



*Member of the FM Global Group*

# **Test Standard for Cable Fire Propagation**

**Class Number 3972**

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# 1 INTRODUCTION

## 1.1 Purpose

This standard describes FM Approvals test requirements and procedures for establishing the classification for cable fire propagation. Cables covered by this standard include electrical and optical cables, herein called cables. The classification rating established in this Specification Test Standard may be used to determine acceptable fire protection techniques applicable to a given field installation.

## 1.2 Scope

1.2.1 This standard is applicable, but not limited, to various types of electrical cables such as communications cables (including fiber optic cables), power distribution cables, feeder branch circuit wiring, etc, having outer insulating coverings or metallic sheath, which may be used for commercial and industrial purposes.

1.2.2 This standard does not assess the cable's ability to provide circuit integrity when cable is subjected to a fire source.

1.2.3 Not applicable to cable coatings applied after the cable has been installed.

## 1.3 Basis for FM Approvals Specification Tested Product Listing

FM Approvals Listing is based on satisfactory evaluation of the product and the manufacturer in the following major areas:

1.3.1 Examination and tests shall be performed on production samples to evaluate flammability characteristics of product formulation; and

1.3.2 An examination of the manufacturing facilities and audit of quality control procedures shall be made to evaluate the manufacturer's ability to produce the product which is examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of FM Approvals Facilities and Procedures Audit Program.

## 1.4 Basis for Continued Listing

Continued Listing is based upon:

- production or availability of the product as currently Listed;
- the continued use of acceptable quality control procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the Specification Tested Product Master Agreement; and
- re-examination of production samples for continued conformity to requirements.

### 1.5 Basis for Requirements

- 1.5.1 The requirements of this standard are based on experience, research and testing. The advice of manufacturers, users, trade associations and loss control specialists was also considered.
- 1.5.2 Subjecting cables to the tests described by this standard will result in their classification as described in Section 5.1 of this standard. The classification is based on the fire propagation (flame spread) characteristics of a cable. Listing requirements prohibit substitution of components in the cable construction without prior authorization.
- 1.5.3 FM Approvals can withhold Specification Tested Product listing even if all criteria are met or can provide a listing if all criteria is not met.

### 1.6 Effective Date

The effective date of a Specification Test Standard mandates that all products tested for Listing after the effective date shall satisfy the requirements of that standard. Products Listed under a previous edition shall comply with the new version by the effective date or else forfeit Listing. The effective date shall apply to the entire specification test standard, or, where so indicated, only to specific paragraphs of the standard.

The effective date of this standard is *January 1, 2010*.

### 1.7 System of Units

Units of measurement are U.S. customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. Appendix A lists the selected units for quantities dealt with in testing these products; conversions to SI units are included. Conversion of the U.S. customary units is in accordance with ASTM E 380.

## 2 GENERAL INFORMATION

### 2.1 Product Information

The cables covered by this standard may be supplied as insulated single- or multiple-conductor having a metallic or non-metallic sheath. The conductor is usually manufactured of electrically conductive materials such as copper or aluminum, or may be a fiber optic material. Various combinations of polymeric materials, modified by additives, are used for insulations and jackets.

### 2.2 Flammability Classification

The flammability characteristics of the cable will fall within the ranges specified in this standard when tested according to the Piloted Ignition and Fire Propagation Test Methods.

## 3 APPLICABLE DOCUMENTS AND GLOSSARY

### 3.1 Documents

The flammability requirements are a result of FM Approvals efforts summarized in the FM Global Research Technical Report 3005351 ‘‘Fire Propagation Behavior of Electrical Cables’’.

### 3.2 Glossary

*CABLE* – a conductor (electrical or optical) with or without insulation and other coverings (single conductor cable) or a combination of conductors insulated from one another (multi-conductor cable)

*CRITICAL HEAT FLUX* – the minimum heat flux at or below which there is no ignition

*CHEMICAL HEAT RELEASE* – the heat release during the fire propagation process and determined from the generation rates of carbon monoxide and carbon dioxide

*HEAT FLUX* – the rate of heat flow measured across a given surface

*INSULATED WIRE* – a slender rod or filament of drawn metal with an insulating cover

*FIRE PROPAGATION INDEX* – a measure of the fire propagation tendency of the cable and is the ratio of the radiant heat flux provided by the flame and the thermal response parameter of the cable

*SELF-SUSTAINED FLAME PROPAGATION* – a cable flame propagation assisted by the flame heat flux from the burning cable only and not by other heat sources

*SMOKE DAMAGE INDEX* – smoke yield multiplied by FPI. It is an indicator of the extent of smoke contamination of the environment during fire propagation.

*THERMAL RESPONSE PARAMETER* – a property of material describing its reaction to heat in terms of ignition temperature, thermal conductivity, density and specific heat

### 3.3 Compliance

Compliance with the flammability requirements is verified by conducting the required testing and obtaining satisfactory performance requirements.

