



Standard Test Methods for Fire Resistive Metallic HVAC Duct Systems¹

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INTRODUCTION

Heating, Ventilation, Air Conditioning (HVAC) duct systems may be subjected to fire- exposure conditions. ISO 6944 is a standard test method used to evaluate ventilation ducts. However, ISO 6944 does not address all of the fire resistive attributes deemed necessary by some authorities having jurisdiction, for example, (1) the fire-resistive, combustibility, flame spread and smoke generation, and durability properties of the fire-resistive materials protecting the HVAC duct, (2) the transition from the horizontal to a vertical HVAC duct, (3) the attachment of the HVAC duct's supports to the fire-separating elements, (4) the termination of an HVAC duct system and the protection of its ends, (5) the effects of rapid cooling and erosion upon the HVAC duct system, (6) the use of fire dampers and (7) the effect of the HVAC duct system on its supporting construction. Many types of fire-resistive materials are used to protect HVAC ducts. These fire-resistive materials are either applied to HVAC ducts in the field or are fabricated as an integral part of the HVAC duct system when shipped from the factory. Evaluating fire-resistive materials used to protect a HVAC duct from fire is an aid for predicting their fire performance and helps to establish uniformity in requirements of various authorities. To do this it is necessary that the fire-resistance properties of HVAC ducts protected with fire-resistive materials be measured and specified according to a common standard expressed in terms that are applicable alike to a wide variety of materials, situations, and conditions of exposure.

1. Scope

NOTE 1—Use of the standard designation ISO 6944 refers to both ISO 6944:1985 and ISO 6944-1:2008.

1.1 These test methods evaluate the fire-resistive materials and the HVAC duct systems surface burning characteristics, non-combustibility, fire resistance, durability, and fire-engulfment with horizontal and vertical through-penetration firestops.

NOTE 2—The intent of these test methods is to provide authorities having jurisdiction a means to evaluate the fire performance of HVAC duct systems to enable their application and use.

1.2 These test methods evaluate the fire performance of HVAC ducts, including both supply (pressurized: Condition A – Horizontal and Condition B – Vertical) and return (exhaust: Condition C – Horizontal and Condition D – Vertical).

1.3 These test methods evaluate the ability of a HVAC duct system to resist the spread of fire from one compartment to other compartments separated by a fire resistance rated construction when the HVAC duct system is exposed to fire under one or more of the following conditions:

1.3.1 *Condition A*—Fire exposure from the outside of the horizontal HVAC duct system without openings,

1.3.2 *Condition B*—Fire exposure from the outside of the vertical HVAC duct system without openings,

1.3.3 *Condition C*—Fire exposure from the outside with hot gases entering the inside of the horizontal HVAC duct system with unprotected openings, and

NOTE 3—Unprotected openings are openings that are not protected by fire dampers.

1.3.4 *Condition D*—Fire exposure from the outside with hot gases entering the inside of the vertical HVAC duct system with unprotected openings.

1.4 These test methods provide a means for determining the fire-resistance of vertical and horizontal HVAC duct systems, when subjected to the standard time-temperature curve of Test Methods E119.

1.4.1 *Condition A*—These test methods provide a means for evaluating a horizontal HVAC duct system, without openings exposed to fire, passing through a vertical fire-separating element.

1.4.2 *Condition B*—These test methods provide a means for evaluating a vertical HVAC duct system, without openings

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 Fire Resistance.

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exposed to fire and outfitted with a horizontal connection, passing through a horizontal fire-separating element.

1.4.3 *Condition C*—These test methods provide a means for evaluating a horizontal HVAC duct system, with unprotected openings exposed to fire, passing through a vertical fire-separating element.

1.4.4 *Condition D*—These test methods provide a means for evaluating a vertical HVAC duct system with a horizontal connection, and with unprotected openings exposed to fire, passing through a horizontal fire-separating element.

1.5 These test methods prescribe a standardized fire exposure for comparing the test results of the fire resistive materials and HVAC duct systems. The results of these tests are one factor in assessing predicted fire performance of HVAC duct systems. Using these test results to predict the performance of actual HVAC duct systems requires the evaluation of test conditions.

1.6 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are for information only, unless the SI units are used consistently to perform all of the test methods referenced herein. In this case, the SI units will be regarded as the standard and will be used in Section 17, Report.

1.7 The text of these test methods references notes and footnotes which provide explanatory material and (excluding those in tables and figures) shall not be considered as requirements of the fire-test-response standard.

1.8 This document specifically excludes evaluating ducts that carry combustibles, flammable vapors, combustible gases, and commercial kitchen ventilation systems commonly called grease ducts or hazardous exhaust ducts, which are tested in compliance with Test Methods E2336.

1.9 This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

1.10 *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.*

1.11 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

2. Referenced Documents

2.1 ASTM Standards:²

C411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

E84 Test Method for Surface Burning Characteristics of Building Materials

E119 Test Methods for Fire Tests of Building Construction and Materials

E136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

E176 Terminology of Fire Standards

E631 Terminology of Building Constructions

E814 Test Method for Fire Tests of Penetration Firestop Systems

E2226 Practice for Application of Hose Stream

E2307 Test Method for Determining Fire Resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multi-story Test Apparatus

E2336 Test Methods for Fire Resistive Grease Duct Enclosure Systems

2.2 Other Standards:

UL 385 Standard for Play Pipes for Water Supply Testing in Fire-Protection Service

ISO 6944:1985 Fire Resistance Tests – Ventilation Ducts

ISO 6944-1:2008 Fire Containment – Elements of Building Construction – Part 1: Ventilation ducts

3. Terminology

3.1 For definitions of terms used in these test methods and associated with fire issues, refer to the definitions contained in Terminology E176.

3.2 For definitions of terms used in these test methods and associated with building issues, refer to the definitions contained in Terminology E631.

3.3 When there is a conflict between Terminology E176 and Terminology E631 definitions, Terminology E176 definitions shall apply.

3.4 Definitions of Terms Specific to This Standard:

3.4.1 *fire resistive material, n*—the product applied to or a part of the HVAC duct to provide fire resistance.

3.4.2 *fire-separating element, n*—floors, walls, and partitions having a period of fire resistance determined in accordance with fire resistance test methods such as Test Methods E119.

3.4.3 *fire side, adj*—the surface of the test assembly or test specimen exposed to the heat or flame, or both, of the test apparatus.

3.4.4 *integrity, n*—the absence of cracks, holes or openings that appear outside the furnace on the fire-resistive material or firestop, or both, or through which flames or hot gases pass as determined by the cotton pad test.

3.4.5 *orifice, n*—the continuous hollow area or opening within the HVAC duct.

3.4.6 *stability, n*—the ability of the HVAC duct, support and fastening system to fulfill their intended function.

3.4.7 *supporting construction, n*—the arrangement of building sections forming the fire-separating elements into which the HVAC duct system is installed.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.4.8 *support system, n*—the vertical or horizontal devices used to sustain the HVAC duct and its fire-resistive materials and their fastening means.

3.4.9 *test assembly, n*—the complete construction composed of a test specimen(s) together with its supporting construction.

3.4.10 *test specimen, n*—a material, product, or assemblage of a specific design, composition, density, and dimension, for example, a HVAC duct protected with a fire-resistive material(s) that is secured by fastening system, which is suspended by a support system, and protected by a firestop(s).

3.4.10.1 *Discussion*—The fire-resistive material or the HVAC duct system are examples of test specimens.

3.4.11 *unexposed side, n*—the surface not directly exposed to the heat or flame, or both, of the test apparatus.

3.4.12 *unexposed surface thermocouple, n*—temperature-measuring device placed on the unexposed surface.

3.4.13 *HVAC duct, n*—a tube or conduit utilized for conveying air without combustible materials, flammable vapors, and combustible gases.

3.4.14 *HVAC duct system, n*—consists of the HVAC duct, a fire-resistive material(s), a support system, the through-penetration firestop(s) and fastening system(s).

4. Summary of Test Method

4.1 Representative test specimens of the fire-resistive material or the HVAC duct system are subjected to the selected tests for the purposes of assisting the authority having jurisdiction in qualifying an HVAC duct system to a an explicit set of their requirements. These test methods describe the following test sequence and procedures:

4.1.1 A combustion characteristics of building materials test, Test Method **E136**, demonstrates the measure of fire-resistive material's combustibility at a standardized temperature and duration.

4.1.2 A durability test intended to simulate the effects of long-term exposure of typical in-service conditions, only when the service temperature exceeds 125°F, on the thermal transmission qualities of the fire-resistive materials when subjected to a modified version of Test Method **C518**.

NOTE 4—The service temperature refers to the temperature inside the HVAC duct system or the ambient temperature surrounding the HVAC duct system.

4.1.3 A fire-engulfment test uses a standardized fire exposure to simulate a fire occurring on the outside of the HVAC duct system in Conditions A and B, or a fire occurring on the inside and outside of the HVAC duct system in Conditions C and D, and demonstrates the ability of the HVAC duct system to remain intact without a through opening appearing in supporting construction or the HVAC duct system outside the furnace or raising the temperature on its unexposed surface above the limitations of these test methods or conveying hot gases into other compartments. The fire-engulfment test also tests the fastening methods used to secure the fire-resistive material to the HVAC duct and the support system. The fire-engulfment test also provides a means to test a through-penetration firestop to determine its compatibility with the HVAC duct when mounted in a horizontal or vertical fire-

separating element. A hose stream test is also performed on the test assembly in accordance with the provisions in Practice **E2226**.

4.1.4 Surface burning test, Test Method **E84**, provides a means to evaluate the flame spread and smoke developed of the fire-resistive material.

4.1.5 A hot-surface performance test, Test Method **C411**, provides a means of evaluating the covering's and lining's ability to resist flaming, glowing, smoldering or smoking while in service.

5. Significance and Use

5.1 These test methods are intended to evaluate the ability of the HVAC duct system and its supporting construction to do the following:

- 5.1.1 Resist the effects of a standardized fire exposure, and
- 5.1.2 Retain its integrity.

5.2 These test methods provide for the following measurements and evaluations where applicable:

- 5.2.1 Ability of the fire-resistive material to resist flaming (combustion) when exposed to 1382°F (750°C).
- 5.2.2 Ability of the tested support system to carry the load of the HVAC duct and its fire-resistive material(s) during a standardized fire-engulfment test.

5.2.3 Ability of the firestops to meet the requirements of Test Method **E814** when used as part of a HVAC duct system.

5.2.4 Ability of the HVAC duct system to resist the passage of flames and hot gases onto its unexposed surface during a standardized fire-resistance test.

5.2.5 Transmission of heat through the HVAC duct system during a standardized fire-resistance test.

5.2.6 Ability of the firestop to resist the passage of water during a standardized hose stream test.

5.2.7 Comparative measurement of temperature aging of the fire-resistive material(s) when subjected to a standardized thermal cycling during the durability test.

5.2.8 Measurement of flame spread over the surface of the fire-resistive material or HVAC duct system.

5.2.9 Ability of the covering and lining to resist flaming, glowing, smoldering or smoking while in service.

5.3 These test methods do not provide the following:

5.3.1 Full information as to performance of the fire-resistive material, supporting construction, or the HVAC duct system constructed with components, densities, or dimensions other than those tested.

5.3.2 Evaluation of the degree by which the fire-resistive material or HVAC duct system contributes to the fire hazard by generation of toxic gases, or other products of combustion.

5.3.3 Measurement of the degree of control or limitation of the passage of smoke or products of combustion through the HVAC duct system.

