

High Energy Metals

Explosion Bonded Bimetallic Cryogenic Transition Fittings



High Energy Metals, Inc.

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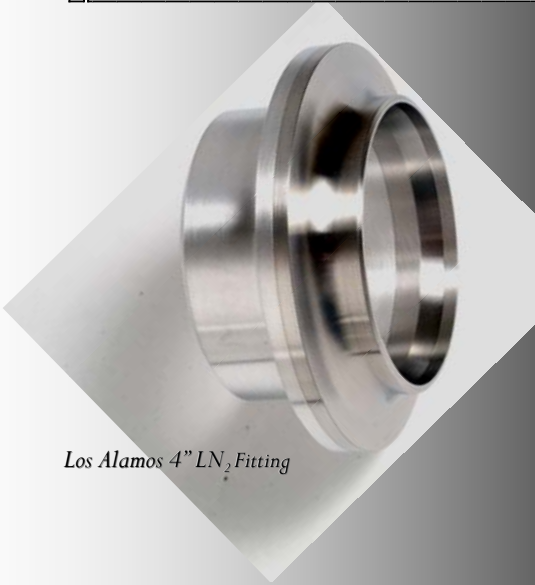
- Applications

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.

Lawrence Livermore LH₂ Fitting

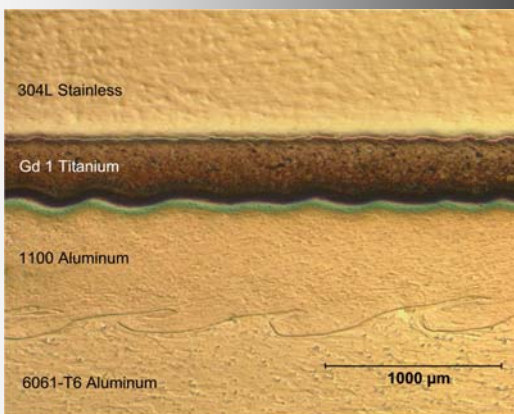


Los Alamos 4" LN₂ Fitting



Los Alamos 1" LN₂ Fitting

Lawrence Livermore LH₂ Fitting



Metallographic Image of HEMI Bonded Fitting



12" Diameter GOX Fitting

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- Explosion Bonding

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.



Explosion Bonding Event

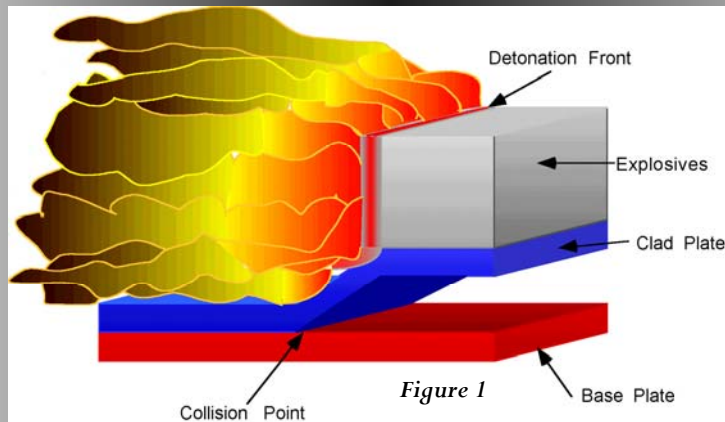
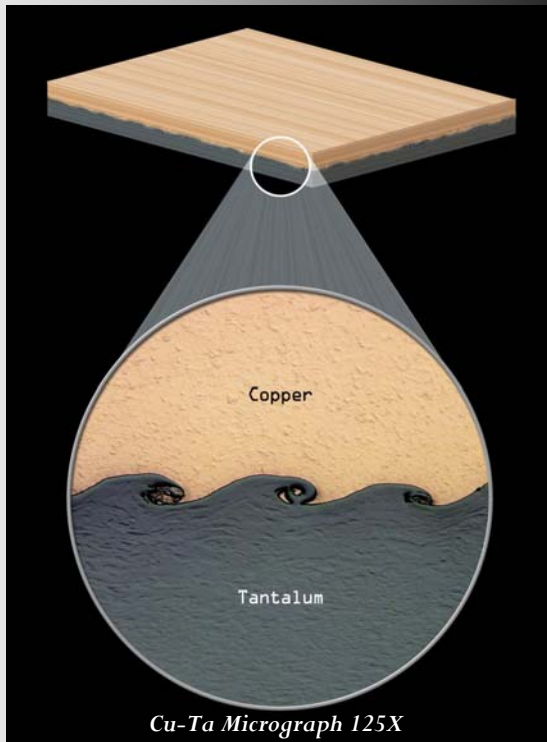


Figure 1



Cu-Ta Micrograph 125X



As-bonded Copper-Stainless Plate

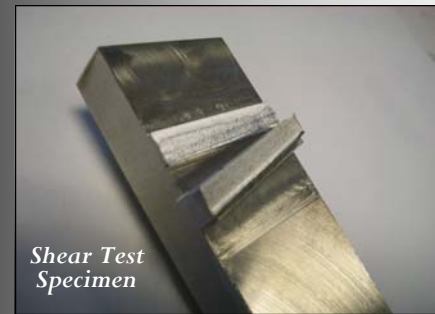
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- Testing & Quality

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.