### 3.4 Specification Testing Requirements

To apply for a Specification Tested examination the manufacturer, or its authorized representative, should submit a request to:

Materials Director  
FM Approvals  
1151 Boston-Providence Turnpike  
PO Box 9102  
Norwood, MA 02062  
U.S.A.

The manufacturer shall provide the following preliminary information with any request for Specification Testing:

- complete list of all models, types, sizes, and options for the products or services being submitted for consideration:
- complete set of manufacturing drawings, materials list, anticipated marking format, nameplate format, brochures, sales literature, spec. sheets, and the number and location of manufacturing facilities.
- all documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.
- This standard does not test cable for their electrical or mechanical properties.

## 4 GENERAL REQUIREMENTS

### 4.1 Markings

4.1.1 The marking, to be placed along the length of the cable, shall be repeated at intervals not exceeding 24 inches (610 mm) and shall bear a classification marking shown below:

FM Approvals GP-1 or  
FM Approvals GP-1-4910

NOTE: THE MARKING SHALL BE OF A CONTRASTING COLOR WITH RESPECT TO THE BACKGROUND (E.G., WHITE MARKING ON BLACK BACKGROUND).

4.1.2 The classification marking (FM Approvals GP-1 or FM Approvals GP-1-4910) shall be used in conjunction with the products which have been tested by FM Approvals. The classification marking shall not be used in a manner (including advertising, sales, or promotional purposes) that suggests or implies FM Approvals endorsement of a specific manufacturer or distributor. Also, it shall not be implied that Listing extends to a product not covered by specific written agreement with FM Approvals. The classification mark signifies only that the product has met certain requirements as reported by FM Approvals.

#### 4.2 Drawings/Formulations/Specifications

- 4.2.1 Drawing(s), formulation(s) and specifications identifying materials, formulations and construction details shall be provided to FM Approvals for each configuration tested (i.e., itemized percentage of combustible material types per unit length). Information submitted to FM Approvals by the manufacturer with their cables shall include notification of any insulation/jacket materials having very high halogen contents (>60%) in their structures.
- 4.2.2 A drawing(s) shall be provided to FM Approvals indicating the size and location of the FM Approvals marking as it will be shown on the product.
- 4.2.3 The manufacturer shall also provide to FM Approvals copies of all brochures, sales literature and specification sheets relating to the cable(s) submitted for test.

#### 4.3 Manufacturers Responsibilities

- 4.3.1 The manufacturer shall furnish a total minimum cable length of 100 ft (30 m) from its standard production line of each different cable type to be tested. For ease of shipment, the cable may be cut into segments of lengths not less than 3 ft (0.91 m) each. A “different cable type” is defined for purposes of this standard, as variations in overall cable diameter and combustible materials (types and quantities) used in its construction. The cable, as supplied by the manufacturer, shall be cleaned of all foreign materials. The samples shall be labeled so as to properly identify each sample so that they correspond to the documentation provided.
- 4.3.2 Cable construction of the samples tested shall be representative of production samples and shall conform to the specifications and drawings provided by the manufacturer.
- 4.3.3 Submitted cable samples must meet all required National and International electrical testing standards for electrical or fiber optic cables prior to cable samples being submitted to FM Approvals for testing. This Standard does not test cable for their electrical or mechanical properties.

## 5 PERFORMANCE REQUIREMENTS

### 5.1 Classification Requirements for FM Approvals GP-1 or FM Approvals GP-1-4910

To be classified as either FM Approvals GP-1 or FM Approvals GP-1-4910, the test results of samples subjected to the Piloted Ignition and Fire Propagation Test Methods shall exhibit one of the following patterns of fire propagation and a corresponding Fire Propagation Index. FM Approvals GP-1-4910 cables are tested in accordance with Test Standard 4910, FM Approvals Cleanroom Materials Flammability Test Protocol for Smoke Damage Index (SDI).

FM Approvals GP-1 – Non-self sustained flame propagation having a Fire Propagation Index less than  $10 (m/s^{1/2})/(k/W/m)^{2/3}$

FM Approvals GP-1-4910 – Non-self sustained flame propagation having a Fire Propagation Index (FPI)  $\leq 6 (m/s^{1/2})/(k/W/m)^{2/3}$  and a Smoke Damage Index (SDI) of  $\leq 0.4 [(m/s^{1/2})/(k/W/m)^{2/3}] [g/g]$ .

NOTE 1: THE FIRE PROPAGATION INDEX IS GIVEN AS THE RATIO OF THE RADIANT FRACTION OF CHEMICAL HEAT RELEASE RATE OF THE CABLE TO THE THERMAL RESPONSE PARAMETER OF THE CABLE.

NOTE 2: THE PILOTED IGNITION TEST METHOD IS CONDUCTED TO DETERMINE THE THERMAL RESPONSE PARAMETER OF THE CABLE AND IS USED IN DETERMINING THE FIRE PROPAGATION INDEX.

NOTE 3: THE FIRE PROPAGATION TEST METHOD IS CONDUCTED TO DETERMINE THE CHEMICAL HEAT RELEASE RATE OF THE CABLE AND IS USED IN DETERMINING THE FIRE PROPAGATION INDEX.

