Standard Test Methods for Fire Tests of Fire-Resistive Barrier Systems for Electrical System Components[1]

This standard is issued under the fixed designation E 1725; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover fire-test-response.

1.2 These fire-test-response test methods provide information on the temperatures recorded on the electrical system component within a fire-resistive barrier system during the period of exposure.

1.3 *This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire hazard or fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard or fire risk assessment of a particular end use*.

1.4 Potentially important factors and fire characteristics not addressed by these test methods include, but are not limited to:

1.4.1 The performance of the fire-resistive barrier system constructed with components other than those tested.

1.4.2 An evaluation of the functionality of the electrical system within the fire-resistive barrier system.

1.4.3 An evaluation of the ampacity of the electrical system within the fire-resistive barrier system.

1.4.4 An evaluation of the smoke, toxic gases, corrosivity, or other products of heating.

1.4.5 A measurement of the flame spread characteristics over the surface of the fire-resistive barrier system.

1.4.6 An evaluation of through-penetration sealing methods.

1.4.7 Combustibility of materials in the fire-resistive barrier system or of the electrical system components.

1.4.8 The need for supports beyond those normally required.

1.4.9 Environmental conditions in the area of service.

1.5 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.6 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 119 Test Methods for Fire Tests of Building Construction and Materials[2]

E 176 Terminology of Fire Standards[2]

E 1529 Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *air drop*—lengths of open run conductors or cables supported only at each end.

3.1.2 *electrical system components*—cable trays, conduits and other raceways, open run cables and conductors, cables, conductors, cabinets, and other components, as defined or used in the National Electrical Code, and air drops as defined in 3.1.1.

3.1.3 *fire-resistive barrier system*—a specific construction of devices, materials, or coatings installed around, or applied to, the electrical system components.

3.1.4 *specimen*—a construction consisting of electrical system components and a fire-resistive barrier system.

3.1.5 *test assembly*—horizontal or vertical construction on which test specimens are to be mounted together with associated instrumentation.

4. Significance and Use

4.1 These fire-test-response test methods evaluate, under the specified test conditions, the ability of a fire-resistive barrier system to inhibit thermal transmission to the electrical system component within.

4.2 In these procedures, the specimens are subjected to one or more specific sets of laboratory test conditions. If different test conditions are substituted or the end-use conditions are changed, it may not be possible by or from these test methods

[1] These test methods are under the jurisdiction of ASTM Committee E05 on Fire Standards and are the direct responsibility of Subcommittee E05.11 on Construction Assemblies.

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[2] *Annual Book of ASTM Standards*, Vol 04.07.

to predict changes in the fire test response characteristics measured. Therefore, the results are valid only for the fire test exposure conditions described in these procedures.

4.3 These test methods provide a measurement of the transmission of heat to the electrical system components within the barrier system.

4.4 These test methods provide qualification of a fireresistive barrier system as one element of an electrical system designed to maintain continuous operation of critical functions and processes for a specific fire endurance rating.

4.4.1 In addition to the temperature data provided by these test methods, numerous other factors, such as referenced in 1.4 shall be considered in specifying such a system.

5. Control of Fire Test

5.1 *Fire Test Exposure Conditions*:

5.1.1 *Time-Temperature Curve*—Maintain the fire environment within the furnace in accordance with the standard time-temperature curve shown in Test Method E 119 or the rapid temperature rise curve shown in Test Method E 1529.

5.2 *Furnace Temperatures*:

5.2.1 The temperature fixed by the curve shall be the average temperature obtained from readings of thermocouples distributed within the test furnace. Disperse the thermocouples as symmetrically as possible within the furnace to measure the temperature near all exterior surfaces of the specimen. Do not place the thermocouples at locations where temperature readings would be effected by drafts within the furnace.

5.2.2 Measure and report the temperatures at intervals not exceeding 1 min.

5.3 *Furnace Thermocouples*:

5.3.1 *Test Method E 119*—Enclose the thermocouples in sealed protection tubes of such materials and dimensions that the time constant of the protected thermocouple assembly lies within the range from 300 to 400 s[3]. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. (305 mm).

5.3.2 *Test Methods E 1529*—Measure the temperature of the gases adjacent to and impinging on the test specimens using factory manufactured 0.25-in. (6-mm) outside diameter (OD), Inconel[4]-sheathed, Type K, chromel-alumel[4] thermocouples. The time constant, in air, of the thermocouple assemblies shall be less than 60 s. Use standard calibration thermocouples with an accuracy of ± 0.75 %. A minimum length of 20 diameters (125 mm) of the sheathed junction end of the thermocouple shall be mounted parallel to the surface of the test specimen.

5.4 *Furnace Thermocouple Locations*—Position the furnace control thermocouples before the start of the fire exposure test. It shall be permitted to move the thermocouple to avoid touching the specimen as a result of its deflection during the test.

5.4.1 Place the junction of each thermocouple 12 ± 1 in. (305 ± 25 mm) from the surface of horizontal constructions or 12 ± 1 in. from the surface of specimens mounted in horizontal constructions.

5.4.2 Place the junction of each thermocouple 6 ± 1 in. (152 ± 25 mm) from the surface of vertical constructions or 6 ± 1 in. from the surface of specimens mounted in vertical constructions.

5.4.3 Use a minimum of three thermocouples.

5.4.3.1 For specimens mounted in horizontal constructions, there shall be no less than five thermocouples per 100 ft^2 (9 m^2) of exposed area. Calculate the exposed area to be the sum of the exterior surface area of the fire-resistive barrier system plus the area of the horizontal construction exposed to the furnace fire.

5.4.3.2 For specimens mounted in vertical constructions, there shall be no less than nine thermocouples per 100 ft^2 (9 m^2) of exposed area. Calculate the exposed area to be the sum of the exterior surface area of the fire resistive barrier system plus the area of the vertical construction exposed to the furnace fire.

