2009 BFRL Project Description

Project Title: Fire Growth and Spread on Real Objects

August 12, 2008

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Co-Investigator(s):

BFRL Program: Reduced Flammability of Materials

Objective: To provide a reference data set and improved understanding of burning behavior to guide the development of models capable of predicting fire growth and spread on non fire retarded polyurethane and simple geometry upholstery.

Problem:

What is the problem? Residential fires continue to be responsible for roughly 80 % of human and financial losses due to fire in the United States (NFPA). The largest fuel sources in homes are typically mattresses and upholstered furniture, which contain large masses of polyurethane. A substantial number of fire deaths occur when these objects are the first object ignited. (NFPA) However, it is likely that their role is much more important than indicated by these statistics since fire deaths and financial losses are dominated by fires that attain flashover (on-going NFPA study). The high percentage of fuel loads in these items in most homes means that fire spread and growth on them is typically necessary for flashover to develop so that fire spread to them and the subsequent fire growth is crucial even when they are not the first object ignited. A current focus of FDS research is the development of realistic fire spread and growth algorithms for real objects. Only limited experimental data are available to guide this development and for validation. Fire spread and growth measurements on well defined materials having simple geometries are an important step in this development. An improved understanding of the mechanisms of fire growth and spread is also required by researchers who are striving to improve, e.g., through the addition of nanoparticles, the fire performance of polyurethane and other man-made materials. An understanding of the physical processes that affect fire growth and spread allows additives to be tailored to modify these properties. Eventually, it will be possible to compare directly the effectiveness of the such approaches by making similar measurements on retarded samples.

Why is it hard to solve? Real-scale measurements of fire growth and spread on real materials require specialized equipment for time-resolved heat release rate and for measuring flame front location. Fire growth and spread is a stochastic process, and large variations are frequently observed between nominally identical experiments. Even though large numbers of real objects are burned in standard fire tests, very few measurements are made under conditions appropriate for characterizing fire growth and spread in a manner consistent with fire model

development and testing. The burning behaviors of materials such as polyurethane and combinations of polyurethane and fabrics are complex and need to characterized at a level sufficient for model development.

How is it solved today, and by whom? There are numerous laboratories working on related subjects such as pyrolysis behavior of materials and small-scale burning behavior of materials. However, we are unaware of any other efforts aimed at developing reference data for fire growth and spread characterization and prediction on real-scale objects. Only limited experimental measurements derived from fire test having different goals (e.g., fire tests related to the Station Nightclub fire) are currently available.

Why NIST? NIST/BFRL has developed and maintains the full-scale facilities necessary to make the reference measurements with known uncertainties. The project utilizes BFRL's core competency in fire protection and fire spread within buildings and communities. Measurements are designed to provide understanding and reference data that directly impact other projects in two of BFRL's priority areas: Measurement Science for Sustainable Infrastructure Materials and Measurement Science for Innovative Fire Protection.

Approach:

What is the new technical idea? This project is intended to provide reference data for fire growth and spread over polyurethane and fabric-covered polyurethane as well an improved understanding of the controlling fire behaviors. These data are designed to feed into on-going efforts within BFRL to extend FDS to modeling of fire spread and growth and to develop novel ways of improving the fire performance of polyurethane foam based on nanoparticle additives. The real-scale measurements are supported with targeted small-scale experiments designed to improve the understanding of polyurethane burning.

Why can we succeed now? Both of the BRFL efforts that this project supports have shown significant promise and progress in the recent past. Each is a significant effort with the potential for high pay off in terms of usefulness in the Nation's fight against fire losses.

What is the research plan? In the short term there are two components of the research effort. The first is a series of fire tests in which spread and growth is measured for fires spreading across non fire retarded 1.22 m x 1.22 m polyurethane slabs of variable thicknesses and with the foam covered with either polypropylene (thermoplastic) or rayon (charring material). Repeated measurements of spread rate, heat release rate, mass loss rate, surface heat flux, and internal temperature are made with the material held at various angles. The second component is aimed at understanding the burning behavior of polyurethane. Details concerning burning behavior are derived from the measurements and visual observations of the tests. Selected small scale tests are utilized to more carefully characterize polyurethane behaviors which are important for fire spread and growth.

In the longer term the experiments will be extended to investigate fire-retarded polyurethane foam (assuming such foams will burn under the test conditions employed). These experiments require foam samples having the same dimensions as those in our earlier work. The first focus will be commercially available foam that passes the California 117 fire test.

Concurrently, effort will be made to procure more exotic foam formulations (likely requiring special preparation by foam manufacturers) incorporating nano additives.

Recent Results: This project has been ongoing for three years. Three test series of polyurethane fires have been completed with the third and final test series with upholstered polyurethane completed in July, 2008. Cone calorimetry measurements for this foam have also been made. Results of preliminary findings for the first test series were presented at the Annual fire Conference. These findings have also been communicated to staff working on the FDS fire growth and spread model

Standards and Codes: CPSC is in the final stages of rule making for an upholstered furniture fire standard. This standard has been controversial since it focuses nearly entirely on smoldering sources. It is likely that additional efforts on flaming ignition will be forthcoming. This project deals explicitly with this type of fire. Environmental concerns have been raised about some of the flame retardants currently used to improve the fire performance of polyurethane foam. The improved understanding of polyurethane foam may prove useful in the search for alternate approaches of improving performance.