



## Manufacturing & Prototyping

### Self-Healing, Inflatable, Rigidizable Shelter

**Military applications include self-sealing fuel tanks on vehicles or aircraft. Commercial applications include leak protection systems for railroad tank cars or tanker trucks carrying hazardous materials.**

*Marshall Space Flight Center, Alabama*

Any manned missions to extraterrestrial locations will require shelter structures for a variety of purposes ranging from habitat to biomass production. Such shelters need to be constructed in such a way as to minimize stowed volume and payload weight. The structures must also be very durable and have the ability to survive punctures without collapsing. Ways of increasing available crew-load volume without greatly increasing launch weight or volume are also sought. Inflatable structures are ideal candidates for habitat structures for several reasons: (1) they feature the low stowage volume and payload weight; (2) deployed volume can be easily increased without large increases in launch weight or volume; and (3) they offer unique opportunities for incorporating intelligent and/or multi-functional systems such as self-healing capability, power generation and storage, sensor systems, and radiation protection.

An inflatable, rigidizable shelter system was developed based on Rigidization on Command (ROC) technology incorporating not only the required low-stowage volume and lightweight character achieved from an inflatable/rigidizable system, but also a self-healing foam system incorporated between the rigidizable layers of the final structure to minimize the damage caused by any punctures to the structure.

The technology builds functionality into a conventional inflatable habitat structure by incorporating a light, rigidizable composite material that can be used to make up the outer shell of the habitat structure. This composite material is used to form the two outer layers of a “sandwich” structure in which the inner layer is comprised of a foam-generating system with two components designed and placed such that they will mix upon impact and quickly seal any breaches to the habitat structure, thereby preserving the internal atmosphere of the habitat. The light, rigidizable composite is comprised of a woven glass fabric impregnated with a resin specially formulated to cure upon exposure to ultraviolet (UV) light. These composites cure extremely quickly upon exposure to UV light, either from sunlight or from other UV sources including lamps and LEDs (light emitting diodes). These composites can be extremely strong and tough, depending upon which components are employed in the resin formulation.

The inner foam self-healing system is comprised of separately encapsulated layers of the two major components of urethane foams — polyol and isocyanate — containing all the necessary catalysts, surfactants, and blowing agents required for

function. The two layers are assembled next to each other and, in the event of a puncture, both layers rupture, initiating contact of the two components. The subsequent foaming is rapid and serves to rapidly seal the system. A subscale prototype demonstrator has been designed that will allow for demonstration of all aspects of this technology including deployment, UV rigidization of composite structures using LED illumination, and scaling of punctures using an encapsulated polyurethane foam system.

The encapsulated polyurethane foam system forms the functional heart of this innovation and will greatly enhance the lifetime of inflatable habitat structures on the lunar surface or elsewhere in the solar system. Encapsulating the components ensures a proper ratio of materials to achieve the foam reaction needed for sealing, and the components are chosen such that they will react quickly and with the generation of a large volume of foam in order to seal a puncture.

*This work was done by Andrea Haight and Jan-Michael Gosau of Adherent Technologies, Inc., and Anshu Dixit and Dan Gleeson of ILC Dover for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at [sammy.a.nabors@nasa.gov](mailto:sammy.a.nabors@nasa.gov). Refer to MFS-32845-1.*

### Improvements in Cold-Plate Fabrication

**Improvements in fabrication, cooling fluid, structural parts, and components reduce weight, fabrication steps, and costs.**

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Five improvements are reported in cold-plate fabrication. This cold plate is part of a thermal control system designed to serve on space missions.

The first improvement is the merging of the end sheets of the cold plate with the face sheets of the structural honeycomb panel. The cold plate, which can be

a brazed assembly, uses the honeycomb face sheet as its end sheet. Thus, when the honeycomb panel is fabricated, the face sheet that is used is already part of the cold plate. In addition to reducing weight, costs, and steps, the main benefit of this invention is that it creates a more structurally sound assembly.

The second improvement involves incorporation of the header into the closure bar to pass the fluid to a lower layer. Conventional designs have used a separate header, which increases the geometry of the system. The improvement reduces the geometry, thus allowing the cold plate to fit into smaller area.

The third improvement eliminates the need of hose, tube, or manifold to supply the cooling fluid externally. The external arrangement can be easily damaged and is vulnerable to leakage. The new arrangement incorporates an internal fluid transfer tube. This allows the fluid to pass from one cold plate to the other without any exposed external features.

The fourth improvement eliminates separate fabrication of cold plate(s) and structural members followed by a process of attaching them to each other. Here, the structural member is made of material that can be brazed just as that of the cold plate. Now the

structural member and the cold plate can be brazed at the same time, creating a monolithic unit, and thus a more structurally sound assembly.

Finally, the fifth improvement is the elimination of an additional welding step that can damage the braze joints. A tube section, which is usually welded on after the braze process, is replaced with a more structurally sound configuration that can be brazed at the same time as the rest of the cold plate.

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*Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Hamilton Sundstrand. Inquiries concerning licenses for its commercial development should be addressed to:*

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