Designation: E2912 – 13

Standard Test Method for Fire Test of Non-Mechanical Fire Dampers Used in Vented Construction[1]

This standard is issued under the fixed designation E2912; 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 This fire-test-response standard assesses the ability of non-mechanical fire dampers used in vented construction in its open state to limit passage of hot gases, radiation, and flames during a prescribed fire test exposure. The fire exposure condition in this test method is sudden direct flame impingement, which produces these hot gases, radiation, and flames.

NOTE 1—Non-mechanical fire dampers can be used in vented construction. Vented constructions may be parts of buildings including walls, floors, ceilings and concealed spaces and cavities used for air transfer and to allow ventilation in structures without ductwork. Non-mechanical fire dampers can be located adjacent to combustible construction or materials and situated in exposed or concealed locations, or both. Unlike typical fire resistive assemblies, vented construction uses non-mechanical fire dampers to allow air transfer without the use of ducts. Resistance to flame, radiation, and hot gases may be requirements when direct flame impingement is a credible risk, or when no penetration of flames is required by the authority having jurisdiction, or both. The proposed test method provides procedures that enable an assessment of this direct flame impingement on non-mechanical fire dampers. This test method does not alter any requirements for non-mechanical fire dampers used in fire resistance rated construction and assemblies.

1.2 This fire-test-response standard is intended to provide a means to assess the reaction of a non-mechanical fire damper used in vented construction to sudden direct flame impingement, or as a supplement to existing fire-resistive test methods, or both.

1.3 This test method does not circumvent or eliminate the fire resistance rating requirements for construction. The fire resistance rating of construction shall be tested in accordance with published fire-resistance test standards as appropriate for the relevant application of the construction, or as required by the authority having jurisdiction (regulatory authority), or both. Non-mechanical fire dampers shall be tested to the appropriate fire-resistive test standards required for their application in order to determine a fire resistance rating in those constructions.

NOTE 2—Some of the major international standards development organizations (SDO) include, but are not limited to, ASTM International, CEN, ISO, UL, and ULC. Some examples of standards employing standard time-temperature curves for fire exposure used to determine a construction's fire resistance rating include, but are not limited to, the following: Test Methods E119, E814, E1966, E2307, UL 10B, UL 10C, UL 555, UL 555C etc. The term "authority having jurisdiction" is defined in Practice E2174.

1.4 This test method specifies the fire exposure conditions, fire test protocol, and criteria to evaluate an open state.

NOTE 3—There are currently no published test methods (nationally or internationally) that address the application of sudden direct flame impingement on non-mechanical fire dampers used in vented construction. In the European Union (EU), CEN (European Committee for Standardization) has very recently started a work item to address reaction to sudden direct flame impingement on non-mechanical fire dampers. Also, in the EU, some countries have used large scale tests with 5MW fire exposures to assess test specimens' reactions to sudden direct flame impingement as part of the entire building construction. Standard time-temperature curves used to control gas-fired furnaces do not ensure a sudden direct flame impingement on the test specimen, which this test method is designed to do. A post flashover condition, the spontaneous combustion of materials, ignition of a highly combustible material acting as the source of the fire (for example, stored cleaning solutions or fuels) or the location of materials can create a fire scenario resulting in a sudden direct flame impingement.

1.5 Results generated by this test method provide the following information:

1.5.1 the open state fire performance of vented construction, and

1.5.2 the non-mechanical fire damper's fire-test-response characteristic when exposed to sudden direct flame impingement.

1.6 This test method does not provide quantitative information about the test assembly related to the leakage of smoke, or gases, or both.

1.7 This test method does not apply to a test assembly having other components than those tested.

1.8 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.

1.9 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes

[1] This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.11 on Fire Resistance.

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(excluding those in tables and figures) shall not be considered requirements of this standard.

1.10 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

1.12 *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:*[2]

E119 Test Methods for Fire Tests of Building Construction and Materials

E176 Terminology of Fire Standards

E631 Terminology of Building Constructions

E814 Test Method for Fire Tests of Penetration Firestop Systems

E1966 Test Method for Fire-Resistive Joint Systems

E2174 Practice for On-Site Inspection of Installed Firestops

E2257 Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies

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

2.2 *UL Standards:*[3]

UL 10B Fire Tests of Door Assemblies

UL 10C Positive Pressure Fire Tests of Door Assemblies

UL 555 Fire Dampers

UL 555C Ceiling Dampers

3. Terminology

3.1 *Definitions*—Terms defined in Terminologies E176 and E631 shall prevail for fire and building terms not defined in this document.

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

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

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *closed state, n*—the sealed or closed condition of an opening in vented construction.

3.2.2 *insulation, n*—ability of a test assembly, when exposed to fire on one side, to restrict the temperature rise to below specified levels on its unexposed side.

3.2.3 *integrity, n*—the ability of a test assembly, when exposed to fire from one side, to prevent the passage of flame or hot gases through it or the occurrence of flames on its unexposed side.

3.2.3.1 *Discussion*—In this test method the integrity of the test assembly is determined by Section 11, Integrity Test, and the Ignition Test Procedure in Annex A2.

3.2.4 *non-mechanical fire damper, n*—venting device used as part of vented construction intended to resist the transfer of hot gas, radiation, and flame.

3.2.5 *open state, n*—the unsealed or unclosed condition of the non-mechanical fire damper prior to being closed or sealed.

3.2.6 *open state fire performance, n*—the ability to limit the passage of hot gases, radiation, and flames produced during this test method's standardized, sudden-flaming exposure.

3.2.7 *splice, n*—a connection of parts of test specimens within the vented construction.

3.2.8 *test assembly, n*—the complete assembly of a test specimen(s) installed in the vented construction.

3.2.9 *test specimen, n*—a non-mechanical fire damper with specific attributes such as material(s), gaps, shapes, size, and width.

3.2.10 *vented construction, n*—a building element or construction feature (such as a floor, wall, roof, ceiling, joint, door or wall cavity, crawl space, air gap, etc.) that includes an opening(s) used for venting of spaces or as part of ductless ventilation equipped with one or more non-mechanical fire dampers.

4. Summary of Test Method

4.1 The test assembly is subjected to a standardized fire exposure created using a propane-powered gas burner regulated to a specific heat output as noted in 6.1.5.

4.2 This test method is applicable to either horizontal or vertical test assemblies that are symmetrical or asymmetrical as referenced in 7.5 and 7.6.

4.3 The test assembly is conditioned at specific temperature and humidity ranges as stated in Section 9.

4.4 This test method establishes a specific test procedure in Section 10 to measure the open state fire performance of vented construction when exposed to hot gases, radiation, and flames prior to, and including, its closed state.

4.5 This test method requires the time be reported at which flaming occurs, if any, as noted in 13.1.19 based on information obtained from 10.13, 11.1, and 11.2.

4.6 The open state fire performance is monitored using an integrity test and an insulation test in accordance with Sections 11 and 12, respectively.

4.7 This test method requires the time be reported when individual and average unexposed surface temperature readings exceed the limitations established by this test method as noted in 13.1.20.

[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] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

5. Significance and Use

5.1 This test method provides for the following observations, measurements and evaluations of an open state during the test fire.

5.1.1 Ability of the test specimen to resist the passage of flames, radiation, and hot gases caused by sudden direct flame impingement.

5.1.2 Transmission of heat through the test specimen.

5.2 This test method does not provide the following:

5.2.1 Evaluation of the degree to which the test assembly contributes to the fire hazard by generation of smoke, toxic gases, or other products of combustion.

5.2.2 Measurement of the degree of control or limitation of the passage of smoke or products of combustion through the test specimen or the test assembly.

5.2.3 Measurement of flame spread over the surface of the test specimen or the test assembly.

5.2.4 Durability of the test specimen or test assembly under actual service conditions, including the effects of cycled temperature.

5.2.5 Effects of a load on the test specimen or test assembly.

5.2.6 Any other attributes of the test specimen or the test assembly, such as wear resistance, chemical resistance, air infiltration, water-tightness, and so forth.

5.3 The results of this test method shall not be used as an alternative to, or a substitute for, requirements for a required fire resistance rating of building construction.

6. Apparatus

6.1 *Fire Source:*

6.1.1 A gas burner shall be used as the fire source.

6.1.2 The gas burner shall have a nominal 170 by 170 mm porous top surface consisting of a refractory material (for example, sand) as shown in Fig. 1. Unless otherwise specified, the tolerance for dimensions in figures shall be ±5 %.

