Got A Match?

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“The devil is in the details” is a cliché, but it's true with the standards commonly used to assess the flammability of scenery: NFPA 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films, and NFPA 705, Recommended Practice for a Field Flame Test for Textiles and Films. The two tests are sometimes used on the same piece of scenery, but they can give different results with inherently flame-retardant fabrics. Figuring out how the standards can be changed for more consistency is one of the main agenda items for the Flame Resistance Task Group, part of ESTA's Technical Standards Program. A look at the details of the tests and how they are conducted shows lots of places for lurking demons.

NFPA 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films, and NFPA 705, Recommended Practice for a Field Flame Test for Textiles and Films, are both tests that give pass/fail results with materials based on how much or how readily they burn. NFPA 701 is a laboratory test and is referenced by NFPA 101, the Life Safety Code, which says that, in an assembly occupancy, “combustible scenery of cloth, film, vegetation (dry), and similar materials shall meet the requirements of NFPA 701...”

I've recently written elsewhere that the test methods described in NFPA 701 are not difficult, but after more careful consideration of the equipment required — a convection oven for drying the fabric, a lab ventilation hood, a test chamber made of 12mm thick Marinite mineral board, 97% to 100% pure methane gas for the ignition source, ten samples of fabric for the test totaling 0.6sq-m., etc. — I must now write that I was wrong. The 701 test apparatus and procedure are fussy and impractical for use in the field. NFPA 705, the field test, is much more practical. The test equipment consists of a wooden kitchen match, tongs or pliers to hold the specimen being tested, and a specimen, which is a piece of fabric at least 12.7mm by 101.6mm (about ½" by 4", but it could be larger). Only one sample is needed, although the explanatory annex says, “the more specimens, the better.”

NFPA 705 test procedure is simple. A sample of the material is held so that the long axis is vertical and brought in contact with the flame of a wooden kitchen match, with the bottom of the match flame 12.7mm below the bottom of the sample. The flame is held there for 12 seconds and then removed. The material passes if:

1. The flame doesn't spread 101.6mm (4") or more up the sample;
2. There is no more than two seconds of “after-flame;” and
3. Any parts that drop off or drip do not burn after they reach the floor.

NFPA 701 uses a different method for evaluating the flammability of material. Ten samples are tested. Each sample is to be held from a stainless steel bar in the test chamber, and then a horizontally mounted

laboratory gas burner is moved so that the aperture is 25mm away from the bottom edge of the sample, and the methane flame is allowed to burn in that fixed position for 45 seconds before being removed. The material passes if:

1. Any burning particles that fall off stop burning within two seconds;
2. The specimens on average lose no more than 40% of their weight during the test; and
3. No specimen's weight loss is more than three standard deviations from the mean for the ten specimens.

The NFPA 701 and the NFPA 705 tests give comparable results when used on things that are highly flammable, such as untreated cotton; things that won't burn, such as mineral fiber; and fairly similar results when used on natural fibers that have been treated with flame-proofing compounds. However, on inherently flame-retardant fabrics, the results do not always correlate well. That is, a sample from a bolt of fabric that has passed the 701 test might be judged by a fire inspector to fail the 705 field test when he decides to check the material for himself. This is a problem. When scenery fails the field test, the fire inspector normally requires it to be treated with flame-retardant until it passes or to be removed from the theatre. In some cases, the scenery can remain but only with a fire watch.

Inconsistent results between the 701 lab test and the 705 field test should surprise no one. NFPA 705 says in its scope: “There is no known correlation between this recommended practice and NFPA 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films, or full-scale fire behavior.” Furthermore, NFPA 705 says, “The field test method has utility only when the authority having jurisdiction has no reliable data and, therefore, is forced to rely solely on the field test findings.”

The 705 standard itself says that it's unreliable, doesn't tell you how things will burn in a full-scale fire, and shouldn't be used when better data is available, so a fire inspector shouldn't take a match to a bit of soft goods if there is a credible certificate stating that the material has passed the 701 lab test. However, a campaign to get fire inspectors to stop doing field tests is not likely to be successful. Fire inspectors are passionate about public safety, and no inspector wants a disaster on his watch. Few are going to entrust the lives of an audience or their careers to a piece of paper offered by a stranger. If an inspector has a shadow of a doubt, he'll want proof with his own eyes. It would be easier to change the 705 standard than to change the inspectors.

