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IEEE Standards

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IEEE Standard Cable-Penetration Fire Stop Qualification Test

IEEE Power Engineering Society

Sponsored by the
Insulated Conductors Committee

IEEE

3 Park Avenue, New York, NY10016-5997, USA

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American National Standard (ANSI)

IEEE Std 634™-2004
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IEEE Standard Cable-Penetration Fire Stop Qualification Test

Sponsor

Insulated Conductors Committee
of the
IEEE Power Engineering Society

Approved 7 February 2005

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Approved 15 November 2004

IEEE-SA Standards Board

Abstract: This standard is applicable to fire stops of various materials and construction. Cable-penetration fire stops are intended for use in fire-resistive barriers. Tests conducted in conformance with this standard will record the performance of fire stops during the test exposure. The resistance of a fire stop to an external force imposed by a hose stream or water spray will also be considered in this standard. The intent of this standard is to develop data to assist in determining the suitability of a fire stop for use where fire resistance is required.
Keywords: cable-penetration, fire-resistant, fire-resistive barrier, fire stop, fire test, fire test facilities, fire test procedure, F-rating, penetration seal, thermocouple, time-temperature curve, T-rating

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Introduction

This introduction is not part of IEEE Std 634-2004, IEEE Standard Cable-Penetration Fire Stop Qualification Test.

Confining a fire to the area of origin is desirable for a number of reasons, including protecting a structure's personnel and/or occupants, preventing excessive damage to a structure's equipment and/or contents, and minimizing the consequential loss as a result of the fire. Fire resistant barriers (e.g., wall, floor, and ceiling partitions) generally provide the primary means of fire containment. However, the effectiveness of a fire resistant barrier may be compromised by the quantity, type, and size of openings or penetrations through the barrier. In the construction of all types of buildings, openings exist through barriers to allow the passage of mechanical and electrical equipment. Such openings must be closed or sealed in order for the fire resistance rating of the barrier to be maintained. The fire resistance rating of a barrier is generally determined by testing in accordance with other industry standards (e.g., ASTM E119[a], NFPA 251). The fire resistance rating of cable-penetration fire stops is intended to be determined using this standard.

IEEE Std 634 was initially developed to provide qualification test procedures for type testing cable-penetration fire stops when mounted in fire rated barriers. Originally approved by the IEEE Standards Board on December 15, 1977, IEEE Std 634 remained unchanged until it was withdrawn in April of 1990. Subsequently, a Cable-Penetration Fire Stop Qualification working group was formed to revive the standard. The principle changes from the previous version of this standard include general test methodology, acceptance criteria, and rating classification. The updated standard incorporates modernized fire testing protocols, such as furnace pressure requirements, variable temperature acceptance criteria based on actual cable properties, and separate rating classifications for cable-penetration fire stops which limit flame propagation alone or in addition to limiting unexposed side temperature rise (e.g., F-ratings and T-ratings).

This standard is intended to provide a controlled method by which cable-penetration fire stops can be tested to determine their fire resistance capability. However, this standard does not address the following conditions related to cable-penetration fire stops.

Pressure seals: Some cable-penetration fire stops may also be required to function as a pressure seal to maintain an existing differential pressure between areas separated by the barrier in which it is installed. This standard does not address the ability of a cable-penetration fire stop to serve as a pressure resistant seal, even though a correlation could be made to a minor pressure rating based on the specific furnace pressure condition under which this test is performed.

Ampacity derating due to cable-penetration fire stops: It is recognized that the thermal insulating characteristics of a cable-penetration fire stop may have an effect on the ampacity of the cables passing through the penetration. Design of the cable-penetration fire stop should address this effect. However, ampacity considerations are not part of this qualification test and, consequently, are not within the scope of this standard.

Electrical penetration assemblies in containment structures: Electrical penetration assemblies in containment structures are not covered in this standard. For guidance in this area, refer to IEEE Std 31™.

Seismic, radiation, aging, and loss-of-coolant accident (LOCA): Although it is recognized that seismic, radiation, aging, and LOCA conditions may be required to be considered and evaluated for nuclear power plants, these effects are not within the scope of this standard. For guidance in these areas, refer to ANSI/IEEE Std 344™and IEEE Std 323™.

[a]Information on references can be found in Clause 2.

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Test limitations and cautions: This test is performed with a specific standard fire. This fire may or may not be as severe as fires actually experienced and hence may not predict the performance of the cable penetration fire stop in actual service. It is the judgment of those experienced in the field that relative performance is accurately portrayed, and the relative values may be used as a basis for engineering judgment in a particular design situation.

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IEEE Standard Cable-Penetration Fire Stop Qualification Test

1. Overview

This standard provides two methods for qualifying the performance of cable-penetration fire stops (also referred to as "fire stops") when they are installed in rated fire-resistive barriers. The two methods are the general acceptance qualification (Type I) and a cable-specific qualification (Type II). The cables used for Type II tests shall be tested to determine their flash-ignition and self-ignition temperatures before their inclusion in a fire-stop qualification test. Annex A provides a series of figures that may be used as guidance when developing a test assembly for Type I qualification. Annex B contains the bibliography associated with this standard.

1.1 Scope

This standard is applicable to fire stops of various materials and construction. Cable-penetration fire stops are intended for use in fire-resistive barriers. Tests conducted in conformance with this standard will record the performance of fire stops during the test exposure. However, this test shall not be used to determine the suitability of a fire stop for use after it is exposed to a fire. This standard also considers the resistance of a fire stop to an external force imposed by a hose stream or water spray. This standard shall not be used to determine the performance of a fire stop during actual fire conditions when subjected to additional forces, such as failure of cable support systems and falling debris. The intent of this standard is to develop data to assist in determining the suitability of a fire stop for use where fire resistance is required. This standard should be used to measure and describe the response of the fire stop material under a set of controlled conditions but should not be used to describe or appraise the fire hazard or fire risk of that fire stop under the actual fire conditions. However, the results of this test may be used as an element of a fire hazard assessment or a fire-risk assessment that takes into account all of the factors that are pertinent to a particular end use. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.2 Purpose

The purpose of this standard is to establish type tests to assure that cable-penetration fire stops meet the required fire rating.

