D. Shuman 6/29/2010

Quartz tube theoretical buckling pressures; quick estimate. Formulas from table 35 Roark's Formulas for Stress and Strain, 6th ed. These values are not conservative, as slight imperfections will reduce buckling pressure, but realistic buckling values might be as high as 80-90% of theoretical. Required Factor of safety on buckling is not clear, it is probably not 8, as required on strength for brittle materials.

from http://www.insaco.com/MatPages/mat_display.asp?M=Quartz

modulus of elasticity — Poisson's ratio

$E := 10.5 \cdot 10^6 \text{psi}$ $\qquad \nu := 0.17$

try several thicknesses in parallel calculation $\quad t := \begin{pmatrix} 2 \\ 3 \\ 4 \end{pmatrix} \text{mm}$

tube nominal radius $\quad r := 1.5\text{in}$

very long tube ($l > l_{cr}$):

$$l_{cr} := 4.9 r \cdot \sqrt{\frac{r}{t}} \qquad l_{cr} = \begin{pmatrix} 0.815 \\ 0.665 \\ 0.576 \end{pmatrix} \text{m}$$

buckling pressure:

$$p_{cr\_lt} := \frac{1}{4} \frac{E}{1 - \nu^2} \cdot \frac{t^3}{r^3} \qquad p_{cr\_lt} = \begin{pmatrix} 26.6 \\ 89.8 \\ 212.8 \end{pmatrix} \text{bar}$$

for short tube, length l, or long constrained circular at lengths l: $\quad l := 0.62\text{m}$

$$p_{cr\_st} := \overrightarrow{\left[0.807 \cdot \frac{E \cdot t^2}{l \cdot r} \cdot \sqrt[4]{\left(\frac{1}{1 - \nu^2} \right)^3 \cdot \frac{t^2}{r^2}} \right]}$$

$$p_{cr\_st} = \begin{pmatrix} 22.9 \\ 63 \\ 129.3 \end{pmatrix} \text{bar}$$