Overview

The severity and impact of building fires is dictated by the flammability of the furnishings and contents, the performance of fire protection systems, and the actions of occupants and firefighters. Furnishings are the items first ignited in a large fraction of building fires including those fires responsible for many of the fire deaths in the United States. A primary tool used to limit fire growth in buildings is regulation of wall and ceiling materials, based on standard tests of the flammability and fire resistance. The development, revision, and approval of fire test standards has been a role of ASTM Committee E5 on Fire Standards. Recent advances in fire science and engineering have led to the development of computer models to predict the development of fire in buildings and new measurement methods to provide input data for those models. These analytical tools have highlighted the importance of ignitability, heat release, and flame spread rate of furnishings and contents on the growth of fire. Other scientific advances, particularly in the United States and in Europe on material flammability, are resulting in products such as upholstered furniture, mattresses, curtains, drapes, wall, and floor covering materials which will reduce the incidence, severity, and impact of building fires.

These advances in product flammability and measurement coupled with the introduction of new regulations on furniture flammability in various states in the United States and in European countries, prompted ASTM Committee E5 to sponsor an international symposium on "Fire and Flammability of Furnishings and Contents of Buildings," held in Miami, Florida, on 7 Dec. 1992. The fourteen technical papers published in this Special Technical Publication (STP) were presented at that symposium. The STP provides test laboratory personnel, regulators, researchers, and producers of furnishings and building materials with the recent international developments in flammability measurement and the significance of those measurements in fire hazards in buildings. Nine of the papers relate to furniture and five concern room lining materials.

M. M. Hirschler's papers on fire tests and interior furnishings provides an excellent introduction to the subject. The papers contain a broad international review of the development of fire tests and regulations on upholstered furniture, bedding, wall and floor coverings, apparel, and cabinetry. They cover the involvement of ASTM, the National Fire Protection Association, the California Bureau of Home Furnishings, limited State organizations, European and international standards organizations, and various manufacturing trade associations.

In the late 1970s, ASTM's subcommittee on Building Furnishings and Contents was charged with the responsibility of developing fire hazard standards for a variety of furnishings. Its response was to develop ASTM E 931-85, an empirical practice which assesses layout by various classes of occupancy and allows the user to develop rough performance criteria for furnishings used in those occupancies. In light of the more recent publication of a standard guide for the development of fire hazard assessment standards (ASTM E 1546), a more quantitative approach to hazard assessment, ASTM E 931-85 eventually will be withdrawn. However, since no actual fire hazard assessment standards using that new guide have yet been developed, Dr. Hirschler has outlined the history and concepts behind ASTM E 931-85. His papers published here should be of help to those interested in understanding the dangers involved in fires in buildings as the estimated resulting numbers still have actuarial value.

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Upholstered furniture and bedding represent the two leading classes of first items ignited in fatal fires in the United States. As a result, these items have received attention by researchers, test developers, and regulators. Measuring the rate of heat release of these items in full scale is expensive, making the use of bench-scale methods attractive. Vyto Babrauskas' paper compares the capabilities of bench-scale test methods in predicting full-scale heat release of mattresses and upholstered chairs. In addition, he identifies work that remains to be done, including the effect of ignition source location and a systematic study of smoke production.

The State of California has led the introduction of testing requirements for upholstered furniture. The California Bureau of Home Furnishings (CBHF) developed a test in which the conditions within a standard room are monitored and the rate of heat release measured when a piece of furniture is subjected to a flaming ignition source. The test and criteria for acceptance of public occupancy furniture have been adopted by a number of other states and are becoming a benchmark. Large numbers of chairs have been tested against the standard at private testing laboratories and at CBHF. Papers by A. Grand et al. and G. H. Damant et al. report on some of these tests and identify material selections and furniture design features that affect test performance.

