

IEEE Standard Cable Penetration Fire Stop Qualification Test

Sponsor

**Insulated Conductors Committee of the
IEEE Power Engineering Society**

Approved December 15, 1977

IEEE Standards Board

Approved June 21, 1979

American National Standards Institute

Copyright © 1978 by

The Institute of Electrical and Electronics Engineers, Inc.

*No part of this publication may be reproduced in any form,
in an electronic retrieval system or otherwise,
without prior written permission of the publisher.*

Approved December 15, 1977

IEEE Standards Board

William R. Kruesi, *Chairman*

Irvin N. Howell, Jr, *Vice Chairman*

Ivan G. Easton, *Secretary*

**William E. Andrus
Jean Jacques Archambault
Mark Barber
Edward J. Cohen
Warren H. Cook
Louis Costrell
R. L. Curtis
David B. Dobson**

**R. O. Duncan
Charles W. Flint
Jay Forster
Ralph I. Hauser
Joseph L. Koepfinger
Irving Kolodny
Benjamin J. Leon
Thomas J. Martin**

**Donald T. Michael
Voss A. Moore
William S. Morgan
William J. Neiswender
Ralph M. Showers
Robert A. Souderman
Leonard W. Thomas, Sr.
B. W. Whittington**

Foreword

(This Foreword is not a part of IEEE Std 634-1978, Cable Penetration Fire Stop Qualification Test.)

This standard provides qualification test procedures for type testing cable penetration fire stops when mounted in rated fire barriers.

In the course of construction of all types of buildings, cables in raceways penetrate barriers such as walls, floors, or floor-ceiling assemblies of that building. If these barriers are rated as fire resistive barriers, the penetrations should be as resistant to fire as required of the barriers. Thus, in order to test the penetration and rate it, the penetration should be mounted in a rated wall, floor, or floor ceiling assembly as it would be used in practice and the combination exposed to the same standard fire as used for the wall, floor, or floor-ceiling assembly.

Rating of a Fire Resistive Barrier, with No Penetrations

This rating is expressed in hours and represents the ability of that barrier to withstand, without failure, exposure to a standard fire for that length of time. A fire rating for a barrier may be arrived at by testing it according to the procedure outlined in ANSI A2.1-1972, Methods of Fire Tests of Building Construction and Materials (ASTM E119-1971) (ISO 834).

A barrier achieves its rating if, during the specified time, it contains the fire, and its surface unexposed to the fire does not heat up sufficiently to ignite cotton waste or the temperature does not exceed 250°F above ambient. In addition, following the fire, the barrier is required to withstand a specified standard fire hose test on the hot face.

Caution Re: ANSI A2.1-1972, Limitations

ANSI A2.1-1972 cautions that its results give only a *relative* measure of fire performance of comparable barriers (see 2.2), that it does not measure degree of control or limitation of smoke or products of combustion through the assembly (see 2.4.3), and does not consider the effect of conventional openings, that is, electrical receptacle outlets or plumbing pipe, etc (see 2.4.6).

Standard Fire in ANSI A2.1-1972

The standard fire is defined by a time-temperature relationship which must be produced by the test furnace. The seven defined points on this curve are given as follows:

1000° F (538° C)	at 5 min
1300° F (704° C)	at 10 min
1550° F (843° C)	at 30 min
1700° F (927° C)	at 1 hr
1850° F (1,010° C)	at 2 hr
2000° F (1,093° C)	at 4 hr
2300° F (1,260° C)	at 8 hr or more

A more detailed description is given in ANSI A2.1-1972, Appendix A1 which lists intervening points and tabulates the integrated area under the time-temperature curve as a function of time.

The same standard fire is used on the cable penetration fire stop qualification test.

Fundamental Difference Between a Fire Test on a Barrier Alone and a Penetration-Barrier Combination

The fire resistive barrier described above has a relatively low thermal conductivity so that it can maintain a 1300-1600°F temperature difference between the face exposed to the fire and the opposite face. A cable penetration has a metallic electrical conductor which has a very high thermal conductance. It may have many large copper conductors and steel trays or conduits or metal parts of the penetration, all of which pass through the barrier. On the cool side of the barrier, these metal parts are necessarily at a higher temperature than the wall adjacent to the penetration. The stop material filling the interstices between cables or between cables and the barrier should give comparable thermal conductance to the barrier itself, in addition to resisting the fire.

Thus the higher temperature rise of the metallic parts of the penetration presents a new and different problem and may make it impossible to use the same pass-fail criteria as for the barriers. An obvious failure occurs when sufficient heat is transmitted so that the insulation of the cable on the cold side bursts into flame. This is discussed further in 2.3.

Maximum Allowable Cable Penetration Fire Stop Face Temperature

If one examines the temperatures across the unexposed face of the cable penetration fire stop near the end of a 3 h test, the temperatures will vary widely depending on the distance from a cable or a raceway. The temperature of the unexposed face of the cable penetration fire stop material at a point away from the cable or the raceway will also depend on the thermal conductivity of the cable penetration fire stop material. The *maximum* temperature on that face is the important one. If this temperature is at the interface between the cable jacket and the cable penetration fire stop material, and if this temperature rises to the self-ignition temperature of the cable jacket or the stop material, a fire may result.

