THICKNESS GUIDE

MATERION

Materion Electrofusion Beryllium Window Thickness Guidelines

Beryllium x-ray windows frequently operate in differential pressure situations with atmospheric pressure on one side and vacuum on the other. The following equations are suggested as a means of computing stress on x-ray windows in typical differential pressure installation conditions.

Beryllium foil is not characterized for its mechanical properties, but a design strength of 40,000 PSI or 275 MPa is typical. Note that appropriate safety factors should be employed in all calculations. The procedure to determine deflection and stress at any given foil thickness is to use a math program or spreadsheet to solve for deflection "y" in the first equation. Then, use that value to solve for maximum stress "σ" in the second equation. This analysis considers x-ray windows to be flat circular plates with the edges held and fixed, as would be the case for diffusion bonded window assemblies. These formulas take into account shear stress and diaphragm stress, which is the stress in the material carried as tension, so it is valid for windows even if they undergo a deflection larger than half the material thickness. These equations are intended for use on circular apertures. If applications require rectangular apertures, a practical approximation is to use the following guideline: substitute the small dimension of the rectangle for the diameter of the aperture.

We're here to help. Please don't hesitate to contact us for thickness recommendations or calculation assistance. Our experience with prior and similar designs can be an invaluable time-saver.

Solve for: y = Maximum deflection (solve for this first)
σ = Maximum stress due to bending and tension.
Variables: t = Beryllium thickness
r = Radius of aperture (inches or meters)
q = Unit lateral pressure, typically 15psi or 101kPa for 1 ATM
Constants: ν = Poisson's Ratio for Be = 0.03 — 0.08
E = Young's Modulus for Be = 44MSI, (44×10^6 PSI), or (303 GPa)

$K_1 = 5.33/(1-\nu^2)$
$K_2 = 2.6/(1-\nu^2)$
$K_3 = 2/(1-\nu)$ {at center}
$K_4 = 0.976$ {at center}
$K_3 = 4/(1-\nu^2)$ {at edge}
$K_4 = 0.476$ {at edge}

Stress & Strain Equations

$$\frac{qr^4}{Et^4} = K_1 \frac{y}{t} + K_2\left(\frac{y}{t}\right)^3$$

Equation 1 – Deflection

$$\frac{\sigma r^2}{Et^2} = K_3 \frac{y}{t} + K_4\left(\frac{y}{t}\right)^2$$

Equation 2 – Maximum Stress

These equations are from pages 477 & 478, Roark's Formulas for Stress & Strain by Warren C. Young, 6th Edition, (1989) McGraw-Hill.

Health & Safety Note:

Handling solid beryllium material poses no significant health risks. However, as with many other industrial materials—materials containing beryllium may pose a health risk, if and when recommended safe handling practices are not followed and adhered to. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) have set mandatory limits on occupational respiratory exposures. Read and follow the guidance set forth in the Material Safety Data Sheet (MSDS) before working with beryllium. For additional information on safe handling practices or technical data on beryllium, contact Materion Electrofusion.

ELECTROFUSION
44036 South Grimmer Boulevard
Fremont, CA 94538-6346
+1 510.623.1500
electrofusion@materion.com

MATERION CORPORATION
www.materion.com/electrofusion

EQF 30-05 12/2011