The Commission of the European Communities (CEC) recently issued a draft furniture directive that states that the atmosphere in a room in which a piece of upholstered furniture is on fire must remain for a reasonable period of time after ignition such that it does not endanger the lives or physical well-being of persons. To achieve this goal the rate of heat release and smoke and toxic gas production will be controlled, but test procedures have not yet been finalized. Within the European standards and research communities attempts are being made to identify the relationships between bench-scale tests such as the cone calorimeter, full scale tests such as the furniture calorimeter, and conditions within a room to ensure that test procedures reflect the goals of the directive. The paper by B. Sundstrom reports progress by fire laboratories in the Nordic countries.

The cone calorimeter is a useful bench-scale test to explore the flammability performance of various material combinations used in the construction of upholstered furniture. Barrier materials between the foam cushion and the cover fabric can improve performance. H. H. Forsten's paper reports cone calorimeter measurements on a range of fabrics with and without a barrier material. Correlation between the cone calorimeter results and full furniture measurements is explored.

In addition to upholstered furniture and bedding materials, window treatments such as curtains and drapes provide fuel load, but because they provide a convenient conduit for spread they can be significant contributors to the development of home fires. C. H. Nelson et al. report the results of a series of reduced scale flammability tests, using a kitchen match as an ignition source, on combinations of ten different drapery fabrics and six drapery liners. Each of the materials also was tested individually using NFPA 701, Standards Methods of Test for Flame Resistant Textiles and Films. The results demonstrate the possibility for additional fire risk from home draperies and drapery liners due to the change in flammability potential of individual components when burned in combination.

Fire losses in Ontario, Canada, are comparable to those occurring throughout North America rendering them among the highest in the world. The paper by D. Crawford and M. Prencipe examines the role of furnishings and building contents as ignition sources and as items first to ignite structural fires. The analysis shows, as expected, the items involved vary according to property category such as educational, health care, retail, warehouse, and residential.

As stated earlier, standard tests for the flammability of room lining materials have been used traditionally as the basis for building codes and regulations. These tests, designed to represent specific full-scale fire scenarios, usually do not provide the input data necessary for newly developed fire risk and hazard analysis using computer models. E. Smith who developed the Ohio State University (OSU) computer model, one of the few room fire models available for evaluation of the contribution of wall and ceiling lining materials to compartment fire growth, recognized the need for data on the ignition and rate of heat release of materials and developed the OSU heat release rate apparatus. H. C. Tran's paper compares the predictive capabilities of the OSU model with full-scale fire tests on rooms lined with various materials, mostly wood or wood products. After a critical analysis of the OSU model and its limitations, one of which is the reliance on data from the OSU apparatus, M. Janssens describes a modified OSU room fire model, MOSURF, that uses as input heat release rate measurements from the cone calorimeter and flame spread measurements from the ASTM E 1321, Standard Test Method for Determining Material Ignition and Flame Spread Properties. A. Kim provides more extensive test data to compare small-scale methods for measuring the heat release rate and smoke production rate of room lining materials, discussing at length the cone calorimeter and the OSU test method. He reasons that higher heat release rates are obtained on the OSU apparatus than on the cone calorimeter because of thermal feedback from the enclosure and forced ventilation in the OSU. Small-scale test data from thirteen typical construction materials were used to attempt to classify materials that would flashover in a full-scale room burn. Some direct correlations were found in the prediction of flashover time but no correlations were found in smoke data, although it was possible to group materials into classes.

Current classification methods for building lining materials and surface finish products are based on separate tests that are difficult to relate to complete fire hazard. Furthermore, in Europe it has proved difficult to obtain any correlation between the different tests used in various countries. As a result of research under a Nordic program, EUREFIC, P. J. Hovde proposes a new classification system based on the time to flashover in a new room/corner test. He also reports encouraging progress towards an alternate method using results from the cone calorimeter. That method will require the use of mathematical models to calculate room corner test performance. B. Karlsson reports reasonably good agreement between results of model calculations and large-scale tests for two different fire scenarios. Success in these efforts will lead to international agreement on a classification system of building materials that is based on measurable fire hazard.

The advances presented at the International Symposium and reported in this STP reflect the effort underway on both sides of the Atlantic and should prove useful to those working to reduce the severity and impact of building fires around the world.

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