5.4 The test specimens are subjected to one or more specific tests under laboratory conditions. When different test conditions are substituted or the end-use conditions are changed, it is not always possible by, or from, these test methods to predict changes to the characteristics measured. Therefore, the results

of these laboratory tests are valid only for the exposure conditions described in these test methods.

5.5 These test methods require a test specimen to be exposed to a standard fire that is controlled to achieve specified temperatures throughout a specified time period. The engulfment test is followed by the application of a standardized hose stream test. These test methods provide a relative measure of the fire-test-response of comparable fire-resistive materials and HVAC duct systems under these exposure conditions. The fire exposure is not representative of all fire conditions because conditions vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. Variation from the test conditions or test specimen construction, such as size, materials, method of assembly, also affects the fire-test-response. For these reasons, evaluation of the variation is required for application to construction in the field.

NOTE 5—When the size of the HVAC duct exceeds the capability of the test furnace to test it, the authority having jurisdiction (AHJ) should be consulted to determine what test and evaluation of the variation is required for application to construction in the field.

6. Apparatus

6.1 *Furnace*—An enclosure capable of containing a fire being controlled to the time-temperature curve as required by the test method being conducted, for example, Test Methods E119, and meeting the dimensional requirements to contain the test assembly.

6.2 *Furnace Thermocouples:*

6.2.1 The furnace thermocouples shall comply with the time constant, dimensional and physical requirements of those specified in the fire resistance test method being conducted: Test Methods E119 and E814.

NOTE 6—A typical furnace thermocouple assembly meeting the time constant requirements of Test Methods E119 and E814 is fabricated by fusion-welding the twisted ends of No. 18 gage Chromel-Alumel wires, mounting the leads in porcelain insulators and inserting the assembly so the thermocouple bead is approximately 0.5 in. (12.7 mm) from the sealed end of the standard weight nominal 0.5-in. (12.7-mm) iron, steel, or Inconel³ pipe. The time constant for this and for several other thermocouple assemblies was measured in 1976. Another option is to calculate the time constant from knowledge of its physical and thermal properties.⁴

6.3 *Pressure-sensing Probes:*

6.3.1 The pressure-sensing probes shall meet the requirements specified in the fire resistance test method being conducted: Test Methods E119 and E814.

6.4 *Unexposed Surface Thermocouples:*

6.4.1 The unexposed surface thermocouples, which shall be covered by the thermocouple pads described in 6.5 during testing, shall meet the requirements specified in the fire resistance Test Method E2307.

6.5 *Thermocouple Pads:*

6.5.1 The thermocouple pads used to cover each thermocouple on the unexposed side of the test specimen or test

assembly shall be made of materials that meet the requirements specified in the fire resistance Test Method E2307.

6.6 *Differential Pressure Measurement Instruments:*

6.6.1 The differential pressure measurement instrument shall be:

6.6.2 A manometer or equivalent transducer meeting the requirements specified in the fire resistance test method being conducted: Test Methods E119 and E814.

6.6.3 Capable of reading in graduated increments of no greater than 0.01 in. H₂O (2.5 Pa) with a precision of not less than ± 0.005 in. H₂O (± 1.25 Pa).

6.7 *Hose Stream Delivery System:*

6.7.1 The hose stream delivery system shall consist of the same apparatus used in Practice E2226.

6.7.2 Maintain the hose stream on the test assembly for the duration of application in accordance with Practice E2226.

6.8 *Air Flow Systems:*

6.8.1 For Conditions A and B, a pressurization fan or similar apparatus capable of producing a negative pressure of 1.20 ± 0.06 in. H₂O (300 ± 15 Pa) within HVAC duct as compared to the fire-exposure environment during the fire-engulfment test. The fan is connected, either directly or by a suitable length of flexible ducting, to the measuring device.

6.8.2 For Conditions C and D, an exhaust fan or similar apparatus capable of producing an air velocity when extracting gas from the HVAC duct of at least 3 m/s (10 ft/s) measured at ambient temperature in the HVAC duct before the fire-engulfment test. The fan is connected, either directly or by a suitable length of flexible ducting, to the measuring device. Maintain the air velocity at 3 ± 0.45 m/s (9.8 ± 1.5 ft/s) during the test, except for the 5-min period each 30 min. During this 5-min period, the fan either (1) remains on but the air flow is not drawn through the HVAC duct, or (2) the fan is shut off at the beginning of the 5-min period and restarted after the 5-min period. The integrity of the HVAC duct is determined during this 5-min period. Refer to 10.5. The 5-min period begins at 25 min and is repeated every 30 min.

7. Sampling, Test Specimens, and Test Assemblies

7.1 *Sampling:*

7.1.1 Document the origin of the materials being tested.

7.1.1.1 Document the materials' lot number, batch number, product name, packaging and other relevant information on the packaging, for example, third-party marks, test method references, etc.

7.1.1.2 Document whether samples were submitted by test sponsor.

7.1.1.3 Document whether samples were randomly selected from test sponsor's inventory by an independent third-party. Include the date of the sampling, the sample method, the location of the sampling, the person performing the sampling.

7.1.1.4 Document whether production of the samples was witnessed and their quality, manufacturing procedures, and composition were documented by an independent third-party. Include the date of the sampling, the sample method, the location of the sampling, the person performing the sampling.

NOTE 7—Some evaluation services require an approved inspection

³ Inconel is a registered trade name of INCO Alloys, Inc., 3800 Riverside Dr., Huntington, WV 25720.

⁴ Supporting data is available from ASTM International Headquarters. Request RR:E05-1001.

agency or certification body to witness the fire-resistive material production to establish traceability to the test specimens and that the fire-resistive material be representative of the product as applied in the field.

7.2 Combustion Characteristics of Building Materials' Test Specimens:

7.2.1 Each test specimen shall be prepared in accordance with Test Method **E136**.

7.2.2 Properties of the materials, such as density and dimensions, used in the test specimen shall be determined and recorded. Document the description of the fire-resistive material test specimens. Include such information as the lot number, trade name, and all recorded information.

7.3 Durability Test Specimens:

7.3.1 Eight test specimens of the fire-resistive material shall be required.

7.3.2 The test specimens shall be prepared in accordance with Test Method **C518**.

7.3.3 Properties of the materials, such as density and dimensions, used in the test specimen shall be determined and recorded. Document the description of the fire-resistive material test specimens. Include such information as the lot number, trade name, and all recorded information.

7.4 Fire-Engulfment Test Specimen:

7.4.1 The test specimen shall be representative of the construction for which Interpretation of Results is desired, as to materials, workmanship, and details, such as dimensions of parts, joints, and expansion joints, and shall be built under conditions representative of those in building construction and operation. The test specimen sections passing through the fire separating element shall be symmetrical. Alternatively, when asymmetrical test specimen sections pass through the fire separating element, testing from each side of the fire separating element shall be performed unless it is documented that the side with the lower fire resistance rating is being tested. The physical properties of the materials and ingredients used in the test specimen shall be determined and documented.

7.4.1.1 Construct the HVAC duct using the maximum dimensions and minimum metal thickness (gage) for which approval is sought. Document the HVAC duct material, dimensions, thickness of material, the type of any internal and external reinforcement, and the connection (joint) type.

NOTE 8—A successful test on the HVAC duct in **7.4.1.1** normally qualifies the fire-resistive material for use on rectangular ducts with equal or less widths and equal or less cross-sectional areas, and round ducts with equal or less cross-sectional areas.

7.4.1.2 Document the support system used to carry the load of the HVAC duct and its fire-resistive materials and their fastening means, for example, metal angle size and length, hole size and location on metal angle, threaded rod diameter and length, location and spacing relationship (distance) between HVAC duct and threaded rods, location and spacing between support systems, anchoring means and installation method used to secure the support system, etc.

7.4.2 The test specimen shall be constructed or assembled, or both, in accordance with the manufacturer's instructions. All construction methods shall be documented.

7.4.3 All sections of the HVAC duct shall have joints. The type of joint tested shall be documented. When a specific type

of joint or support is designated by industry nomenclature, for example, SMACNA, that particular nomenclature shall be used to describe the joint or support. The HVAC duct system conditions (A and B) shall have a branch connection.

7.4.4 The opening area shall be 50 ± 5 % of the cross sectional area of the HVAC duct made from one or more openings. The interior area of the branch, 'T' or elbow, shall be 25 ± 5 % of the interior area of the HVAC duct.

7.4.5 Testing qualifies the performance of HVAC ducts, either supply (pressurization: Condition A – Horizontal and Condition B – Vertical) or return (exhaust: Condition C – Horizontal and Condition D – Vertical) or both (test all Conditions). The HVAC duct shall be one or more of the following:

7.4.5.1 *Condition A*—Fire from the outside of the horizontal HVAC duct system without openings, shall consist of the following minimum components assembled to meet the layout and the dimensional requirements in **Fig. 1** that has at least: one joint on the fire side, one joint located on the unexposed side, one straight section, one "T" section, and one 90-degree elbow with an end cap.

7.4.5.2 *Condition B*—Fire from the outside of the vertical HVAC duct system without openings, shall consist of the following minimum components assembled to meet the layout and the dimensional requirements in **Fig. 2** that has at least: one joint on the fire side, one joint located on the unexposed side, one straight section, one 'T' section with an end cap at both openings.

7.4.5.3 *Condition C*—Fire exposure from the outside with hot gases entering the horizontal HVAC duct system with openings, shall consist of the following minimum components assembled to meet the layout and the dimensional requirements in **Fig. 3** that has at least: one joint on the fire side, one joint located on the unexposed side, one straight section having an end cap, and one of the sections in the furnace with two openings. The opening area shall total 50 % of the cross sectional area of the HVAC duct with the height of the opening one half the height of the HVAC duct, and shall be located at least 20 in. (508 mm) from the fire-separating element through which the HVAC duct passes.

7.4.5.4 *Condition D*—Fire exposure from the outside with hot gases entering the inside of the vertical HVAC duct system with openings, shall consist of the following minimum components assembled to meet the layout and the dimensional requirements in **Fig. 4** that has at least: one joint on the fire side, one joint located on the unexposed side, one straight section having an end cap, and one of the sections in the furnace with two openings. The opening area shall total 50 % of the cross sectional area of the HVAC duct with the width of the opening one half the width of the HVAC duct, and shall be located at least 20 in. (508 mm) from the fire-separating element through which the HVAC duct passes.