5.5 *Furnace Control*:

5.5.1 *Test Method E 119 Time-Temperature Curve*:

5.5.1.1 The control of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the furnace thermocouple readings, is within 10 % of the corresponding area under the standard time-temperature curve for fire tests of 1 h or less duration, within 7.5 % for those over 1 h and not more than 2 h, and within 5 % for tests exceeding 2 h in duration.

5.5.2 *Test Method E 1529 Time-Temperature Curve*—The control of the furnace shall be such that the area under the time-temperature curve of the average of the gas temperature measurements is within 10 % of the corresponding curve developed in the furnace calibration for tests of 30 min or less duration, within 7.5 % of those over 30 min and not more than 1 h, and within 5 % for tests exceeding 1 h.

5.5.3 If the indicated rating for the protection system is 60 min or more, it shall be increased or decreased by the following correction to compensate for significant variation of the measured furnace temperature from the standard time-temperature curve. The correction is to be expressed by the following formula:

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

where:

C = correction in the same units at I,
I = indicated fire resistance period,
A = area under the curve of the average furnace temperature for the first three fourths of the indicated period,

[3] A typical thermocouple meeting these time-constant requirements may be fabricated by fusion-welding the twisted ends of No. 18 B&S gage, 0.040 in. (1.02 mm), chromel-alumel wires, mounting the leads in porcelain insulators and inserting the assembly so the thermocouple bead is 0.50 in. (13 mm) from the sealed end of a standard weight, nominal ½ in. iron, steel, or Inconel (a registered trademark of INCO Alloys Inc., 3800 Riverside Dr., P.O. Box 1958, Huntingdon, WV 25720) pipe. The time constant for this and for several other thermocouple assemblies was measured in 1976. The time constant may also be calculated from knowledge of its physical and thermal properties. See Research Report RR:E05-1001, available from ASTM Headquarters.

[4] Buchanan Splice Caps No. 2006S, crimped with a Buchanan C-24 pres-SURE-tool have been found suitable for this purpose (Buchanan Construction Products, Inc., Hackettstown, NJ 07840). The cylindrical splice caps are constructed of thin copper and result in a very secure and robust attachment with the addition of a minimal thermal mass.

A_s = area under the standard time-temperature curve for the first three fourths of the indicated period, and

L = lag correction in the same units as A and A_s 54°F·h or 30°C·h (3240°F·min or 1800°C·min). L is only applicable to thermocouples described in 5.3.1 and becomes zero for thermocouples described in 5.3.2.

5.6 *Furnace Calibration*—Test Method E 1529 contains a calibration procedure, that is described in the following sections. Test Method E 119 does not contain a calibration procedure.

5.6.1 Expose the test specimen to heat flux and temperature conditions representative of total continuous engulfment in the luminous flame regime of a large free-burning fluid-hydrocarbon-fueled pool fire. Use calibration assemblies to demonstrate that the required heat flux and temperature levels are generated in the fire test facility.

5.6.2 Measure the total heat flux using a circular foil heat flux gage (often called a Gardon gage after the developer).

5.6.3 The test setup will provide an average total cold wall heat flux on all exposed surfaces of the test specimen of 50 000 $\pm$ 2500 Btu/ft^2·h (158 $\pm$ 8 kW/m^2). The total cold wall heat flux can be controlled by varying the flow of fuel and air. Attain the cold heat flux of 50 000 Btu/ft^2·h within the first 5 min of the test exposure; maintain this heat flux for the duration of the test.

5.6.4 The temperature of the environment that generates the heat flux of 50 000 Btu/ft^2 ·h shall be at least 1500°F (815°C) after the first 3 min of the test and shall be between 1850°F (1010°C) and 2150°F (1180°C) at all times after the first 5 min of the test.

5.7 *Furnace Pressure*—The furnace pressure control described in the sections that follow pertain to tests performed using either of the two time-temperature curves.

5.7.1 Measure the pressure differential between the laboratory ambient air and the interior of the fire test furnace with a minimum of two pressure probes.

5.7.1.1 The pressure measuring probe tips shall be either of the "T" type as shown in Fig. 1, or of the "tube" type as shown in Fig. 2, and shall be manufactured from stainless steel or other suitable material.

5.7.2 *Horizontal Test Assembly*—Maintain the differential pressure at neutral at a point not less than 12 in. (305 mm) below the exposed surface of the test assembly. No specimen shall be positioned within the heated area of the furnace such