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1.2.1 General

This test method is used to determine the performance of a cable-penetration fire stop when exposed to the standard time-temperature curve for control of fire tests from ASTM E814,[1] and followed by a hose stream test. The performance of a cable-penetration fire stop is dependent upon the specific assembly of materials tested, including the number, type, and size of the module and the fire-resistive barrier in which it is installed. An F-rating and T-rating are established for each fire stop tested. An F-rating of a specified duration establishes that the fire stop successfully retarded the passage of fire, flame, and water during the fire endurance and hose stream tests. A T-rating of a specified duration establishes that, in addition to satisfying the F-rating criteria, the fire stop effectively maintained unexposed side temperatures at or below 181 °C (325 °F) above initial temperature (for Type I tests) or (at or below) the auto ignition temperature of the cable type tested (for Type II tests). These ratings are intended as an aid in assessing the performance of a cable-penetration fire stop.

1.2.2 Applicability

Cable-penetration fire stops that meet the requirements outlined herein are intended for use in power-generating stations including, but not limited to, nuclear-generating stations, commercial, and industrial installations. Among the categories of cables covered, but not limited to, are those used for the power, the control, and the instrumentation services of those installations. When applying the results of this test to a particular end use application, consideration should be given to the appropriate type of rating (F-rating or T-rating) based on facility construction and specific requirements of the authority having jurisdiction.

1.2.3 Method of approach

When a cable-penetration is used in a rated fire-resistive barrier, the cable-penetration fire stop should remain intact, prevent the spread of fire, and restrict the passage of hot gases through that barrier for the required time. A fire-resistive barrier should meet the requirements of ASTM E119. The ASTM E119 test is also known as NFPA 251 and ANSI A2.1[B1].[2] The ASTM E119 test is designed to measure the amount of heat transferred through a fire-resistive barrier from its fire side to its unexposed side. The fire side is exposed to the flame and hot gases of the test furnace and the unexposed side is exposed to the ambient conditions of the test facility. Fire-resistive barriers that meet the requirements of ASTM E119 fire tests are rated by the amount of time that they resist the effects of a controlled fire without exceeding the temperature limits set forth in the standard. ASTM E119 temperature limits are a maximum temperature rise of 181 °C (325 °F) above the initial temperature for individual thermocouples and a maximum temperature rise of 139 °C (250 °F) above the initial temperature for the average of all unexposed side thermocouple readings. This standard provides two methods to determine the impact of a cable-penetration on a rated fire-resistive barrier. The first method, Type I, is a general evaluation of a cable-penetration fire stop that establishes a broad qualification. Type I tests invoke a maximum unexposed temperature of 181 °C (325 °F) above the initial temperature for all required thermocouple locations. The second method, Type II, is a cable-specific evaluation of a cable-penetration fire stop that establishes a qualification for a specific cable type only. For Type II tests the flash-ignition and self-ignition temperatures of the cables to be tested in the cable-penetration fire stop shall be established by ASTM D1929. Type II tests use the data obtained from ASTM D1929 to establish the temperature limiting factor for the cable-penetration fire stop test conducted using this standard.

[1] For information on references, see Clause 2.

[2] The numbers in brackets correspond to those of the bibliography in Annex B.

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2. Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASTM D1929-96 (2001), Standard Test Method for Determining Ignition Temperature of Plastics.[3]

ASTM D2863, Standard Test Method for Measuring Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index).

ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

ASTM E119, Standard Test Methods for Fire Tests of Building Construction and Materials.

ASTM E814, Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

IEEE Std 317™- IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.[4]

NFPA 251, Standard Methods of Tests of Fire Endurance of Building Construction and Materials.[5]

3. Definitions

For the purposes of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms* [B2] should be referenced for terms not defined in this clause.

3.1 cable-penetration: An assembly that is designed to allow electrical cables to pass through a fire-resistive barrier.

3.2 cable-penetration fire stop: Any material, device, or an assembly that allows a cable-penetration to pass through a fire-resistive barrier without diminishing its required fire rating.

3.3 cable-penetration fire stop material: The material that is placed around the cable or raceway in a penetration to provide a seal.

3.4 fire rating: The endurance rating of a fire-resistive barrier indicates the time (hours and minutes) in which a barrier can be exposed to a standard time-temperature curve and still satisfy acceptance criteria.

3.5 fire-resistive barrier: A wall, floor, or floor-ceiling assembly that is erected to prevent the spread of fire. To be effective, fire-resistive barriers must have sufficient fire resistance to withstand the effects of the most severe fire that may be expected to occur in the adjacent area and must provide a complete barrier to resist the spread of fire.

[3] ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).
[4] IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).
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3.6 fire-resistive barrier rating: The amount of time that is expressed in hours and minutes that indicates how long the wall, floor, or floor-ceiling assembly can withstand fire exposure of ASTM E119 and meet acceptance criteria.

3.7 F-rating: An F-rating of a specified duration establishes that the cable-penetration fire stop successfully retarded the passage of fire, flame, and water during the fire endurance and hose stream tests.

3.8 module: An opening, or openings, in a fire-resistive barrier that is located so that its performance will not affect the performance of any other cable-penetration fire stop. A module may take on any shape to permit the passage of one or more cable-penetrations; or, one or more raceways.

3.9 raceway: Any channel that is designed and used expressly for supporting or enclosing wires, cable, or bus bars. Raceways consist primarily of, but are not restricted to, cable trays and conduits.

3.10 test assembly: The entire structure that is subjected to the fire test; this includes, but is not limited to, the fire-resistive barrier, one or more modules, one or more raceways, one or more cable-penetration fire stops.

3.11 T-rating: A T-rating of a specified duration establishes that, in addition to satisfying the F-rating criteria, the cable-penetration fire stop effectively maintained unexposed side temperatures at or below 181 °C (325 °F) above initial temperature (for Type I tests) or at or below the auto-ignition temperature of the cable type tested (for Type II tests).

3.12 unexposed side: The side of a rated fire-resistive barrier that is not exposed to fire during the test; it is also referred to as the “cold side.”

4. Test description

4.1 General

This clause describes the two methods for testing cable-penetration fire stops that penetrate a fire-resistive barrier.

4.1.1 Applicability

This standard is designed to test the cable-penetration fire stop. It is not the intent of this standard to test the fire-resistive barrier in which the fire stop is installed or any other structural member associated with the fire-resistive barrier. Therefore, no simulated structural loading is required.