NOTE 4—The burner and its output were selected to produce a sudden direct flame impingement on the test specimen that is constant. The burner configuration and its output were based upon those prescribed in Test Method E2257. The distance between the test specimen and the fire source (gas burner) was set to address variables typically seen in building occupation that contribute to sudden direct flaming. Two of many possible examples are: *(1)* Interior vents located in storage rooms and offices where combustibles are stacked on top of filing cabinets, *(2)* Exterior vents in contact with landscaping (vegetation or forestation, or both). In many cases, these combustibles are just inches from the vent, which is open to allow airflow, and are subject to a sudden direct flame impingement.

6.1.3 The burner shall be supplied with CP[4] grade propane (99 % purity) with a net heat of combustion of 46.5 ± 0.5

[4] Commonly called commercial propane.

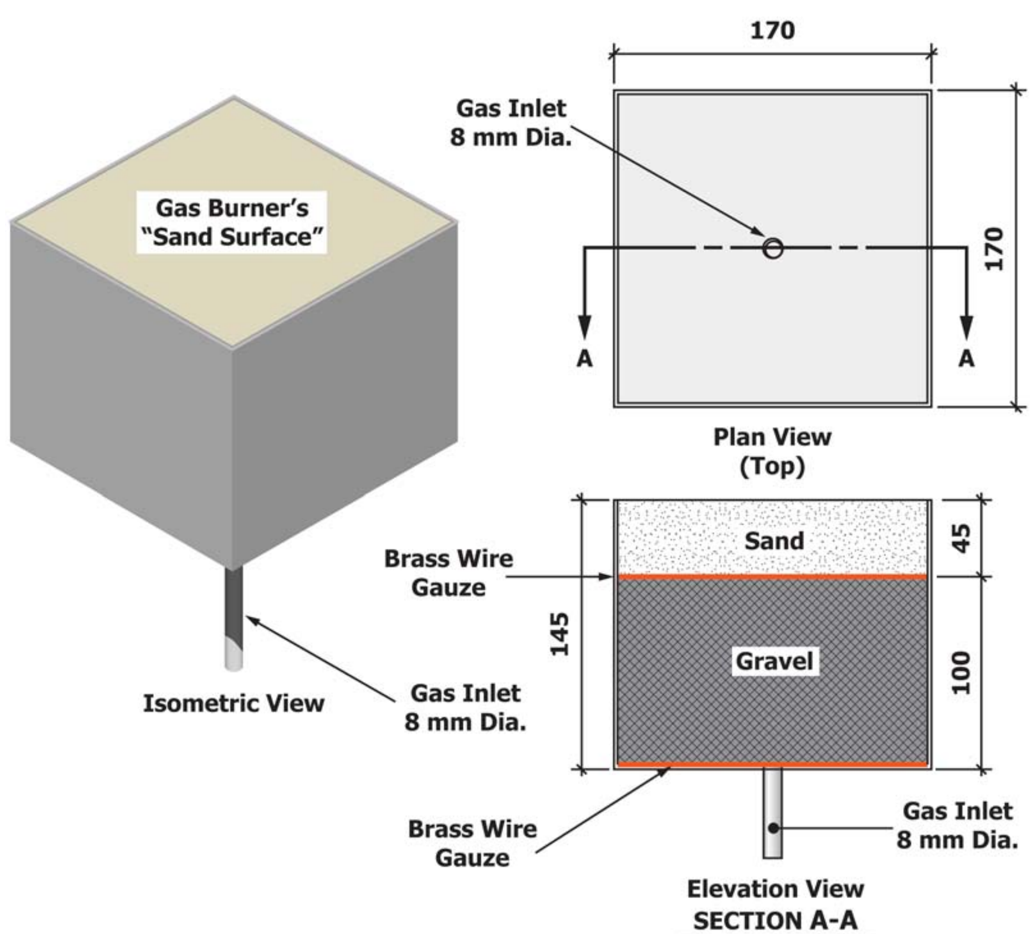

FIG. 1 Gas Burner Exposure Fire Source

MJ/kg. The gas flow to the burner shall be measured to an accuracy of at least ±3 %. The flow measuring equipment shall be calibrated per the manufacturer's instructions at least once per year.

6.1.4 The heat output to the burner shall be controlled within ±5 % of the prescribed value.

6.1.5 The gas supply to the burner shall produce a constant net heat output of 300 ± 10 kW for at least 10 min.

6.2 *Test Bench:*

6.2.1 The test bench shall be constructed of framing and shall use materials suited to withstand the duration of the fire test. Unless otherwise specified, the tolerance for dimensions in figures and text in this section shall be ±5 %.

6.2.2 The test bench shall have the following surface dimensions measured from inside the framing:

6.2.2.1 Length 2300 mm.

6.2.2.2 Width 1150 mm.

6.2.2.3 The overall length and width of the test bench will vary depending on the thickness of the framing and other materials used to construct the test bench.

NOTE 5—Wood framing and gypsum board have been found to be suitable materials with which to build a test bench. The wood framing should be protected from the heat source. However, other combinations of materials may also be appropriate for this use, such as steel framing, calcium silicate board, cement board, etc.

6.2.3 The test bench shall be constructed to have the dimensions and characteristics illustrated in Figs. 2-7, inclusive.

6.2.3.1 The test bench surface shall have a 500-mm square opening located as illustrated in Fig. 4.

6.2.3.2 A 400-mm skirt shall cover the two sides and the front of the test bench as illustrated in Figs. 5-7.

6.2.3.3 *Discussion*—The skirt is intended to provide some shielding for laboratory personnel from the effects of the gas burner. However, the laboratory shall implement additional safeguards as necessary to ensure laboratory personnel safety. The skirt is also used to avoid flames circumventing the opening in the bench and affecting the unexposed side of the test specimen. Excessive flue gas is also channeled out the open end of bench by the skirts.

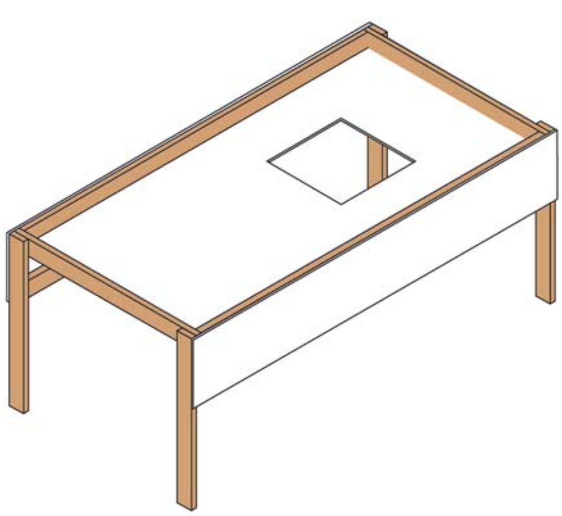

FIG. 2 Left Isometric View of Test Bench

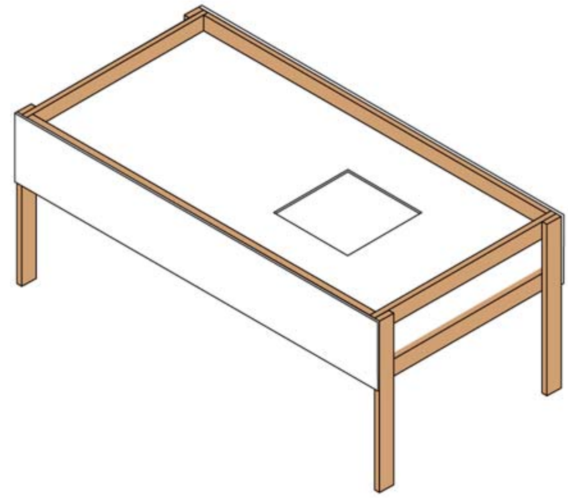

FIG. 3 Right Isometric View of Test Bench

6.2.4 The height of the test bench shall be as necessary to meet the clearance dimensions illustrated in Fig. 8.

6.2.5 Fig. 4 and Fig. 8 show the test bench top surface, with the 500-mm square opening.

6.2.6 The top surface of the gas burner, referred to as the gas burner's "sand surface" in Fig. 4 and Fig. 8, shall be positioned parallel to the bottom surface of the test bench as illustrated in Fig. 8.

6.2.7 Locate the gas burner's sand surface a distance of 250 mm below the bottom surface of the test bench, as shown in Fig. 8, and center the burner in the 500-mm square opening as shown in Fig. 4 and Fig. 8, creating a concentric annular space of 165 mm around the gas burner in the plan view.

