# Cryogenic Moisture Analysis of Spray-On Foam Insulation (SOFI)

*Thermal Protection System (TPS) Enhancements*

The NASA Cryogenics Test Laboratory at Kennedy Space Center conducted long-term testing of SOFI materials under actual-use cryogenic conditions. The lab tested NCFI 24-124 (acreage foam), BX-265 (close-out foam, including intertank flange and bipod areas), and a potential alternate material, NCFI 27-68 (acreage foam with the flame retardant removed).

Specimens of all three materials were placed at a site that simulated aging (the Vehicle Assembly Building [VAB]) and a site that simulated weathering (Atmospheric Exposure Test Site [beach site]). After aging/weathering intervals of 3, 6, and 12 months, the samples were retrieved and tested for their ability to absorb moisture under conditions similar to those experienced by the Space Shuttle External Tank (ET) during the loading of cryogenic propellants.

The Cryogenic Moisture Apparatus (CMA) is designed to determine the amount of water or ice taken into the specimen under actual-use cryogenic conditions. To simulate actual-use conditions, the top of the specimen is fixed at the temperature at which nitrogen remains liquid, while the bottom (outside) face is exposed to moist air at a constant humidity (90 percent) inside an environmental chamber. In order to the keep the air quiet and the convection currents minimized, fans are not used. The surface temperatures of the specimen are also monitored by thermocouples and recorded by a LabVIEW data acquisition system. The edges of the CMA are guarded from moisture intrusion and from substantial heat leakage. The moisture uptake is measured by the water or ice taken into the specimen vertically (i.e., through the thickness of the specimen). Figure 1 shows the CMA and test setup.

All tests were conducted at ambient pressure (760 torr). The typical run time was 8 hours from start of cooldown to simulate the timeline for loading the Space Shuttle ET with cryogenic propellants. The warm boundary temperature (WBT) was approximately 293 K and the cold boundary temperature (CBT) was approximately 78 K. The specimen, including its edge guard ring, was quickly removed and replaced every hour to measure the weight gain.

Some results for the weathering case are shown in the table. These typical results are averaged values for a number of test runs and are given in percentage weight gains, using a 7-inch effective heat transfer area (between the 6-inch-diameter cold chamber and the 7-inch-diameter exposed face) for an 8-hour cold soak. Figures 2 and 3 compare the weight change for specimens of NCFI 24-124 at the aging (VAB) and at the weathering (beach) sites.

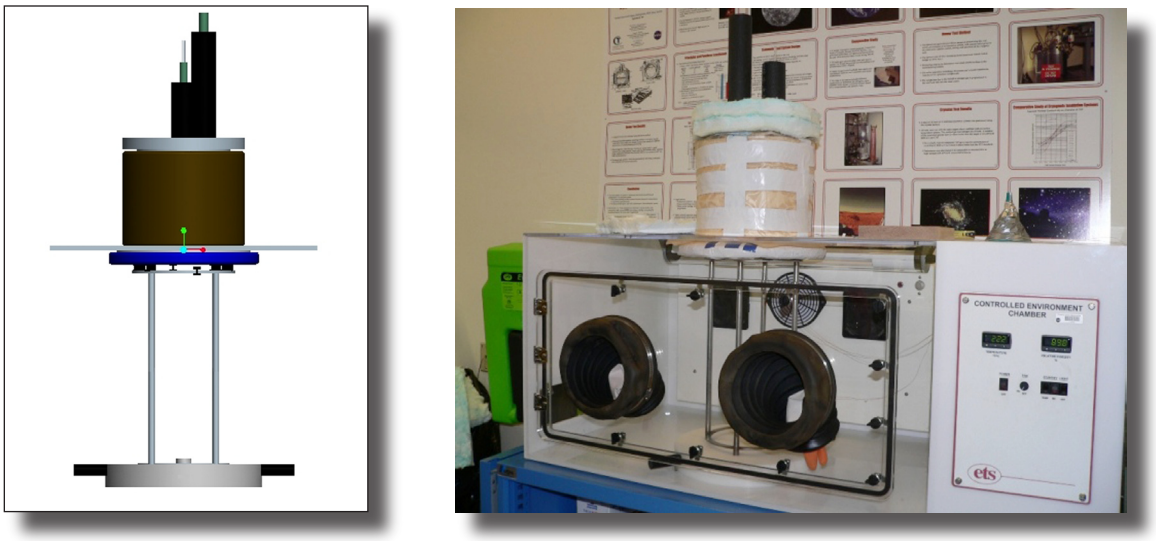


*Figure 1. Cryogenic Moisture Apparatus: schematic (left) and overall view, including environmental control chamber (right).*

