High Energy Metals

Explosion Bonded Bimetallic Cryogenic Transition Fittings

High Energy Metals, Inc.
**Explosion Bonded Aluminum / Stainless Steel Fittings**

2000, 5000 and 6000 series aluminum alloys can be bonded to 300 series stainless steels using interlayers of pure aluminum, titanium and copper to produce joints that can withstand the rigors of cryogenic applications. HEMI’s fittings are in use by Los Alamos, Lawrence Livermore, Argonne National Laboratories and many other important industrial companies.

HEMI’s fittings can be welded into systems for liquid hydrogen, helium and many other LG’s. Special weld-in preparations can be fabricated and recommended weld procedures are available.
**The Explosion Bonding Process**

Explosion welding, or bonding, is a solid state welding process that is used for the metallurgical joining of metals. Explosion welding can be used to join a wide variety of dissimilar or similar metals. Simply stated, explosion bonding uses the controlled detonation of explosives to accelerate one or both of the constituent metals into each other in such a manner as to cause the collision to fuse them together.

As shown in Figure 1, the metallurgical joining occurs when the clad metal is driven down into the base metal by the explosive energy. The force of the explosion sets up an angular collision which produces an ejected plasma. The plasma jet acts to remove impurities from both metals' surfaces in front of the collision point, leaving behind clean metal for joining. The pressures at the collision point, which can be from 100,000 – 600,000 psi, are enough to squeeze the metals into behaving like viscous fluids. The fluid-like behavior is responsible for creating the wave pattern bond line in an explosive weld.

![Figure 1](image1.png)

**Explosion Bonding Event**

**As-bonded Copper-Stainless Plate**
Mechanical Testing

Test specimens are removed from areas that have passed ultrasonic inspection and are mechanically tested. Tensile and shear strengths are equal to or higher than the weaker material in the bonded system.

Pressure and leak testing of the bonded fittings are performed per customer requirements.

**Typical Data Properties**

<table>
<thead>
<tr>
<th>Material Configuration</th>
<th>Tensile (MPa)</th>
<th>Tensile (-196°C)</th>
<th>Shear (MPa)</th>
<th>Shear (-196°C)</th>
<th>Comp (MPa)</th>
<th>Impact (J)</th>
<th>Impact (-196°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5083-O Al/1100 Al/Gd 1 Ti/Cu/304L SS</td>
<td>186</td>
<td>80 (min)</td>
<td>83</td>
<td>45 (min)</td>
<td>345</td>
<td>14</td>
<td>14 (min)</td>
</tr>
<tr>
<td>5083-O Al/1100/Gd 1 Ti/304L SS</td>
<td>207</td>
<td>80 (min)</td>
<td>89</td>
<td>45 (min)</td>
<td>350</td>
<td>20</td>
<td>14 (min)</td>
</tr>
<tr>
<td>6061-T6 Al/1100 Al/Gd 1 Ti/Cu/304L SS</td>
<td>193</td>
<td>80 (min)</td>
<td>83</td>
<td>45 (min)</td>
<td>345</td>
<td>14</td>
<td>14 (min)</td>
</tr>
<tr>
<td>6061-T6 Al/1100/Gd 1 Ti/304L SS</td>
<td>214</td>
<td>80 (min)</td>
<td>89</td>
<td>45 (min)</td>
<td>350</td>
<td>20</td>
<td>14 (min)</td>
</tr>
</tbody>
</table>
Contact Ultrasonic Testing
Bonded plates are ultrasonically inspected to ASTM A578. Loss of back reflection is indicative of non-bond areas.

Continuous Ultrasonic Testing
C-scan images can be provided per ASTM and HEMI internally developed procedures. C-scan images can be used to map out quality bonded areas or areas to avoid during further processing.

Typical bonded plate with central detonation point and edge non-bond. Note standards on left side of the scan.
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