Thermal Effects of an Advanced Wire Mesh Packaging Material*

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In order to be certified for transportation of radioactive materials, a container must pass a series of rigorous structural and thermal tests. Typical materials used in the construction of radioactive material transportation containers include stainless steel, mild steel, cellotex and organic foams. This paper presents the thermal characteristics of an advanced composite material for use in radioactive material transportation containers. Experimental and analytical methods were used to characterize the advanced packaging material.

The packaging material is made up of layers of aluminum wire mesh and insulating material. The wire mesh component of the composite material was sent to a certified test laboratory to determine the thermal conductivity. Laboratory results indicate that the wire mesh thermal conductivity is highly anisotropic. In and out-of-plane wire mesh thermal conductivity differ by an order of magnitude, with the in-plane thermal conductivity higher than the out-of-plane thermal conductivity.

A test package was built consisting of a stainless steel outer shell, an overpack, made of the advanced packaging material and a stainless steel containment vessel. The package was 39 inches long and had a diameter of 18 inches. A steady state experiment simulating normal transport mode and a transient experiment simulating an accident condition were conducted to characterize the packaging material in an actual packaging application. A heat source of 20 watts was included in the package to simulate the payload. The package was instrumented with type K thermocouples and temperatures were recorded during the test with a data acquisition system.

The transient test simulated the thermal boundary conditions specified in Title 10, Code of Federal Regulations, Part 71 (10CFR71). The test took place at Sandia National Laboratories Radiant Heat Facility. The previously described test package was used in the transient test.

The accident condition test results also show that the packaging material is a viable alternative to typical materials used in construction of radioactive material transportation containers. The seal temperatures did not exceed the maximum operating temperature of elastomeric materials. There was some localized melting of the overpack to a depth of between 1/4 and 1/2 inch from the inside surface of the outer shell. The melting may help the fire resistance of the package in that the melt zone provided a constant temperature boundary condition. In addition, an oxidation of the outer layers of wire mesh was formed which also contributed to the fire resistance of the package.

Testing was also performed to characterize the material as the material is crushed. A sample of the material was crushed, then the sample was subjected to a high heat flux. The results of the tests show that as the material is crushed, the out-of-plane thermal resistance decreases. The decrease in thermal resistance is due in part to a decrease in the thermal contact resistance between the layers.

A thermal model was developed for a specific package incorporating the packaging material as an overpack. The model was used in analyses of normal transport and accident condition. The model results correlated with the experimental data.

The experimental and analytical results show that the wire mesh composite material is a viable packaging material for use in construction of radioactive material transportation containers. A significant advantage of the wire mesh package technology is that even with tears in the outer skin, no additional heat load is presented to the containment vessel as would be experienced if combustible materials were used.

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