Reduced-scale test to assess the effect of fire barriers on the combustion behavior of core flammable materials: an upholstery-material composites case study

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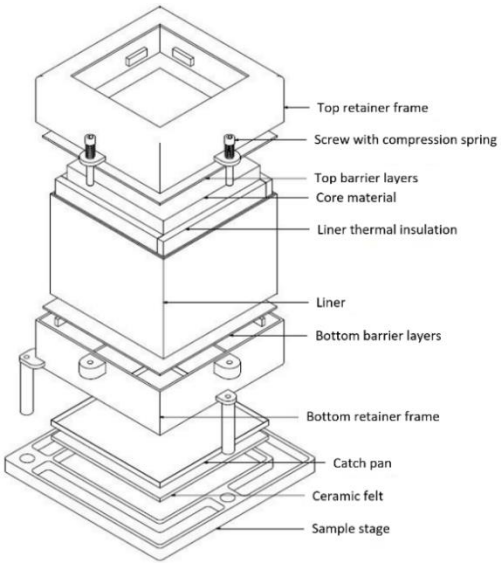
Keywords: reduced-scale testing, cone calorimeter, pool-fire

NIST has developed a reduced-scale test ("Cube" test) that aims to capture the effects of fire barriers on the combustion behavior of composites in which the core material is the primary fuel load. Upholstery material/composites employed in residential upholstery furniture (RUF) are used here as a case study. RUF are multi-component products including cover fabrics, interlinings, padding materials and frame elements in which the core material is the primary fuel load. The core material in RUF is a padding material (e.g., polyurethane foam and/or polyester fiber fill). Interactions among the combustion of the components make the prediction of real-scale performance based on single-component performance very challenging, if not infeasible.

RUF combustion is further complicated by the gradual collapse of the core material during combustion, and the formation of liquid products that ultimately drip and accumulate under the burning item to form a pool. Such a pool can ignite to form a pool-fire. Formation of a pool-fire under burning upholstered furniture can dramatically increase the peak heat release rate (up to roughly one order of magnitude) and thereby increase the fire hazard. The Cube test is a modified cone calorimeter test designed to identify the tendency of composites with a flammable core material to form a pool-fire. An exploded schematic and a photo of the specimen and specimen holder are shown in Fig. 1.

(a)



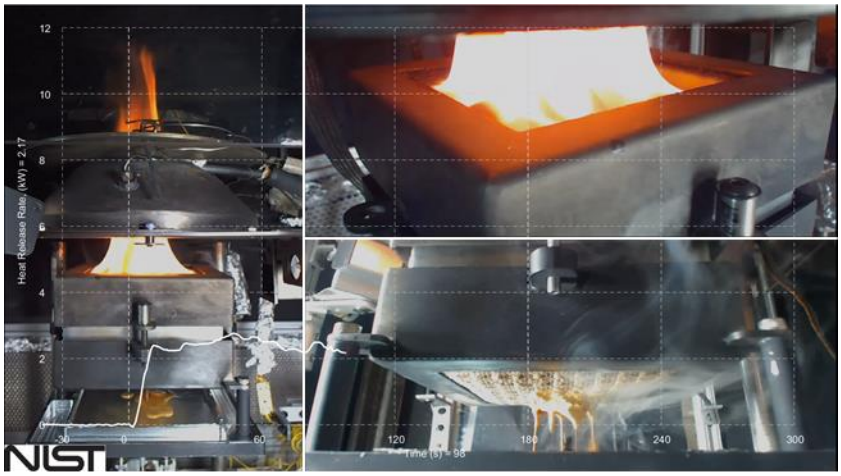
(b)

Figure 1. Specimen and sample holder: (a) exploded schematic and (b) photo of the assembly.

A cube-shaped piece of flexible polyurethane foam (nominal uncompressed length of 106 mm) is used as core material. Top and bottom barrier layers (e.g., cover fabrics, fire barriers, interliners, and a combination thereof) cover the top and bottom faces of the cube, respectively. The side walls around the core material are insulated. The barrier layers are sealed in place by compression between a metal liner and the top/bottom frame; metal springs ensure well-defined compression in repeated tests. Various barrier layers and core materials can be easily combined in the specimen holder to represent the construction of real-scale RUF cushions.

Fig. 2 shows a composite picture (wide view on the left, top view on the top right, and bottom view on the bottom left) for a given sample at the time of pool formation (Fig. 2a) and at the time of peak heat release rate (Fig. 2b).

(a)



(b)

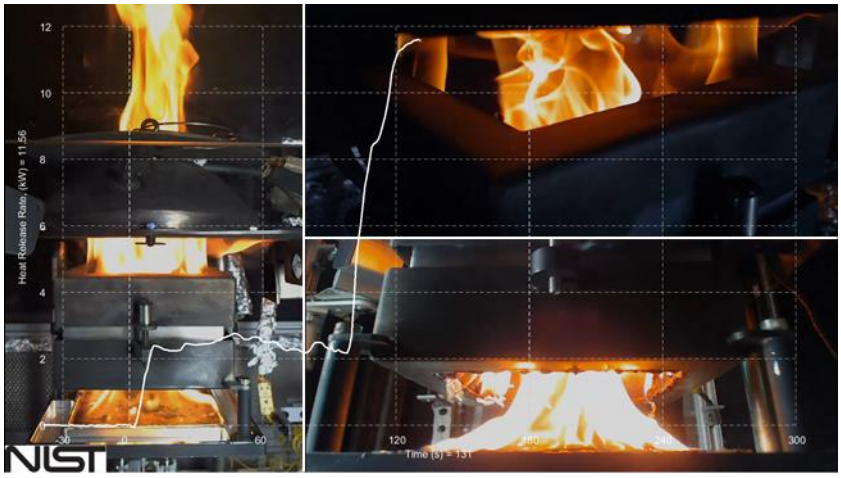


Figure 2. Composite picture for a given sample at the time of: (a) pool formation; and, (b) peak of heat release rate. The heat release curve (white line) is shown.

On-going research is intended to quantify how better performing upholstery materials in the reduced-scale test (a lower likelihood of developing a pool-fire with its associated relatively large peak heat release rate) are related to the performance of the same upholstery materials when tested in full-scale as an actual RUF item.