

**BEST PRACTICES:
THE FEDERAL SAFETY PRECEDENT OF SETTING BOTH
FLAMMABILITY AND SMOKE EMISSION REGULATORY STANDARDS**

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FLAME RESISTANCE AND SMOKE EMISSION REGULATORY STANDARDS**

I. Over 30 Years of Federal Experience in Researching and Setting Smoke Density Standards

- ▶ The federal government has over 30 years experience in researching and setting smoke emission standards *as well as* flammability standards for the specific purpose of helping people escape from enclosed environments following a disaster.
- ▶ The Federal Railroad Administration (FRA) has enacted and updated both flammability and smoke density standards for the various materials used in locomotive cabs and rail passenger cars. Standards limiting flame propagation and limiting smoke emission are used in conjunction with each other to create a unified fire safety regulatory regime.
 - Research to develop the flammability and smoke emission standards was conducted by the National Institute of Standards and Technology (NIST) and the Department of Transportation's (DOT's) Volpe National Transportation Systems Center.
- ▶ As NIST explained in paper written jointly with DOT, "In 1973, the Urban Mass Transportation Administration (UMTA) (now FTA) initiated an effort to evaluate and improve transit vehicle fire safety. As part of that effort, guideline specifications for flammability and smoke emission tests and performance criteria were developed."¹
- ▶ The NIST paper went on to note that in "1984, the FRA issued passenger train fire safety guidelines containing tests and performance criteria identical to UMTA. The FRA issued revised guidelines in 1989 that used terms and categories to more closely reflect passenger train design and furnishings and include smoke emission performance criteria for floor coverings and elastomers."²
- ▶ NIST also explained that the FRA guidelines used test methods to measure the "four different fire performance phenomena: ignition resistance, flame spread, smoke generation, and fire endurance."³

¹ Peacock, R.D. and Bukowski, R.W. (Building and Fire Research Laboratory, National Institute of Standards and Technology) and Markos, S.H., (Volpe National Transportation Systems Center, U.S. Department of Transportation), "Evaluation of Passenger Train Car Materials in the Cone Calorimeter," Fire and Materials '98 International Conference, 5th. Proceedings, p. 3, found at <http://www.fire.nist.gov/bfrlpubs/fire98/PDF/f98012.pdf>.

² Ibid.

³ Ibid.

- ▶ NIST’s research identified heat release rate (HRR) as “a key indicator of fire performance.... Even if passengers do not come into direct contact with the fire, they could be injured from high temperatures, heat fluxes, and toxic 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 a real fire.”⁴
- ▶ NIST used the Cone Calorimeter as their primary analysis tool. As the agency explained, the “Cone Calorimeter (ASTM E 1354) is a single test method which provides measurements of HRR, specimen mass loss, smoke production, and combustion gases.” and “the HRR and other measurements generated from the Cone Calorimeter can also be used as an input to fire modeling and hazard analysis techniques to evaluate the contribution of the individual components and materials to overall passenger train fire safety.”⁵
- ▶ The FRA agreed that Cone Calorimeter was valuable modeling tool for fire safety. As the agency explained in a 1999 Final Rule on Passenger Equipment Safety Standards, “The results of the Phase I tests showed a strong correlation between the FRA-cited test data and the Cone Calorimeter test data.”⁶
- ▶ The FRA regulation also explained that the “results of the NIST research project will help in developing a broad set of performance criteria for materials using the Cone Calorimeter and the Furniture Calorimeter in a context similar to that provided generally in the table of FRA fire safety requirements contained in Appendix B to part 238. In addition, unlike data derived from most test methods referenced in Appendix B, heat release rate and other measurements obtained from the Cone Calorimeter and the Furniture Calorimeter can be used in a fire modeling methodology to evaluate the contribution of materials to the overall fire safety of a passenger train.”⁷
- ▶ The FRA rule also discusses the instance by a rail workers union, the Brotherhood Railway Carmen (BRC, a division of the Transportation Communications International Union) on the need to for smoke density regulatory standards. Specifically, the

*The BRC, in its comments on the NPRM, stated that interior materials in passenger equipment must be required to meet strict standards for flammability **and** smoke emission.*⁸

⁴ Ibid.

⁵ Ibid., p. 4.

⁶ 64 Fed. Reg. 25554, May 12,1999.