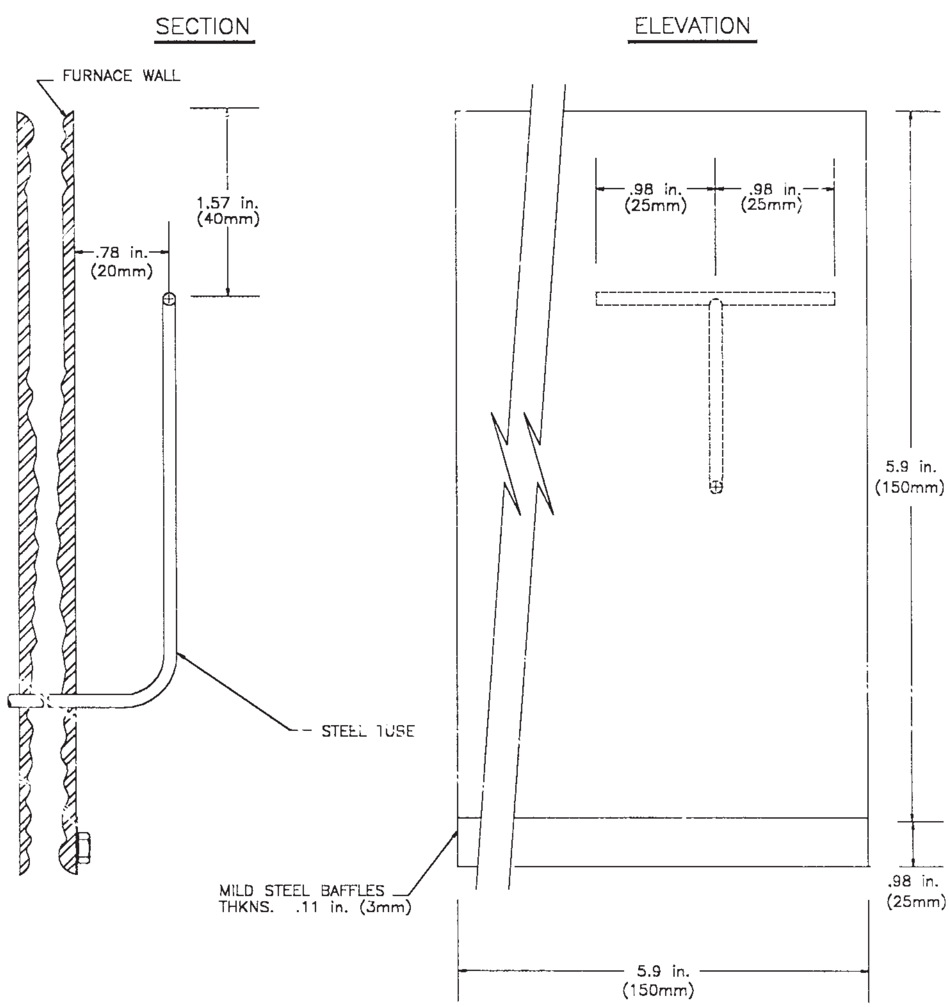


FIG. 1 Furnace Pressure Probe 1

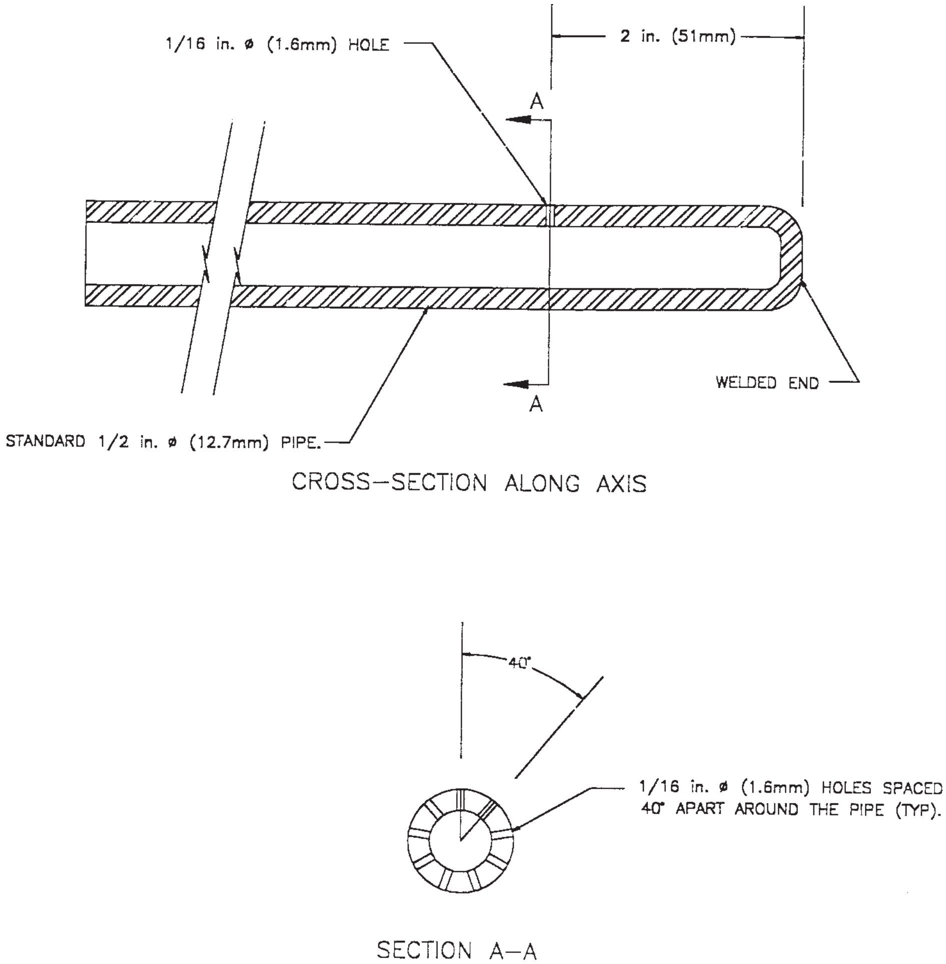


FIG. 2 Furnace Pressure Probe 2

that the entire exposed vertical dimension lies below the neutral pressure plane.

5.7.2.1 Locate the pressure measuring probe tips within 6 in. of the vertical centerline of the test specimen. Separate the probes by a minimum of one third of the longest inside dimension of the test furnace. Alternatively, separate the two probes by a minimum of 12 in. (305 mm) vertical distance within the furnace, and the location of the neutral plane calculated as a function of their vertical separation and their pressure difference.

5.7.3 *Vertical Test Assembly*—Position specimens within the heated area of the furnace such that at least one half of the vertical dimension lies above the neutral pressure plane.

5.7.3.1 Separate at least two probes by a vertical distance within the furnace equal to one half the furnace height or 12 in. (305 mm), whichever is greatest, and calculate the location of the neutral plane as a function of their vertical separation and their pressure difference.

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

6. Specimen Construction

6.1 Construct the horizontal or vertical test assembly of materials that offer adequate support for the test specimen during the fire exposure. The designs and installation of the fire-resistive barrier systems and electrical system components shall be representative of actual end use.