4.1.2 Cable-penetration fire-stop components—excluding cable

All of the individual components of a cable-penetration fire stop, except the cable, shall have a flame spread rating of 25 or less when tested and rated in accordance with ASTM E84. Any component that can not be tested and rated in accordance with ASTM E84 shall be tested in accordance with IEEE Std 317 or ASTM D2863, and shall have a minimum limiting oxygen index of 25.

4.1.3 Method of testing

Qualification shall be obtained by testing an actual full-sized cable-penetration fire stop or a module that is indicative of the installed conditions.

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4.1.4 Test experience

A cable-penetration fire stop and/or a module that has successfully met the requirements of this standard is considered qualified for an equal or less severe fire rating. Testing in the floor-ceiling position qualifies the cable-penetration fire stops for either a floor or a wall penetration provided the tested cable-penetration fire stop is a symmetrical design that will provide an equal fire rating from either side of the fire-resistive barrier. For asymmetrical designs, refer to 4.3.5.

4.2 Test specimens

4.2.1 General

This standard provides a method of test for the following types of cables: power, control and instrumentation (including signal and communications). A cable-penetration fire stop shall be installed in an opening through a fire-resistive barrier that may be lined with metallic components. Depending on its intended configuration, a cable may penetrate the fire-resistive barrier with or without a raceway.

4.2.2 Cable selection and raceway fill

The sizes, construction, and materials of the cable-penetration fire stop (its cables and the amount that the raceway is filled with them) and the opening or module that are to be tested shall be representative of those to be used in the actual installed condition.

The cable sizes and cable fill listed in Table 1 may be used. If these sizes, constructions, or fills are not representative of the actual installed conditions, then more suitable selections shall be used. Do not mix different construction types (that is, instrumentation and medium-voltage power cable) to be installed in the same cable-penetration fire stop test unless this is indicative of the actual conditions.

Table 1—Suggested cable types and fill levels

Test no.	Cable-penetration fire stop cable type[a]	Cable size and construction	Fraction of total fill[b] for each cable type
1	Medium-voltage power	3/C No. 6 AWG	1/3
		3/C No. 2/0	1/3
		3/C No. 4/0	1/3
2	Low-voltage power	3/C No. 6 AWG	1/3
		3/C No. 2/0	1/3
		3/C No. 4/0	1/3
3	Control and instrumentation	7/C No. 12	1/2
		1 Pr. No. 16 AWG shielded	1/2

[a] Special use cables (e.g., fiber-optic cables, co-ax cables, tri-ax cables) shall be tested in conjunction with other cable types and concentrations representative of end use applications. Additionally, single plenum fiber-optic cables shall not be used to represent multiple plenum fiber-optic cables.

[b] Total fill is the total quantity of cable to be installed in the test penetration. For example, this could be 40% of the cross-sectional area of the raceway or penetration area for cables not routed in raceways.

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In order to assess the design of a cable-penetration fire stop under this standard, only similar designs and cable fills (i.e., maximum 0%) shall be tested and compared.

When a large test module is used in the fire-resistive barrier to permit several cable systems to pass through it, then one or more intermediate percent fills, as well as minimum and maximum fill levels, shall be tested. If all of the fills that were tested meet the test requirements, then all of the fills between the maximum and zero fills that were tested will also be qualified. For further guidance, refer to Figure A.4, Figure A.5, and Figure A.6.

4.2.3 Opening dimensions and configuration

The dimensions and configuration of the opening to be tested shall be representative of those to be used. The sizes and configurations of the openings listed in Table 2 may be used as a basis for selection where several variations of the same type penetration are used. If the sizes or types in Table 2 are not representative of end-use applications, then more suitable selections shall be used.

Table 2—Suggested penetration opening dimensions

Opening Type—lining; penetrating items	Opening size in mm (in)	Test slab thickness mm (in)
Round—no metal sleeve; cables pass through without raceway	152 (6)	152 or 305 (6 or 12)
Round—no metal sleeve; cables pass through in metal raceway	152 (6)	152 or 305 (6 or 12)
Round—metal sleeve; cables pass through without raceway	152 (6)	152 or 305 (6 or 12)
Round—metal sleeve; cables pass through in metal raceway	152 (6)	152 or 305 (6 or 12)
Rectangular—no metal lining; cables pass through without raceway	203 × 1029 or 1219 (8 × 42 or 48)	152 or 305 (6 or 12)
Rectangular—no metal lining; cables pass through in metal raceway	203 × 1029 or 1219 (8 × 42 or 48)	152 or 305 (6 or 12)
Rectangular—metal lining; cables pass through without raceway	203 × 1029 or 1219 (8 × 42 or 48)	152 or 305 (6 or 12)
Rectangular—metal lining; cables pass through in metal raceway	203 × 1029 or 1219 (8 × 42 or 48)	152 or 305 (6 or 12)

The largest module, opening, or both shall be tested and the cable shall be selected in accordance with 4.2.2 in order to assess the design of a cable-penetration fire stop.

If the largest cross-sectional module meets the requirements of this standard, then all of the modules of the same type and size or smaller will also be qualified. This condition applies to seal assemblies that are installed within or abutting the fire barrier. Arrays of openings or modules that meet this standard's requirements shall also qualify similar arrays with the same or larger spacing.

Any cable-penetration fire stop or any module that was qualified by itself shall demonstrate that the influence of any adjacent cable-penetration fire stop, module, or both does not compromise their qualification. For further guidance, refer to Figure A.1 through Figure A.7.

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4.3 Fire test facility and procedure

4.3.1 Test conditions

Prior to fire test, condition the various components of the test assembly as follows.

4.3.1.1 Test slab

Within a reasonable time, ensure any masonry component has achieved a moisture condition approximately representative of that likely to exist in a similar construction. This moisture condition is considered as that which would be established at equilibrium resulting from drying in an ambient atmosphere of 50% relative humidity at 23 °C (73 °F). However, with some test assemblies it may be difficult or impossible to achieve the equilibrium moisture condition within a reasonable period of time. Therefore, these assemblies may be tested when their dampest portion has achieved a moisture content corresponding to drying to equilibrium with air in the range from 50% to 75% relative humidity at 23 °C ± 3 °C (73 °F ± 5 °F). If the assembly dried in a heated building fails to meet these requirements after a 12-month conditioning period, or if the nature of the construction is such that drying of the assembly will be prevented by hermetic sealing, these requirements may be waived with the following exception. Do not test until a sufficient strength exists to retain the cable-penetration fire stop securely in its installed position without alteration. Any assembly meeting this requirement may be tested in the condition in which it then exists.