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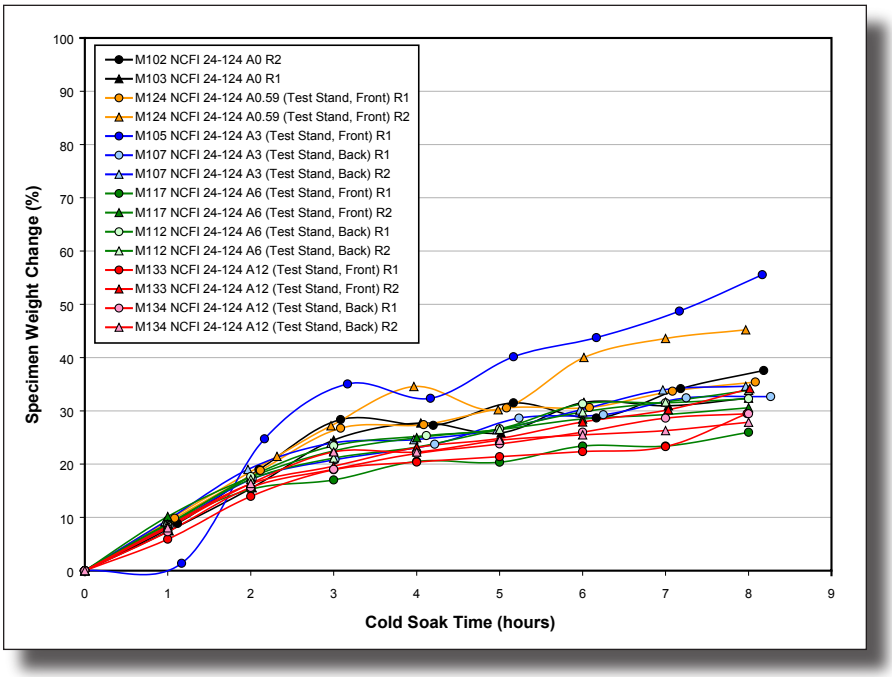
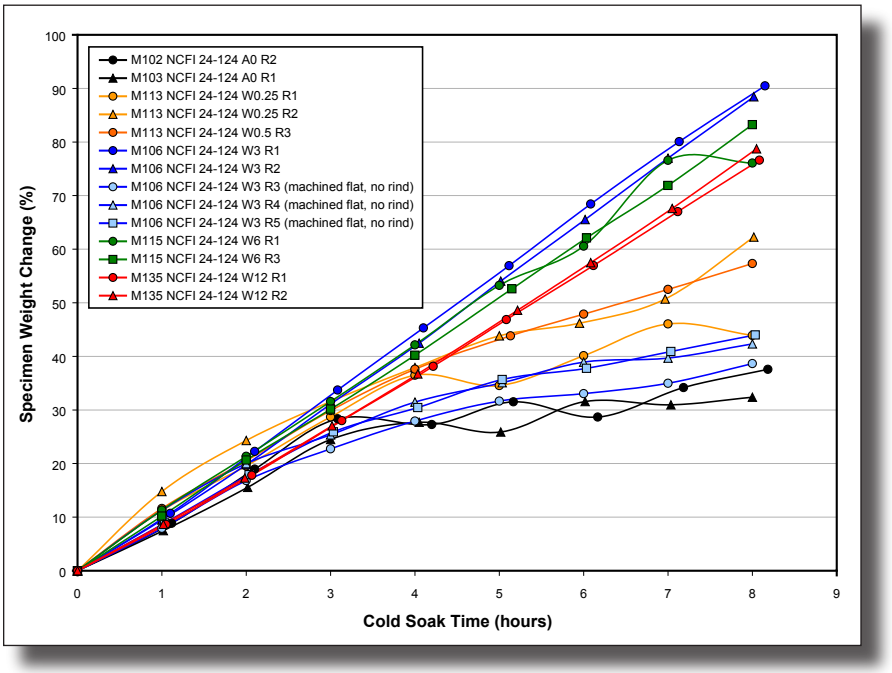
*Weight gain results of SOFI weathering tests.*

| Material | Baseline (%) | 3 Month (%) | 6 Month (%) |
|---|---|---|---|
| NCFI 24-124 | 30 | 78 | 74 |
| NCFI 27-68 | 32 | 72 | 72 |
| BX-265 | 30 | 70 | 95 |




*Figures 2. Uptake of cryogenic moisture in aged NCFI 24-124 samples (12-month data).*




*Figures 3. Uptake of cryogenic moisture in weathered NCFI 24-124 samples (12-month data).*