6.2 *Electrical System Components*—Test components at their full size and linear dimensions for which evaluation is desired. If the full-size component's linear dimensions are greater than those specified under each component type in this section, utilize the dimensions shown, unless data is required for a unique design. Cable trays, conduits, and other raceways are tested without conductors, unless the test is for a unique design. Suggested arrangements are shown in Figs. 3 and 4.

6.2.1 *Cable Trays, Raceways, and Open-Run Cables—Horizontal Assemblies*:

6.2.1.1 The exposed vertical depth of the test specimen shall not be less than 36 in. (914 mm).

6.2.1.2 The exposed horizontal length between the inside surfaces of the vertical sections shall not be less than 60 in. (1524 mm).

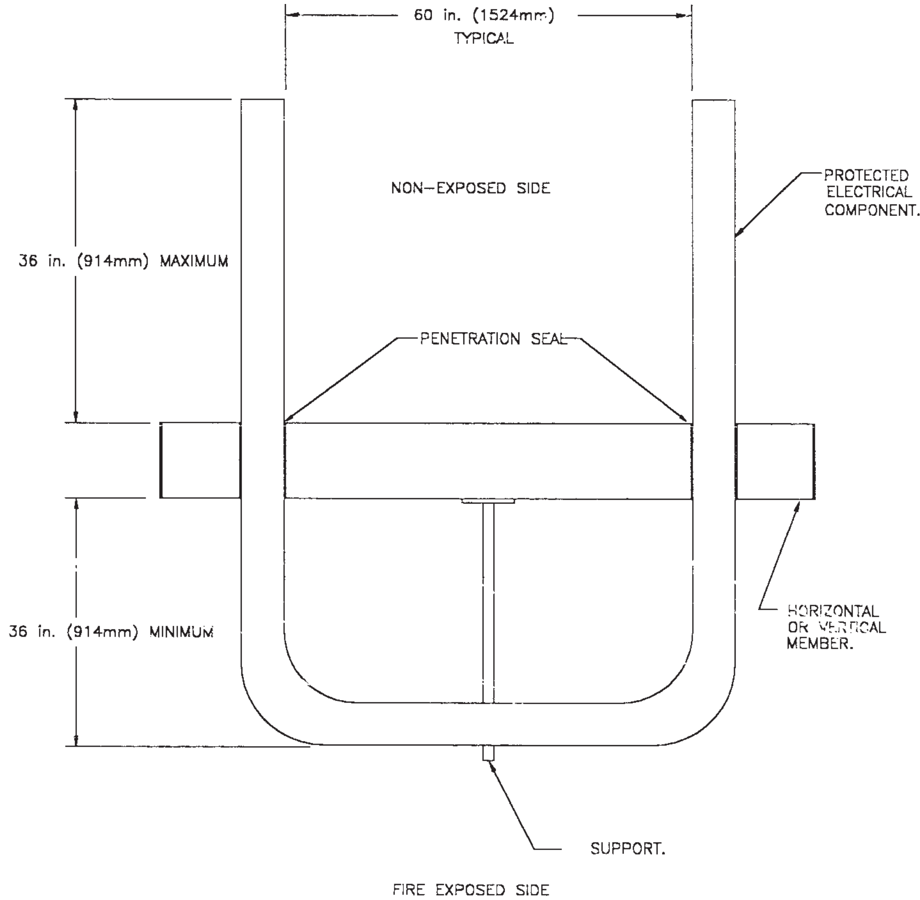


FIG. 3 Standard Electrical Component Assembly

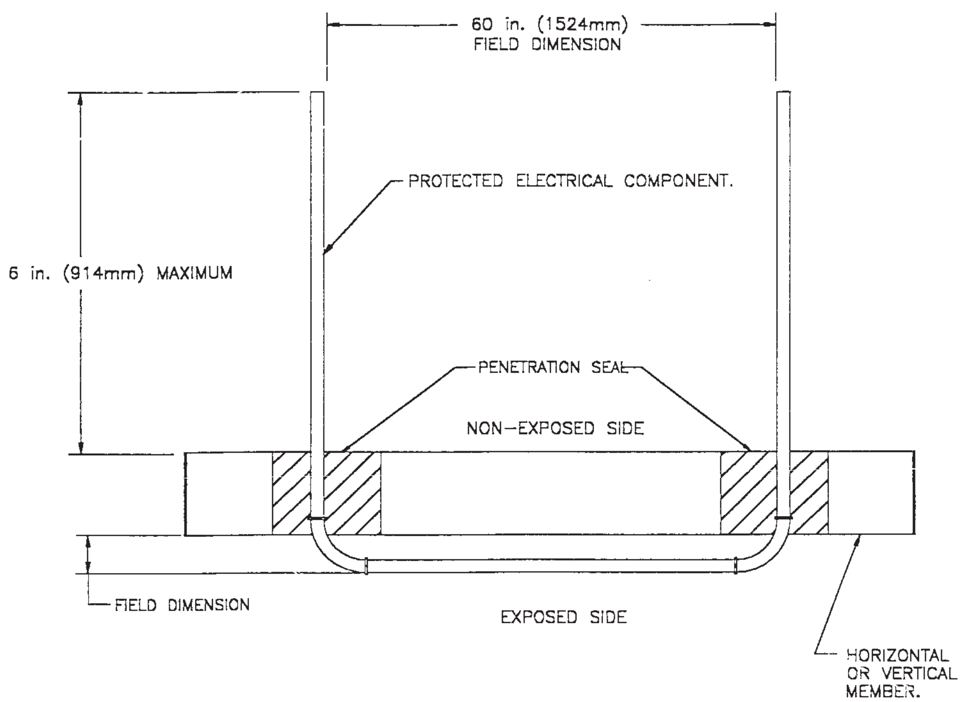


FIG. 4 Unique Electrical Component Assembly

6.2.2 *Cable Trays, Raceways, and Open-Run Cables—Vertical Assemblies*:

6.2.2.1 The exposed vertical height of the test specimen shall not be less than 60 in. (1524 mm).

6.2.2.2 The exposed horizontal depth between the vertical test assembly and the closest surface of the vertical specimen shall not be less than 36 in. (914 mm).