Non-masonry components shall be cured or conditioned in accordance with the material's manufacturer's instructions.

4.3.1.2 Fire-stop components

Materials used in the construction of the fire-stop assemblies shall be allowed to cure to a state representative of that likely to exist in a similar construction. In most cases the minimum cure time should be equal to or greater than that prescribed by the fire stop material manufacturer. However, in certain circumstances, it may be desirable to perform the fire endurance test on a specimen with a shorter cure time, if the shorter cure time is intended to be used in actual applications.

4.3.1.3 Test environment

Protect the testing equipment, and the test assembly undergoing the fire test, from any condition of wind or weather that might lead to abnormal results. The ambient air temperature at the beginning of the test shall be within the range from 10 °C to 32 °C (50 °F to 90 °F). If the test equipment is not located indoors, the velocity of air across the unexposed surface measured just before the test begins shall not exceed 1.3 m/s (4.4 ft/s) as determined by an anemometer placed at right angles to the unexposed surface. If mechanical ventilation is employed during the test, do not direct an air stream across the surface of the specimen.

4.3.2 System test

The cable-penetration fire stop shall be tested as a complete system. All of the following shall be representative of the actual installed conditions: the raceway mounting and anchoring to the cable-penetration fire stop assembly, the cable arrangement that includes its attachment to raceway, and, the raceway fill. The test assembly shall be of sufficient size and includes cables, required supports, or other through-penetrating items so as to produce a truly representative design for which evaluation is desired. Install and test the cable-penetration fire stop in each construction type for which ratings are desired.

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4.3.3 Cable and raceway installation

Install the cables and raceways, if provided, so that they extend 305 mm (12 in) on the exposed side and 914 mm (36 in) on the unexposed side unless either or both of these extensions are not typical of actual field installations. In such cases, the installation shall be representative of actual field installations. Support the extended portion of cables and raceways, if provided, on the unexposed side so as to minimize relative movement between them and the restraining frame in which the test assembly is mounted. Vertical cables in floor penetration tests shall be supported on the unexposed side to simulate continuous cables in an actual installation. Cap or otherwise seal the individual ends of the cables and raceways on the exposed side of the test assembly if the test is intended to be representative of a closed system that is not normally vented or open to the atmosphere (e.g., a continuous conduit run). Cable ends on the unexposed side of the test assembly should be capped or otherwise sealed to limit smoke and hot gas migration from the test furnace.

4.3.4 Opening locations

No part of the cable-penetration fire stop shall be closer than 1½ times the thickness of the test assembly or 305 mm (12 in) to the furnace edge, whichever is greater.

4.3.5 Orientation

Testing in the floor-ceiling position will qualify a symmetrical cable-penetration fire stop for either a floor or wall penetration. Cable-penetration fire stops that are symmetrical with respect to design and location in the wall or floor need only be fire tested on one side. Cable-penetration fire stop designs that are asymmetrical in design or location may require testing on both sides for qualification. For examples of asymmetrical designs (e.g., different material types exposed on opposite sides of the penetration) and locations, refer to Figure A.6 and Figure A.7.

4.3.6 Time-temperature curve

The test penetration module shall be subjected to the standard time-temperature curve in Table 3 for the time necessary to obtain the required fire rating.

Table 3—Standard time-temperature curve

Time	Temperature	Area above 68 °F base		Temperature	Area above 20 °C base	
h:min	°F	°F-min	°F-hr	°C	°C-min	°C-hr
0:00	68	00	0	20	00	0
0:05	1 000	2 330	39	538	1 290	22
0:10	1 300	7 740	129	704	4 300	72
0:15	1 399	14 150	236	760	7 860	131
0:20	1 462	20 970	350	795	11 650	194
0:25	1 510	28 050	468	821	15 590	260
0:30	1 550	35 360	589	843	19 650	328
0:35	1 584	42 860	714	862	23 810	397
0:40	1 613	50 510	842	878	28 060	468
0:45	1 638	58 300	971	892	32 390	540
0:50	1 661	66 200	1 103	905	36 780	613
0:55	1 681	74 220	1 237	916	41 230	687
1:00	1 700	82 330	1 372	927	45 740	762

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Table 3—Standard time-temperature curve (*continued*)

Time	Temperature	Area above 68 °F base		Temperature	Area above 20 °C base	
1:05	1 718	90 540	1 509	937	50 300	838
1:10	1 735	98 830	1 647	946	54 910	915
1:15	1 750	107 200	1 787	955	59 560	993
1:20	1 765	115 650	1 928	963	64 250	1 071
1:25	1 779	124 180	2 070	971	68 990	1 150
1:30	1 792	132 760	2 213	978	73 760	1 229
1:35	1 804	141 420	2 357	985	78 560	1 309
1:40	1 815	150 120	2 502	991	83 400	1 390
1:45	1 826	158 890	2 648	996	88 280	1 471
1:50	1 835	167 700	2 795	1 001	93 170	1 553
1:55	1 843	176 550	2 942	1 006	98 080	1 635
2:00	1 850	185 440	3 091	1 010	103 020	1 717
2:10	1 862	203 330	3 389	1 017	112 960	1 882
2:20	1 875	221 330	3 689	1 024	122 960	2 049
2:30	1 888	239 470	3 991	1 031	133 040	2 217
2:40	1 900	257 720	4 295	1 038	143 180	2 386
2:50	1 912	276 110	4 602	1 045	153 390	2 556
3:00	1 925	294 610	4 910	1 052	163 670	2 728
3:10	1 938	313 250	5 221	1 059	174 030	2 900
3:20	1 950	332 000	5 533	1 066	184 450	3 074
3:30	1 962	350 890	5 848	1 072	194 940	3 249
3:40	1 975	369 890	6 165	1 079	205 500	3 425
3:50	1 988	389 030	6 484	1 086	216 130	3 602
4:00	2 000	408 280	6 805	1 093	226 820	3 780
4:10	2 012	427 670	7 128	1 100	237 590	3 960
4:20	2 025	447 180	7 453	1 107	248 430	4 140
4:30	2 038	466 810	7 780	1 114	259 340	4 322
4:40	2 050	496 560	8 110	1 121	270 310	4 505
4:50	2 062	506 450	8 441	1 128	281 360	4 689
5:00	2 075	526 450	8 774	1 135	292 470	4 874
5:10	2 088	546 580	9 110	1 142	303 660	5 061
5:20	2 100	566 840	9 447	1 149	314 910	5 248
5:30	2 112	587 220	9 787	1 156	326 240	5 437
5:40	2 125	607 730	10 129	1 163	337 630	5 627
5:50	2 138	628 360	10 473	1 170	349 090	5 818
6:00	2 150	640 120	10 819	1 177	360 620	6 010
6:10	2 162	670 000	11 167	1 184	372 230	6 204
6:20	2 175	691 010	11 517	1 191	383 900	6 398
6:30	2 188	712 140	11 869	1 198	395 640	6 594