Thus, the test procedure finds the maximum temperature on the unexposed cable penetration fire stop face and compares it with a maximum allowable temperature. The maximum allowable temperature is defined as one at which the insulation systems expected to be used should not ignite.

The maximum allowable temperature is arrived at by an examination of the known ignition temperatures of insulating materials. Ignition temperature is measured by a procedure in ANSI K65.111-1971, Method of Test for the Ignition Properties of Plastics (ASTM D129-1968). This is described as a hot-air ignition furnace. The values obtained represent the lowest ambient air temperature that will cause ignition of the material under the conditions of test. Measured properties are "flash-ignition temperature" where an igniting source is present (small gas flame) and "self-ignition temperature," where ignition occurs spontaneously.

For ignition, there must be adequate temperature; the combustible gases released from the hot insulation must be mixed with the correct proportion of air.

The required temperature to cause ignition would be much higher than the ASTM value because the hot gases released are swept away by air drafts, and a higher temperature is needed to produce a higher rate of release of gases so that an ignitable gas-air ratio can be attained. Thus, there is a good factor of safety in the assigned maximum allowable temperature.

Typical values of the ignition temperatures as determined in ANSI K65.111-1971 are given below in degrees Fahrenheit:

Material	Flash-Ignition	Self-Ignition
Cotton	446-511	490
Newspaper	445	445
Pine shavings	406-507	500
Wool	401	—
Polyethylene	645	660
Polyvinyl chloride	735	850
Polytetrafluoroethylene	—	986
Polyvinyl chloride-acetate	608-644	815-1035
Polystyrene	635-680	910-925
Nylon 66	750-790	788-806

The maximum allowable temperature selected for a cable penetration fire stop should be based on the self-ignition temperature of the outer cable covering the fire stop materials, or materials in contact with the cable penetration fire stop, whichever has the lower self-ignition temperature. For cable penetration fire stops the self-ignition temperatures of the outer cable covering and fire stop materials are generally above 700° F.

The maximum allowable temperature is the actual measured temperature on the unexposed side and *not* temperature rise. This is because the ignition of a given material occurs at a specific temperature of degrees Fahrenheit.

What This Standard Does Not Do, and Problems Yet to Be Covered

Pressure Seals

A penetration fire stop and the fire barrier itself should, in some locations, function as a seal to maintain any existing pressure difference and should not pass through hot gases or smoke. It should maintain that ability for the duration of the rating test. While this problem is recognized, the present standard does not address it, nor does the ANSI A2.1-1972 test. This should be a future task.

If it is desired by the user of this standard, he can specify an added test, outside the scope of this standard and supplementing the information it provides, which would require a check of the ability of the penetration to maintain a differential pressure before, during, and after the fire test. There has been no standard method yet proposed and accepted for checking this seal during a fire test.

Ampacity Derating Due to Penetration Stops

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

Adequacy of Test Furnace

Furnaces used in these rating tests are sometimes operated at lower than atmospheric pressure, and thus hot gases or smoke would not tend to leak outward, but cold air would tend to flow inward toward the fire. This test may not represent a typical situation in a real fire and should be the subject of future investigations.

Test Limitation and Cautions

Just as in the case of the fire barrier in ANSI A2.1-1972, this test is run 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 barrier combination 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.

The test, as already pointed out, gives no information on the necessity, if any, for ampacity derating of cables within the cable penetration, nor does it give any indication of the capability of the stop to maintain a pressure differential between the opposing faces of the barrier before, during, or after a fire test.

Furthermore, the user must consider the higher temperature of those components emerging from the face of the barrier not exposed to fire, for example, the conductors and metallic elements, such as the tray, conduit, or structural parts of the penetration. These higher temperatures must be considered by the designer who will perform a hazards analysis and will take steps necessary to counter these hazards if any are found.

Electric Penetration Assemblies in Containment Structures

Electric penetration assemblies in containment structures are not covered in this standard. For guidance in this area, refer to IEEE Std 317-1976, Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

Seismic, Radiation, Aging, and 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 IEEE Std 344-1975, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, and IEEE Std 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

This standard was prepared by Task Force 12-40 of the Insulated Conductors Committee and at the time of approval had the following membership:

A. R. Fitzpatrick,* Chairman

J. R. Perkins,* Secretary

G. P. Adams
A. T. Baker*
E. W. Bennett, Jr
T. P. Burke
M. D. Calcamuggio*
R. E. Cotta*
R. T. Currier
J. M. Davis*
R. deBlasio*
R. Feit*
J. B. Gardner
J. J. Garland*
A. Garshick
D. C. Gasda
R. A. Guba
S. B. Hamilton
V. J. Herter*

R. R. Howard
J. D. Hunt
C. V. Johnson
J. W. Johnson
R. J. Kasper*
E. R. Kingsbury
R. Kruger
F. E. LaFetra
J. H. Lawson
T. H. Ling
R. Luther*
I. J. Marwick
E. J. McGowan
E. E. McIlveen
A. V. Morisi*
P. Neuger

P. A. Nobile
M. G. Noble
J. O'Brien
R. A. Pace*
W. M. Pate
J. Pedlow
J. G. Quin
S. T. Sabnis
D. E. Sandwick*
J. L. Steiner
C. H. Sudduth*
R. B. Taylor*
W. A. Thue
E. M. Walton
R. H. Watkins
G. D. Weatherford*
O. Willis

***Members of Steering Committee**