6.2.3 *Airdrop*:

6.2.3.1 To evaluate an airdrop in the vertical configuration only, the exposed vertical length of the test specimen shall not be less than 24 in. (610 mm) (see Fig. 5).

6.2.3.2 To evaluate an airdrop in the horizontal configuration only, the exposed horizontal length shall not be less than 24 in. (610 mm).

6.2.3.3 To evaluate an airdrop for both vertical and horizontal with a bend, the exposed vertical length shall not be less than 24 in. (610 mm) and the exposed horizontal length shall not be less than 24 in. (see Fig. 6).

6.2.4 *Cabinets (Junction and Pull Boxes)*—Test these items at their full dimensions for which evaluation is desired.

6.3 Provide assembly with through-penetration fire stops and internal specimen seals. Construct these using materials and techniques capable of withstanding the fire exposure test. Internal seals in cable trays and raceways shall be required in order to eliminate convective cooling of the test specimen.

6.4 Locate the periphery of the specimen not closer than 12 in. (305 mm) from the inside furnace edge and maintain a minimum separation distance between adjacent test specimens of 12 in. unless it is documented that closer placement does not affect the results.

7. Conditioning

7.1 Establish a moisture equilibrium resulting from the drying of the specimen(s) and test assembly in air having 50 ± 5 % relative humidity at 73 ± 5°F (23 ± 3°C) prior to testing. When impractical to achieve this condition, the tests are permitted to be conducted when the dampest portion of the fire-resistive barrier system or test assembly has achieved an equilibrium moisture condition corresponding to drying in air having 50 ± 5 % relative humidity at 73 ± 5°F (23 ± 3°C). The specimen is permitted to be conditioned independently of the assembly. Various methods can be utilized to determine moisture equilibrium, such as periodic moisture meter readings or weight determinations of the specimen or representative pieces of similar materials.

7.2 *Exception*—These moisture requirements are permitted to be waived when:

7.2.1 The required moisture condition is not achieved within a twelve month conditioning period or,

7.2.2 The construction is such that drying of the interior of the specimen is prevented by hermetic sealing of the construction materials.

8. Specimen Instrumentation

8.1 *Temperature Measurement*—Make temperature measurements by thermocouples placed at the following locations (see Fig. 7):

8.1.1 *Cable Trays*—Place thermocouples on the outside longitudinal center surface of each side rail and on a bare No. 8 AWG stranded copper wire placed outside the horizontal center of the tray and attached to the bottom of the tray. Place cable tray thermocouples as follows:

