Testing Tensile and Shear Epoxy Strength at Cryogenic Temperatures
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Background
• In order to attach MLI blankets to spacecraft in a manner to survive a combination of acceleration, acoustic, and venting loads while minimizing the parasitic heat load to the tank. The attachments serve as direct heat loads to the tank and often are a significant portion of a tank applied heat load [1]. There have been instances where MLI was not appropriately attached to spacecraft and has been lost or damaged, compromising the mission [2,3]. Based on a review of typical attachment methods, most use plastic (nylon or ultem) holders to minimize conduction loss through a blanket. However, these plastics have a much larger coefficient of thermal contraction and often contract 1% or more than most base metals [4]. As such, an epoxy must be able to handle the differential contraction between the two materials and also handle the many other forces that it may encounter.
• A typical insulation system for a cryogenic upper stage would include spray-on foam insulation (SOFI) underneath the MLI blankets to prevent air liquefaction. The polyether-imide standoffs would be attached to the tank and protrude through the SOFI to provide points of attachment for the MLI blankets. Previous attempts to attach the MLI directly to SOFI has induced cracking in the SOFI as shown in Figure 1 [5].
• For reference, Figure 2 shows a possible configuration of a standoff with an MLI blanket. The flat, disk portion of the standoff is bonded to the tank wall with epoxy. The strength of that epoxy bond at cryogenic temperatures is important since failure of that bond would cause the MLI to separate from the tank and increase the boil-off of cryogenic propellants. Therefore tests were conducted to assess the tensile and shear epoxy strength to aluminium, primed aluminium, and stainless steel samples at cryogenic temperatures.

Coupon Preparation and Cooling
15 Epoxies (65 coupons) tested in tensile and shear over the last 8 months.

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Conclusions/Results
• Best performance from CTD CryoBond 621, Masterbond EP29LPSP, and Scotchweld 2216
• Sound indicators of epoxy and standoff failures
• 5 of 6 standoff failures occurred above 25lbs
• 24 of 65 samples survived tensile and shear testing (not including standoff breaks)