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Research Results

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Passenger Train Fire Safety

SUMMARY

Heat release rate (HRR) has been recently identified as a key indicator of real-scale fire performance of a material or construction, as well as ignition, flammability, and smoke emission. In 1994, the Federal Railroad Administration (FRA) began a multi-phase research study to investigate the use of fire hazard assessment using HRR data to provide a more credible and cost-effective means to predict the actual fire behavior of passenger train materials. HRR-based fire performance data for 30 materials used in typical Amtrak intercity rail cars were obtained from the conduct of Cone Calorimeter tests. The Cone Calorimeter test data and data from current FRA-cited test methods were compared. For the majority of materials, the relative ranking from "best" to "worst" was similar in both test methods.

Selected seat, wall panel, carpet and other assemblies from Amtrak trains were tested in the Furniture Calorimeter to provide further HRR data for fire hazard analysis. Hazard analyses of three different passenger car designs were then performed. Data from the Cone Calorimeter and Furniture Calorimeter were used as input to a computer fire model to predict the time to untenable conditions within a passenger rail car resulting from specified design fires and rail car fire scenarios. Each of the analyses confirmed that, in addition to material controls, design features, (e.g., geometry of the car) passive and active fire protection measures, and emergency evacuation equipment and procedures can have an impact on the resulting fire safety of the overall design. Full-scale tests using a donated Amtrak coach rail car were conducted to verify the fire hazard analysis predicted by the computer fire model.

Based on the results of this research program, the material fire performance table, as originally issued by FRA in the form of guidelines in 1984 and 1989 was revised and issued on May 12, 1999, as part of the Passenger Rail Equipment Safety Standards (49 CFR, Part 238). A clarification of the fire performance requirements was issued and published on June 25, 2002.

Figure 1. Full-scale fire test

BACKGROUND

ON May 12, 1999, the FRA issued passenger equipment safety standards that prescribe certain flammability and smoke emission test methods and performance criteria for rail cars. These requirements are based on guidelines for intercity and commuter rail cars which FRA first issued in 1984 and revised in 1989.

Based primarily on small-scale test methods which demonstrate fire characteristics of individual materials, the FRA tests and performance criteria form a prescriptive set of design specifications which historically have been used to evaluate transportation vehicle material fire performance. This approach provides a screening device to allow interested parties to identify particularly hazardous materials and select preferred combinations of individual components; material suppliers can independently evaluate the fire safety performance of their own materials.

However, in a report prepared for the FRA, published in 1993, the National Institute of Standards and Technology (NIST) identified hazard analysis based on heat release rate (HRR) as an alternative means to more cost-effectively evaluate the real fire behavior of an actual rail car.

HRR is considered to be a key indicator of fire performance and is defined as the amount of energy that a material produces while burning. For a given confined space (e.g., rail car interior), the air temperature is increased as the HRR increases. Even if passengers do not come into direct contact with the fire, they could be injured by high temperatures, heat fluxes, and/or smoke and gases emitted by materials involved in the fire. Accordingly, the fire hazard to passengers of these materials can be directly correlated to the HRR of an actual fire.

ADVANTAGES OF HAZARD ANALYSIS / HRR APPROACH

HRR and other data measurements generated from oxygen consumption calorimeters (e.g., Cone Calorimeter) can be used as an input to evaluate the contribution of a material's overall contribution to the fire hazard in a particular rail car application. Fire modeling and hazard analysis techniques allow evaluation of a range of design parameters, including material flammability, geometry, fire detection, fire suppression, and evacuation, as well as design tradeoffs which may arise from combinations of the parameters. However, further tests and assessment were considered necessary to evaluate the suitability of fire modeling and hazard analysis techniques for application to typical passenger train fire scenarios.

NIST RESEARCH PROGRAM

NIST is currently conducting a multi-phase research study to provide the basis for using this alternative to substitute or supplement the existing FRA individual material test methods and performance criteria approach. The primary focus of the first phase was to compare the performance of 30 materials used in typical Amtrak rail cars using FRA-cited test data and data obtained from Cone Calorimeter tests. A correlation between the Cone Calorimeter test data and the FRA-cited test data was performed.

Then, full-scale assembly tests were performed using trash bags and gas burner ignition sources in a large- scale Furniture Calorimeter. Rail car assemblies included seats, wall panels, carpeting, window and door curtains and drapes, windows, and mattresses. The assembly test data and the Cone Calorimeter data were used as inputs to three fire hazard analyses: a single level coach car, and bi-level dining and sleeping cars. The evaluation included different ignition sources, changes in rail car design and materials, detection and suppression systems, and passenger evacuation, to assess the relative impact on fire safety for a range of design parameters.

Finally, selected full-scale proof tests of an Amfleet I passenger rail car were conducted (Figure 1) to verify the predicted system performance against the small-scale and real-scale assembly tests and hazard analysis studies. It included two different types of tests to assess the accuracy of the results of fire hazard analyses conducted: 1) a series of gas burner tests conducted to evaluate the accuracy of the fire performance curves for an actual train car geometry and 2) a smaller series of tests to evaluate fire spread and growth for actual train car furnishings exposed to a range of initial fire sources.

Recommendations for further revision of the FRA table of test methods and performance criteria will be prepared for consideration in the

next phase of the passenger rail equipment rule development.

AMTRAK SEAT ASSEMBLY TESTS

Six proposed seat assemblies comprised of current upholstery and several alternative cushion foams, including fire blocking layers, proposed for the Amtrak High-Speed Trainset were tested in March 1997.

There was a complete lack of fire spread across seat surfaces following ignition and no substantial heat and/or smoke releases and/or carbon monoxide releases occurred with the assemblies tested. Several of the test assemblies used fire blocking layers similar to what are used on aircraft. The issue of vandalism is addressed by the use of Kevlar/Nomex combination which resists puncture and cutting.

PASSENGER RAIL EQUIPMENT RULEMAKING

The FRA issued requirements for fire analysis and material fire tests and performance criteria in the safety standards issued on May 12, 1999 (49 CFR, Part 238). The standard included table reorganization, expanded notes, material size and location exceptions, and allowance for seat assembly testing. The tests and performance criteria were based on input obtained from a workshop conducted in July 1997 with participants from the Volpe Center, NIST, passenger train system operators, rail car builders, material manufacturers, and test laboratories, as well as the results of the NIST research program. On June 25, 2002, the FRA issued a clarification to the May 12, 1999 safety standards that addressed petitions for reconsideration filed by Amtrak and commuter railroads. The revised rule clarified material requirements and suspended electrical wire and cable requirements pending further study.

CONCLUSIONS

The study has demonstrated that a strong correlation exists between the Cone Calorimeter data and flammability and smoke emission data obtained from other tests. In addition, the FRA fire safety requirements in 49 CFR, Part 238 introduced the concept of HRR test criteria for seat assemblies and small parts. Pending the completion of the research program, additional revisions to the fire test criteria may be appropriate.

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