6.3 *Cotton Pads and Applicator Frame:*

6.3.1 Refer to Annex A1 for drawings and descriptions.

6.4 *Unexposed Surface Thermocouples:*

6.4.1 The wires for the thermocouple in the length covered by the pad shall be not heavier than No. 18 B&S gage (1.02 mm) and shall be electrically insulated with heat-resistant or moisture-resistant coatings, or both.

6.5 *Thermocouple Pads:*

6.5.1 The insulating pads shall be dry, felted, refractory fiber pads.

6.5.2 The pads shall be 9.5 ± 1.6 mm thick.

6.5.3 The pads length and width shall measure 50 ± 1 mm.

6.5.4 The pads shall have a density of 500 ± 10 kg/m^3.

6.6 *Other Temperature Detection Devices:*

6.6.1 A visual imaging camera or calibrated thermal imaging camera is permitted to be used as an additional means of observation of flame penetration on the unexposed surface of the test specimen.

6.7 *Time Measurement:*

6.7.1 A computer chronograph used as part of the temperature data acquisition equipment and either:

6.7.1.1 an electric clock with a sweep hand or

6.7.1.2 a digital clock.

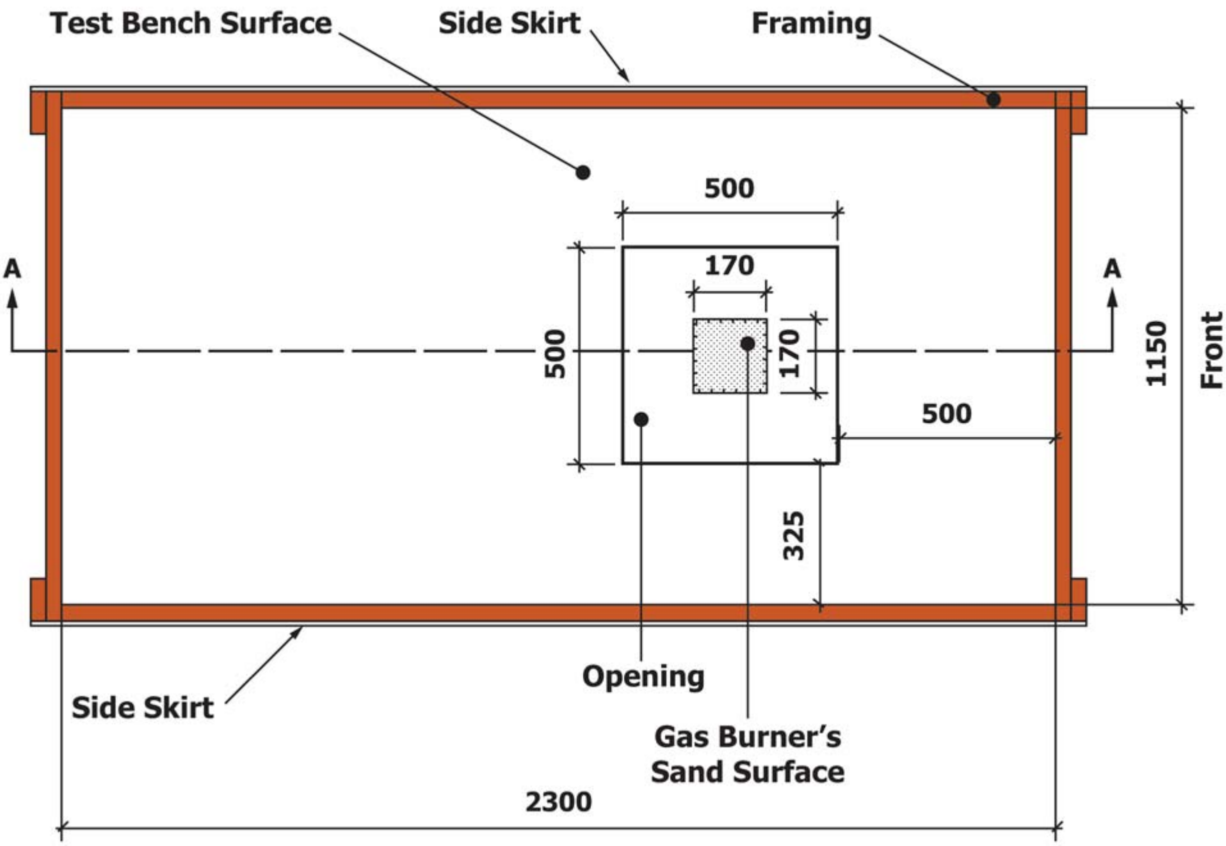

FIG. 4 Plan View of Test Bench

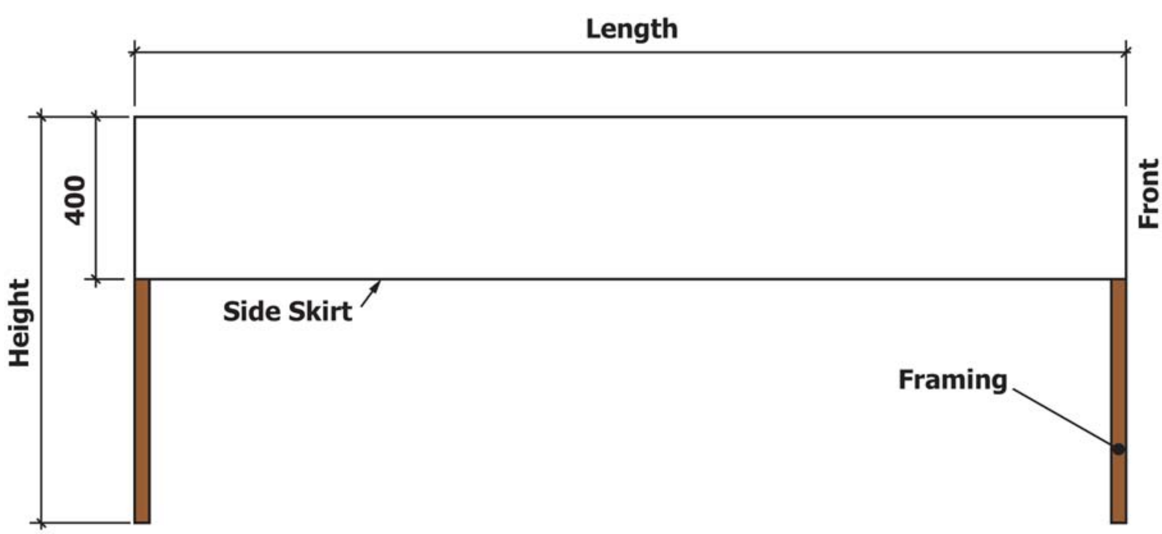

FIG. 5 Side Elevation View of Test Bench

7. Test Specimen and Test Assembly

7.1 The test assembly shall be representative of the vented construction and the test specimen shall be representative of the non-mechanical fire damper for which the open state fire performance and the fire-test-response characteristic are to be recorded, with respect to materials, components, workmanship, and details.