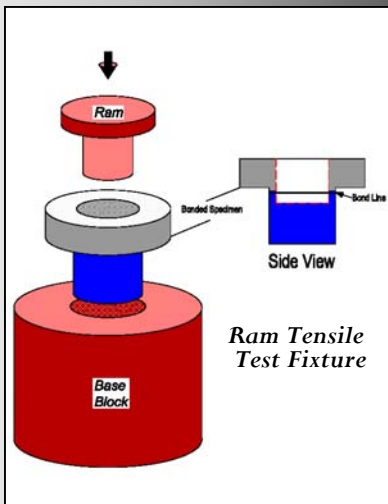
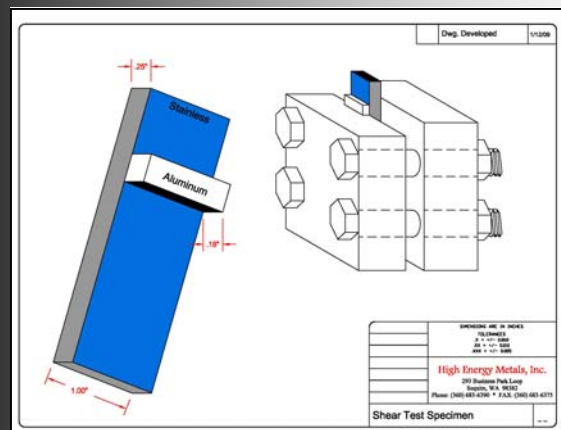
Pressure and leak testing of the bonded fittings are performed per customer requirements.



Shear Test Specimen



Tensile Test Specimen



Ram Tensile Test Fixture

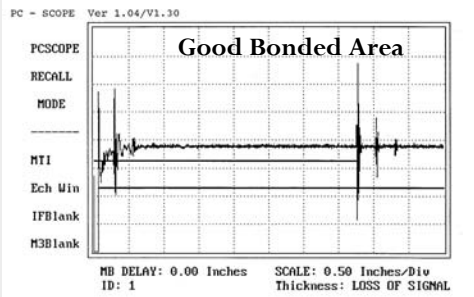


Pressure Test Fixture

<i>Typical Data Properties</i>	Tensile (MPa)	Tensile (-196°C)	Shear (MPa)	Shear (-196°C)	Comp (MPa)	Impact (J)	Impact (-196°C)
5083-O Al/1100 Al /Gd 1 Ti/Cu/304L SS	186	80 (min)	83	45 (min)	345	14	14 (min)
5083-O Al/1100/Gd 1 Ti/304L SS	207	80 (min)	89	45 (min)	350	20	14 (min)
6061-T6 Al/1100 Al /Gd 1 Ti/Cu/304L SS	193	80 (min)	83	45 (min)	345	14	14 (min)
6061-T6 Al/1100/Gd 1 Ti/304L SS	214	80 (min)	89	45 (min)	350	20	14 (min)

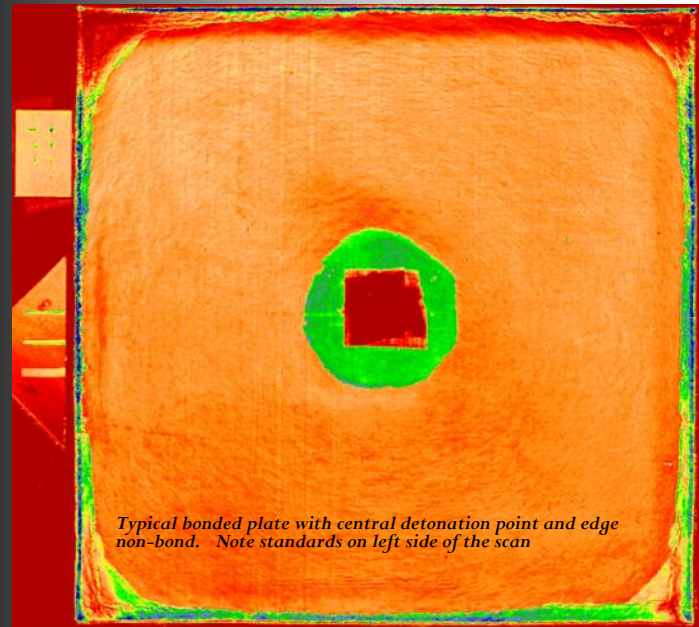
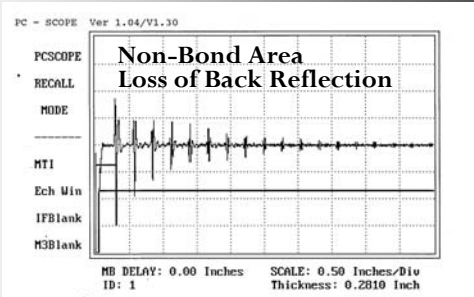
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- Testing & Quality



Contact Ultrasonic Testing

Bonded plates are ultrasonically inspected to ASTM A578. Loss of back reflection is indicative of non-bond areas.

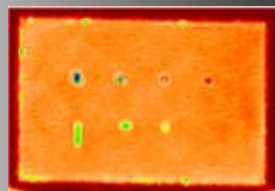


Continuous Ultrasonic Testing

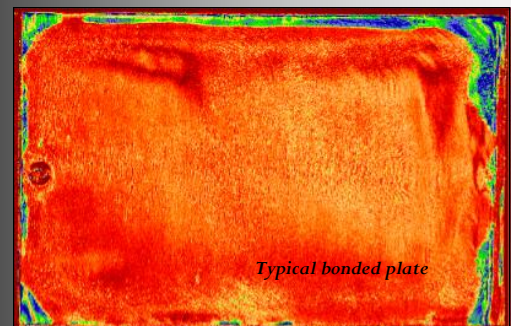
C-scan images can be provided per ASTM and HEMI internally developed procedures. C-scan images can be used to map out quality bonded areas or areas to avoid during further processing.



C-scan Color Gradient
 Percent of Interface Reflection



Ultrasonic C-scan Standard



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