7.4.6 All vertical sections of the HVAC duct not within the furnace shall be supported as in practice at the horizontal separating element. The vertical section of an HVAC duct within the furnace shall have at least one joint. When equipped

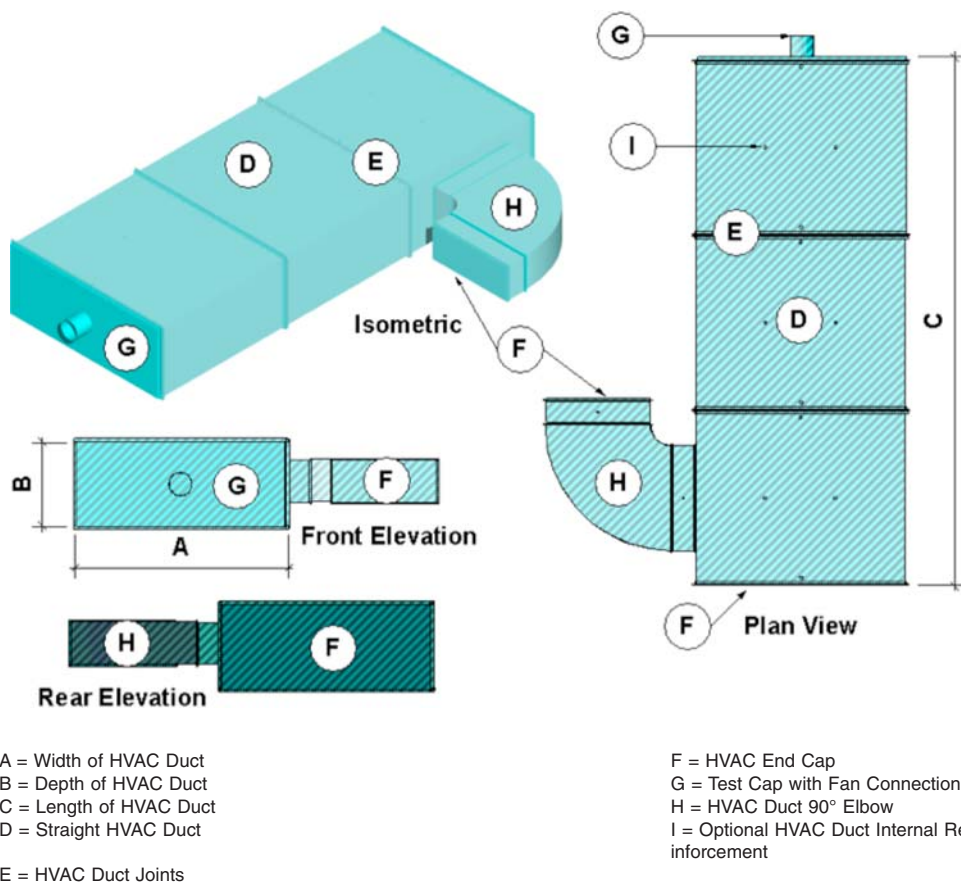


FIG. 1 Condition A – Horizontal HVAC without Openings

with a horizontal transition of the HVAC duct inside the furnace, support the horizontal transition as in practice with a support system.

7.4.7 All HVAC ducts shall have a least one joint within the furnace located a minimum of 12 in. (305 mm) from the supporting construction.

7.4.8 All fire-resistive materials used shall also have at least one joint within the furnace located a minimum of 12 in. (305 mm) from the supporting construction.

7.4.9 Properties of the materials, such as density and dimensions, used in the test specimen shall be determined, documented, and recorded. Document the description of the test specimens. Include such information as the lot number, trade name, and all recorded information.

7.4.10 Test Assemblies:

7.4.10.1 Construct a test assembly to house one or more HVAC duct system conditions. When two or more HVAC ducts are tested simultaneously provide a minimum separation distance of 12 in. (305 mm) between the HVAC ducts and a minimum distance of 12 in. (305 mm) from the furnace walls. Construct the test assembly using the following:

7.4.10.2 Create a horizontal fire-separating element, a vertical fire-separating element, or a combination of both fire-separating elements sized to meet the requirements needed to test the desired HVAC duct system condition or conditions.

(1) Create an opening through the fire-separating element, which is sized in accordance with the test sponsor's

specification, for the penetration of the HVAC duct through the fire-separating element and application of a through-penetration firestop system. Document and report the size of the opening and its location in the fire-separating element.

(2) For a solid horizontal homogeneous fire-separating element, for example, concrete, the fire-resistance rating of the fire-separating element surrounding the opening for a minimum distance of 12 in. (305 mm) shall be equal to the intended fire-resistance of the HVAC duct system.

(3) For a vertical fire-separating element containing cavities, for example, stud wall or CMU, the fire-resistance rating of the fire-separating element surrounding the opening for a minimum distance of at least one vertical course or stud cavity adjacent to the opening shall be equal to the intended fire-resistance of the HVAC duct system.

NOTE 9—Spans of thin concrete floors require substantial structural reinforcement. Solid concrete resists lateral heat transfer. Concrete is thermally stable at locations 6 in. (152 mm) away from openings.

NOTE 10—At least one full stud cavity in gypsum wall assemblies should bound each side of the HVAC duct system. The effect of the HVAC duct system's radiation may enter the cavity of the gypsum wall assembly and increase the unexposed surface temperature at a rate greater than the rest of the wall assembly.

7.4.10.3 Extend one end of the HVAC duct at least 36 in. (914 mm) beyond the unexposed side of the surface fire-separating element and project the other end of the HVAC duct a minimum of 72 in. (1829 mm) beyond the exposed side of the

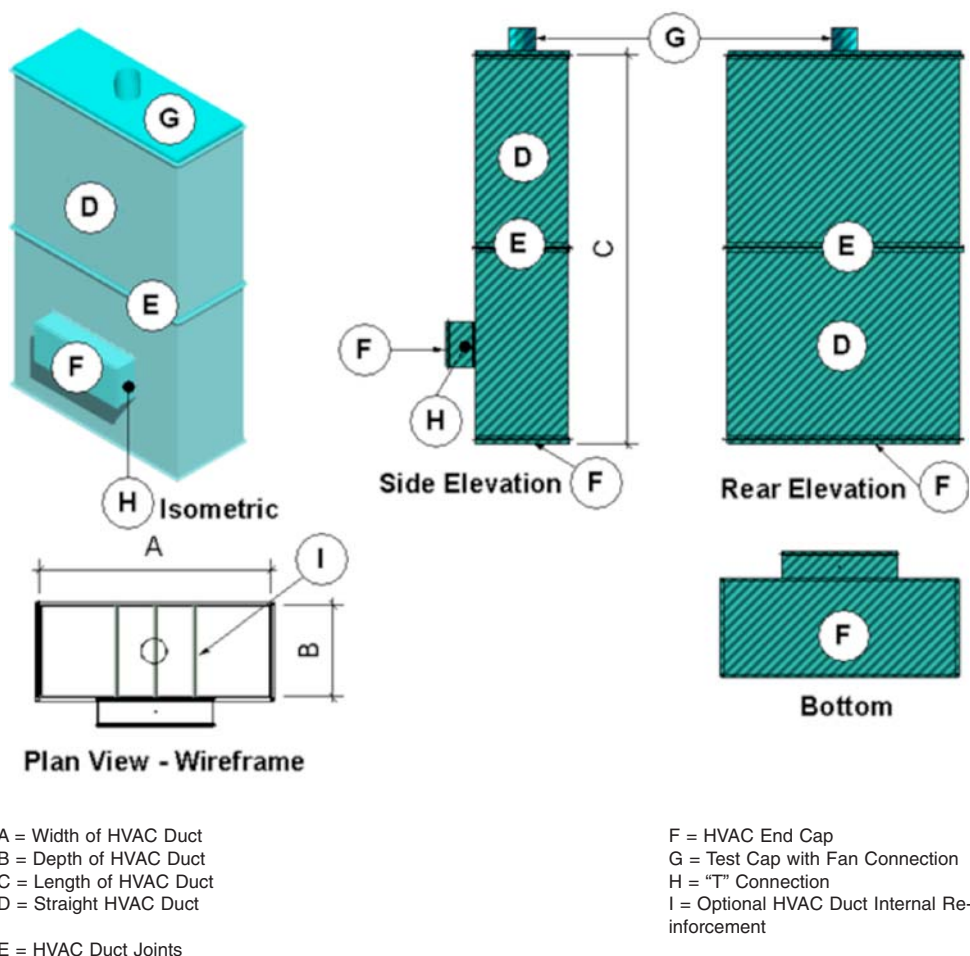


FIG. 2 Condition B – Vertical HVAC Duct without Openings

surface fire-separating element and support HVAC duct as in practice. Suspend the HVAC duct from the fire-separating element using a support system specified by the test sponsor and intended to carry the load of the HVAC duct system being tested. Install the support system in accordance with the test sponsor's installation instructions. Document and report the support system components and the installation method.

7.4.10.4 The orifice at the end of the HVAC duct unexposed to fire shall be capped, sealed, and equipped with the apparatus required for pressurization or air flow. Document the dimensions of the HVAC duct and the closure method.

7.4.11 Test Assembly Information for Condition A:

7.4.11.1 Refer to Fig. 1, Fig. 5, Fig. 6 and Fig. 7 Condition A – Horizontal HVAC Duct without Openings, and 7.4.5.1 for information regarding the Condition A, HVAC Duct.

7.4.12 Test Assembly Information for Condition B:

7.4.12.1 Refer to Fig. 2, Fig. 8, Fig. 9 and Fig. 10 Condition B – Vertical HVAC Duct without Openings, and 7.4.5.2 for information regarding the Condition B, HVAC Duct.

7.4.13 Test Assembly Information for Condition C:

7.4.13.1 Refer to Fig. 3, Fig. 11, Fig. 12 and Fig. 13 Condition C – Horizontal HVAC Duct with Openings, and 7.4.5.3 for information regarding the Condition C, HVAC Duct.

7.4.14 Test Assembly Information for Condition D:

7.4.14.1 Refer to Fig. 4, Fig. 14, Fig. 15 and Fig. 16 Condition D – Horizontal HVAC Duct with Openings, and 7.4.5.4 for information regarding the Condition D, HVAC Duct.

7.5 Through Penetration Firestop Test Specimen:

7.5.1 The annular space created around and between the HVAC duct and the fire-separating element shall be sealed with a through-penetration fire-stop system specified by the test sponsor. Install the material(s) using the test sponsor's installation instructions into the annular space of opening that passes through the fire-separating element. Document, photograph and report the application method used to install the materials.

NOTE 11—The through-penetration fire-stop system can be made from any combination of materials or cement, mortar or grout where the separating element is concrete or masonry walls and the penetrating item is less than 6-in. (152 mm) nominal diameter and the area of the opening through the wall does not exceed 144 in.² (929 cm²).

7.5.1.1 Document the size and location of the annular space on all sides of the HVAC duct.

7.5.1.2 Document the material(s) installed into the annular space.

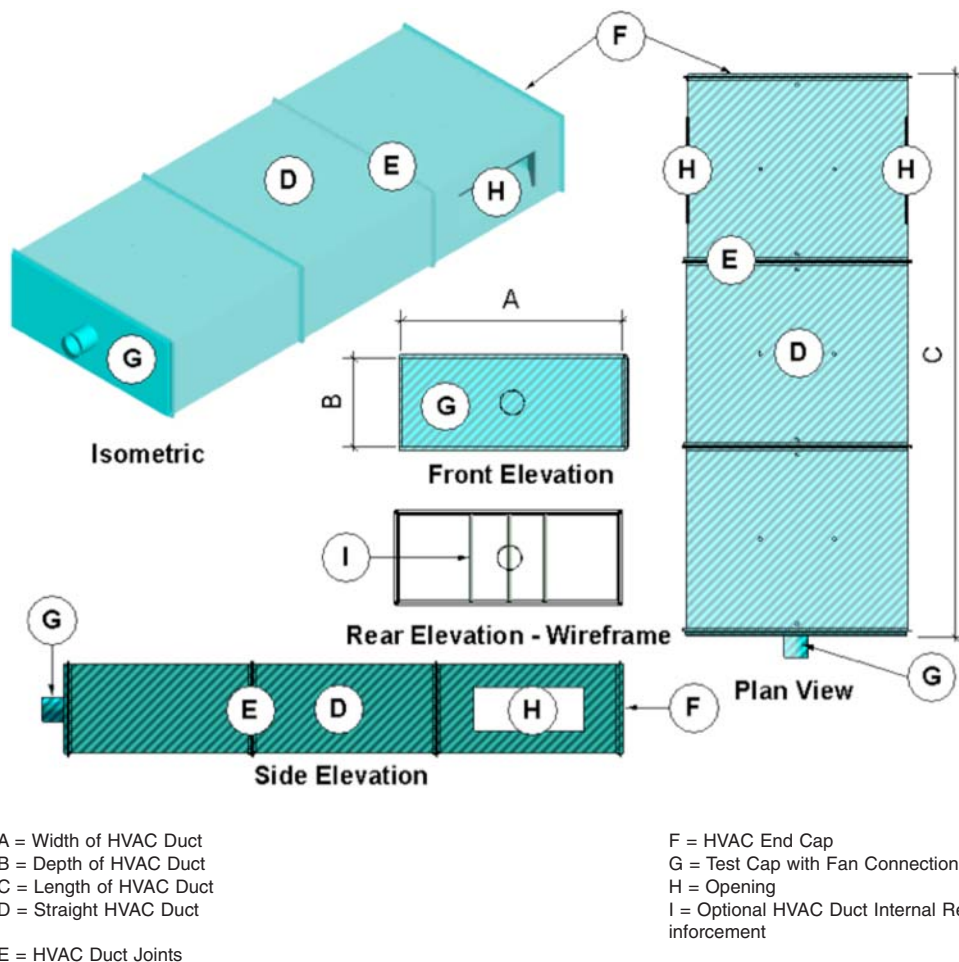


FIG. 3 Condition C – Horizontal HVAC Duct with Openings

7.5.1.3 Document the mass, density, and compression ratio of material(s) installed into the annular space.

NOTE 12—The compression ratio is the nominal width of the material installed into the annular space in relationship to the distance of the annular space into which that material width is installed.

