Beryllium X-ray windows

STANDARD SPECIFICATIONS - NGK BERYLLIUM WINDOWS

Standard Chemical Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beryllium</td>
<td>98 % minimum</td>
</tr>
</tbody>
</table>

Standard Size and Tolerances

<table>
<thead>
<tr>
<th>Form</th>
<th>Dimensions</th>
<th>Dimensional Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc</td>
<td>Ø 10 mm - 90 mm</td>
<td>Diameter Tolerance: ± 0.2 mm</td>
</tr>
<tr>
<td>Rectangular or Square Plate</td>
<td>Width: 10 - 120 mm</td>
<td>Width / Length Tolerance: ± 0.2 mm (Dimensions greater than 75 mm: ± 0.5 mm)</td>
</tr>
<tr>
<td></td>
<td>Length max.: 120 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Thickness Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03 – 0.10 mm</td>
<td>± 0.01 mm</td>
</tr>
<tr>
<td>0.10 – 0.3 mm</td>
<td>± 0.05 mm</td>
</tr>
<tr>
<td>0.3 – 2.0 mm</td>
<td>± 0.1 mm</td>
</tr>
</tbody>
</table>

- For higher purity and/or non-standard dimensions/tolerances, please contact us.
- Beryllium windows can be surface-treated to meet specific requirements. Please contact us.

BERYLLIUM PROPERTIES

Fourth element of the periodic table, divalent element of the alkaline-earth metal group, metal with a silvery gray appearance

An unique combination of properties

- Light weight, low density (beryllium is 1/3 lighter than aluminium)
- High specific stiffness (about 6 times of steel) and elasticity
- Excellent heat resistance
  (Beryllium has the highest melting point of all light metals)
- Excellent acoustic velocity and transparency of the sound
  (Pure beryllium diaphragms are used in top-of-the-range audio equipment)
- Excellent X-ray transmissivity. Beryllium also is non-magnetic
- Excellent optical reflectivity. Beryllium is used for mirrors of laser scanners
- Excellent thermal and electrical conductivity
Properties of beryllium in comparison with aluminium and iron

<table>
<thead>
<tr>
<th>Properties</th>
<th>Beryllium Be</th>
<th>Aluminium Al</th>
<th>Iron Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomic Number</td>
<td>4</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>Atomic Weight</td>
<td>9.013</td>
<td>26.98</td>
<td>55.85</td>
</tr>
<tr>
<td>Crystal Structure</td>
<td>Hexagonal Close-Packed</td>
<td>Face-Centred Cubic</td>
<td>Body-Centred Cubic and Face-Centred Cubic</td>
</tr>
<tr>
<td>Density (g/cm³)</td>
<td>1.84</td>
<td>2.69</td>
<td>7.86</td>
</tr>
<tr>
<td>Modulus of Elasticity (kN/mm²)</td>
<td>275</td>
<td>75</td>
<td>205</td>
</tr>
<tr>
<td>Melting Point (°C)</td>
<td>1285</td>
<td>660</td>
<td>1530</td>
</tr>
<tr>
<td>Specific Heat (J/(kg.K))</td>
<td>1779</td>
<td>921</td>
<td>461</td>
</tr>
<tr>
<td>Thermal Conductivity (W/(m°K))</td>
<td>180</td>
<td>222</td>
<td>75</td>
</tr>
<tr>
<td>Thermal Expansion Coefficient (/K)</td>
<td>11.6 x 10⁻⁶</td>
<td>23.6 x 10⁻⁶</td>
<td>11.7 x 10⁻⁶</td>
</tr>
<tr>
<td>Acoustic Velocity (m/s)</td>
<td>12600</td>
<td>6420</td>
<td>5950</td>
</tr>
<tr>
<td>Tensile Strength (N/mm²)</td>
<td>275 – 635</td>
<td>100- 490</td>
<td>600 - 650</td>
</tr>
<tr>
<td>Yield Strength (N/mm²)</td>
<td>205 – 410</td>
<td>100 - 410</td>
<td>205 – 235</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>1 - 20</td>
<td>30</td>
<td>50 - 60</td>
</tr>
</tbody>
</table>

Benefits of beryllium in radiography

- Excellent X-ray transmissivity: the absorption coefficient of beryllium is low, i.e. the transmissivity capacity is high.
  
  See graph (µm : Linear Absorption Coefficient - γ : Density):

  For a given wavelength (for example 1 Ångström = 0.1 nm), the absorption coefficient of X-rays is much lower for Beryllium (Be) compared to Aluminium (Al). This confirms that the transmissivity rate of X-rays is much more better for Be versus Al. X-rays are very short electromagnetic waves (0.001 up to 2.5 Å). They can pass through air or matter. They hardly penetrate high density materials. The low density of beryllium gives it excellent transmissivity.

- Low secondary radiation due to X-ray irradiation.

- X-rays are produced in vacuum tubes and exit through beryllium windows. The vacuum tightness of beryllium also is an important advantage (Leak amount of He gas ≤ 5 x 10⁻¹¹ (Pa.m³/s))

EXAMPLES OF APPLICATION OF BERYLLIUM WINDOWS

Medical examination (CT scanner, radiology, mammography, etc.)

Chemicals analysis, security screening of luggages, X-ray diffraction etc.
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