FDR Design Inc.

rle@fdrdesign.com or sniffler@infi.net
763-682-6096 763-682-6197 (fax)
www.fdrdesign.com
303 12th Avenue South
Buffalo, MN 55313

Rules of thumb for elevation change

I ran some quick calculations using both the Grace program which is based on the National Research Council of Canada sponsored work in the 70's and manual calculations using the gas laws*.

The degrees of temperature to feet of elevation will work for any size spacer as it is only concerned with volume change. If you want to develop rules for how far you can push the sealed unit we will have to make it specific to spacer thickness as the wider or thicker the spacer is, the more volume there is to change. Yet the glass has the same amount of flex before it breaks, irrespective of spacer thickness.

As I have noticed before for some reason the Grace program does not agree exactly with manual calculations, could be I am using a different reference for elevation or something but numbers are close enough for what we are trying to accomplish. In my manual calculations I assume 30" Hg for build elevation and 1"Hg for every 978 feet elevation change.

The calculations show you need to seal a unit at 52° F @ 1000 feet to have the pressure neutral at 70° F @ sea level. Conversely you need to seal a unit at 88° F @ sea level to have the pressure neutral at 70° F @ l000 feet .

Unit size 20" x 24" x 0.250" cavity volume = 2.36 liters
1000' = 14.2 psi
0' = 14.7 psi
52°F to 70°F will expand 2.36 liters of gas to 2.44 liters (0.08 liters)
1000' to 0' will reduce 2.36 liters of gas to 2.28 liters (0.08 liters)

The rule of thumb would then be:

18°F for 1000 feet of elevation

or

1.8°F for 100 feet.

1°C = 1.8° F

so

1°C for 100 feet elevation change.

Keep in mind that barometric pressure also plays a role, a 1 inch of mercury change when a front comes through is equal to 1000 feet of elevation change as well.

***Gas Laws — The expansion of air (gas) due to pressure or temperature changes is predictable. The General Gas Law is the combination of Charles' Law and Boyle's Law.**

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Charles' Law states:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Where: V = volume and
T = absolute temperature °C+273

The volume of gas is proportional to the temperature. The higher the temperature, the greater the volume, if pressure is constant. If we know the starting temperature, the average temperature of the gas in the IG when it was sealed, and if we know the temperature at the installation site, we can calculate the effect temperature has on the volume of gas trapped in the IG.

Boyle's Law states:

$$P_1 V_1 = P_2 V_2$$

The volume of a fixed mass of gas at constant temperature is inversely proportional to the pressure. If pressure goes up, volume goes down. The value of pressure times volume becomes a constant.

$$V_2 = \frac{P_1 V_1}{P_2}$$

So if we know starting elevation, P_1 (pressure one) and we know destination elevation, P_2 (pressure 2) and we know how much air or gas is in the IG, V_1 (the initial volume of gas) we can calculate V_2, the volume of air or gas at the destination.