7.5.2 Install the test assembly in a horizontal furnace capable of attaining the standard fire exposure conditions required by Test Methods E119. Maintain the minimum distance, designated Min. A in the figures, between the test specimen and the interior furnace walls.

7.5.3 For horizontal HVAC ducts, Conditions A and C, penetrating a vertical fire-separating element, the neutral plane shall be located a minimum of 12 in. (305 mm) below the bottom of the opening in the vertical fire-separating element. Monitor, document and report the furnace pressure at 1 min intervals.

7.5.4 For vertical HVAC ducts, Conditions B and D, penetrating a horizontal fire-separating element, the neutral plane shall be located a minimum of 12 in. (305 mm) below the lowest point of the exposed side of the horizontal fire-separating element.

7.5.5 The through-penetration firestop system shall be conditioned after installation in accordance with Test Method E814.

7.6 Surface Burning Test:

7.6.1 The fire resistive material shall be prepared in accordance with Test Method E84.

7.7 Hot-Surface Performance Test—The fire resistive material shall be prepared in accordance with Test Method C411.

8. Preparation of Apparatus

8.1 Combustion Characteristics of Building Materials Test—Prepare the apparatus in accordance with Test Method E136.

8.2 Durability Test—Prepare the apparatus in accordance with Test Method C518.

8.3 Fire-Engulfment Test—Prepare the furnace, test assembly, and data acquisition equipment in accordance with Test Methods E119.

8.4 Through Penetration Firestop Test—Prepare the furnace, test assembly, and data acquisition equipment in accordance with Test Method E814.

8.5 Surface Burning Test—Prepare the tunnel in accordance with Test Method E84.

8.6 Hot-Surface Performance Test—Prepare the apparatus in accordance with Test Method C411.

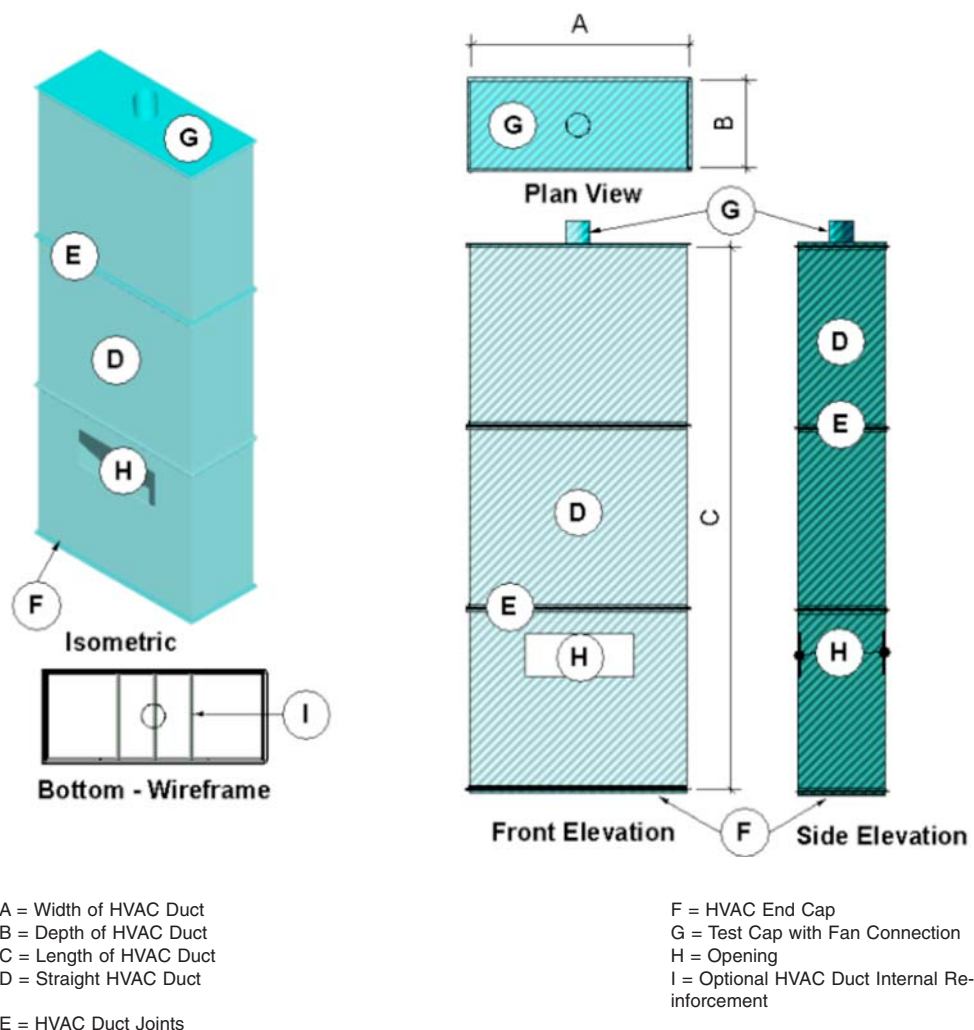


FIG. 4 Condition D – Vertical HVAC Duct with Openings

9. Calibration and Standardization

9.1 When calibration procedures are specified in the test methods which are referenced in this standard, follow those calibration procedures.

9.2 Prior to performing the tests, the following devices shall be calibrated or their calibration shall be verified:

- 9.2.1 The thermocouple wire, and
- 9.2.2 The data acquisition equipment.

10. Conditioning

10.1 *Combustion Characteristics of Building Materials Test Specimen Conditioning*—Refer to and follow protocols in Test Method E136.

10.2 *Durability Test Specimen Conditioning*—Refer to and follow protocols in Test Method C518.

10.3 *Fire-Engulfment Test Specimen Conditioning*—Refer to and follow protocols in Test Methods E119.

10.4 *Through Penetration Firestop Test*—Refer to and follow protocols in Test Method E814, including the use of another test specimen for the hose stream test. The test

specimen used for the hose stream test must duplicate the through-penetration firestop and the section of the HVAC duct system passing through the fire-separating element.

10.5 *Surface Burning Test*—Refer to and follow protocols in Test Methods E84.

10.6 *Hot-Surface Performance Test*—Refer to and follow protocols in Test Method C411.

11. Combustion Characteristics of Building Materials Test Procedures

11.1 Test the test specimen in accordance with the requirements of Test Method E136.

11.2 Document information required by Test Method E136.

12. Durability Test Procedure

12.1 Test four test specimens in accordance with Test Method C518 and document the data as a base reference for comparison to the temperature transmission data acquired on the temperature aged test specimens in 12.2 to determine changes, if any, in thermal transmission properties.

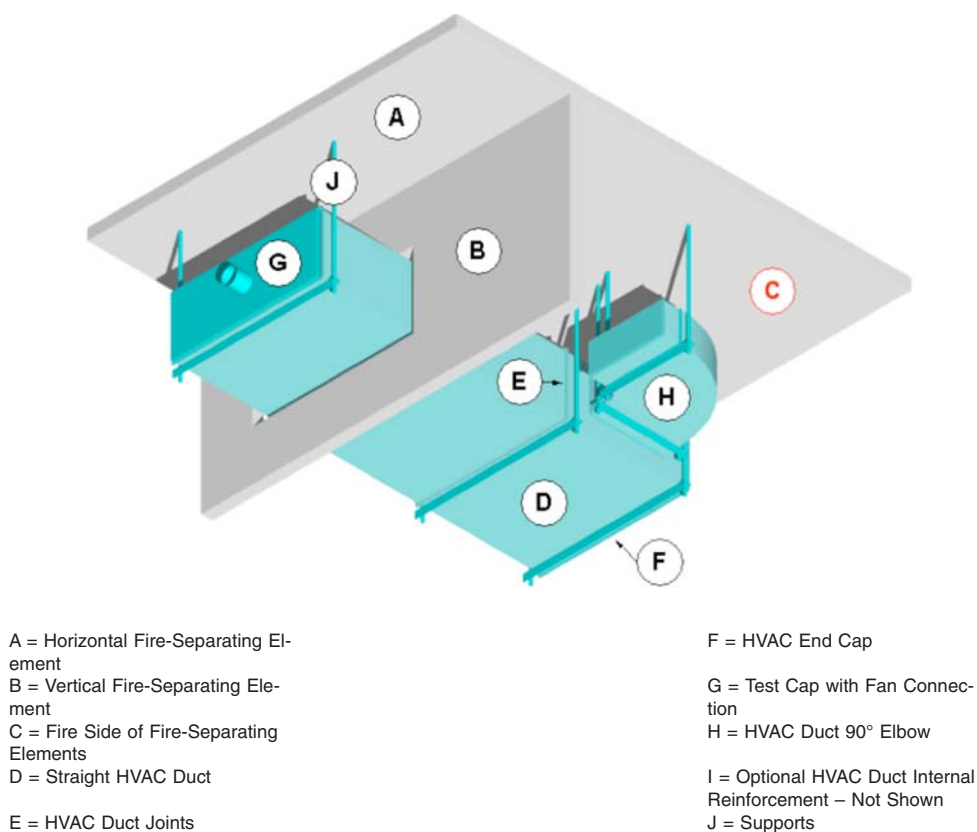


FIG. 5 Isometric View of Test Assembly Condition A – Horizontal HVAC Duct without Openings

12.2 Test another four test specimens in accordance with Test Method C518 with the following modifications:

12.3 Place the test specimens on a rack in a vertical position, with a clearance between each test specimen of $\frac{3}{8}$ to $\frac{3}{4}$ in. (9.5 to 19.1 mm).

12.4 Place the rack into an oven that has been preheated to a temperature of 300°F (149°C).

12.5 After 12 h $\pm$ 5 min, shut off the oven and allow the test specimens to cool for 12 h $\pm$ 5 min.

12.6 Repeat this cycle 10 times.

12.7 On completion of the final cycle, remove the test specimens from the oven and allow them to cool for a period of 2 h $\pm$ 5 min at standard atmospheric conditions.

NOTE 13—The intent of this temperature aging test is to simulate the effects of long-term exposure of typical in-service conditions on the thermal transmission qualities of the fire-resistive materials.