## 5.2 Determining Fire Propagation Index

The Fire Propagation Index (FPI) as a function of time is expressed as:

$$\text{FPI} = \frac{750(\dot{Q}_{\text{ch}} / w)^{1/3}}{\text{TRP}}$$

where FPI is the *Fire Propagation Index*,  $\dot{Q}_{\text{ch}}$  in kW,  $w$  is the circumference of the cable in meters (not just the conductor) and Thermal Response Parameter is in  $(\text{kW}/\text{m}^2) \times (\text{sec})^{1/2}$  which was determined in the piloted ignition test.

The Fire Propagation Index (FPI) value is determined by FM Approvals FPA test procedure.

## 5.3 Test Representation

The following cable representation is allowed provided that the only difference in cable construction is the overall diameter of the cable:

5.3.1 The larger cables, employing the same construction and material as the smaller cables, shall be acceptable for the same group marking as the smallest cable satisfactorily tested.

## 5.4 Smoke Damage Index (SDI)

Smoke Damage Index is defined as the yield of smoke multiplied by the Fire Propagation Index (FPI). The FPI values from small and large-scale tests provide very similar information for the fire propagation behaviors of materials, especially the non-propagating behavior beyond the ignition zone for  $\text{FPI} \leq 6$ . The smoke yields for various materials from small and large-scale tests show good agreement. Thus SDI values from small and large-scale tests are in agreement. In the fire propagation tests, visual observations are made for the amount of smoke released and its blackness.

In the tests, small amounts of smoke with slight greyish/white haze is observed for materials with SDI values  $\leq 0.4$ . For materials with SDI values between 0.4 and 0.5, the amount of greyish smoke released is slightly higher than smoke released from materials with SDI values  $\leq 0.40$ .

Based on these visual characteristics of smoke, *SDI  $\leq 0.4$ , with uncertain results between 0.40 and 0.50, has been used as the criterion for limited contamination of the environment by smoke during fire propagation.* The limit is based on visual observations for the amount of smoke released and its blackness



during the fire propagation tests. Basic combustion chemistry relationships between release of smoke and amounts of carbon, hydrogen, oxygen, and halogenated atoms and nature of chemical bonds in the chemical structure of the material were also used in formulating the SDI criterion.

The Smoke Damage Index (SDI) value is determined by FM Approvals test procedure FM 4910 Parallel Panel Test Method.

## 6 OPERATIONS REQUIREMENTS

### 6.1 Demonstrated Quality Control Program

6.1.1 A Quality Control Program is required to assure that each cable produced by the manufacturer shall present the same product uniformity and construction as the specific cable samples examined. Design quality, conformance to design, and performance are the areas of primary concern.

Design quality is determined during the examination and testing.

Conformance to design is verified by control of quality in the following areas:

- existence of corporate quality control guidelines
- incoming assurance, including testing
- in-process assurance, including testing
- final inspection and test
- equipment calibration
- drawing and change control
- packaging and shipping
- handling discrepant materials.
- Quality of performance is determined by field performance and by re-examination and test.

6.1.2 The manufacturer shall establish a system of product configuration control to prevent unauthorized changes, including, as appropriate:

- engineering drawings
- engineering change requests
- engineering orders
- change notices

These shall be executed in conformance with a written policy and detailed procedures. Records of all revisions to all Listed products shall be kept.

6.1.3 The manufacturer shall assign an appropriate person or group to be responsible to obtain FM Approvals authorization of all changes applicable to Listed products. FM Approvals Form 797, Approved Product/Specification Tested — Revision Report or Address/Contact Change Report, is provided to notify FM Approvals of pending changes.

**6.2 Facilities and Procedures Audit (F&PA)**

- 6.2.1 An inspection of the product manufacturing facility shall be part of the specification tested product investigation. Its purpose shall be to determine that equipment, procedures, and the manufacturer's controls are properly maintained to produce a product of the same quality as initially tested.
- 6.2.2 Unannounced follow-up inspections shall be conducted to assure continued quality control and product uniformity.

**APPENDIX A: Conversion of Measurement Units****LENGTH:**

in. - "inches"  
(mm - "millimeters")

$$\text{mm} = \text{in.} \times 25.4$$

ft - "feet"  
(m - "meters")  
 $\text{m} = \text{ft} \times 0.3048$

**VOLUME:**

ft<sup>3</sup> - "cubic feet per minute"  
(L/min - "liters per minute")

$$\text{L/min} = \text{ft}^3/\text{min} \times 28.32$$

**TEMPERATURE:**

°F - "degrees Fahrenheit"  
(°C - "degrees Celsius")

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5/9$$

**ENERGY:**

Btu/ft<sup>2</sup>/min - "British thermal units per  
square foot per minute"  
(kW/m<sup>2</sup> - "kilowatts per square meter")  
 $\text{kW/m}^2 = \text{Btu/ft}^2/\text{min} \times 0.1891$