8.1.1.1 One inch (25 mm) from the junction of the tray and the fire exposed side of the penetration seal,

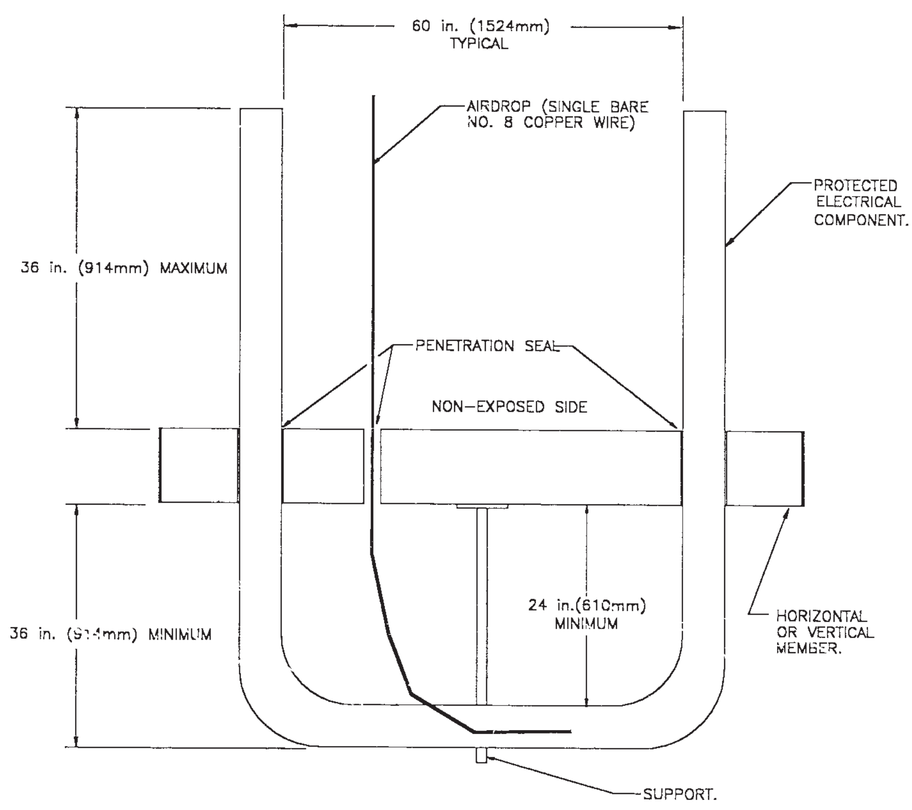


FIG. 5 Vertical Air Drop Assembly

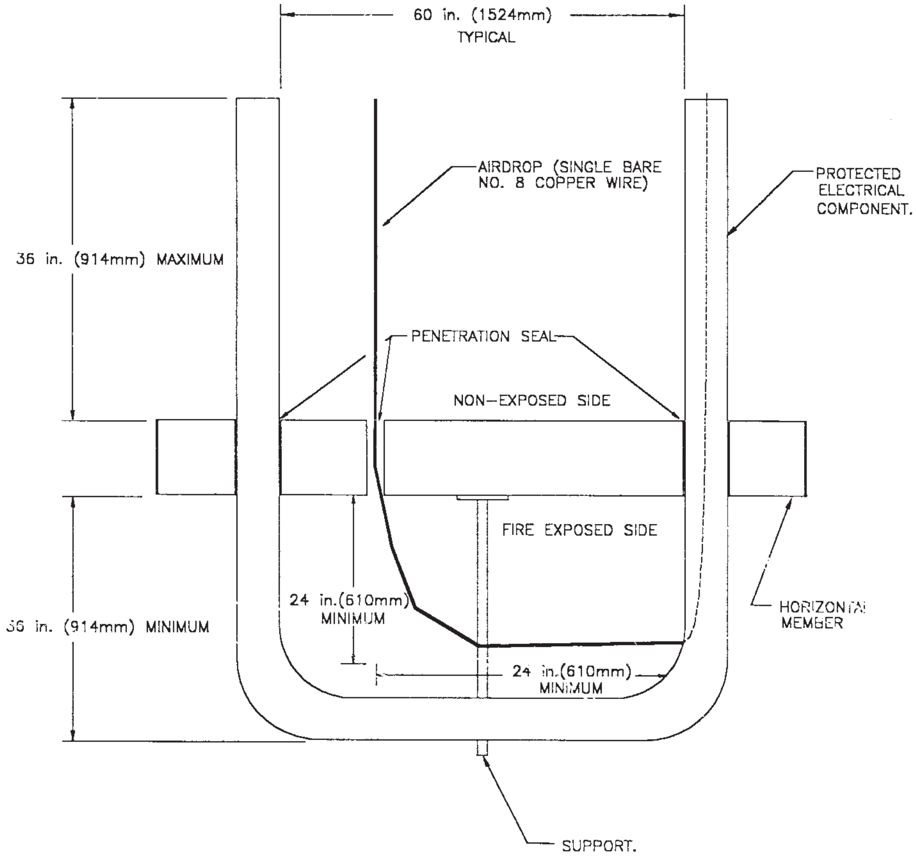


FIG. 6 Vertical and Horizontal Air Drop Assembly

8.1.1.2 Immediately adjacent to any support members, and

8.1.1.3 At points 6 ± ½ in. (152 ± 13 mm) along the rail/copper wire.

8.1.2 *Conduits and Other Raceways*—Place thermocouples on the outside surface of the conduit closest to the furnace floor or furnace wall, or both. Place conduit thermocouples as follows:

8.1.2.1 One inch (25 mm) from the junction of the conduit and the fire-exposed side of the penetration seal,

8.1.2.2 Immediately adjacent to any support members, and

8.1.2.3 At points 6 ± ½ in. (152 ± 13 mm) along the length of the conduit.

8.1.3 *Cabinets (Junction or Pull Boxes)*—Place thermocouples on the outside surface. Place thermocouples as follows:

8.1.3.1 Each face shall have a minimum of one thermocouple, located at its geometric center,

8.1.3.2 One thermocouple for every square foot of surface area per face, and

8.1.3.3 At a point within 1 in. (25 mm) of each penetration connector/interface.

8.1.4 *Airdrops and Open Runs*—Place thermocouples on a single bare No. 8 AWG stranded copper wire. Place airdrop thermocouples as follows:

8.1.4.1 One inch (25 mm) from the junction of the airdrop and the fire-exposed side of the penetration seal or cable tray, and

8.1.4.2 At points 6 ± ½ in. (152 ± 13 mm) along the length of the copper wire.

8.2 Consider each configuration of thermocouples a "set" of thermocouples; that is, each side rail equals one set, one bare No. 8 AWG equals one set.

8.3 Temperature measurements are allowed to be made at locations in addition to those described in 8.1 for the purpose of providing additional information on the performance of the fire-resistive barrier system.