12.8 Document information required by Test Method C518 for all eight of the test specimens.

13. Fire Engulfment Test & Through Penetration Firestop Procedure

13.1 When required, add additional furnace thermocouples to maintain the exposure requirements of Test Method E814 when testing multiple test assemblies.

13.2 The test sponsor shall specify a fire exposure period of time. Use a test construction with a fire-resistance rating equal to the time specified by the test sponsor. Subject the test assembly to fire-exposure conditions in accordance with Test Method E814.

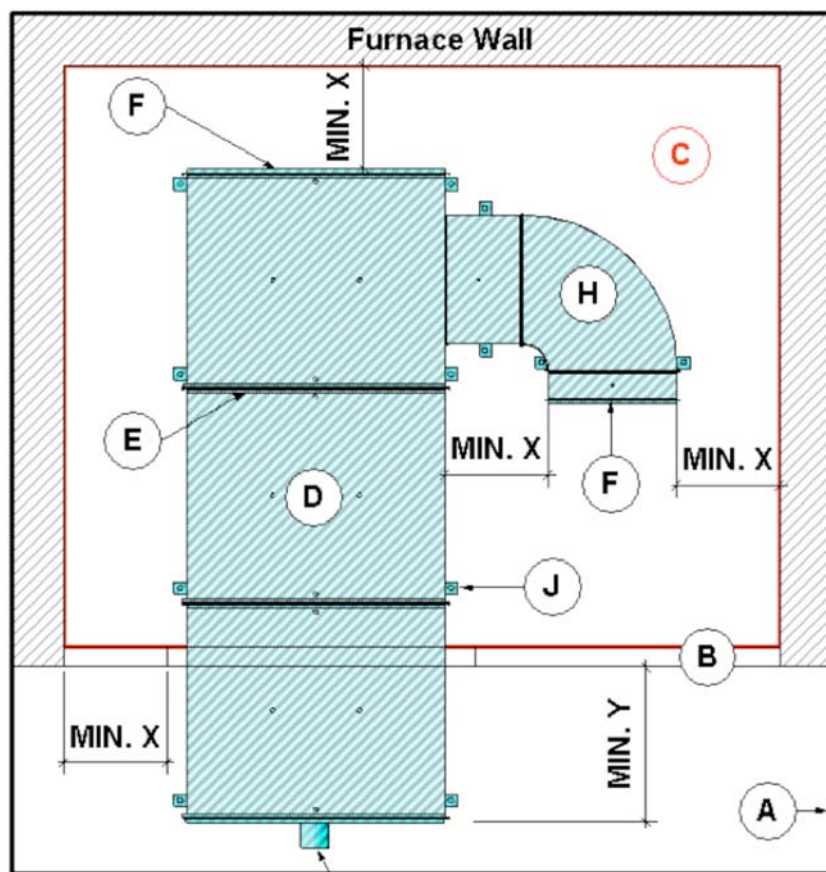
13.3 Apply unexposed surface thermocouples to the unexposed side of the through-penetration fire-stop systems in accordance with Test Method E814. Document the locations of the unexposed surface thermocouples. In addition to the unexposed surface thermocouples required by Test Method E814, additional thermocouples shall be placed as follows:

13.3.1 For Conditions C and D, place internal duct thermocouples in the center of the HVAC duct at the following locations for informational purposes only. Record the temperatures of these internal duct thermocouples. Refer to Fig. 17 and Fig. 18.

13.3.1.1 At least one internal duct thermocouple at the opening (designated H) in Figs. 11-16.

13.3.1.2 At least one internal duct thermocouple 12 $\pm$ 1 in. (305 $\pm$ 25 mm) from the unexposed end of the HVAC duct.

13.3.1.3 At least two internal duct thermocouples spaced every 12 $\pm$ 1 in. (305 $\pm$ 25 mm) from the unexposed side of the separating element towards the unexposed end of the HVAC duct.



A = Horizontal Fire-Separating Element
 B = Vertical Fire-Separating Element
 C = Fire Side of Fire-Separating Elements
 D = Straight HVAC Duct
 E = HVAC Duct Joints
 F = HVAC End Cap

G = Test Cap with Fan Connection
 H = HVAC Duct 90° Elbow
 I = Optional HVAC Duct Internal Reinforcement – Not Shown
 J = Supports
 MIN. X = 12 in. (305 mm)
 MIN. Y = 36 in. (914 mm)

FIG. 6 Plan View of Test Assembly Condition A – Horizontal HVAC Duct without Openings

13.3.2 For Conditions A, B, C, and D place unexposed surface thermocouples on the mid points of the sides of the HVAC duct at the following locations. Refer to Fig. 19.

13.3.2.1 At least one unexposed surface thermocouple on each side of the HVAC duct at a distance of $1 \pm \frac{1}{16}$ in. (25 ± 1.6 mm) away from where the HVAC duct passes through the separating element.

13.3.2.2 At least two unexposed surface thermocouples on each side of the HVAC duct every 12 ± 1 in. (305 ± 25 mm) from the unexposed side of the separating element towards the unexposed end of the HVAC duct. It is allowed to place additional unexposed surface thermocouples to create a temperature profile on the HVAC duct surfaces.

13.4 When requested by the test sponsor, sandwich two thermocouples between the HVAC duct and the inside face of the fire-resistive material, one-half the distance down the length of the horizontal section of HVAC duct inside the furnace, at its mid-height, for informational purposes only.

13.5 For Conditions A and B, establish within the first 15 min and maintain for the duration of the test, a negative pressure of 1.20 ± 0.06 in. H₂O (300 ± 15 Pa) within the HVAC duct compared to the laboratory's ambient atmospheric pressure.

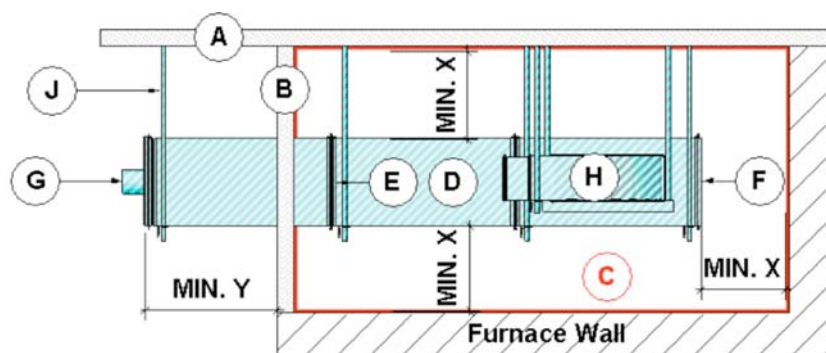
13.6 For Conditions C and D, start the fan in the section of the HVAC duct, establish, and maintain an air flow rate of 3 m/s (10 ft/s). The fan setting shall remain set for the duration of the test but the air flow shall be managed as explained in 6.8.2.

13.7 Start and continue the fire-resistance test until failure occurs, or until the period of time specified in 13.2 has expired.

13.8 Document the information required by Test Methods E119 and Test Method E814.

13.9 At the request of the test sponsor, continue the test beyond the time specified in 13.2.

NOTE 14—Often the purpose in continuing the test beyond the time



A = Horizontal Fire-Separating Element
B = Vertical Fire-Separating Element
C = Fire Side of Fire-Separating Elements
D = Straight HVAC Duct
E = HVAC Duct Joints
F = HVAC End Cap

G = Test Cap with Fan Connection
H = HVAC Duct 90° Elbow
I = Optional HVAC Duct Internal Reinforcement – Not Shown
J = Supports
MIN. X = 12 in. (305 mm)
MIN. Y = 36 in. (914 mm)

FIG. 7 Side View of Test Assembly Condition A – Horizontal HVAC Duct without Openings

specified in the Interpretation of Results is to obtain additional data.

13.10 Subject a duplicate HVAC duct system meeting the requirements in Section 7 of Test Method E814 to a fire-exposure test for a period equal to one half of that indicated as the resistance period in the fire test, but not more than 60 min, immediately after which subject the specimen to the impact, erosion, and cooling effects of a hose stream as described in Practice E2226, and in accordance with the pressures and durations specified in Table 1.

13.11 When requested by the test sponsor, and with the advice and consent of the testing body, the hose stream test shall be made on the specimen subjected to the fire test immediately following the fire test. Subject a duplicate specimen to a fire-exposure test for a period equal to one half of that indicated as the resistance.

13.12 Document the hose stream application and information required by Practice E2226.

14. Surface Burning Test

14.1 Document information required by Test Method E84.

15. Hot-Surface Performance Test

15.1 Document information required by Test Method C411.

16. Interpretation of Results

16.1 All of the Interpretation of Results in this section shall be met and clearly reported in order to comply with this test method. Publish the results either as a single report or as a separate report for each test method referenced in this document.

16.2 *Combustion Characteristics of Building Materials Test*—The test specimen shall meet the passing requirements of Test Method E136.

16.3 *Durability Test*:

16.3.1 The average thermal conductivity of the temperature aged test specimens shall not be greater than 110 % of the average thermal conductivity of the control test specimens.

16.4 *Fire-Engulfment and Through Penetration Firestop Test*:

16.4.1 All test specimens (Condition A, B, C and or D) shall sustain the test conditions and conform with these Interpretations of Results for a period of time equal to that specified by the test sponsor in 13.2.

16.4.2 For Conditions A, B, C, and D, there shall be no visible through openings created into the HVAC duct that is unexposed to the furnace fire during the fire-engulfment test.

16.4.3 Unexposed surface temperatures as measured by the unexposed surface thermocouples on the HVAC duct shall not exceed a temperature rise of 325°F (181°C) during the fire-engulfment test.

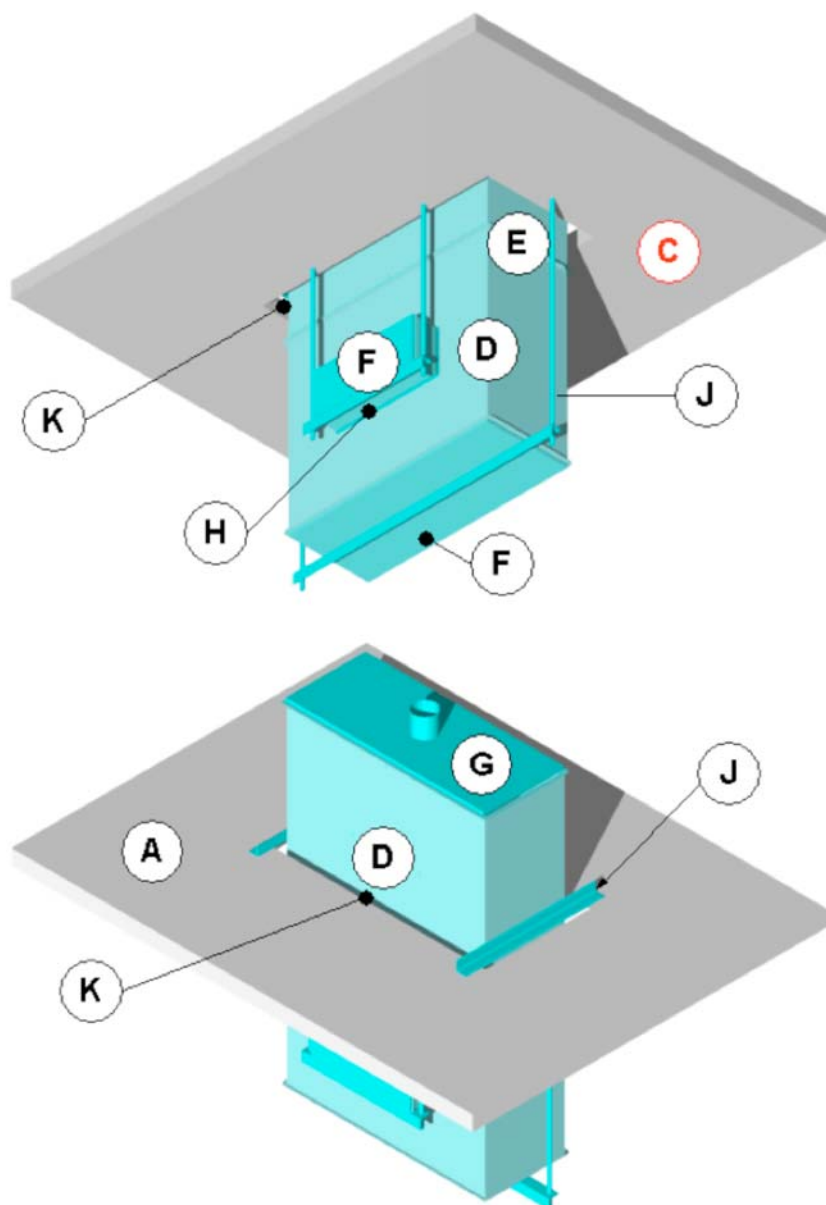
16.4.4 No flaming shall occur on any portion of the unexposed surface of the test specimen during the fire-engulfment test.