7.2 *Test Specimen Splices:*

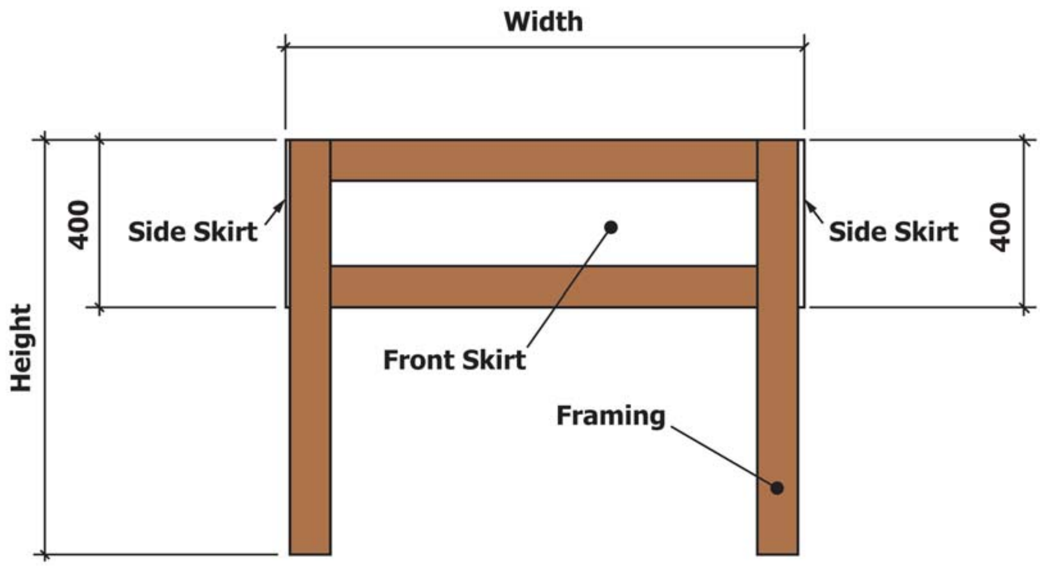

FIG. 6 Front Elevation View of Test Bench

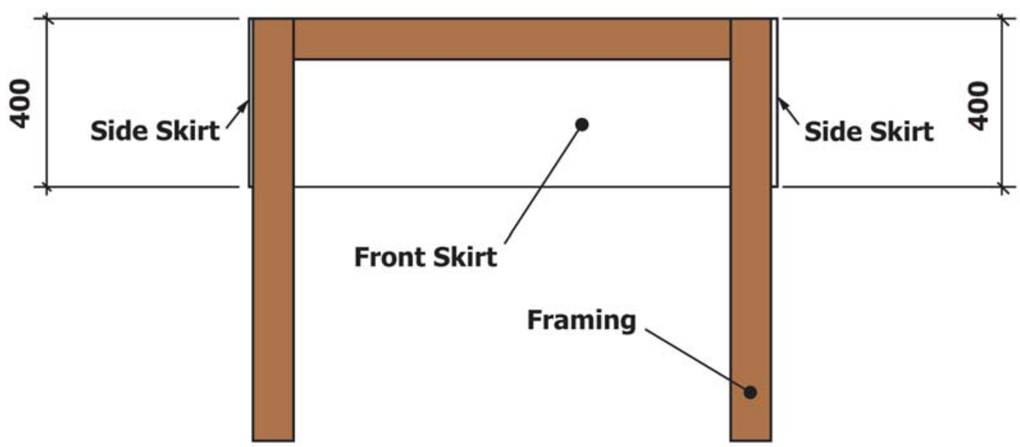

FIG. 7 Rear Elevation View of Test Bench

7.2.1 When a test specimen is able to be spliced during manufacture or in the field, or both, test the factory-manufactured splice and the field splice, as applicable. Photograph the splicing procedure and document the splicing instructions.

7.2.2 When the factory-manufactured splice is the same as the field splice technique, test one splice.

7.2.3 Position the splice in the middle of the test specimen. When testing splices position them equidistant in the length of the test specimen. The total area of the splices shall not exceed 25 % of the test specimen's area. No more than two splices shall be tested as part of the test specimen. The laboratory shall decide whether splices can be tested as part of the test specimen. When the laboratory believes that splices have the potential to increase performance of the test specimen, splices shall be tested separately.

7.2.3.1 *Discussion*—Calculate the splices' positions using the equation: $L/(x + 1)$. Where x is the number of splices to be created in the test specimen's length (L). Separate two splices by a distance of $L/3$.

7.2.4 When applicable to the end use of the test specimen, test each type of end sealing condition. Photograph the sealing procedure and document the sealing instructions.

7.3 *Test Specimen Size:*

7.3.1 The test specimen shall be 500 mm long (L) or high (H) by 500 mm wide (W).

7.3.2 When the test specimen's maximum dimensions are less than those required in 7.3.1, test the maximum length and width of the test specimen.

7.3.3 Document the dimensions of the test specimen tested.

7.4 *Test Specimen Installation:*

7.4.1 Install the test specimen into the test assembly in accordance with the manufacturer's installation instructions. Photograph the installation procedure and document the installation instructions. Document whether the test specimen and test assembly are symmetrical or asymmetrical.

7.5 *Horizontal Test Specimens:*

7.5.1 Horizontal test specimens used in horizontal assemblies (for example, floors, roofs, or ceilings) shall be installed

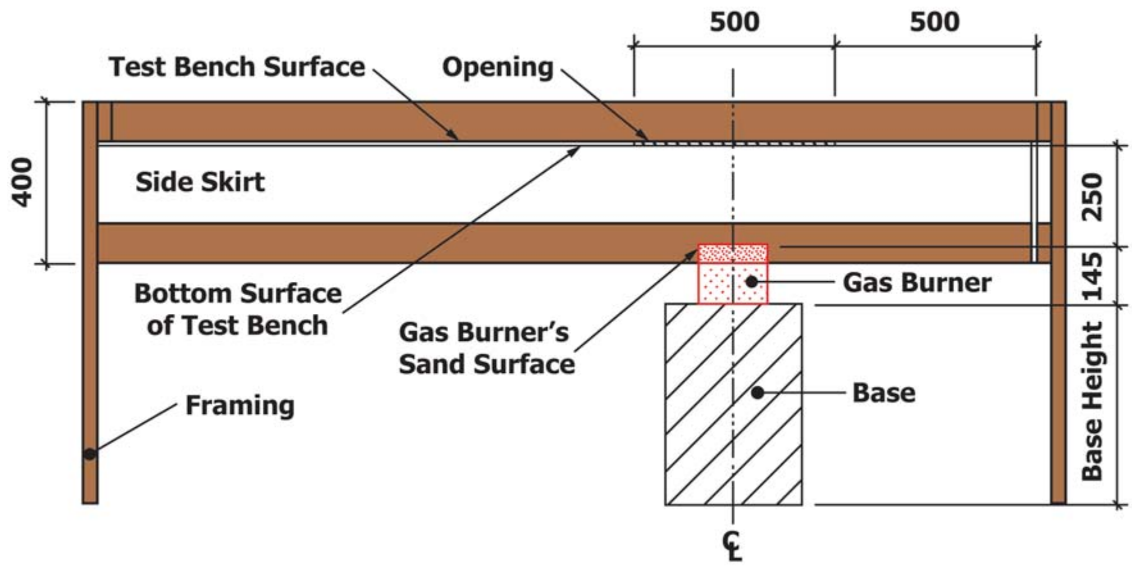

FIG. 8 Section View A-A of Fig. 4 – Burner Location as used with Test Bench

as intended for use. Refer to Fig. 11 for various locations of horizontal test specimens that create symmetrical and asymmetrical test assemblies.

7.5.2 Test the horizontal test assembly centered over the opening in the test bench surface as shown in Fig. 10, Section A–A.

7.5.3 Horizontal test specimens used in vertical assemblies (for example, wall cavities) shall be tested at as shown in Fig. 12.

7.5.4 For symmetrical horizontal test assemblies, install the test specimen in the center ($T/2$) of the test assembly's thickness (T) as shown in Section A-A of Fig. 10, where the recess from the top (rt) equals the recess from the bottom (rb): $rt = rb$.

7.5.5 For asymmetrical horizontal test assemblies, mount the test specimen as it is intended to be installed in the field: either flush with the test assembly's top surface (where $rt = 0$) or bottom surface (where $rb = 0$) or offset (where $rt >$ or $< rb$) within the test assembly's thickness as shown in Fig. 11.

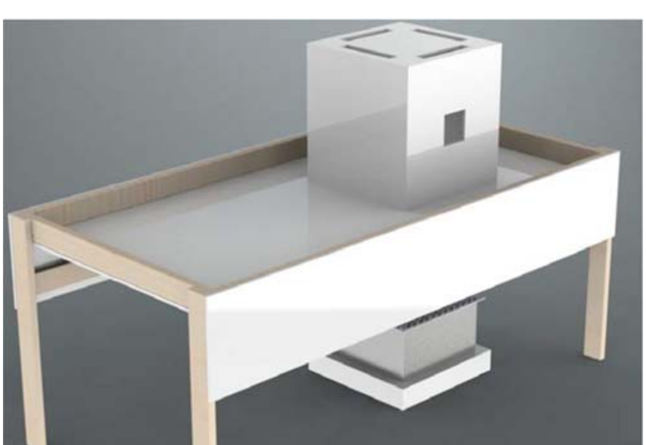

FIG. 9 Example of Test Bench, Fire Source, and Test Box in Test Configuration

Document the test specimen's position in terms of "*rt*" and "*rb*" using mm as the dimensions.