⁷ Ibid.

⁸ 64 Fed. Reg. 25555, May 12,1999. [Emphasis added.]

II. Current FRA Fire Safety Regulatory Requirements Use ASTM Standard Tests

- ▶ In 2002, the FRA completed its rulemaking process setting passenger equipment standards. The rule sets standards for both flame resistance and smoke density for the various materials used in locomotive cabs and passenger cars. The table of flammability and smoke emission regulatory requirements is found in Appendix A.
- ▶ The smoke density test used in the rail safety regulations is ASTM E 662–01, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
- ▶ The metric produce by the test is “Specific optical density (Ds)” which is defined as “the optical density measured over unit path length within a chamber of unit volume, produced from a specimen of unit surface area, that is irradiated by a heat flux of 2.5 watts/cm² for a specified period of time.”⁹ The optical density “shall be measured in either the flaming or non-flaming mode, utilizing the mode which generates the most smoke.”¹⁰
- ▶ The smoke density standards are used in conjunction with ASTM flame-spread and flame-propagation standards.
- ▶ For example, the regulation requires that window gaskets, door nosings, inter-car diaphragms and other specified materials must meet two standards:
 - ASTM C 1166-00, Standard Test Method for Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories with an “Average flame propagation \leq 4 inches” **and**
 - ASTM E 662–01, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials with a Ds after 1.5 minutes \leq 100 and a Ds after 4 minutes \leq 200.¹¹
- ▶ Thermal and acoustic insulation used in trains is required to meet:
 - ASTM E 162–98, Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source with a flame spread index (Is) \leq 25 **and**
 - ASTM E 662–01 with a Ds after 4 minutes \leq 100.¹²

⁹ 67 Fed. Reg. 42910, June 25, 2002.

¹⁰ 67 Fed. Reg. 42912, June 25, 2002.

¹¹ 67 Fed. Reg. 42911, June 25, 2002.

¹² 67 Fed. Reg. 42911, June 25, 2002.

III. Other Federal Agencies Require Both Flame Resistance and Smoke Density Standards

- ▶ The Federal Aviation Administration (FAA) also uses a combination of flame resistance and smoke density standards. Specifically, the FAA's regulations include a "Test Method To Determine the Smoke Emission Characteristics of Cabin Materials" sets an acceptance criteria that the "specific optical smoke density (D_s), which is obtained by averaging the reading obtained after 4 minutes with each of the three specimens, shall not exceed 200" using ASTM F814-83.¹³
- ▶ NASA's "Safety Standard for Fire Protection" for its headquarters and other buildings also requires that materials meet both flame resistance and smoke density standards. The NASA standards were initially set in August 2000 and revalidated in April 2006.¹⁴ NASA notes that its standards are "a compilation of pertinent requirements from the Occupational Safety and Health Administration (OSHA), National Fire Protection Association (NFPA)" and agency-unique requirements. NASA uses an NFPA standard for smoke density specific for building materials.
 - An example of the agency recognizing the need for both flame propagation and smoke density standards is: "Interior walls, partitions, modular partitions, and ceiling finish materials shall have a Flame Spread Index less than 25 and a Smoke Density Index less than 450 as determined by the test method described in NFPA 255."¹⁵
- ▶ Similarly, the State Department has employed a combination of both flame-resistance and smoke density standards to protect diplomats. For example, the fire resistance section of a document on "resilient wall base" product specifications requires a "ASTM E 662/NFPA 258 (Smoke Density) – 450 or less."¹⁶
- ▶ The Department of Energy's Sandia National Laboratory has set flammability and smoke density standards for the flooring used in "cleanrooms." For flammability Sandia requires "ASTM E 648; NFPA 253; NBSIR 75-950 result to be not less than 0.45 watts per square centimeter, Class 1" and for smoke density "ASTM E 662, NFPA 258, NBS smoke density, less than 450."¹⁷

¹³ Appendix F to Part 25 of Title 14 of the Code of Federal Regulations, found at <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e2d38628bc782b5163fa7c6ce27bc0a4&rgn=div9&view=text&node=14:1.0.1.3.11.7.201.35.20&idno=14>.

¹⁴ NASA, "Safety Standard for Fire Protection: NASA Technical Standard" found at <http://www.hq.nasa.gov/office/codeq/doctree/871911.pdf>.

