Thermal and Structural Testing of Repaired Orbiter Thermal Protection Tiles

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Johnson Space Center (JSC) and The Boeing Company collaborated on thermal and structural testing and analysis of orbiter thermal protection tiles that have been repaired with Shuttle Tile Ablator 54 (STA-54). Tile repair is a new aspect of mission support since the return to flight effort following the space shuttle *Columbia* accident in 2003.

Using STA-54 to repair tile damage is one contingency option that has been developed and tested to understand the thermal and structural behavior of the ablative tile repair material and tile-ablator combination in the sequence of environments the orbiter experiences throughout its trajectory from space, reentry into the Earth's atmosphere, and landing. Analytical tools developed by Boeing are used to assess STA-54 and are correlated with ground-based STA-54 vacuum-dispensed test data. Scientists conducted a series of tests to develop and compare on-orbit-dispensed and ground-dispensed STA-54 test data to show that analytical tools are valid for assessing on-orbit dispenses.

In March 2008, orbiter tile test articles with large cavities simulating tile damage were filled with STA-54 on-orbit during STS-123. In parallel, tiles with the same configuration were filled with STA-54 in a vacuum. Upon return from flight, two of the flight test articles and a ground-filled test article were thermally tested at JSC's Arc Jet facility and subsequently structurally tested in the JSC Structures Test Laboratory.

Fig. 1. *STS-123 on-orbit STA-54 dispense (top); STA-54 on-orbit dispensed test articles post-flight (bottom).*

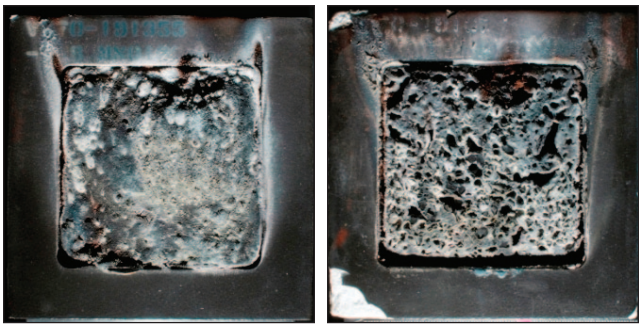

Fig. 2. *On-orbit dispensed Arc Jet test articles.*

Thermal and Structural Testing

During Arc Jet tests, which simulate the orbiter's reentry heating environment, the tiles were subjected to a 927°C (1700°F) environment for 900 seconds. Post test, the test articles were three-point flexure tested at room temperature to a deflection an order of magnitude greater than the maximum deflection expected during flight.

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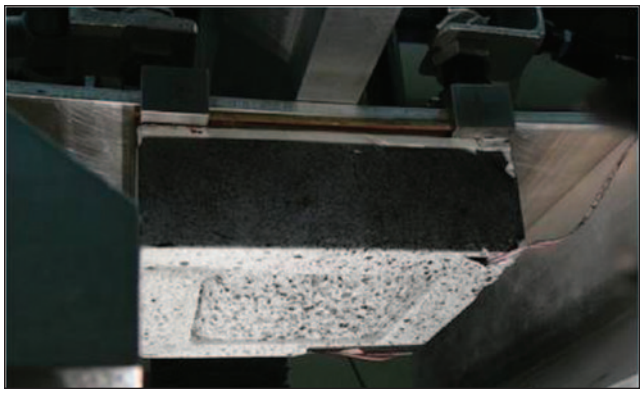

Fig. 3. *Three-point flexure test.*

Thermal test results indicate that both ground-dispensed and on-orbit-dispensed test articles performed similarly in STA-54 ablation and swell. Transient temperature profiles closely matched for ground-dispensed, on-orbit dispensed, and the baseline nominal undamaged tile. Tile strain data collected during flexure testing for STA-54 ground-dispensed and on-orbit-dispensed tile were within range of each other, exhibiting very small tile strain—200 micro-strain at most. Test data show similar thermal and structural performance of ground-dispensed and on-orbit dispensed Arc Jet tile repairs, a favorable outcome that demonstrates the analytical tools correlated with ground-dispensed STA-54 tile repairs are valid for on-orbit STA-54 tile repairs. These results build confidence in the thermal and structural performance of STA-54. Confidence is also gained in the material as a viable contingency option for tile repair that will protect the orbiter's aluminum structure from high heat during reentry—an important role in bringing the crew home safely.