7.6 *Vertical Test Specimens:*

7.6.1 For vertical test assemblies as shown in Fig. 13, construct a test box as shown in Fig. 14 using gypsum board. Record the thickness of the gypsum board. Create a square 500-mm opening and four (50-mm wide by 300-mm long) slots in the test box top as shown in Fig. 14. When reinforcement (for example, light gauge angle) is used on the test box's edges, apply the reinforcement to the test box's exterior without obstructing the test box opening or slots.

NOTE 6—The test box allows test specimens in a vertical orientation to be assessed using a similar flame impingement exposure as the horizontal orientation of test specimens. Through a "trial and error" method, the slots on the top of the box were sized and positioned to develop a constant and steady flame impingement on the test specimen positioned in the square 500-mm opening as is done in the horizontal orientation. The design of the test box is intended to produce a simple reproducible device to subject the test specimen to a credible sudden direct flame impingement. The pressure within the test box is slightly positive based on the convective heat flow as in most real life fire scenarios. Positive pressure is a more severe condition than negative pressure when assessing insulation and integrity of the test specimens.

7.6.2 Mount the test specimen in a vertical position against the test box as shown in Fig. 16.

7.6.3 For symmetrical vertical test assemblies, mount the vertical test specimen in the center ($T/2$) of the vertical test assembly's thickness (T) using the same method previously described in 7.5 for the installation of the symmetrical horizontal test specimens where $rt = rb$.

7.6.4 For asymmetrical vertical test assemblies, use the same method previously described in 7.5 for the installation of the asymmetrical horizontal test specimens to mount the vertical test specimen as it is intended to be installed in the field: either flush with the test assembly's front (exterior) surface (where $rt = 0$) or back (interior) surface (where $rb = 0$) or offset (where $rt >$ or $< rb$) within the test assembly's thickness.

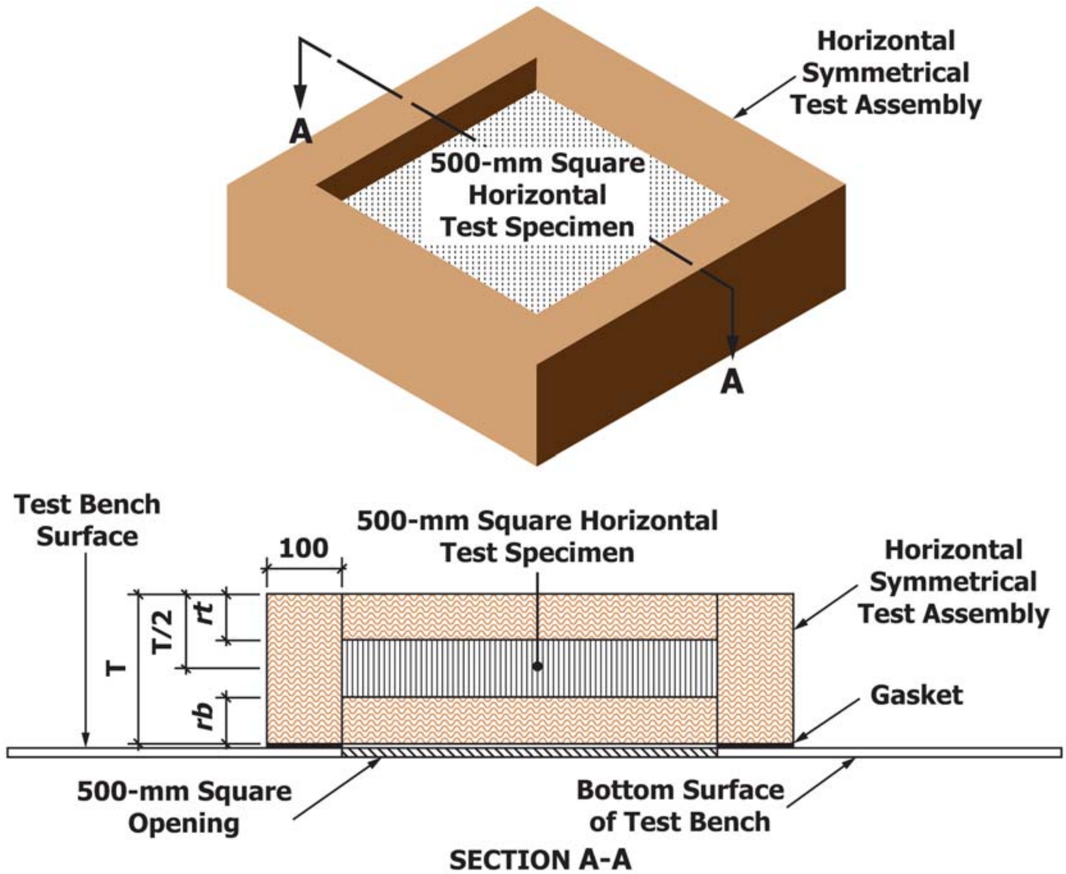

FIG. 10 Horizontal Symmetrical Test Assembly

7.6.5 Test asymmetrical vertical test assemblies with either side (front or back) exposed to the fire. Document the asymmetrical vertical test assembly's configuration (refer to Fig. 13) and the side exposed to the fire.

7.6.6 When testing both sides of an asymmetrical vertical test assembly, use duplicate test specimens of the same lot, and test each side independently. For each side tested, document the integrity as described in Section 11 and insulation as described in Section 12.

7.6.7 Mount and seal the test assembly against the square 500-mm square opening of the test box as shown in Fig. 16. The interior dimensions of the test box shall be 800-mm high by 800-mm wide by 800-mm long. When required to properly position the test assembly against the opening, use a support for the vertical test assembly as shown in Fig. 16.

NOTE 7—The mounting and sealing method is usually determined by the individual laboratory. However, the following may provide some guidance. Mechanical devices, such as C-clamps, may be placed so that the test assembly is clamped to the test box. When the mechanical device is tightened, the gasket between the test assembly and the test box is compressed, sealing the two together.

7.6.8 Attach a flexible, high-temperature, gasket to the bottom of the test assembly and, when used, the test box. Refer to Fig. 10, Fig. 12 and Fig. 16. This gasket will seal the perimeter of the opening of the test bench surface between the test box and the test bench surface. When the test assembly is smaller than the opening, a support for the vertical test assembly or horizontal assembly is also used to cover the opening. Also, attach the gasket to the support as shown in Fig. 16.

NOTE 8—The type of flexible, high-temperature gasket and method used to attach the gasket is usually determined by the individual laboratory. However, the following may provide some guidance. Each laboratory may employ different methods of placing the test assembly over the opening. One such placement method is to slide the test assembly. In this case, the flexible, high-temperature gasket should resist fraying. Two commonly available materials that meet the 7.6.8 criteria for flexible, high-temperature gaskets are thin ceramic sheets or papers. An adhesive, such as a silicone sealant, is one attachment method that can be employed to attach the flexible, high-temperature gasket. Another attachment method would be to use mechanical fasteners, such as staples or metal brads, recessed into the flexible, high-temperature gasket.

8. Preparation of Apparatus

8.1 *Fire Test Apparatus:*

8.1.1 Verify the burner, when set to the heat output specified in 6.1.5, generates flames that protrude approximately 1 m above the square 500-mm opening in the test bench surface. Perform this verification no more than 20 min prior to start of the fire test.

