Fire Chemistry Testing of Spray-On Foam Insulation (SOFI)

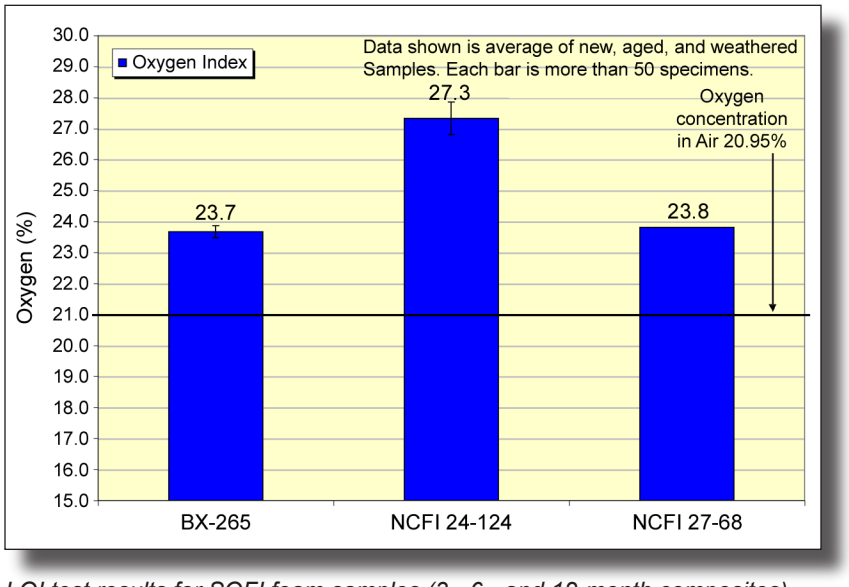
Flight Environment Measurement

An experimental study was initiated that included the long-term testing of the following SOFI materials, which make up the majority of the Thermal Protection System of the Shuttle External Tank: NCFI 24-124 (acreage foam) and BX-265 (close-out foam, including the intertank flange and bipod areas). A potential alternate material, NCFI 27-68 (acreage foam with flame retardant removed), was also tested. Specimens of all three foam materials were placed at two locations: an aging site (Vehicle Assembly Building [VAB]) and a weathering site (Atmospheric Exposure Test Site, [beach site]). Fire chemistry testing was completed on samples that were retrieved after aging/weathering at intervals of 3, 6, and 12 months. The testing included three standard test methods: limiting oxygen index (ASTM G125), radiant panel (ASTM E162), and cone calorimeter (ASTM E1354).

During the 12-month weathering period, all foams showed little to no change in the limiting oxygen index (LOI). The LOI test, which measures the ease with which a flame is extinguished, indicated that NCFI 24-124 is an inherently flame-retardant material, whereas BX-125 and NCFI 27-68 are not. In essence, all foams tested will burn in an enriched-oxygen atmosphere (i.e., oxygen leak). Figure 1 shows the results of the LOI test.

The results of radiant-panel testing, which measures the critical ignition energy for a sample (flame spread factor) along with heat evolution, showed that the flame spread was quite high for NCFI 27-68 and BX-265 and that the flame spread rate increased with aged samples. A rind surface burns hotter, but slower (downward) than a machined surface for NCFI 27-68. The rind surface is also more susceptible to upward flash fire, according to the flame spread index. Both aging and weathering of SOFI samples increased the flame spread index.

Cone calorimetry measures the peak heat release of a sample, along with the heat release rate, time to ignition, and smoke density. The heat release rates of BX-265 and NCFI 27-68 were not affected by the aging or weathering of these materials as measured by cone calorimetry. However, weathering did reduce the heat release rate of NCFI 24-124 as measured by cone calorimetry. The flame spread index and heat evolution factor were higher for samples with a rind, which reached the peak heat release rate faster. Samples with a rind also burned faster and hotter. The order of heat release rate based on machined data was BX-265 > NCFI 27-68 > NCFI 24-124. Additional samples will be tested to confirm these preliminary results.



LOI test results for SOFI foam samples (3-, 6-, and 12-month composites).