16.4.5 No visible through openings shall occur on any portion of the unexposed surface of the test specimen during the fire-engulfment test.

16.4.6 The support system shall carry the load of the HVAC duct (Condition A, B, C, and D) during the fire-engulfment test.

NOTE 15—Section 16.4.6 is not a requirement for the hose stream test because the hose stream test is only designed to determine whether a projection of water reaches the unexposed side of the test assembly and the load bearing supports are on the exposed side.

16.4.7 No visible through openings shall occur on any portion of the unexposed surface of the test assembly (for example, the minimum specified distance around the opening through the fire-separating element, the HVAC duct, and the firestop) during the application of the hose stream.



A = Horizontal Fire-Separating Element
 B = No Vertical Fire-Separating Element
 C = Fire Side of Fire-Separating Elements
 D = Straight HVAC Duct
 E = HVAC Duct Joints
 F = HVAC End Cap

G = Test Cap with Fan Connection
 H = "T" Connection
 I = Optional HVAC Duct Internal Reinforcement – Not Shown
 J = Supports
 K = Opening in Fire-Separating Element

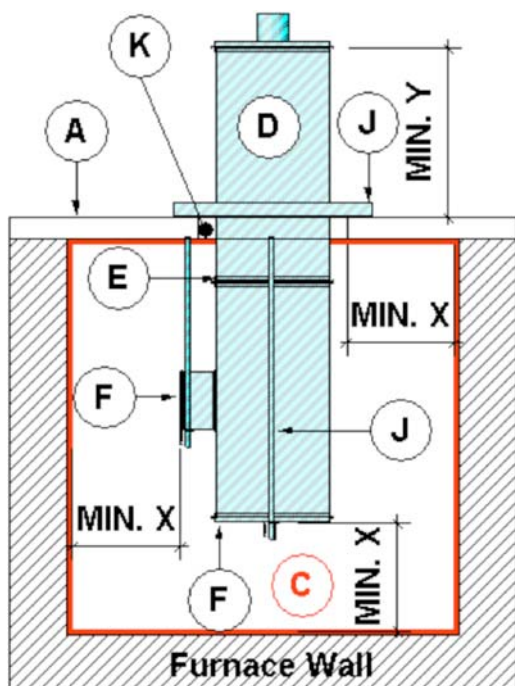
FIG. 8 Isometric Views of Test Assembly Condition B – Vertical HVAC Duct without Openings

16.4.8 The through-penetration firestop shall comply with the F-Rating requirements of Test Method E814 for the same period of time as the fire-engulfment test.

16.4.9 For penetrations of horizontal fire-separating elements, the through-penetration firestop shall comply with

the T-Rating requirements of Test Method E814 for the same period of time as the fire-engulfment test.

NOTE 16—Some building codes and nationally-recognized evaluation services may not require an equal F-Rating and T-Rating when a vertical



- | | |
|---|---|
| A = Horizontal Fire-Separating Element | H = "T" Connection |
| B = No Vertical Fire-Separating Element | I = Optional HVAC Duct Internal Reinforcement – Not Shown |
| C = Fire Side of Fire-Separating Elements | J = Supports |
| D = Straight HVAC Duct | K = Opening in Fire-Separating Element |
| E = HVAC Duct Joints | MIN. X = 12 in. (305 mm) |
| F = HVAC End Cap | MIN. Y = 36 in. (914 mm) |
| G = Test Cap with Fan Connection | |

FIG. 9 Side View of Test Assembly Condition B – HVAC Duct without Openings

fire-separating element is penetrated and protected by a through-penetration firestop. One example, the current version of *Acceptance Criteria for Metallic HVAC Duct Enclosure Assemblies* (AC179) by ICC Evaluation Services, does not require equal F- and T-Ratings for all applications.

16.5 Surface Burning Test:

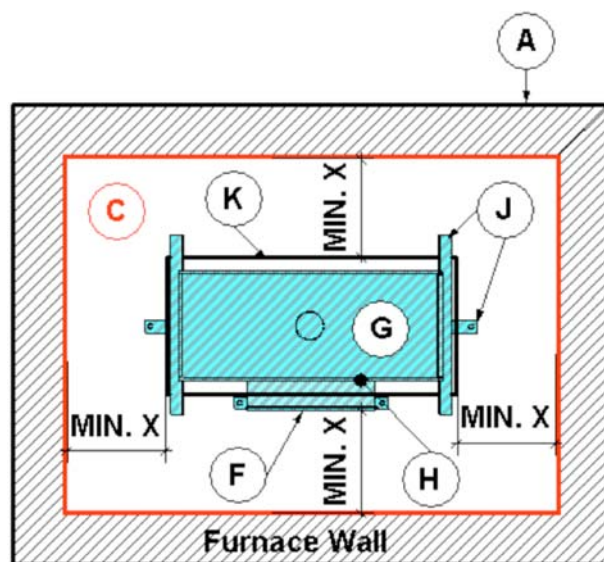
16.5.1 Report the flame spread and smoke development index in accordance with Test Method E84.

NOTE 17—Typically, HVAC ducts are used in plenum areas which normally requires materials with a flame spread index of 25 or less and a smoke developed index of 50 or less.

16.6 Hot-Surface Performance Test:

16.6.1 Document the presence of flaming, glowing, smoldering or smoking of the test specimen used in Test Method C411.

NOTE 18—There are references to Test Method C411 in various codes and standards, for example: Section 604.3 of the 2009 International Mechanical Code requires that "Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C)."



- | | |
|---|---|
| A = Horizontal Fire-Separating Element | H = "T" Connection |
| B = No Vertical Fire-Separating Element | I = Optional HVAC Duct Internal Reinforcement – Not Shown |
| C = Fire Side of Fire-Separating Elements | J = Supports |
| D = Straight HVAC Duct – Not Shown | K = Opening in Fire-Separating Element |
| E = HVAC Duct Joints – Not Shown | MIN. X = 12 in. (305 mm) |
| F = HVAC End Cap | MIN. Y = 36 in. (914 mm) |
| G = Test Cap with Fan Connection | |

FIG. 10 Plan View of Test Assembly Condition B – Vertical HVAC Duct without Openings

17. Report

17.1 Report which test methods and document sections were selected and conducted.

17.2 Report all information required to be documented in this test method.

17.3 Report the construction of test assemblies.

17.4 Report the details and description (for example, whether or not the fire-resistive material is faced or encapsulated, density, and dimensions, etc.) of all test specimens.

17.5 *Combustion Characteristics of Building Materials Test*—Report whether this test was conducted and, when conducted, all information in accordance with Test Method E136, and whether or not the test specimen met the Interpretation of Results in 16.2.

17.6 *Durability Test*—Report whether this test was conducted and, when conducted, report all information in accordance with Test Method C518, and the percent increase in thermal conductivity as determined in accordance with Section 12, and whether or not the test specimen met the Interpretation of Results in 16.3.

NOTE 19—Typically, when the service temperature of the HVAC duct system exceeds 125°F (52°C) this test method is conducted to ensure the materials durability.

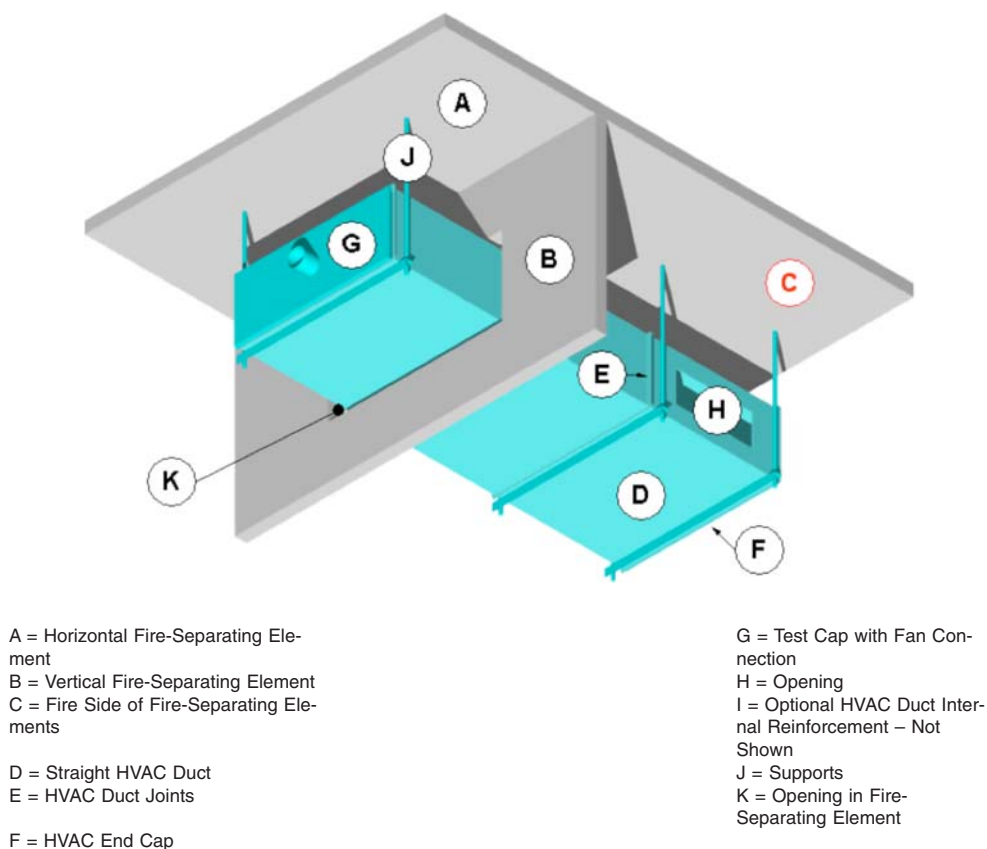


FIG. 11 Isometric View of Test Assembly Condition C – Horizontal HVAC Duct with Openings

17.7 *Fire Engulfment and Through Penetration Firestop Test*—Report whether this test was conducted and, when conducted, report all information in accordance with this test method including which test specimen(s) was tested (i.e. Condition A, B, C, D), and whether or not the test specimen met the Interpretation of Results in 16.4.

