X-38

Test Program Description

The X-38 is a vehicle being developed for crew transfer to support the International Space Station (ISS). The X-38 was once known as an Experimental Crew Return Vehicle (XCRV). It is now simply referred to as a Crew Return Vehicle (CRV). Several series of hypervelocity impact tests have been conducted at the HITF on samples of Thermal Protection Materials (TPS) for the X-38.

The tests were conducted to determine under what conditions an impact would result in failure. Three failure modes were identified:

- direct penetration of the tile and the underlying aluminum honeycomb

- non-penetrating damage sufficient to cause tile damage which would lead to failure by heating during subsequent atmospheric re-entry

- non-penetrating damage sufficient to pose a threat while docked to the Space Station.

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Test Program Description

The TPS materials were of two basic types. One was a hard tile intended for the underside of the X-38, very similar to a Space Shuttle TPS. This type is sometimes referred to as "TUFI". These tiles were bonded to a backing of composite honeycomb sandwich material. The second type of TPS sample was an AFRSI (Advanced Flexible Reusable Surface Insulation) blanket meant for the upper surface of the X-38. The AFRSI blanket panels were bonded to the same type of honeycomb backing as the TUFI tiles.

Projectiles used in these test series were aluminum spheres, fired from light gas guns at impact velocities of approximately 7 km/sec. Most tests were conducted with the velocity vector normal to the TPS surface (which we define as 0° impact angle); one in the second series was conducted at an impact angle of 45°.

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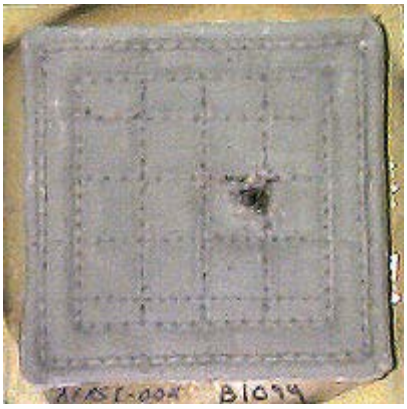
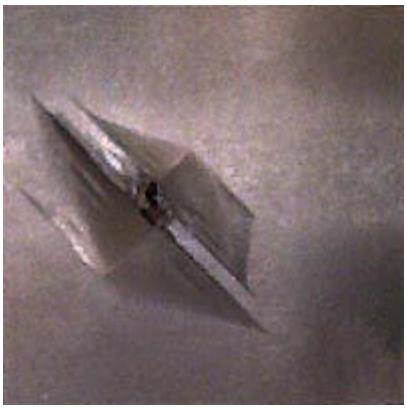
Test Program Results

The purpose for the first test series was simply to learn what projectile sizes would penetrate completely through the TUFI tile and the honeycomb backing, or cause spall from the rear of the honeycomb. For the AFRSI blankets, the failure criterion also required the impact to pentrate or cause detached spall from an aluminum sheet rear wall mounted 10 cm (4") behind the honeycomb. These failure criteria, for TUFI and AFRSI, would endanger crew members of an actual X-38 attempting to enter Earth's atmosphere.



The tests indicated that the minimum projectile size to cause failure was between 5.56 mm (7/32") and 6.35 mm (1/4") for TUFI tile targets. For AFRSI targets, the projectile size for failure was slightly larger than 6.35 mm (1/4").



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Test Program Results

The second X-38 test series addressed the following question: if the X-38 TPS were struck by a projectile not large enough to cause target failure by itself, could subsequent heating during atmospheric entry cause failure at the damaged spot? In this test series, after impact, the targets were subjected to heating at the JSC Arc Jet Laboratory. Once a sufficient number of subpenetrating impacts were achieved for the heating studies, additional impact tests attempting full penetration were conducted.

Subpenetrating projectile sizes used were 3.57 mm (9/64") to 5.56 mm (7/32") against TUFI tile targets, and 2.8 mm to 3.57 mm (9/64") against AFRSI blanket targets.

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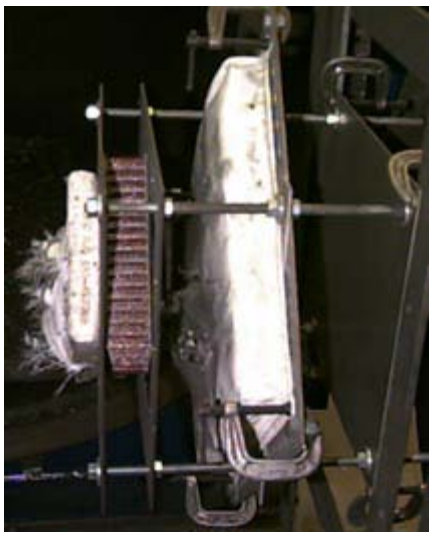
Test Program Results

The third X-38 test series was to address a question of Space Station safety. While the X-38 is docked to the ISS, what scale of impact on X-38 TPS materials would not only render the X-38 inoperable, but would threaten Station atmospheric integrity as well? To cause failure in this case, an impact not only had to penetrate the TUFI tile or AFRSI blanket and the honeycomb, it also had to penetrate a thermal insulation pad and a 0.09" (2.29 mm) thick aluminum rear wall representing the ISS pressure hull, or cause spall on that rear wall.



Projectiles up to 1.0 cm in diameter were fired against TUFI tile targets, and projectiles up to 8.73 mm (11/32") in diameter were fired against AFRSI blanket targets. In no case did the rear wall fail. The rear wall was dented in several impacts, but there was never any indication of penetration, cracking, or spall.