4.3.7 Exposed-side test instrumentation

The temperature fixed by 4.3.6 shall be the average obtained from the readings of thermocouples symmetrically placed within the test furnace to establish the temperature near all parts of the test assembly. Not less than three thermocouples shall be used unless the exposed surface is greater than 9.29 m^2 (100 ft^2). Then, not fewer than five thermocouples per 9.29 m^2 (100 ft^2) of exposed floor surface shall be used; or, not fewer than nine thermocouples per 9.29 m^2 (100 ft^2) of exposed wall surface shall be used.

These thermocouples shall be in sealed protection tubes so that the time constant of the protected thermocouple lies within the range from 300 s to 400 s. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 305 mm (12 in). Other types of protection tubes

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are acceptable provided that temperature measurements obtained in accordance with 4.3.6 are within the limit of accuracy that applies for furnace temperature measurements.

In a floor furnace, the ends of the protected thermocouples shall be placed 305 mm (12 in) away from the exposed face of the test assembly. In a wall furnace, the ends of the protected thermocouples shall be positioned 152 mm (6 in) away from the exposed face of the test assembly. These thermocouples shall not touch the test assembly as a result of deflection that may occur during the fire test.

4.3.8 Exposed side temperature reading intervals

The temperatures shall be read at intervals that are not to exceed 1 min.

4.3.9 Furnace accuracy

The accuracy of the furnace temperature control shall be such that the area under the time-temperature curve that is obtained by averaging the readings from the device in compliance with 4.3.7 is within: a) 10% of the corresponding area under the standard time-temperature curve for fire tests of 60 min or less duration; b) 7.5% for those over 60 min and not more than 120 min; or c) 5% for tests that exceed the 120 min duration.

4.3.10 Unexposed side thermocouples

4.3.10.1 Surface thermocouples

Measure temperatures on the surface of the fire stop and assembly with thermocouples that meet the following requirements. The thermocouple junction shall be located under the center of the pads. The thermocouple leads under the pads shall be not heavier than No. 18 B and S gage (1.02 mm) (0.040 in) and shall be electrically insulated with heat-resistant moisture-resistant coverings.

4.3.10.2 Penetrating item thermocouples

Measure temperatures of each type and size of penetrating item with thermocouples that meet these requirements. The thermocouple leads shall not be heavier than No. 22 B and S gage (0.635 mm) (0.025 in) and shall be electrically insulated with heat-resistant and moisture-resistant coverings. The pads as described above shall be held firmly against the penetrating item and shall fit closely about the thermocouples.

4.3.10.3 Thermocouple pads

Thermocouple pads used in unexposed side temperature measurements shall be of suitable inorganic material (e.g., mineral fiber) and shall comply with Table 4 Thermocouple pads shall be held firmly against the surface to which the thermocouple is applied and they shall be centered over the thermocouple junction.

Table 4—Thermocouple pads

Characteristic	Requirement
Length and width	50.8 mm ± 1 mm (2.00 in ± 0.04 in)
Thickness	10 mm ± 1 mm (0.40 in ± 0.05 in)
Density	500 kg/m^3 ± 10 kg/m^3 (31.2 lb/ft^3 ± 0.6 lb/ft^3)
Thermal conductivity at 150 °F	0.055 ± 0.003 W/m·K (0.380 Btu·in./hr·ft^2·°F ± 0.027 Btu·in./hr·ft^2·°F)

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4.3.11 Unexposed side thermocouple locations

Temperatures on the cold side of the cable-penetration fire stop shall be measured with thermocouples and pads described in 4.3.10. The following is the minimum number of thermocouples that shall be located on the unexposed surface during the test:

a) At least three shall be placed on the unexposed surface of the cable-penetration fire stop material. These thermocouples shall be located equidistant from penetrating items or penetrating items and the opening perimeter. Fewer than three (but at least one) thermocouples shall be used when penetration size is not conducive to placing three thermocouples on the unexposed surface of the cable-penetration fire stop material.

b) At least one shall be placed on the surface of the cable-penetration fire stop material approximately 25 mm (1 in) from each representative cable type or size tested.

c) At least one shall be placed on the cable jacket of each representative cable type or size in the cable-penetration. It shall be placed approximately 25 mm (1 in) from the surface of the fire stop.

d) At least one shall be placed on the surface of the cable-penetration fire stop material approximately 25 mm (1 in) from each representative through metallic component other than insulated cable conductors.

e) At least one shall be placed on each representative through metallic component other than insulated cable conductors. It shall be placed approximately 25 mm (1 in) from the surface of the fire stop.

f) At least one shall be placed on the surface of the cable-penetration fire stop material approximately 25 mm (1 in) from the perimeter of the opening.

g) At least one shall be placed on any sleeve or liner forming the penetration opening. If the sleeve or liner extends beyond the face of the barrier, then the thermocouple shall be located approximately 25 mm (1 in) away from the surface of the fire stop.

h) At least one shall be placed a minimum of 305 mm (12 in) from the sealed opening on the unexposed surface of the fire-resistive barrier that is penetrated provided it is not within the area described in 4.3.4.

4.3.12 Unexposed side temperature reading interval

Temperature readings shall be taken at intervals that do not exceed 1 min.