8.2 *Unexposed Surface Thermocouple Placement:*

8.2.1 Measure the temperatures on the unexposed surface of the test assembly with thermocouples placed under thermocouple pads as specified in 6.5. When positioned on the test assembly, the sides of the thermocouple pads shall never touch

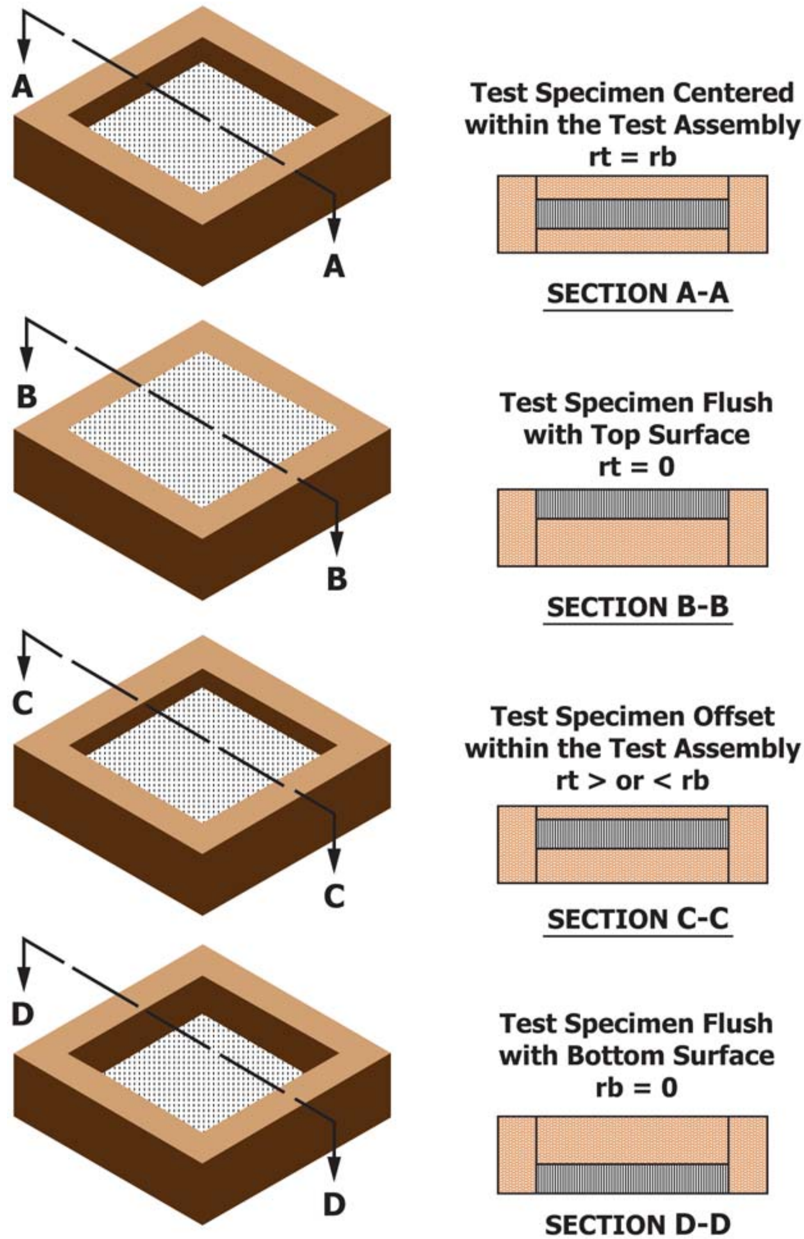

FIG. 11 Horizontal Symmetrical and Asymmetrical Test Assemblies

each other but the corners of the pads are allowed to touch each other. When the thermocouple's specified location is positioned on a less onerous location of the test specimen, the laboratory shall adjust the location to a more representative location. The thermocouple shall not be located over fasteners such as screws, nails, or staples that will be higher or lower in temperature than at a more representative location if the aggregate area of any part of such fasteners on the unexposed surface is less than 1 % of the area within any 152-mm diameter circle, unless the fasteners extend through the test assembly.

NOTE 9—Locations and sizes of pads may have to be modified at the discretion of laboratory due to grids, mesh, perforations, gaps, slats or other irregular surfaces on the test assembly.

8.2.2 Locate at least the number of thermocouple junctions covered by thermocouple pads on the test assembly as follows. The tolerance for thermocouple junction placement is within ±3 mm of the location shown.

8.2.2.1 Position five (evenly distributed) thermocouple junctions on the unexposed surface area of the test specimen. Place four (perimeter) thermocouple junctions on the unexposed surface area of the test specimen. Place four thermocouple junctions on the unexposed surface area of the test assembly (on vented construction). Refer to Fig. 17.

8.2.2.2 When the test specimen area is <0.25 m^2 to 0.10 m^2, position three (evenly distributed) thermocouple junctions on the unexposed surface area of the test specimen. Place two (perimeter) thermocouple junctions on the unexposed surface

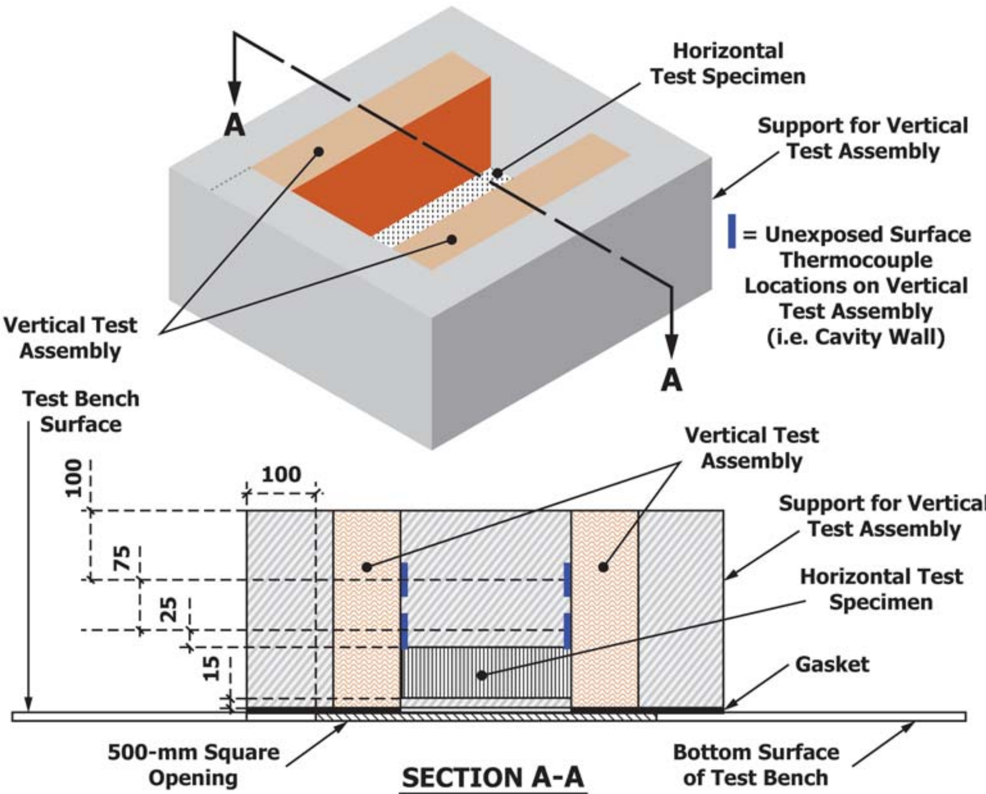

FIG. 12 Horizontal Test Specimen in Vertical Test Assembly and Unexposed Surface Thermocouple Locations

area of the test specimen. Place four thermocouple junctions on the unexposed surface area of the test assembly (on vented construction). Refer to Fig. 18.

8.2.2.3 When the test specimen area is <0.10 m^2 to 0.04 m^2, position two (evenly distributed) thermocouple junctions on the unexposed surface area of the test specimen. Place two (perimeter) thermocouple junctions on the unexposed surface area of the test specimen. Place four thermocouple junctions on the unexposed surface area of the test assembly (on vented construction). Refer to Fig. 19.

8.2.2.4 When the test specimen area is <0.04 m^2 to 0.01 m^2, position one thermocouple junction on the unexposed surface area of the test specimen. When possible, place one (perimeter) thermocouple junction on the unexposed surface area of the test specimen. Place four thermocouple junctions on the unexposed surface area of the test assembly (on vented construction).

8.2.2.5 When the test specimen area is <0.01 m^2 or when the length or width of the test specimen is less than 25 mm, thermocouple junctions on the unexposed surface area of the test specimen (evenly distributed and perimeter) are not required. Place four thermocouple junctions on the unexposed surface area of the test assembly (on vented construction).

8.2.2.6 For a horizontal test specimen installed as part of a vertical test assembly, place thermocouple junctions (cavity wall) at a distance of 25 mm and 100 mm from the unexposed surface of the test specimen as illustrated in Fig. 12.

8.2.3 Position the center of the thermocouple pad over the thermocouple junction and cover the thermocouple junction.

8.2.4 When necessary, secure the thermocouple pad over the thermocouple junction without sealing the perimeter of the thermocouple pad.

8.3 *Unexposed Surface Temperatures:*

8.3.1 The three general areas for unexposed surface thermocouple locations are: the unexposed surface of the test specimen, the unexposed surface of the test assembly, and the perimeter edges of the test specimen.

8.3.2 The two unexposed surface temperature measurements are: average temperature of specific thermocouples on the test specimen and maximum temperature of each thermocouple.