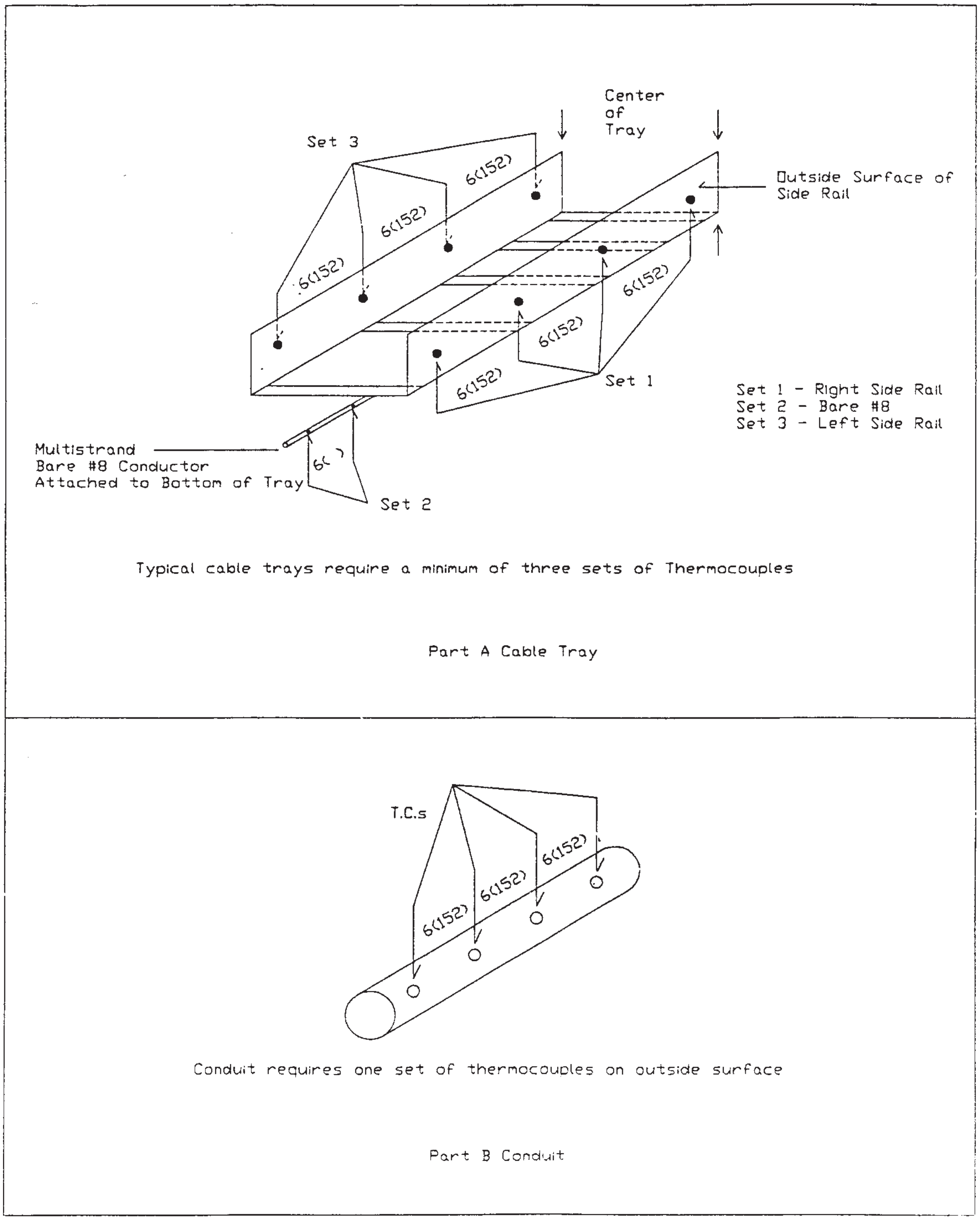
8.4 Measure temperatures on the surfaces of the components with thermojunctions screwed, riveted, welded, or peened to the surface. The thermocouple leads shall be no larger than No. 24 AWG and electrically insulated with heat- and moisture-resistive coverings capable of withstanding a minimum single-exposure temperature of 600°F (316°C).

8.5 Measure temperatures on the bare No. 8 AWG stranded copper wire with thermojunction placed in direct contact with the copper wire. Attach the thermocouples mechanically to the bare No. 8 AWG stranded copper wire.[4] The thermocouple leads shall be no larger than No. 24 AWG and electrically insulated with heat- and moisture-resistive coverings capable of withstanding a minimum single-exposure temperature of 600°F (316°C).

NOTE 1—PTFE-insulated thermocouple wire has been found suitable for this purpose.

9. Conditions of Acceptance

9.1 Determine the fire endurance rating of a fire-resistive barrier system for a specific electrical system component as the maximum time before which one of the following conditions occurs:



All dimensions are in inches
All dimensions in ( ) are in millimeters

FIG. 7 Specimen Thermocouples

9.1.1 The average temperature of any set of thermocouples for the electrical system component is raised more than 250°F (139°C) above the initial temperature, or

9.1.2 The temperature of any one thermocouple of the set for each electrical system component is raised more than 325°F (181°C) above the initial temperature.

9.1.3 Systems reaching the criteria of 9.1.1 or 9.1.2, or which are terminated, at times other than even-hour time periods shall be rated to the 15-min increment immediately preceding the time at which the criteria condition or termination occurred.

10. Procedure

10.1 *Air Temperature*—The average temperature inside the fire-resistive barrier system at the beginning of the test shall not be less than 50°F (10°C). Protect the test equipment and test assembly undergoing the fire test from any condition of wind or weather that might lead to abnormal results.

10.2 *Fire Test*:

10.2.1 After the first 10 min, control the furnace pressure so as to position the neutral pressure plane as specified in 5.7.

10.2.2 Continue the test at least until the desired evaluation period is reached, the conditions of performance are satisfied, or until failure occurs.

10.2.3 Measure and report temperatures and furnace pressures at intervals not exceeding 1 min.

11. Report

11.1 Report the following information:

11.1.1 A description and identification of the fire-resistive barrier system, the electrical system components, and the test assembly, including drawings depicting geometry, size (length, width, and thickness), and location of test specimen(s) within the test assembly. For unique designs where conductors are included, report additional data including quantity of conductors, cable and conductor size and type, manufacturer, diameter, and cross section,

11.1.2 Documentation in accordance with Section 7, indicating that equilibrium has been reached,

11.1.3 The temperature curve employed, the temperatures of the furnace, and all specimen temperatures recorded during the fire exposure test,

11.1.4 Furnace pressure readings throughout the test at one-minute intervals,

11.1.5 Observations of significant details of the behavior of the fire-resistive barrier systems, to include, but not limited to, creation of openings, etc., during and after the fire test, and

11.1.6 The time at which the condition of performance of the fire-resistive barrier as specified in Section 9 occurs, to the nearest integral minute.

12. Precision and Bias

12.1 No statement is made about either the precision or bias of these test methods for measuring the conditions of performance, since the result merely states whether there is conformance to the criteria specified in the procedure.

13. Keywords

13.1 air drop; cable tray; conduit; electrical system components; fire endurance rating; fire-resistive barrier systems; fire-test-response method; junction box; open run cables; pull box; raceway; thermal transmission

APPENDIXES

(Nonmandatory Information)

X1. COMMENTARY

X1.1 This commentary has been prepared to provide the user of these fire-test-response methods with background information on the development of the standard and its application in inhibiting thermal transmission to electrical system components (conduits, cable trays, airdrops, pull boxes, junction boxes, etc.). It also provides guidance in the planning and performance of fire tests and in reporting the results. No attempt has been made to incorporate all the available information on fire testing in this commentary. The serious student of fire testing is strongly urged to pursue the reference documents for a better appreciation of the history of fire-resistant design and the intricate problems associated with testing and with the interpretation of test results.[5,6]

X1.2 These test methods are needed to clarify and standardize current testing practices. Certain electrical system components are required to be provided with a delay from the potential consequences of a fire due to safety significance or other practical reasons. Thus, these test methods were developed to be applicable for those applications discussed in more detail in the significance and use section (see Appendix X2).