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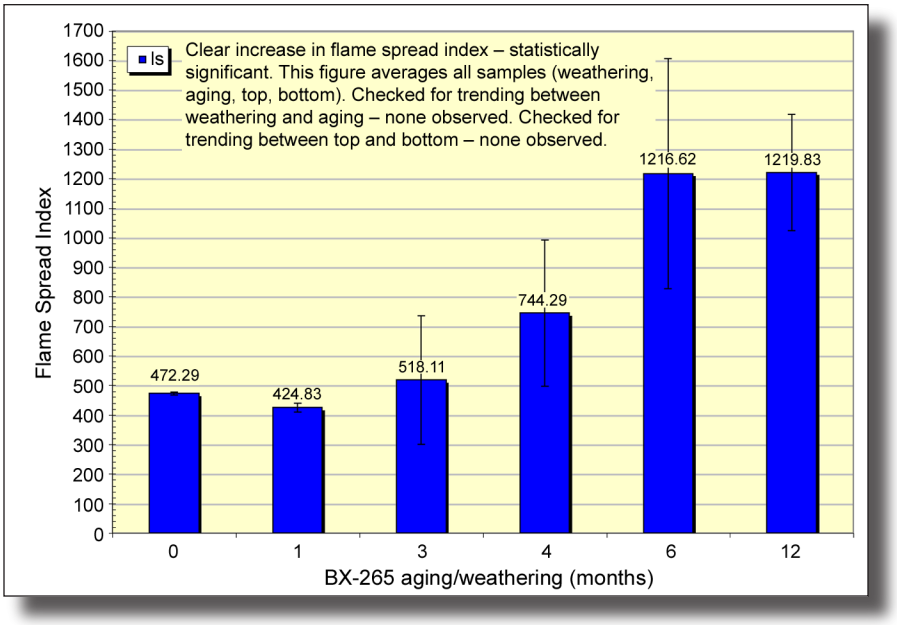
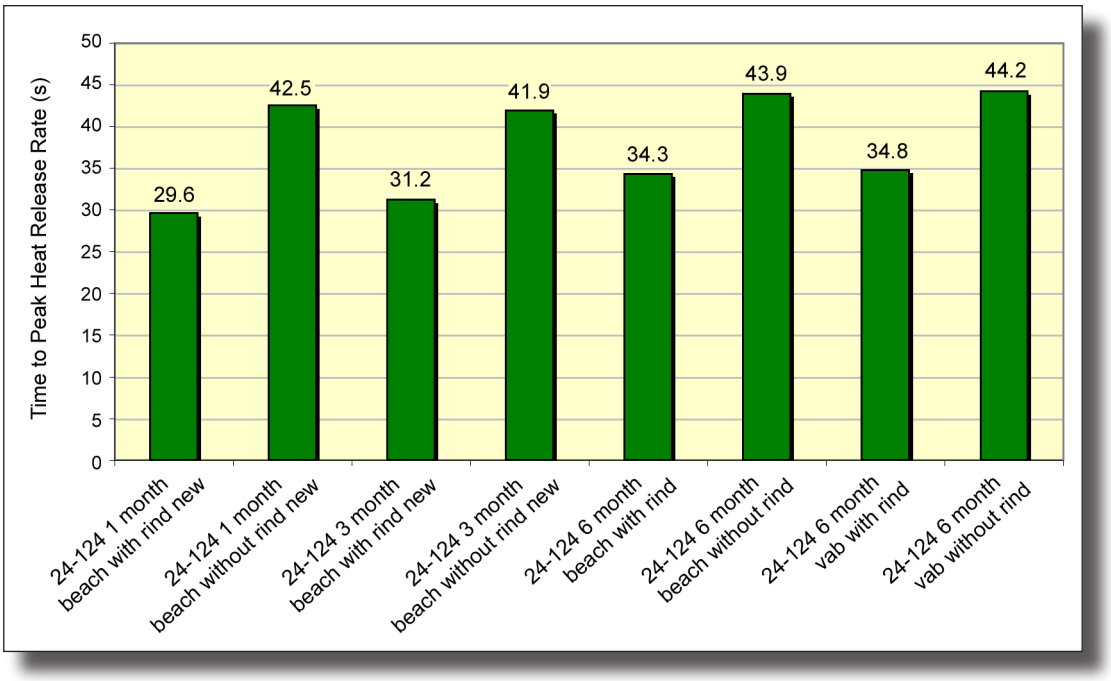


Radiant panel test results for BX-265.



Core calorimetry test results for NCFI 24-124.