8.3.3 When there are two or more unexposed surface thermocouple locations, calculate the average temperature rise using only the temperature readings of the unexposed surface thermocouple locations that are evenly distributed over the unexposed surface of the test specimen.

8.3.4 The maximum temperature rise applies to all unexposed surface thermocouples referred to in 8.3.1 placed on the test assembly.

9. Test Assembly Conditioning

9.1 Prior to testing, condition the test assembly in air having 50 % relative humidity at 20 ± 3°C ambient temperature conditions. Maintain the test assembly in this environment until all of its components are dry as specified by the manufacturer's product instructions. Document the time required to dry the test assembly. Either condition the test

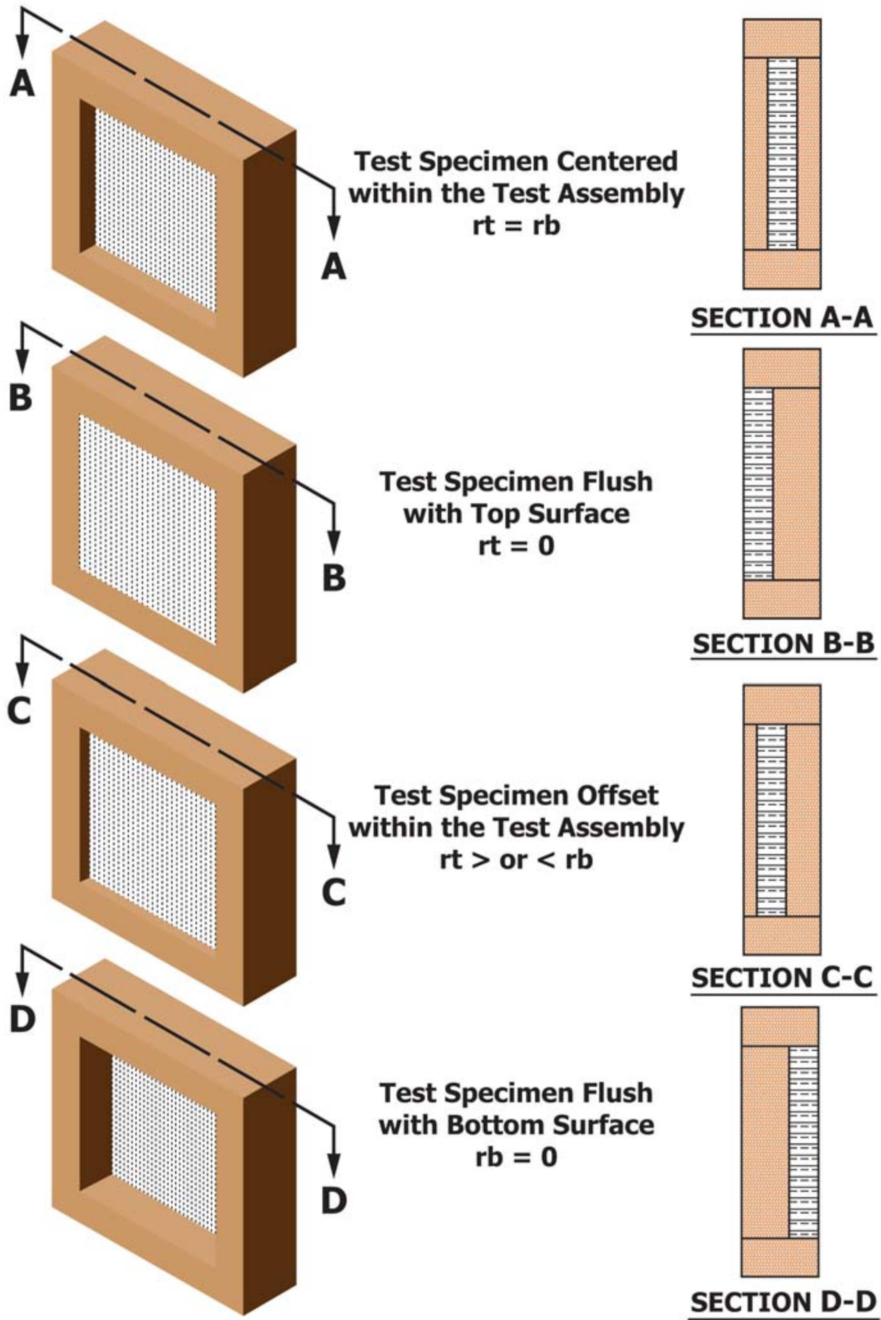

FIG. 13 Vertical Symmetrical and Asymmetrical Test Assemblies

assembly completely assembled or condition the components separately and then assemble them together prior to testing. Document whether the drying of the test assembly was performed as a unit or as individual components.

9.2 When accelerated techniques are used to dry the test assembly, avoid procedures that will alter the fire-test-response characteristics of the test assembly. Document the accelerated drying techniques used.

NOTE 10—As an example, an accelerated technique may be employed where concrete is dried at elevated temperatures in a "heated area" to more rapidly obtain the conditions described in 9.1. In such cases, temperatures other than 73°F are used to reach the dry condition.

10. Test Procedure

10.1 Conduct the fire test indoors. Document observations, record unexposed surface temperatures, and create a video recording of the unexposed surfaces of the test assembly throughout the fire test. Include the following in the observations: flaming locations, deformation, spalling, cracking, charring, burning, and production of smoke.

10.2 Verify the ambient air temperature at the start of the fire test is within the range of 10 to 32°C. Verify the velocity of air across the unexposed surface of the test assembly, measured within 3 min before the test begins, is less than 1.3

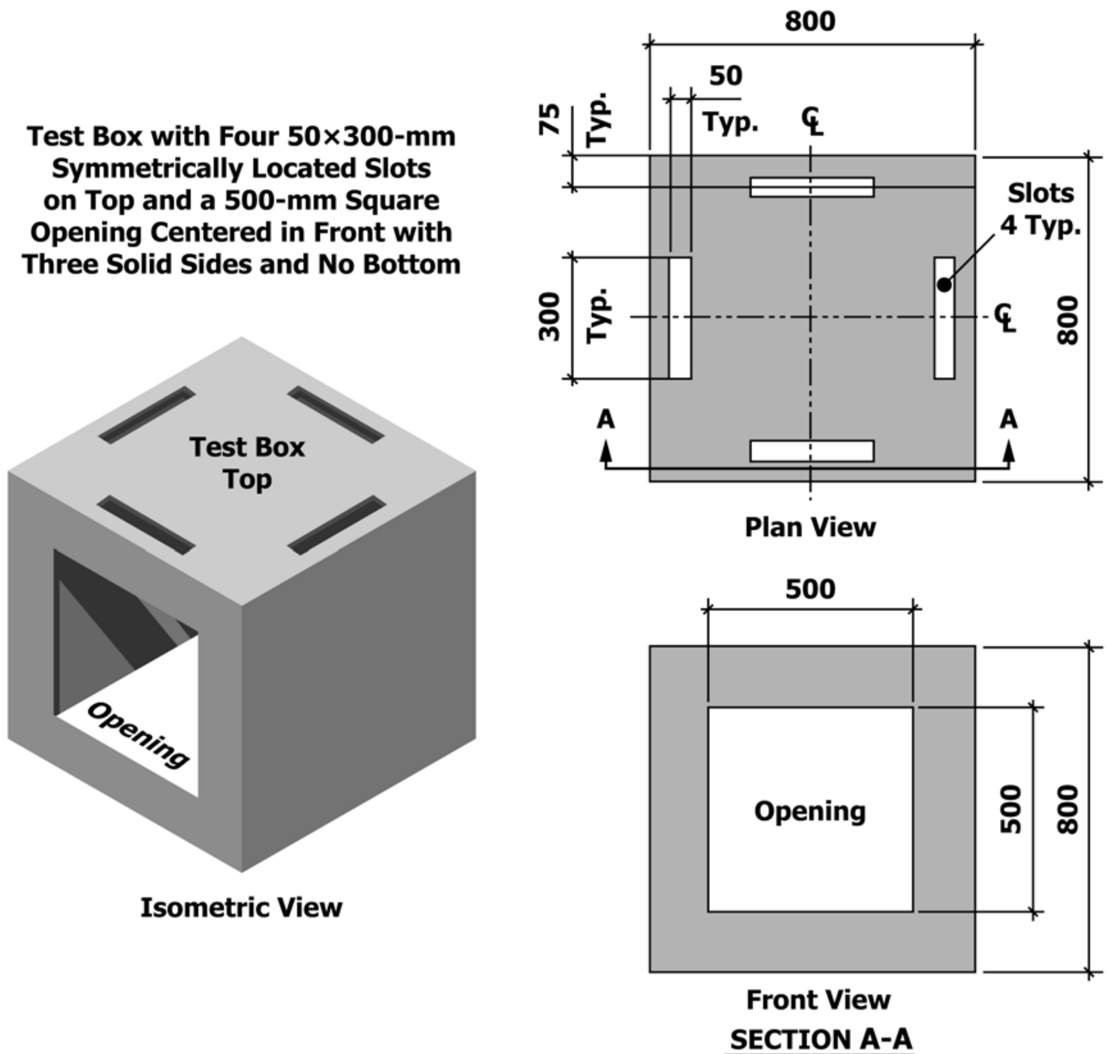

FIG. 14 Test Box for Vertical Test Assembly

m/s, as determined by an anemometer placed at right angles to the unexposed surface of the test assembly. Measure the relative humidity. Document the ambient air temperature, air velocity, and relative humidity at the start of the fire test.

