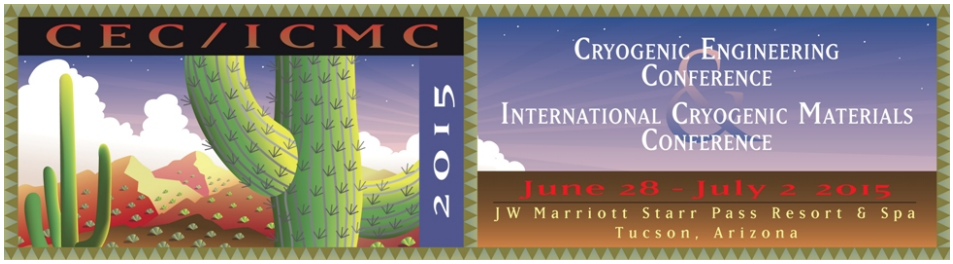

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Demonstration of Hybrid Multilayer Insulation for Fixed Thickness Applications

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Once on orbit, high performing insulation systems for cryogenic systems need just as good radiation (optical) properties as conduction properties. This requires the use of radiation shields with low conductivity spacers in between. By varying the height and cross-sectional area of the spacers between the radiation shields, the relative radiation and conduction heat transfers can be manipulated. However, in most systems, there is a fixed thickness or volume allocated to the insulation. In order to understand how various combinations of different multilayer insulation (MLI) systems work together and further validate thermal models of such a hybrid MLI set up, test data is needed. The MLI systems include combinations of Load Bearing MLI (LB-MLI) and traditional MLI. To further simulate the space launch vehicle case wherein both ambient pressure and vacuum environments are addressed, different cold-side thermal insulation substrates were included for select tests.
The basic hybrid construction consists of some number of layers of LB-MLI on the cold side of the insulation system followed by layers of traditional MLI on the warm side of the system. The advantages of LB-MLI on the cold side of the insulation blanket are that its low layer density (0.5 –0.6 layer/mm) is better suited for lower temperature applications and is a structural component to support heat interception shields that may be placed within the blanket. The advantage of traditional MLI systems on the warm side is that radiation is more dominant than conduction at warmer temperatures, so that a higher layer density is desired (2 - 3 layer/mm) and less effort need be put into minimizing conduction heat transfer. Liquid nitrogen boil-off test data for a cylindrical calorimeter are presented along with analysis for spacecraft tank applications.

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