4.3.13 Differential pressure

The pressure differential between the exposed and unexposed surfaces of the test assembly, as defined in this standard, shall be measured at two points 20 mm (0.78 in) from the exposed surface of the test assembly as follows:

a) *Walls*—At two points along the vertical centerline. The two points shall be separated by a vertical distance that is equal to or greater than one-half of the height of the test assembly.

b) *Floors*—At two points along the longitudinal centerline. The two points shall be approximately *L/4* from the center of the floor, where *L* equals the length of the floor. These points may be adjusted, as necessary, to avoid penetrating items.

Pressure-measuring probes shall be a tee-shaped probe or a tube probe and shall be manufactured from stainless steel or other suitable material.

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Measure the pressure by means of a manometer or equivalent transducer. The manometer or transducer shall be capable of reading 2.5 Pa (0.01 in H_2O) increments with a measurement precision of 1.25 Pa (0.005 in H_2O).

Furnace shall be controlled such that the differential pressure between the exposed and the unexposed surfaces of the test assembly complies with either of the following conditions:

a) *Standard pressure condition*—Except for the first 10 min of the test, the furnace pressure shall be at least 2.5 Pa (0.01 in H_2O) greater than the pressure on the unexposed side of the test assembly at the following locations:

   1) *Walls*—At the lowest elevation of the test specimen. An additional pressure probe is permitted to comply with this requirement.

   2) *Floors*—At the location of the pressure-measuring probes.

b) *Unique pressure condition*—The differential pressure shall be specified by the test sponsor. The furnace shall be controlled such that the specified differential pressure is maintained throughout the duration of the test within 20% of the specified pressure, excluding the first 10 min.

4.3.14 Hose stream test

A hose stream test shall be conducted. Two methods are available and the method selected for the test shall be noted in the test report. Method A is a concentrated stream of water and Method B employs the use of a fog nozzle. Method A is considered to be the more severe of the hose stream tests and is applicable for most test specimens. Method B is applicable to fire stop assemblies designed for installation in power generating facilities, including nuclear power plants. If desired, both hose stream tests may be performed on a test specimen. In this instance, the most applicable method should be applied first and, if successful, followed by the other method immediately upon completion of the first hose stream test.

4.3.14.1 Hose stream specimen

Subject a duplicate specimen to a fire exposure test for a period equal to one-half of that indicated as the resistance period of the fire test, but not more than 60 min, immediately after which subject the test assembly to the impact, erosion, and cooling effects of a hose stream directed first at the lower right edge of the test assembly and then at all parts of the exposed face, with changes in direction being made slowly.

4.3.14.2 Optional hose stream specimen

The test sponsor may elect, with the advice and consent of the testing body, to have the hose stream test performed on the specimen subjected to the fire test and immediately following the fire test.

4.3.14.3 Method A (concentrated stream)

Deliver the stream through a 2½ in hose and discharge it through a National Standard playpipe of corresponding size equipped with a 1⅛ in discharge tip of the standard-taper, smooth-bore pattern without a shoulder at the orifice. The water pressure and duration of application shall be as specified in Table 5. The nozzle orifice shall be 6.1 m (20 ft) from the center of the exposed surface of the test specimen if the nozzle is so located that, when directed at the center, its axis is perpendicular to the surface of the test specimen. If otherwise located, its distance from the center shall be less than 6.1 m (20 ft) by an amount equal to 305 mm (1 ft) for each 10° of deviation from perpendicular, not to exceed 30°.

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Table 5—Water pressure and duration (Method A only)

Resistance period	Water pressure at base of nozzle kPa (psi)	Duration of application s/m^2 (s/ft^2) of exposed area
240 min and over if less than 480 min	310 (45)	32 (3.0)
120 min and over if less than 240 min	210 (30)	16 (1.5)
90 min and over if less than 120 min	210 (30)	10 (0.90)
60 min and over if less than 90 min	210 (30)	6 (0.60)
Less than 60 min if desired	210 (30)	6 (0.60)

4.3.14.4 Method B (fog nozzle)

For power generating stations, including nuclear generating stations, the hose stream shall be delivered through a 1½ in hose and it shall be discharged through a nozzle approved for use on fires in electrical equipment. This nozzle shall produce a spray that is: a long range, a narrow angle (30°–90° set at 30° included angle), and a high velocity. The hose stream shall be applied to the exposed side of the test assembly. The water shall have a pressure of 75 psi when it is calculated or measured at the base of the nozzle; and, it shall have a minimum flow of 75 gpm. This water projection shall be applied at a duration of application of 2½ min per 9.29 m^2 (100 ft^2) of test assembly area. The nozzle distance shall be 3 m (10 ft) from the center of the exposed surface of the test specimen with the nozzle so located that, when directed at the center, its axis is perpendicular to the surface of the test specimen.

5. Evaluation of test results

5.1 Type I tests

The Type I classification is for general approval. Cable-penetration fire stops meeting the criteria of 5.1.1shall be designated as having an F-rating equal to the duration of the fire endurance test. Cable-penetration fire stops shall further be assigned a T-rating based on the duration of the test during which the criteria set forth in 5.1.2 was satisfied.

5.1.1 F-rating

A cable-penetration fire stop shall achieve an F-rating if the following criteria are met.

5.1.1.1 Fire propagation

The cable-penetration fire stop shall prevent the passage of flame during the fire endurance portion of the test, as demonstrated by not allowing any cable or component of the fire stop to ignite on the unexposed side of the test assembly; nor allowing any visible flame on the unexposed side of the test assembly.

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5.1.1.2 Hose stream integrity

The cable-penetration shall maintain integrity during the hose stream portion of the test, as demonstrated by not becoming dislodged during the hose stream test; nor developing any opening that would permit a projection of water from the hose stream beyond the unexposed side of the test assembly.

5.1.2 T–rating

A cable-penetration fire stop shall achieve a T-rating if the following criteria are met.

5.1.2.1 Temperature

The transmission of heat through the cable-penetration fire stop shall not have been such as to raise the temperature of any thermocouple on the unexposed surface of the fire stop or on any penetrating item more than 181 °C (325 °F) above its initial temperature. Additionally, the cable-penetration fire stop shall have satisfied the F-rating criteria of 5.1.1 for a duration greater than or equal to that of the desired T-rating.