NOTE 20—Reporting the average unexposed surface temperature of the HVAC duct is not a requirement of these test methods but this information may be useful to the test sponsor or authority having jurisdiction and, when requested, shall be included in the report.

17.8 Surface Burning Test:

17.8.1 Report whether this test was conducted and, when conducted, report all information in accordance with Test Method E84 as determined by the Interpretation of Results in 16.5.

17.9 *Hot-Surface Performance Test*—Report whether this test was conducted and, when conducted, report all information in accordance with Test Method C411 as determined by the Interpretation of Results in 16.6.

17.10 Report all other information required to be documented by this standard.

18. Precision and Bias

18.1 *Combustion Characteristics of Building Materials Test*—Refer to Test Method E136.

18.2 *Durability Test*—Refer to Test Method C518.

18.3 *Fire-Engulfment Test*—Refer to Test Methods E119.

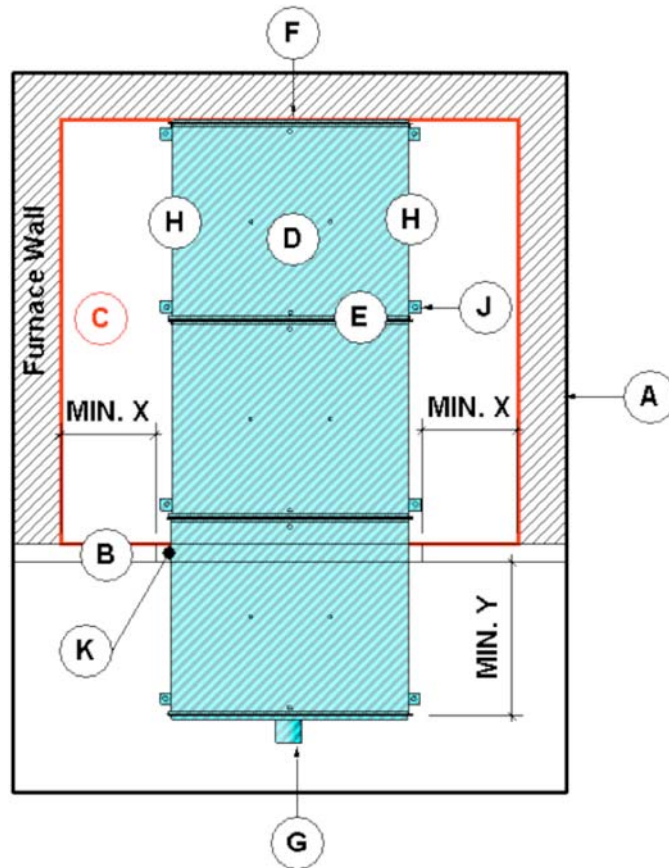
18.4 *Through Penetration Firestop Test*—Refer to Test Method E814.

18.5 *Surface Burning Test*—Refer to Test Method E84.

18.6 *Hose Stream Test*—Practice E2226 does not contain a precision and bias.

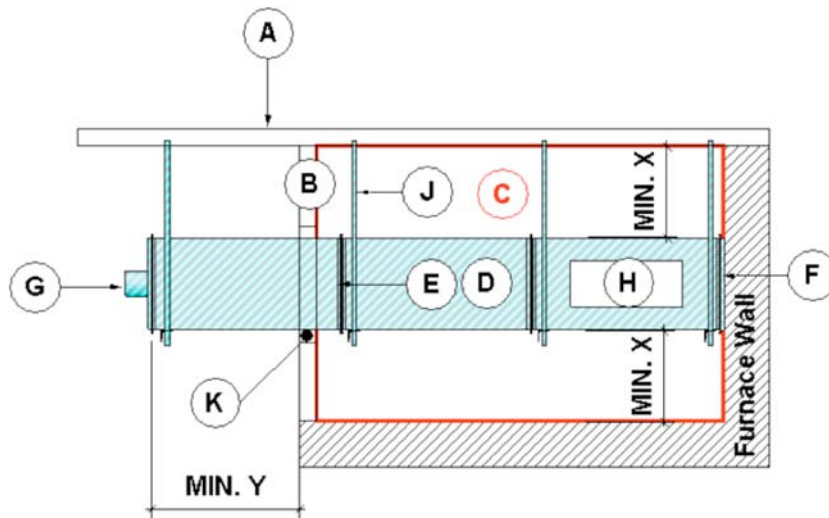
19. Keywords

19.1 engulfment test; fire resistive; fire-resistive material; fire-separating elements; hose stream; HVAC duct; HVAC duct system; internal fire test



- | | |
|--|---|
| A = Horizontal Fire-Separating Element | H = Opening |
| B = Vertical Fire-Separating Element | I = Optional HVAC Duct Internal Reinforcement – Not Shown |
| C = Fire Side of Fire-Separating Element | J = Supports |
| D = Straight HVAC Duct | K = Opening in Fire-Separating Element |
| E = HVAC Duct Joints | MIN. X = 12 in. (305 mm) |
| F = HVAC End Cap | MIN. Y = 36 in. (914 mm) |
| G = Test Cap with Fan Connection | |

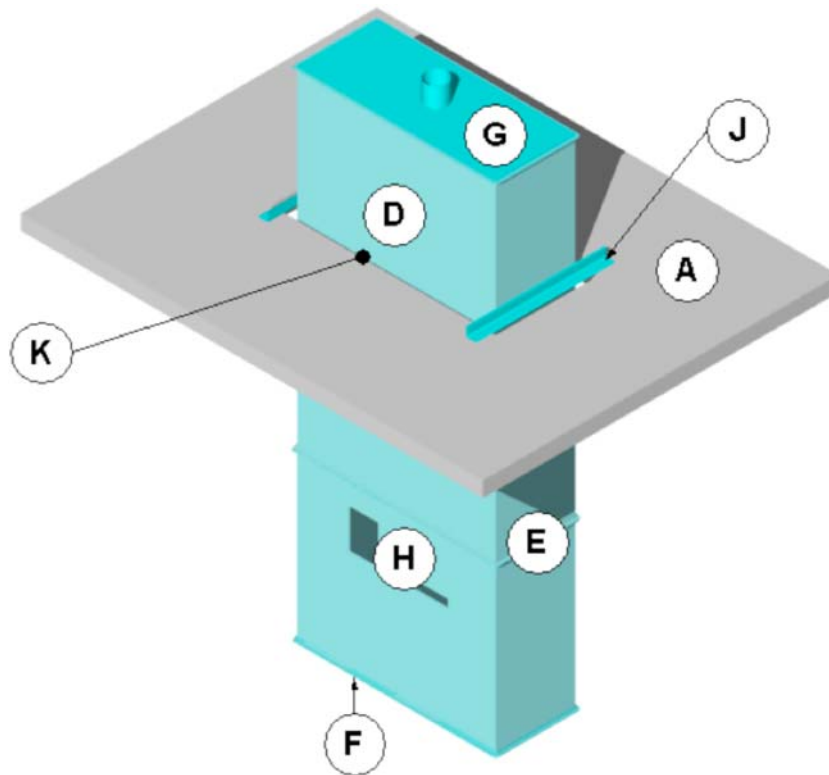
FIG. 12 Plan View of Test Assembly Condition C – Horizontal HVAC Duct with Openings



A = Horizontal Fire-Separating Element
 B = Vertical Fire-Separating Element
 C = Fire Side of Fire-Separating Elements
 D = Straight HVAC Duct
 E = HVAC Duct Joints
 F = HVAC End Cap
 G = Test Cap with Fan Connection

H = Opening
 I = Optional HVAC Duct Internal Reinforcement – Not Shown
 J = Supports
 K = Opening in Fire-Separating Element
 MIN. X = 12 in. (305 mm)
 MIN. Y = 36 in. (914 mm)

FIG. 13 Side View of Test Assembly Condition C – Horizontal HVAC Duct with Openings



A = Horizontal Fire-Separating Element
 B = No Vertical Fire-Separating Element
 C = Fire Side of Fire-Separating Elements

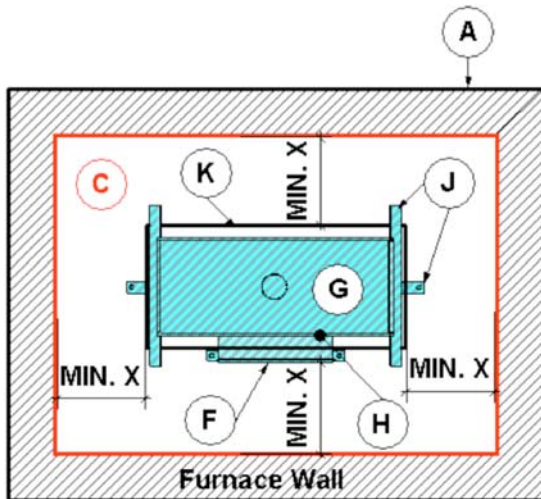
D = Straight HVAC Duct
 E = HVAC Duct Joints

F = HVAC End Cap

G = Test Cap with Fan Connection
 H = Opening

I = Optional HVAC Duct Internal Reinforcement – Not Shown
 J = Supports
 K = Opening in Fire-Separating Element

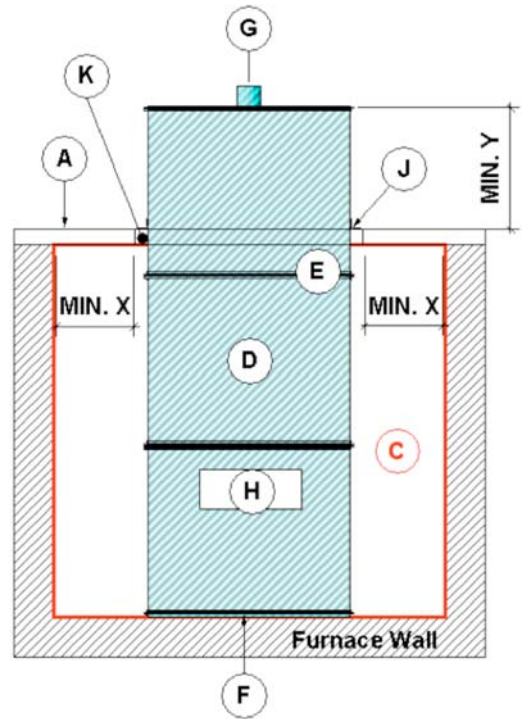
FIG. 14 Isometric View of Test Assembly Condition D – Vertical HVAC Duct with Openings



A = Horizontal Fire-Separating Element
 B = No Vertical Fire-Separating Element
 C = Fire Side of Fire-Separating Elements
 D = Straight HVAC Duct – Not Shown
 E = HVAC Duct Joints – Not Shown
 F = HVAC End Cap
 G = Test Cap with Fan Connection