X1.3 Fire-protective cable wrap has been used in industrial applications in the United States for a number of years. Specific examples include the requirement by the U.S. Nuclear Regulatory Commission (US NRC) for protection of certain safety cables in nuclear power plants in the early 1980s. The standard referenced in their efforts was Test Method E 119, since it was the closest to the application they desired. It was informally recognized that certain aspects of Test Method E 119 were not directly applicable, and shortly after that American Nuclear Insurers followed by ASTM began an effort to write a standard specifically aimed at protecting electrical-system components.

[5] Babrauskas, V., and Williamson, R. B., "Historical Basis of Fire Resistance Testing, Part I and Part II" *Fire Technology*, Vol 14, No. 3 and No. 4, 1978, pp. 184–194, 304–31X5.

[6] Shoub, H., "Early History of Fire Endurance Testing in the United States," *Symposium on Fire Methods, ASTM STP 301*, ASTM, 1981, pp. 1–9.

X2. SIGNIFICANCE AND USE

X2.1 These test methods were originally intended to measure the ability of electrical conductors to carry current when the protected system was exposed to a standardized fire exposure. Many years and efforts were spent by the task group and testing laboratories to develop a test method to measure cable functionality. Cable functionality is dependent on the chemical makeup of the cable jacket and insulation, and its ability to retain function upon fire exposure. Problems developed due to differences in temperature performance under fire conditions of cables believed to be of identical makeup. Failure temperatures ranged from 300°F (149°C) to 800°F (427°C) for what was believed to be cable with the same composition and classification. Independent oven testing of cables of various compositions has shown that temperature functionality can be different for what are considered to be identical cables. This discovery has led this task group to use temperature as an end point criteria rather than electrical functionality. For this reason, electrical conductors are not evaluated or included in these test methods. In addition, concerning thermal mass, excluding cables from the test specimens would be more conservative and therefore more supportive of the generic applicability of these test methods. This is, however, not intended to prevent users from including cables or other components in test specimens for unique designs which are representative of field conditions or end-use thermal mass. For extension of data, the thermal properties of cables need to be well understood.

X2.2 The use of temperature criteria enables the end user to make decisions based on sound data that can apply to a wide range of conditions. For wall, floor, and ceiling assemblies Test Method E 119 limits end-point temperatures to 250°F (139°C) above initial temperatures on the cold side of the test assembly as an average, and no individual temperature on the cold side shall exceed 325°F (181°C) above initial temperatures. These assemblies are used in many situations to provide separation of fire zones. Electrical system components installed on the other side of a rated assembly would be considered fire protected by that assembly. The barriers and systems used to provide protection of electrical system components could be considered as a fire rated assembly (but not inside the wall or ceiling) and thus the temperature criteria would apply.

X3. TEST DESIGN

X3.1 Test the systems and designs to bracket the sizes and configurations employed in field applications. Test designs should represent the systems employed to support the electrical system components and include support systems similar to those used in the field. Evaluate systems for the fire test response desired. In the nuclear arena the requirements are specified as 1 and 3 h in duration; other areas may require ratings anywhere from 15 min to many hours.

X3.2 *Electrical System Components:*

X3.2.1 *Cable Trays*—The tests are conducted using cable tray constructions representing a specific sizes and materials. Where the evaluation is to include a range of cable tray sizes, then, as a minimum, the smallest and largest tray sizes are evaluated.

X3.2.1.1 The smallest cable tray is defined as that with the smallest cross-sectional area.

X3.2.1.2 The largest cable tray is defined as that with the largest width and height dimensions.

X3.2.1.3 A small cable tray is most affected by the amount of exposed surface area of the finished protected electrical system component. A large cable tray, however, is more affected by the maximum horizontal and vertical dimensions, since physical support mechanisms become dominant.

X3.2.1.4 For any given size cable tray, the minimum weight (in weight per linear length) is tested.

X3.2.1.5 Tests can incorporate cable tray designs of given compositions (aluminum, steel, plastic, fiberglass, etc.).

X3.2.2 *Conduits*:

X3.2.2.1 If the intent of the evaluation is to encompass a range of conduit sizes, then the smallest and largest trade sizes of conduit are evaluated.

X3.2.2.2 If evaluation is to be done covering all wall thicknesses of a conduit of specific composition, the type having the least nominal wall thickness is tested.

X3.2.2.3 Tests can incorporate conduit of various compositions (aluminum, steel, plastic, fiberglass, etc.).

X3.2.3 *Airdrop*—The test is conducted using a specific cross-sectional area of the fire-resistive barrier system. However, if the intent of the evaluation is to encompass a range of sizes, then the minimum and maximum cross-sectional areas of fire-resistive barrier systems are tested.

X3.2.4 *Other Raceways*—Raceways other than conduits have not yet been subjected to testing as a component of a fire resistive barrier system. Therefore, such instrumentation and specimen size are not available at this time. It is undetermined if specifications for cable tray or conduit are relative.

X3.2.5 *Extension of Data to Other Compositions*—The results of tests on one electrical system component composition can be extended to different compositions such as aluminum, steel, plastic, fiberglass, etc., provided sufficient information is known concerning the thermal behavior of the tray or raceway (for example, thermal inertia, etc.).

X3.2.6 *Thermal Inertia*—A function of thermal conductivity, density and specific heat, $k\rho C$:

where:
k = the material's thermal conductivity,
ρ = density, and

C = specific heat.