5.2 Type II

The Type II classification is for cable-specific approval. Cable-penetration fire stops meeting the criteria of 5.2.1 shall be designated as having an F-rating equal to the duration of the fire endurance test. Cable-penetration fire stops shall further be assigned a T-rating based on the duration of the test during which the criteria set forth in 5.2.2 was satisfied.

5.2.1 F-rating

A cable-penetration fire stop shall achieve an F-rating if the following criteria are met.

5.2.1.1 Fire propagation

The cable-penetration fire stop shall prevent the passage of flame during the fire endurance portion of the test, as demonstrated by not allowing any cable or component of the fire stop to ignite on the unexposed side of the test assembly, nor allowing any visible flame on the unexposed side of the test assembly.

5.2.1.2 Hose stream integrity

The cable-penetration shall maintain integrity during the hose stream portion of the test, as demonstrated by not becoming dislodged during the hose stream test, nor developing any opening that would permit a projection of water from the hose stream beyond the unexposed side of the test assembly.

5.2.2 T–rating

A cable-penetration fire stop shall achieve a T-rating if the following criteria are met.

5.2.2.1 Temperature

The transmission of heat through the cable-penetration fire stop shall not have been such as to raise the temperature of any thermocouple on the unexposed surface of the fire stop or on any penetrating item to lowest auto-ignition temperature of any material that was tested in accordance with ASTM D1929. Additionally, the cable-penetration fire stop shall have satisfied the F-rating criteria of 5.2.1 for a duration greater than or equal to that of the desired T-rating.

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6. Documentation of testing

6.1 General

The following information must be recorded to document compliance with this standard. Test data derived from tests shall be organized to present the results in an orderly manner so as to be easily understood and located. The following data shall be recorded.

6.1.1 Cable information

a) Manufacturer of cable

b) Manufacturer's designation for cable and generic name of materials used in its production

c) Temperature and voltage rating of cable

d) Physical dimensions including: conductor size, insulation thickness, jacket thickness, shields, tapes, fillers, and other cable components, as applicable

e) Miscellaneous construction details, including type of raceway, etc.

f) Results of or reference to all tests run on cables that are required by this standard prior to fire test

6.1.2 Cable-penetration fire-stop information

a) Manufacturer of the materials or the devices.

b) Manufacturer's designation and generic name of materials, or devices, or both.

c) Installation methods shall be described; that includes any quality assurance data applicable to the specific materials and installation methods used.

d) Complete description of materials surrounding the cable-penetration fire stop.

6.1.3 Laboratory information

a) Description of the test assembly, including identification of all penetrating items. Drawings depicting geometry, exact size (length, width, thickness) of: the test assembly; the cable-penetration fire stops; or, the modules. The location of the cable-penetration fire stops; or, the modules.

b) Environmental conditions, such as air ambient, air currents, and humidity at the time of the test.

c) Details of hose stream or water spray test. The results, pass or fail, shall be recorded and supplemented with photographs and a statement of the conclusions that were drawn made by those conducting the test.

d) The furnace and the unexposed side temperatures for the duration of the standard fire test. Record these temperature readings and the times that they were taken.

e) The test equipment shall be described in detail, supplemented with record of fuel supply, photographs, dimensioned drawings, and written specifications with not less data than that necessary to reproduce accurately the same test.

f) The location of pressure probes and the differential pressures between the exposed and unexposed surfaces of the test assembly measured during the fire test. If the test was conducted with a unique pressure condition the report shall state the basis for the specified pressure.

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g) Record observations of significant details of the behavior of the cable-penetration fire stops during the test and after the furnace fire is extinguished. These shall include cracks, deformation, flaming, and smoke issuance. Also, these observations should include continued burning within the test assembly after termination of the fire test.

h) Note the cure time for the test slab, as well as all fire-stop materials.

7. Conditions of acceptance and report

7.1 General

Report results in accordance with the performance in the tests prescribed in this test method. Express the results in time periods of resistance to the nearest integral minute. Reports shall include the following:

a) All the data in Clause 6 of this document.

b) The cable-penetration fire stop shall have withstood the fire endurance test as specified and shall be classified as Type I or Type II per the requirements of Clause 5. All information relevant to the classification shall be included in the test report.

c) The cable-penetration fire stop shall have withstood the hose stream test without the hose stream causing an opening through the test specimen. When the indicated fire stop rating period is 60 min or over, a correction shall be applied for variation of the furnace exposure from the prescribed, where it will affect the rating, by multiplying the indicated period by two-thirds of the difference in area between the curve of average furnace temperature and the standard curve for the first three-fourths of the period and dividing the product by the area between the standard curve above a base line of 20 °C (68 °F) for the same part of the indicated period, the latter area increased by 1800 °C•min or 324 °F•min (30 °C •h or 54 °F •h), to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For fire exposure in the test higher than standard, the indicated rating period shall be increased by the amount of the correction and be similarly decreased for fire exposure (below standard). The correction can be expressed as follows in Equation (1):

$$C = \frac{2I(A - A_s)}{3(A_s + L)} \tag{1}$$

where

C is the correction in the same units as I

I is the indicated fire-resistance period

A is the area under the curve of indicated average furnace temperature for the first three fourths of the indicated period

A_S is the area under the standard furnace curve for the same part of the indicated period

L is the lag correction in the same units as A and A_S (30 °C•h or 54 °F•h , 1782 °C•min or 3240 °F•min)

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Annex A

(normative)

Cable-penetration type tests

The following symbol definitions apply to Figure A.1 through Figure A.7.

A, B, C	Largest dimension of opening to be qualified. If largest A, B, C dimension is qualified, all smaller A, B, C of similar design are also qualified.
X_1, X_2, X_3, X_4 X_5	Minimum separation to be qualified. If X_1, X_2, X_3, X_4, X_5 is qualified, all larger X_1, X_2, X_3, X_4, X_5 are also qualified.
F_{max}	Maximum percent cable fill to be qualified.
F_{min}	Minimum percent cable fill to be qualified. If design is to qualified for spares, then F_{min} = 0%.
F_I	Intermediate percent cable fill, usually taken as (F_{max} + F_{min}) / 2