¹⁵ Ibid., p. 11.

¹⁶ Resilient Wall Base: Product Specifications, Sec. 2.4.3 found at http://athens.usembassy.gov/about_us/business/Instr3.pdf.

¹⁷ Special Specification, Section 13039S, "Cleanroom Resistant Flooring," Part 2.02 found at <http://www.sandia.gov/engstds/ConstSpecs/Special/MESA/MicroFab/Division13/13039S.pdf>.

IV. Recent Federal Research Recommendations on Material Selection and Fire Safety

- ▶ The Federal Transit Administration, in collaboration with the Volpe Center, the Transit Cooperative Research Program of the Transportation Research Board, the American Public Transportation Association and other stakeholders published a major report in November 2004 on measures to protect transit systems from terrorist attack.¹⁸
- ▶ The report discussed the importance of selecting materials that reduce fire spread and emission of smoke and toxic gasses. The report recommended that all materials used in passenger areas of transit vehicles comply with ASTM standards for both flame-spread and smoke density. Specifically, the report said,

While there is no completely non-combustible, non-toxic material in existence, certain materials will hinder fire spread, smoke emission, and the release of toxic gases. These types of materials should be used throughout the vehicle to the greatest practical extent, balancing their benefits against other criteria such as durability and cost. All materials in the passenger area should comply with existing fire safety standards (ASTME162 and E662).¹⁹

V. Limiting Toxic Gas Emissions: The Danger from Halogenated Flame Retardants

- ▶ A December 2001 Engineering Note from the Department of Energy notes that cables used in particle physics experiments “must be chosen with regard to fire safety i.e. flame propagation and smoke characteristics. Cable **must** be rated to a recognized standard that shows they are self extinguishing and will not spread a fire. Cables with low smoke density, toxicity, and corrosivity of gasses are **preferred**. Smoke produced by overheated halogenated cable insulation is corrosive to electronics. Whenever possible, cable should be specified as halogen free.”²⁰
- ▶ A 1996 article in Data Communications Magazine discussing the potential benefits of halogen-free cable discussed the dangers halogenated flame-retardants pose to people trying to escape a fire.

There’s something corporate networkers should know. Most of the cable they’re now pulling at central sites and branch offices across the U.S. contains halogens –

¹⁸ US Department of Transportation, “Transit Security Design Considerations,” November 2004 found at <http://transit-safety.volpe.dot.gov/Security/SecurityInitiatives/DesignConsiderations/CD/ftasesc.pdf>

¹⁹ Ibid., pp. 7-15 - 7-16. [Emphasis added].

²⁰ http://www-ppd.fnal.gov/EEDOffice-w/Infrastructure_group/Cables/h011204a.pdf. [Emphasis in original.]

chemical that give off toxic fumes when they burn. In a fire, halogen cable can release acid gases that sear the eyes, nose, mouth, and throat. The fumes can disorient victims, preventing them from escaping the blaze. They can cause severe respiratory damage. And they can kill. Recognizing this potentially deadly problem, a number of international governments have already standardized on zero-halogen cabling.²¹

- ▶ The article describes the situation as “a deadly double blind: Halogen insulation helps prevent cables from catching fire, but if the cable jackets do ignite the resultant fumes can drive up the death toll.”
- ▶ Interest in using halogen-free cables is traced to the Falklands War. “Research showed that most shipboard fatalities during the conflict were the results of the smoke from fires started by missiles and bombs rather than by the weapons themselves. ‘Acid gasses also prevented personnel from fighting the fires,’ says Karen Long, a physicist at the Naval Sea Systems Command (Washington, DC). Long is responsible for developing fiber cabling standards for the U.S. Navy, which has decided to go halogen-free.”
- ▶ The article also notes that many “countries - including Australia, France, Italy, Japan, Korea, New Zealand, and the U.K. – have also moved to halogen-free cabling. And even in countries where the choice of cable is still left to the installer, zero-halogen is becoming the technology of choice...”
- ▶ With respect to safety, proponents of “halogen-free cable are quick to point out that in a fire what can’t be seen is far more lethal than what can. Invisible gasses given off by burning material are the cause of more than 80 percent of fire deaths, according to research published in the British Medical Journal. In the U.S. that translates into as many as 6,000 deaths a year.”
- ▶ When comparing US fire safety standards for cables with those of other countries standards,

The easiest way to see the difference between international and U.S. cabling codes is to compare what they cover. International standards address three issues:

- *fire resistance (how fast cable burns)*
- *smoke density (how much visible smoke is produced)*
- *toxicity (how harmful the smoke is to human beings)*

U.S. codes, in contrast, only address two of those criteria: fire resistance and smoke density. The National Electric Code is silent when it comes to toxicity.