I was interested in seeing for my own eyes how inherently flame-retardant fabric behaves in a 701 and a 705 test and how it compares with treated cotton. I found that I could not reasonably do the 701 test exactly as specified on my own, but I could do an approximation that would show me what happens when a sample of an IFR polyester curtain lining fabric is exposed to a propane gas flame, about the same size as the specified methane flame, in a similarly-sized test chamber, made of gypsum board rather than Marinite. It melts.

The 701 test uses a gas burner held at a fixed position. When my gas jet made contact with the polyester, there were some small flashes of orange flame, but the main thing that happened was that the fabric melted and shrank back from the flame. After a few seconds, I had a gas flame shooting against the back of the test chamber, a small pile of black plastic on the bottom, and a sample of hot fabric with a fused edge hanging from the top of the chamber. The fabric lost less than 6% of its weight. Probably most of the lost mass was in the pile of melted plastic on the bottom of the test chamber, but the standard says not to weigh the debris.

The way the fabric shrinks back from flame complicates the 705 field test. When I tested some treated

cotton, the fabric kept its shape, the bottom of the sample didn't move, and I didn't have to pay much attention to where I was holding the match. With the polyester, the bottom immediately shrank back from the flame. If I held the match stationary, not much more than that happened: the fabric flashed with a few small orange flames, melted back, and I was left holding a lit match below some melted fabric. It passed! However, if I tried to maintain the specified 12.7mm from the bottom of the match flame to the bottom of the fabric, I had to follow the retreating fabric edge with my lit match. This gives a movable ignition source, not a fixed source as in the 701 test, but some inspectors interpret 705 as requiring this. In the specified 12 seconds of the test, I could easily melt away virtually all of a 101.6mm sample. Does the sample fail because the flame spread over the entire sample, even though this spread is completely attributable to my having chased the retreating fabric edge with the burning match?

Another little detail is the kitchen match. It's the specified ignition source, but wooden kitchen matches, while not rare, aren't readily available; fire inspectors frequently use butane lighters instead of matches. The lighter's gas valve has to be held open with a thumb or finger to keep the flame lit. If the flame is small, about kitchen match-size, I found holding the flame under the fabric put my hand in the way of the dripping molten plastic. I could make the flame bigger, so I could hold the lighter off to the side with my hand out of the way. Fine, but then how big should it be? I found that, if I made the flame very large, it could easily cover most of a minimum-sized sample, melting the whole swatch in a few seconds. How do you evaluate the flame spread on a sample that disappears? This is an important question: NFPA 705 allows the evaluation of an entire piece of scenery to depend on the interpretation of the flammability of a single ½" by 4" sample.

The NFPA 705 field test clearly needs some refinement for it to work well with synthetic fabrics and to more closely approximate the results that can be achieved with the 701 test. Obvious areas of work would include the minimum sample size, the number of samples needed to make a determination, a way to average the results from several samples, reconsideration of the ignition source, and better pass/fail criteria. The Flame Resistance Task Group will be offering some suggestions in the next NFPA 705 revision cycle.

In the meantime, there are some things that a person can do to help a fire inspector make a good field-test determination of the flammability of some fabric:

1. Make it easy for the fire inspector to take more than one sample and larger than minimum-sized samples.

   a. If you are making the scenery, be generous so there is extra fabric here and there that can be clipped for samples. Keep in mind that the samples are not supposed to include selvage or to be taken from sections near the selvage.

   b. If it's scenery on your show, note where there is extra fabric, and be ready to help the fire inspector access it.

2. Have wooden kitchen matches readily available, and offer them if it looks like the inspector needs them.

It also helps if you have a good working relationship with the local inspector, and you can talk about the field test, the size and number of samples, and how to evaluate the results. This takes some finesse. Arguing with a fire inspector is not likely to help anyone, but if you can talk, you are more likely to have safe scenery while avoiding having to re-treat scenery that was already flame resistant.

A version of this article appeared in the Spring 2008 issue of Protocol, *the journal of the Entertainment Services and Technology Association. This version draws on additional flammability testing experiments.*