Typical Cross Sections

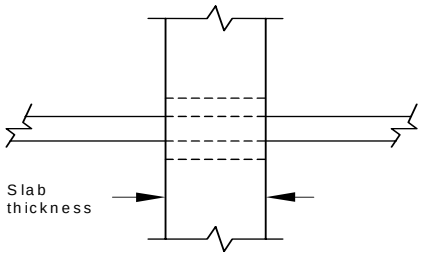

Figure A.1
Raceway passes through fire resistive barrier

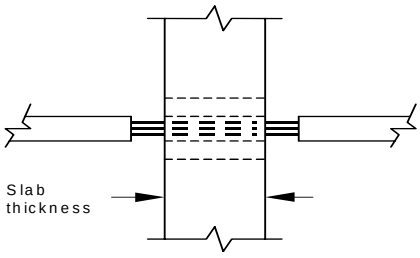

Figure A.2
Raceway does not pass through fire resistive barrier

Example of Single Type Test

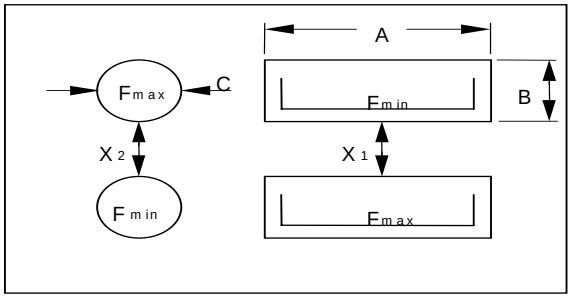

Figure A.3
Four individual modules each with one opening

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Multi-opening single module type test (example)

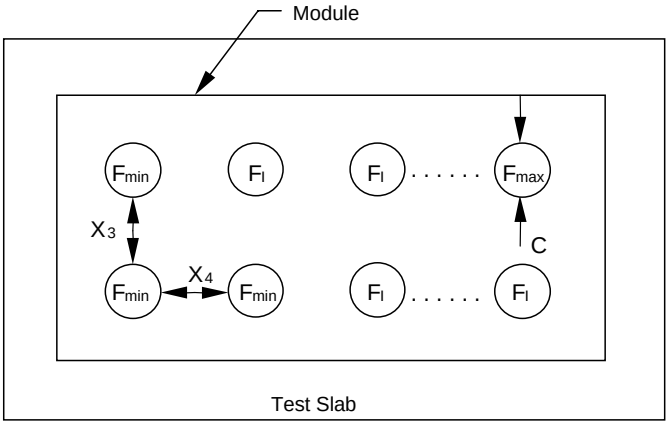

Figure A.4
Typical Conduit or Sleeve Penetration

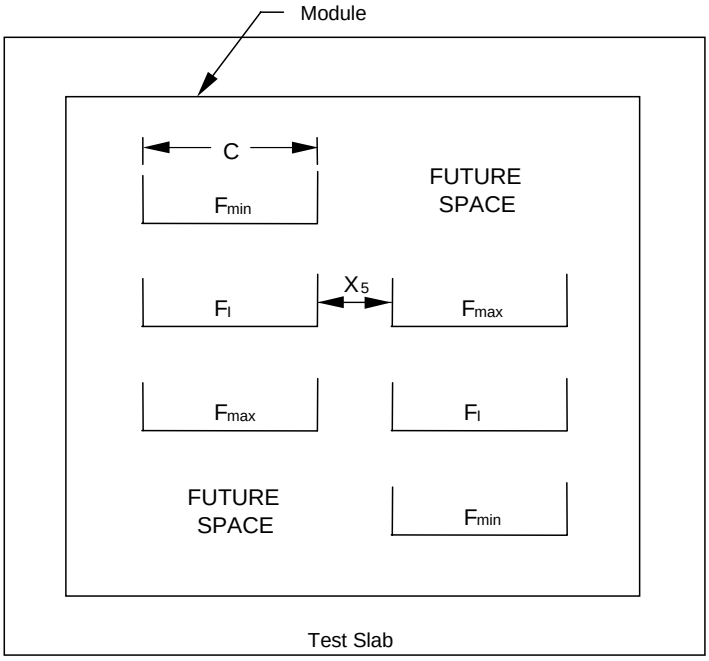

Figure A.5
Typical Tray Opening Penetration

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Examples of Modules with Non-Symmetrical Fire Stops

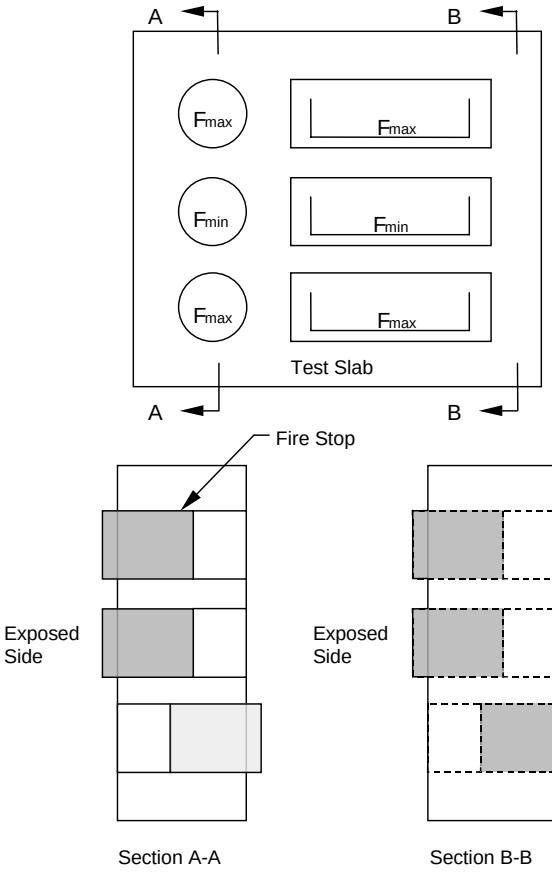

Figure A.6

Fire stop non-symmetrical
with respect to location

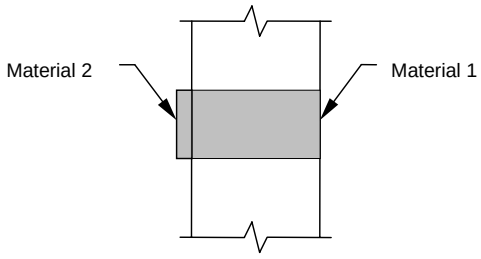

Figure A.7

Fire stop non-symmetrical
with respect to materials

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Annex B

(informative)

Bibliography

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[B2] IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition.

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