²¹ Saunders, S. “Cabling: What You Don't Know Can Kill You,” Data Communications Magazine, 1996 found at http://www.bldgdesign2020.net/news/cabling_can_kill_you.html.

CONCLUSIONS:

- ▶ The Federal Railroad Administration has concluded that protecting worker and passenger safety requires setting regulatory standards limiting both flame spread and smoke density.
- ▶ The FRA was able to set regulatory standards for smoke density using an off-the-shelf ASTM standard testing methodology.
- ▶ The Federal Aviation Administration, NASA, the Department of Energy and other federal agencies also require both flame-resistance and smoke density standards.
- ▶ The regulatory standards set by various agencies indicate the both flame resistance and smoke density standards should be set on a material-specific basis.
- ▶ Smoke toxicity has been demonstrated to be an important fire safety issue in addition to smoke density and flame-resistance. DOE has noted that in addition to being self-extinguishing, it is “preferred” to have cables which have low smoke density and toxicity.
- ▶ Coal miners should not receive less fire safety regulatory protection than rail workers, mass transit passengers, and federal employees.

Test Procedures and Performance Criteria for the Flammability and Smoke Emission Characteristics of Materials Used in Passenger Cars and Locomotive Cabs

CATEGORY	FUNCTION OF MATERIAL	TEST METHOD	PERFORMANCE CRITERIA
Cushions, Mattresses	All ^{1, 2, 3, 4, 5, 6, 7, 8}	ASTM D 3675-98	$I_s \leq 25$
		ASTM E 662-01	$D_s(1.5) \leq 100$ $D_s(4.0) \leq 175$
Fabrics	Seat upholstery, mattress ticking and covers, curtains, draperies, wall coverings, and window shades ^{1, 2, 3, 6, 7, 8}	14 CFR 25, Appendix F, Part I, (vertical test)	Flame time ≤ 10 seconds Burn length ≤ 6 inches
		ASTM E 662-01	$D_s(4.0) \leq 200$
Other Vehicle Components ^{9, 10, 11, 12}	Seat and mattress frames, wall and ceiling panels, seat and toilet shrouds, tray and other tables, partitions, shelves, opaque windscreens, end caps, roof housings, and component boxes and covers ^{1, 2}	ASTM E 162-98	$I_s \leq 35$
		ASTM E 662-01	$D_s(1.5) \leq 100$ $D_s(4.0) \leq 200$
	Flexible cellular foams used in armrests and seat padding ^{1, 2, 4, 6}	ASTM D 3675-98	$I_s \leq 25$
		ASTM E 662-01	$D_s(1.5) \leq 100$ $D_s(4.0) \leq 175$
	Thermal and acoustic insulation ^{1, 2}	ASTM E 162-98	$I_s \leq 25$
		ASTM E 662-01	$D_s(4.0) \leq 100$
	HVAC ducting ^{1, 2}	ASTM E 162-98	$I_s \leq 35$
		ASTM E 662-01	$D_s(4.0) \leq 100$
	Floor covering ^{12, 13}	ASTM E 648-00	C.R.F. ≥ 5 kW/m ²
		ASTM E 662-01	$D_s(1.5) \leq 100$ $D_s(4.0) \leq 200$
	Light diffusers, windows and transparent plastic windscreens ^{2, 14}	ASTM E 162-98	$I_s \leq 100$
		ASTM E 662-01	$D_s(1.5) \leq 100$ $D_s(4.0) \leq 200$
Elastomers ^{1, 10, 11}	Window gaskets, door nosings, inter-car diaphragms, roof mats, and seat springs	ASTM C 1166-00	Average flame propagation ≤ 4 inches
		ASTM E 662-01	$D_s(1.5) \leq 100$ $D_s(4.0) \leq 200$
Structural Components ¹⁵	Flooring ¹⁶ , Other ¹⁷	ASTM E 119-00a	Pass