Executive Summary

On 1 January 1996, the High Speed Craft Code (HSC) entered into force as part of the Safety of Life at Sea (SOLAS) convention. This code deals with all aspects of the construction and operation of high-speed craft. The most common type of ships that are regulated by the code is passenger and vehicle ferries that operate within four hours from the shore. The code permits that a high-speed craft be constructed of combustible materials, provided certain fire performance criteria are met. Materials that meet these criteria are referred to as "fire restricting materials." The determination of fire restricting materials is based primarily on one of two tests. Bulkhead linings and ceiling materials are tested using the International Standard Organization (ISO) 9705 room corner test. Acceptance criteria for ISO 9705 are published in resolution MSC.40(64) of the International Maritime Organization (IMO). Furniture components (other than fabrics, upholstery, or bedding) and other components are tested using the ISO 5660 Cone calorimeter. No acceptance criteria are published for ISO 5660.

The U.S. Coast Guard is seeking to develop Cone calorimeter acceptance criteria to qualify lining, furniture components, and other combustible components of contents as fire restricting materials for high-speed craft. In support, a research program was conducted at Southwest Research Institute between August 1997 and July 1998 to develop data for comparing the results of various fire tests. Eight glass fiber-reinforced composite materials and one textile wall covering were tested in full scale in the ISO 9705 room. The same materials were also evaluated in small scale according to the test procedures of the Cone calorimeter, the IMO surface flammability test (Part 5 of the IMO Fire Test Procedures or FTP Code), and the IMO smoke and toxicity test (Part 2 of the FTP Code). The ISO 9705 room tests and some of the Cone calorimeter experiments were supplemented with toxic gas analysis using Fourier Transform InfraRed (FTIR) spectroscopy. Some of the composite materials were used as framing materials for mock-up chairs and luggage racks. The upholstery of the chairs consisted of a foam/fabric combination that meets the requirements of IMO Resolution A.652(16), "Recommendation on Fire Test Procedures for Upholstered Furniture." Room tests were conducted on these items. The primary objective of the additional full-scale tests was to

determine whether the Cone calorimeter acceptance criteria for linings developed in this study, are suitable pass/fail limits for fire restricting materials used as components of contents. Additional ignition, flame spread, and release rate measurements were made to obtain material properties for modeling.

This report covers the room tests, ISO 5660 Cone calorimeter tests, IMO surface flammability tests, and Lateral Ignition Flame Spread Tests (LIFT).

The results of the ISO 9705 and IMO surface flammability tests are summarized in Table 1. Material Nos. 1 and 6 slightly exceeded the ISO 9705 smoke production limits for fire restricting materials. Material No. 6 is identical to Material No. 5, but painted with an intumescent coating. Material No. 7 did not exceed the ISO 9705 criteria for heat release and smoke production, but failed due to the fact that flaming debris fell to the floor during the test. However, flaming persisted for only a few seconds. Furthermore, this phenomenon occurred only once during the test.

Table 1. Summary of Room and Surface Flammability Test Data

Material	No.	ISO 9705	FTP Code Part 5
FR phenolic	1	Fail (no flashover)	Pass
Fire restricting material	2	Pass	Pass
FR polyester	3	Fail (flashover @ 6.2 min)	Fail
FR vinylester	4	Fail (flashover @ 5.3 min)	Fail
FR epoxy	5	Fail (flashover @ 16.5 min)	Pass
Coated FR epoxy	6	Fail (no flashover)	Pass
Textile wallcovering	7	Fail (no flashover)	Pass
Polyester	8	Fail (flashover @ 1.8 min)	Fail
FR modified acrylic	9	Fail (flashover @ 11.1 min)	Fail

The following set of ISO 5660 acceptance criteria for fire restricting materials is consistent with the results obtained in this study: 1) time to ignition (t_{ig}) greater than 20 seconds; 2) maximum 60-second sliding average heat release rate ($HRR_{60,max}$) less than 60 kW/m^2; 3) total heat release (THR) less than 12 MJ/m^2; 4) maximum 60-second smoke production rate ($SPR_{60,\,max}$) less than 0.01 m^2/second; and 5) average smoke

production rate (SPR_{avg}) below 0.005 m^2/second. These values are averages from three tests conducted at a heat flux level of 50 kW/m^2 in the horizontal orientation using the retainer frame. These criteria are similar to those proposed to IMO by Finland in 1995, based on an analysis of data from the European Reaction to Fire Classification (EUREFIC) program.

The IMO surface flammability test criteria for finish materials appear to be correlative to the heat release rate criteria for fire restricting lining materials. Material No. 5 is the only material that met the IMO surface flammability criteria, but failed in the room/corner test due to excessive heat release. However, the time to flashover was the longest for this material, so there seems to be consistency between the two tests.

The room tests on contents confirmed that materials which meet the requirements for fire restricting linings could safely be used as framing materials and components of furniture and contents. The requirements could perhaps be relaxed, but a hazard or risk assessment is needed to develop revised acceptance criteria that do not compromise safety.