 2. Note that the window diameter is not the same as the unsupported diameter, d, and only the latter should be used in the calculation.

Example:

A Temperature Controlled Demountable Liquid Cell, TFC-S13-3, uses two 13mm Zinc Sulfide windows. From Table 1, the value for m is 10,000 psi. From Table 2, t is equal to 2mm and d is 8mm. Substituting in Equation 1 gives:

$$p_{psi} = \frac{1.333(2\,mm)^2(10{,}000\,psi)}{(8\,mm)^2}$$

$$p_{psi} = 833\,psi$$

The pressure in atmospheres can be readily calculated by:

$$p_{atm} = \left(0.068046/_{psi}\right)(p_{psi}) \tag{2}$$

So, for the example above,

$$p_{atm} = \left(0.068046/_{psi}\right)(833\,psi)$$

$$p_{atm} = 56.7\,atm$$

In a similar fashion, the pressure in torr (equivalent to mm of Hg) can be calculated by:

$$p_{torr} = \left(51.7149\,torr/_{psi}\right)(p_{psi}) \tag{3}$$

For the example above,

$$p_{torr} = \left(51.7149\,torr/_{psi}\right)(833\,psi)$$

$$p_{torr} = 4.31x10^4\,torr$$

Table 1. Modulus of Rupture for Some Common Window Materials

Material	Modulus of Rupture, m (psi)
Barium Fluoride (BaF_2)	3900
Calcium Fluoride (CaF_2)	5300
Potassium Bromide (KBr)	160
Sapphire (Al_2O_3)	65,000
Silicon (Si)	9000
Sodium Chloride (NaCl)	350
UV Quartz (SiO_2)	7100
Zinc Selenide (ZnSe)	8000
Zinc Sulfide (ZnS)	10,000

Table 2. Window Thicknesses and Unsupported Window Diameters for Various Harrick Cells

Cell	Diameter (mm)	Window Thickness, t (mm)	Unsupported Diameter, d (mm)
High Temperature Cell	32	3	26.8
Dewar	25	2	20
Dewar	25	4	20
Dewar	32	3	26.8
Demountable Liquid Cells: DLC-S13, TFC-S13	13	2	8
Demountable Liquid Cells: DLC-S25, TFC-S25	25	2	20
High Pressure Liquid Cells: HPC-C, HPL-TC	13	6	8
Temperature Controlled Gas Cell	25	2	20
Temperature Controlled Gas Cell	25	4	20
HVC Reaction Chamber (vacuum/low pressure)	15	2	13.2
HVC Reaction Chamber (high pressure)	15	4	13.2
Low Temperature Reaction Chamber (CHC-CHA)	15	2	13.2