3. Developing EVA procedures and tools to detect and repair or cover sharp edges from MMOD impacts on handrails.

Since the above changes were incorporated into EVA hardware and procedures, the incidents of cut gloves have been greatly reduced.

Toughened Thermal Blankets for Micrometeoroid and Orbital Debris Protection

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Thermal blankets are used extensively on spacecraft to provide thermal protection from temperature extremes encountered in space. Typical thermal blankets are relatively thin (1/4-in. to 1/2-in. thick) and provide effective thermal protection, but they can provide only minimal protection from hypervelocity MMOD particles. As a consequence, MMOD shielding is often necessary to supplement the protection provided by thermal blankets alone to meet MMOD protection requirements. Because thermal blankets and MMOD shielding share similar physical space on the outside hull of a spacecraft, an integrated hardware design that performs as a thermal blanket and MMOD shield could yield numerous benefits, such as reduced mass and cost.

The JSC ARES Directorate’s HVIT group and the Engineering Directorate’s Structural Engineering Division worked together in 2011 and 2012 to integrate MMOD protection with standard thermal blankets (figure 1). These MMOD toughened thermal blankets incorporate one or more layers of materials near the exterior of the blanket that are effective at breaking up MMOD particles; other layers deeper in the blanket that resist fragment penetration; and low-mass, open-cell foam materials that separate the layers and improve MMOD protection. Typical materials used to enhance the MMOD protection of thermal blankets include fiberglass cloth, ceramic fabrics, and high-strength flexible materials. Hypervelocity impact tests were performed at White Sands Test Facility (WSTF) to demonstrate the effectiveness of the toughened blankets (figure 2), which can stop MMOD particles that are 5-mm to 6-mm in diameter, as opposed to the standard thermal blanket, which is completely penetrated by submillimeter-diameter MMOD particles (typically on order 0.5 mm). This translates roughly into a factor of 1000x decrease in MMOD risk of thermal blanket penetration and damage to underlying equipment. The means to determine the location, depth, and extent of MMOD impact damage is obtained by adding impact detection sensors at one or more locations within the blanket (figure 3). The toughened thermal blankets were tested in thermal-vacuum chambers at JSC (figure 4) to prove that the materials integrated into the thermal blanket to improve MMOD protection did not adversely affect the thermal performance of the blankets.

The toughened thermal blankets have application in a number of areas on the ISS and commercial spacecraft. For instance, the blankets are being considered for use in protecting the metal bulkheads of an inflatable module from MMOD impacts.

Figure 1.– Toughened thermal blankets.

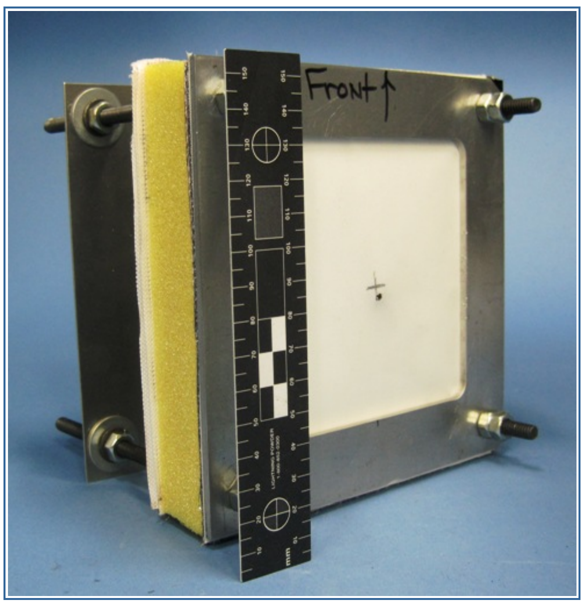

Figure 2.– Hypervelocity impact tests were performed to demonstrate the effectiveness of the toughened thermal blankets.

Figure 3.– Impact sensor film.

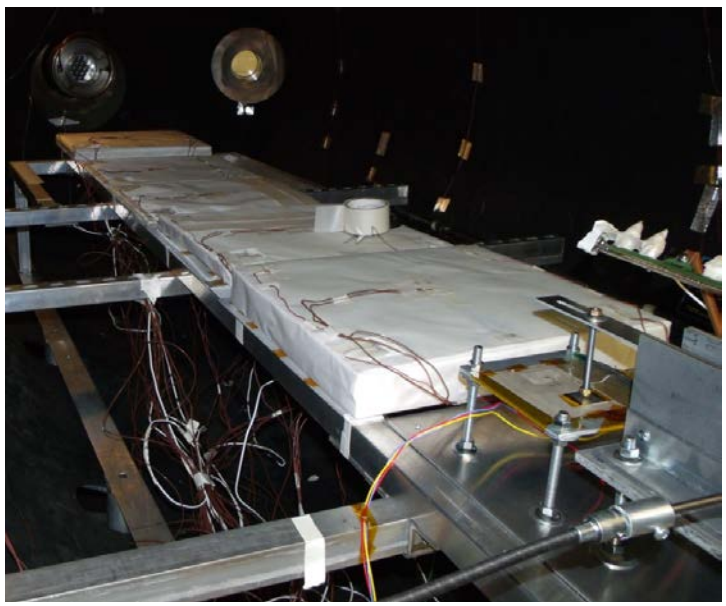

Figure 4.– Thermal-vacuum tests of toughened thermal blankets.