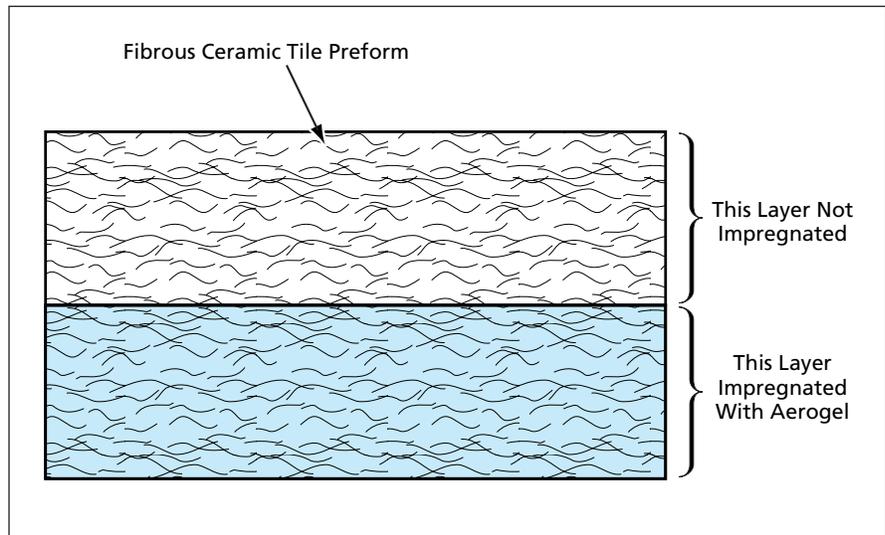


of cryogenic systems, the heat of condensation undesirably adds to the heat flowing to the objects that one seeks to keep cold. Moreover, there is a risk of explosion associated with vaporization of previously condensed gas upon reheating.

- Aerogels offer low permeability, low density, and low thermal conductivity, but are mechanically fragile.

The basic idea of the present invention is to exploit the best features of fibrous ceramic tiles and aerogels. In a composite tile according to the invention, the fibrous ceramic serves as a matrix that mechanically supports the aerogel, while the aerogel serves as a low-conductivity, low-permeability filling that closes what would otherwise be the open pores of the fibrous ceramic. Because the aerogel eliminates or at least suppresses permeation by gas, gas-phase conduction, and convection, the thermal conductivity of such a composite — even at normal atmospheric pressure — is not much greater than that of the fibrous ceramic alone in a vacuum.

In a typical application, a composite tile according to the invention is made from an open-pore rigid ceramic-fiber tile preform by impregnating the preform with an aerogel part way through its thickness (see figure). The details of the impregnation process depend on the specific ceramic and aerogel materi-



A Fibrous Ceramic Tile Preform Is Impregnated with an aerogel part way through its thickness. The invention is not restricted to a single aerogel-impregnated layer as shown here: alternatively, there can be multiple layers impregnated by the same aerogel and/or different aerogels.

als, the desired thickness of the aerogel-impregnated layer, and the desired density of the aerogel. In general, one prepares an aerogel-precursor solution by mixing two component solutions. The preform is partially infiltrated with the precursor solution. The gelation reaction occurs spontaneously between the components of the solution at room temperature. To complete the process, the aerogel is dried in one or more subprocesses that can include fluid extraction at supercritical temperature and

pressure, heating to a temperature above ambient but below the sintering temperature of the aerogel, venting, and/or purging with dry air.

*This work was done by Susan M. White and Daniel J. Rasky of Ames Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-12070.*

## Urethane/Silicone Adhesives for Bonding Flexing Metal Parts

**These adhesives make strong, flexible bonds.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Adhesives that are blends of commercially available urethane and silicone adhesives have been found to be useful for bonding metal parts that flex somewhat during use. These urethane/silicone adhesives are formulated for the specific metal parts to be bonded. The bonds formed by these adhesives have peel and shear strengths greater than those of bonds formed by double-sided tapes and by other adhesives, including epoxies and neat silicones. In addition, unlike the bonds formed by epoxies, the bonds formed by these adhesives retain flexibility.

In the initial application for which the urethane/silicone adhesives were de-

vised, there was a need to bond spring rings, which provide longitudinal rigidity for inflatable satellite booms, with the blades that provide the booms' axial strength. The problem was to make the bonds withstand the stresses, associated with differences in curvature between the bonded parts, that arose when the booms were deflated and the springs were compressed. In experiments using single adhesives (that is, not the urethane/silicone blends), the bonds were broken and, in each experiment, it was found that the adhesive bonded well with either the ring or with the blade, but not both. After numerous experiments, the adhesive that bonded best

with the rings and the adhesive that bonded best with the blades were identified. These adhesives were then blended and, as expected, the blend bonded well with both the rings and the blades.

The two adhesives are Kalex (or equivalent) high-shear-strength urethane and Dow Corning 732 (or equivalent) silicone. The nominal mixture ratio is 5 volume parts of the urethane per 1 volume part of the silicone. Increasing the proportion of silicone makes the bond weaker but more flexible, and decreasing the proportion of silicone makes the bond stronger but more brittle.

The urethane/silicone blend must be prepared and used quickly because

of the limited working time of the urethane: The precursor of the urethane adhesive is supplied in a two-part form, comprising a resin and a hardener that must be mixed. The resulting urethane adhesive has a working time of 3 to 5 minutes. To prepare the urethane/silicone blend, one must quickly add the silicone to the urethane adhesive and mix it in thoroughly within the working time of the urethane.

Once the urethane/silicone blend has been mixed and applied to the bond surfaces, it takes about 2 hours for the adhesive to cure under pressure. However, it takes about 24 hours for the adhesive to reach full strength.

*This work was done by Paul D. Edwards of Caltech for **NASA's Jet Propulsion Laboratory**. Further information is contained in a TSP (see page 1). In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concern-*

*ing rights for its commercial use should be addressed to:*

*Innovative Technology Assets Management  
JPL*

*Mail Stop 202-233  
4800 Oak Grove Drive  
Pasadena, CA 91109-8099  
(818) 354-2240*

*E-mail: [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov)*

*Refer to NPO-30737, volume and number of this NASA Tech Briefs issue, and the page number.*