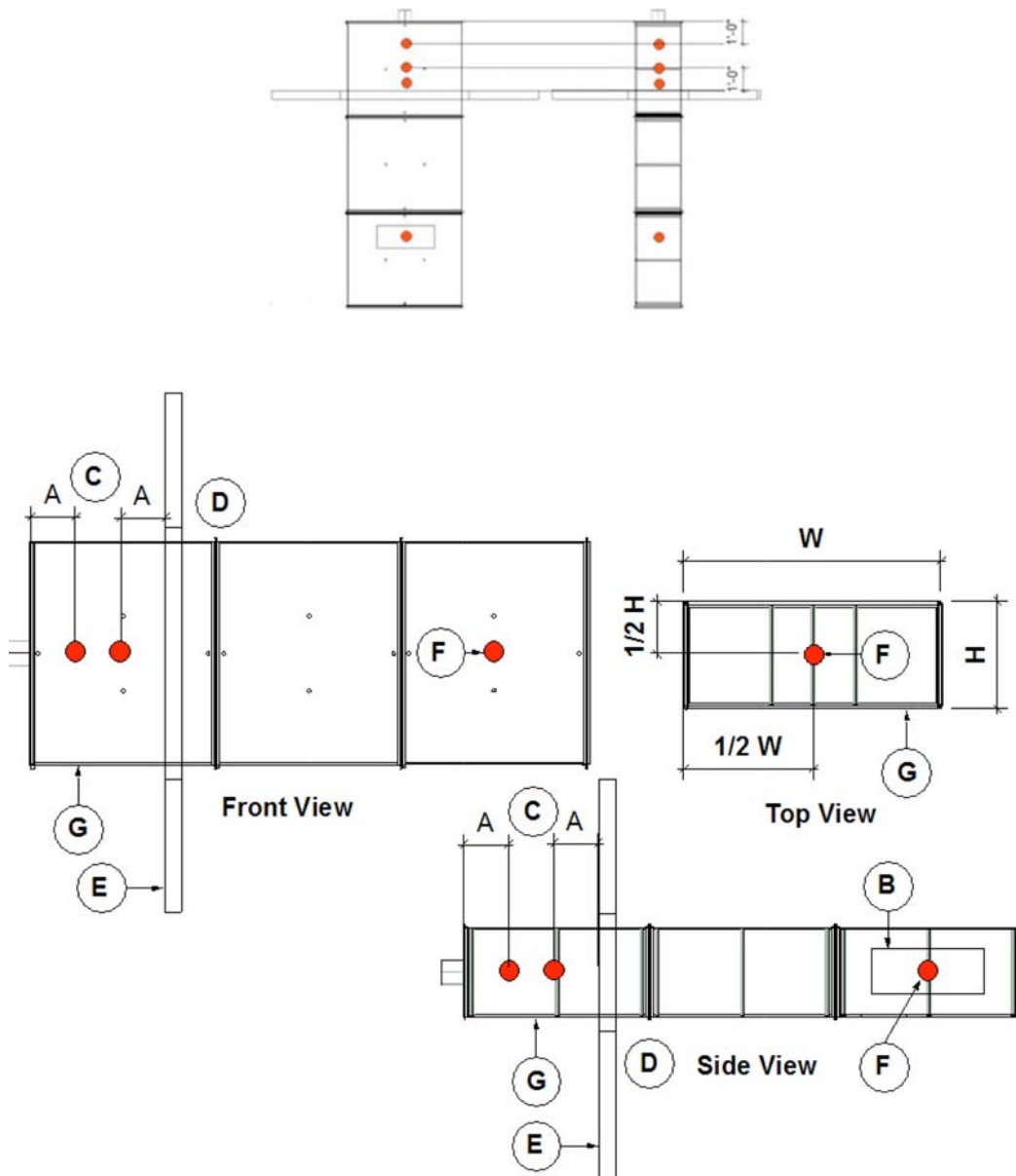
H = Opening
 I = Optional HVAC Duct Internal Reinforcement
 J = Supports
 K = Opening in Fire-Separating Element
 MIN. X = 12 in. (305 mm)
 MIN. Y = 36 in. (914 mm)

FIG. 15 Plan View of Test Assembly Condition D – Vertical HVAC Duct with Openings



A = Horizontal Fire-Separating Element
 B = No Vertical Fire-Separating Element
 C = Fire Side of Fire-Separating Elements
 D = Straight HVAC Duct
 E = HVAC Duct Joints
 F = HVAC End Cap
 G = Test Cap with Fan Connection
 H = Opening
 I = Optional HVAC Duct Internal Reinforcement – Not Shown
 J = Supports
 K = Opening in Fire-Separating Element
 MIN. X = 12 in. (305 mm)
 MIN. Y = 36 in. (914 mm)

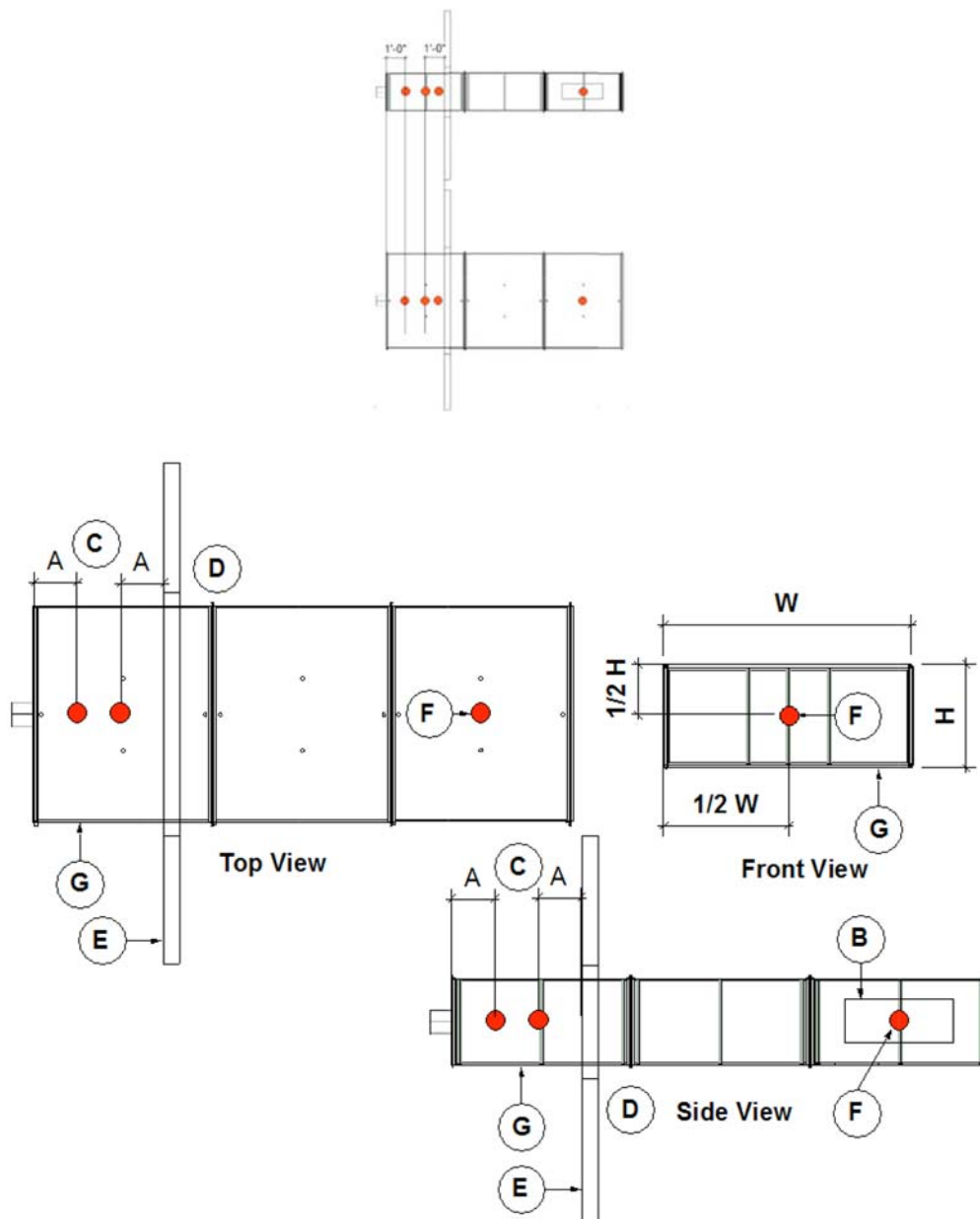
FIG. 16 Side View of Test Assembly Condition D – Vertical HVAC Duct with Openings



A = 12 ± 1 in. (305 ± 25 mm)
 B = Opening
 C = Furnace Environment
 D = Unexposed Side

E = Separating Element
 F = Internal Thermocouples
 G = HVAC Duct

FIG. 17 Internal Duct Thermocouples – Top, Front, and Side Views of Vertical Test Assembly



A = 12 ± 1 in. (305 ± 25 mm)
 B = Opening
 C = Furnace Environment
 D = Unexposed Side

E = Separating Element
 F = Internal Thermocouples
 G = HVAC Duct

FIG. 18 Internal Duct Thermocouples – Top, Front, and Side Views of Horizontal Test Assembly

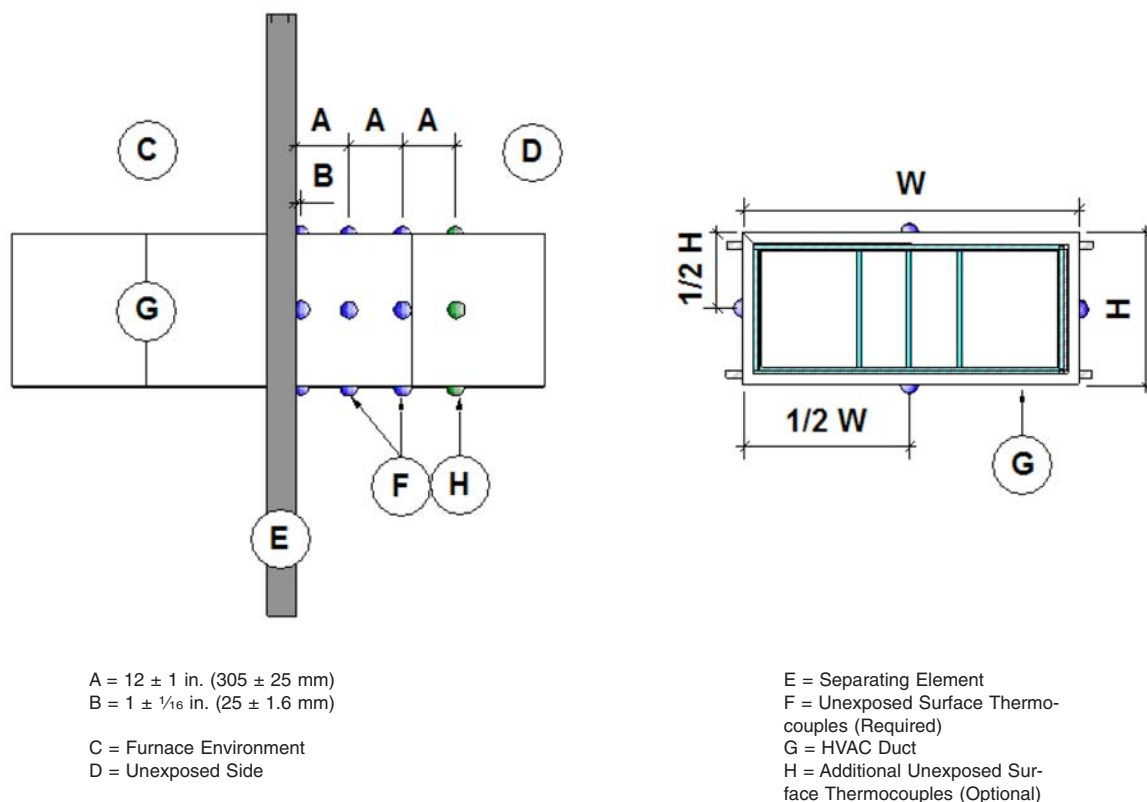


FIG. 19 Unexposed Surface Thermocouples Locations on HVAC Duct – Horizontal and Vertical Test Assemblies

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