Using Aerogel-Based Insulation Material To Prevent Foam Loss on the Liquid-Hydrogen Intertank

Flight Environment Measurement

Uninsulated areas on cryogenic propellant tanks and feedlines cause moisture in the air to condense or ice to form. Flange joints, bracket supports, expansion bellows, and other cavities are uninsulated by design. These areas cannot be sealed because conventional thermal insulation materials would restrict mechanical articulations. Aerogel-based thermal insulation systems are able to seal critical locations such as the liquid-oxygen (LO_2) feedline bellows.

A new thermal insulation system was also necessary between the intertank wall, flange, and the liquid-hydrogen (LH_2) tank dome, where there is a cavity (or crevice) with an exposed 20-K surface. When nitrogen gas is used for purging within the intertank volume, it condenses on this cold surface. Some solid nitrogen may also form on the colder side of the crevice. Voids or discontinuities within the foam can pressurize and cause areas of foam to weaken and break off, reducing thermal efficiency and creating potentially dangerous debris.

To prevent this foam loss, we developed a thermal insulation system using bulk-fill aerogel material and demonstrated it with a one-tenth-scale model of the LH_2 intertank flange area (Figure 1). Temperature sensors were placed in the crevice, in the intertank barrel section, and on the foam surfaces (Figure 2). Cold helium gas sprayed onto the underside of the tank dome helped to maintain a cold-boundary temperature of 20 K ±5 K, and two electric tape-heaters on the lid helped to maintain a warm-boundary temperature of 300 K ±2 K. The intertank volume was purged with nitrogen gas at a controlled flow rate to maintain a thermal balance within the system, with the hot-side lid at 300 K and the cold-side tank dome at 20 K. The aerogel insulation dramatically reduced nitrogen cryopumping and generally increased temperatures throughout the intertank. Only a thin layer of aerogel insulation was required in order to prevent liquid nitrogen (LN_2) from forming. The aerogel material remained completely dry and friable (no free LN_2) in all cases.

These aerogel bulk-fill materials and other aerogel-based insulation systems are viable new options for the design and safe operation of cryogenic propellant tanks.

Contacts: Jared P. Sass <Jared.P.Sass@nasa.gov>, NASA-KSC, (321) 867-0694; and James E. Fesmire <James.E.Fesmire@nasa.gov>, NASA-KSC, (321) 867-7557

Participating Organization: ASRC Aerospace (Dr. Barry J. Meneghelli, Philip A. D'Andreamatteo, and Gary L. Wall)

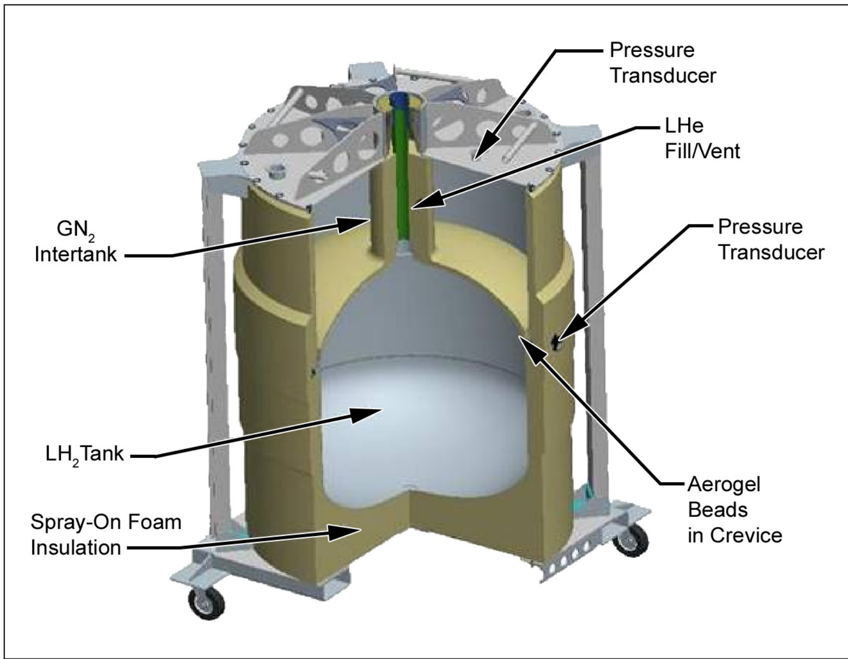

Figure 1. An isometric cutaway view of the LH_2 intertank demonstration test unit, showing main features.

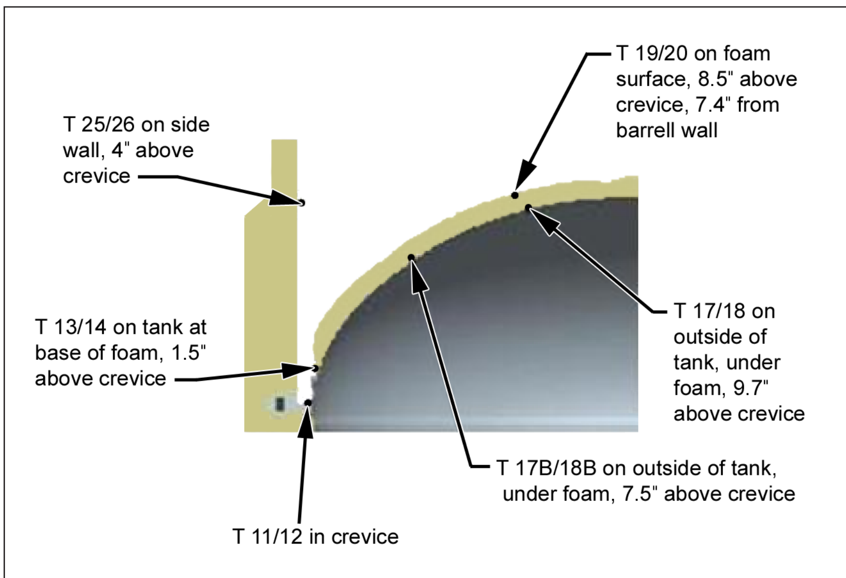

Figure 2. Section view of one-tenth–scale demonstration test unit, showing temperature sensor.