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Strain Compatibility Tests for Sprayed Foam Cryogenic Insulation

A new method for testing rigid, spray-applied polyurethane foam cryogenic insulation realistically simulates actual use conditions. The method involves the application of mechanical stress to a foam-coated specimen while it is maintained at a cryogenic temperature.

The test specimens are produced by spray application of polyurethane foam (density: 2 or 3 lb/ft³) on standard "dogbone" tensile coupons cut from a 0.125-in. thick sheet of aluminum alloy 2014-T6. Various defects may then be deliberately introduced into the foam by: 1) removing the cured foam from the central portion of the specimen, coating the edges with polyurethane resin, and refilling the cutaway section with foam; 2) spraying one half of the coupon, curing the foam, then spraying the other half, overlapping the first application; 3) cutting one or more simulated cracks either all or part way through the foam at various places along the coupon; and 4) coating the central portion of the metal coupon with a mold release agent prior to foaming, so as to produce an area where the foam is not bonded to the metal.

The strain compatibility tension tests are conducted with the aluminum coupon in contact with liquid hydrogen at -423°F, while the surface of the foam is maintained at a temperature between 40° and 125°F. The test apparatus comprises a load train, a cryostat, and assorted instrumentation. The load train consists of a 50,000 lb hydraulic strut, a load cell, and miscellaneous rods and clevises. The test cryostat is a welded aluminum box, insulated with styrofoam and fitted with a copper plate and tubular heat exchanger to maintain the proper surface temperature on the foam. With test specimens placed in the cryostat so that the aluminum coupon is in contact with the liquid hydrogen, the copper plate is placed over the

top surface of the foam. Hot gaseous nitrogen is circulated through the heat exchanger to maintain the proper foam surface temperature. A tensile preload of 2600 ± 500 psi is maintained on the specimen during chilldown. After the aluminum cools to a temperature less than -413°F, tensile stress is applied to the specimen. A maximum load of $72,000 \pm 1000$ psi, corresponding to a strain of 0.0059 in./in. in the aluminum alloy, is reached within a period of 45 to 90 seconds then gradually removed. The specimen is then warmed to a temperature above -200°F, removed from the apparatus, and inspected for defects in the foam or in the foam to metal bond.

Notes:

1. This testing technique was developed by a NASA contractor and successfully used in the development of polyurethane spray foam insulation as cryogenic tank insulation for the Saturn S-II rocket vehicle. It has also been employed as a quality control test, by coating one or more test coupons with foam during the application of each batch.
2. Requests for further information may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
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No patent action is contemplated by NASA.

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