Adhesively bonded joints used in space applications experience large temperature differences. As a result, the coefficient of thermal expansion (C.T.E) mismatches between the adherends induce thermal stresses in the adhesive. This can significantly reduce the load capacity of the joint. In addition, other challenges facing industry include developing analytical models to predict joint behavior and obtaining good correlation with test results. A design by analysis system was implemented to create and fabricate an aluminum fitting to reduce the effects of thermal stresses in the adhesive. The final design was tested, and all specimens showed failure in the composite tube. In addition, most of the thermally cycled joints failed at higher loads than the non cycled joints.

**Design Method**

The double lap joint (fig. G) would be the strongest joint for both loading cases, however it is too costly to manufacture due to the difficulty in machining. The final design (fig. H), was chosen for its manufacturability as well as its high resistance to thermally induced stresses. Tapers were not included due to the small thickness of the aluminum fitting (.050”). Based on analytical data, the final design implements an optimal bond length of 1.25” and a bond thickness of .010”.

An attempt was made to design a balanced joint (E*Ti = E*Ii). This led to an Al 2024 T351 fitting of .035” thick, however, this thickness was increased to .050” to prevent yielding up to 20,000 lbs. Key elements surrounding the bonding process include meticulous surface preparation using acetone and grit blasting. Bond line thickness was controlled using .010” bond wire, and pressure during curing was applied using wire ties.

**Design Development**

The double lap taper tube (fig. G) was chosen for its performance in both loading cases. The center ply is .005” thick and all others are .002” thick. Composite tube lay-up: [0° /+70° /-70° / 0° /-70° /+70° / 0°].

**Results**

<table>
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<th>Test Specimen</th>
<th>Thermal Cycled</th>
<th>FEA Adhesive*</th>
<th>FEA Composite*</th>
<th>Test*</th>
<th>% Correlation</th>
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</table>

*Failure loads given in lbs; “FEA Adhesive” indicates the loads that would be needed to see failure in the adhesive; not our predicted failure loads

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