10.3 When required, place the test bench under an exhaust hood to expel smoke and hot gases created during the fire test. When mechanical ventilation is engaged during the fire test, do not direct or allow an air current across the unexposed surface of the test assembly.

10.4 Prior to commencement of the fire test, verify the test assembly complies with the requirements in Sections 7, 8 and 9. Photograph the test assembly.

10.5 Place the test assembly on the test bench surface next to the opening, protected from ignition and pre-burn exposures. Refer to Fig. 20 and Fig. 22. Photograph the test assembly on the test bench surface.

10.6 Ignite the gas burner, and control the burner to ensure a constant 300 ± 10 kW heat release rate. Photograph the ignition.

10.7 Once the burner output is controlled as stated in 10.6, simultaneously start the timer, marking the beginning of the test, and quickly move the test assembly to cover the opening. Refer to Fig. 21 and Fig. 23. Photograph the flame height when burner output is under control before the test assembly covers the opening, and photograph the test assembly at the beginning of the test.

NOTE 11—There are many ways to safely and quickly move the test assembly over the fire (flame) protruding through the 500-mm square opening. An individual laboratory determines the method their personnel will use. However, the following may provide some guidance. A pole (wood or metal) properly sized and configured not to cause damage to the test assembly may be used to assist laboratory personnel in maintaining a safe distance from the fire while moving (pushing) the test assembly. Another method could be to pull the test assembly over the opening. Guides and a stop (possibly wood furring strips or light gauge metal angles) could be used to assist in facilitating a quick and accurate positioning of the test assembly as required. Based on the test assembly's final construction dimensions, its position centered over the 500-mm square opening can be determined. A stop could be placed to halt the test assembly at the correct length position on the test table. Guides can be placed to center the width of the test assembly on the test bench and over the width of the 500-mm square opening. Another option that would not

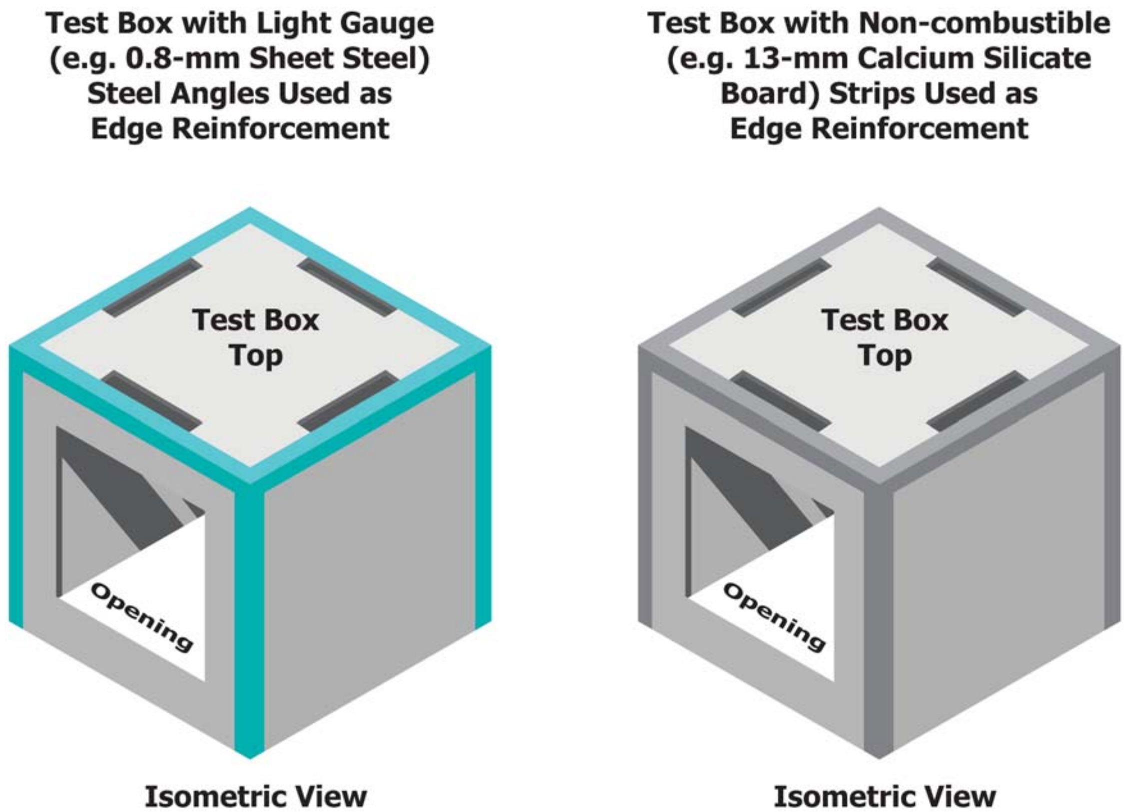

FIG. 15 Examples of Test Box for Vertical Test Assembly with Edge Reinforcement

require guides and a stop would be to use a gypsum sheet panel that fits inside the test bench width. The sheet panel would have a length half as long as the test bench with a 500-mm opening. This would allow a technician to safely slide (move) it over the test bench opening. The test assembly will be pre-sealed to the sheet panel centered over its opening. The sheet panel may not need sealing, depending on how good the fit to the bench surface.

10.8 Commence the recording of measurements and documenting observations on the unexposed side of the test specimen at the moment the test assembly covers the opening. Refer to Fig. 21 and Fig. 23.

10.9 Record all of the initial unexposed surface temperatures on the test assembly. Refer to Fig. 5, Fig. 17, Fig. 18 and Fig. 19.

10.10 Continue the fire test for 10 min. Measure the 10-min test duration from the time the test assembly covers the opening, which is time zero.

10.11 Continue the fire test beyond the time specified in 10.10 when the purpose in doing so is to obtain additional data. Monitor the test assembly for 10 min after termination of the fire test. Photograph the test specimen and test assembly separately at 2 min intervals, including the termination of the fire test and end of the 10-min monitoring period.

NOTE 12—Most time-temperature curves used to control furnaces referenced in fire-resistance test methods do not require or provide direct flame impingement on the test specimen. The minimum exposure period of this test method is 10 min of sudden direct flame impingement on the test specimen to ensure that enough heat does not pass through that could ignite combustibles adjacent to the unexposed surface of the test assembly. Longer exposure periods may be used.

10.12 Record the test assembly's performance by visual observations and unexposed temperature measurements made from time zero.

10.13 When sustained flaming is observed on the unexposed side of the test specimen for more than 60 s, terminate the fire test. Record the time of this occurrence. Photograph the flaming on the test specimen.

10.14 Follow the steps in Section 11 to document and record the integrity of the test assembly; its ability to limit flame, radiation and hot gases from reaching its unexposed surface.

10.15 Record the insulation performance of the test assembly by recording each unexposed surface temperature. Refer to Section 12.

11. Integrity Test

11.1 Record any flames on the unexposed side of the test specimen including the flame's location and duration.

11.2 Record flaming and ignition of cotton pad by hot gases or radiation, or both, throughout the test's duration. Record the time when ignition of the cotton pad occurs.

11.2.1 Use the materials and devices described in Annex A1 Cotton Pad Test Materials and Equipment.

11.2.2 Follow the Ignition Test Procedure in Annex A2.

11.2.3 When no ignition (defined in A2.4) of the cotton pad occurs during the 30-s application, make screening tests that involve short duration application of the cotton pad over and around such areas. Charring of the pad provides only an

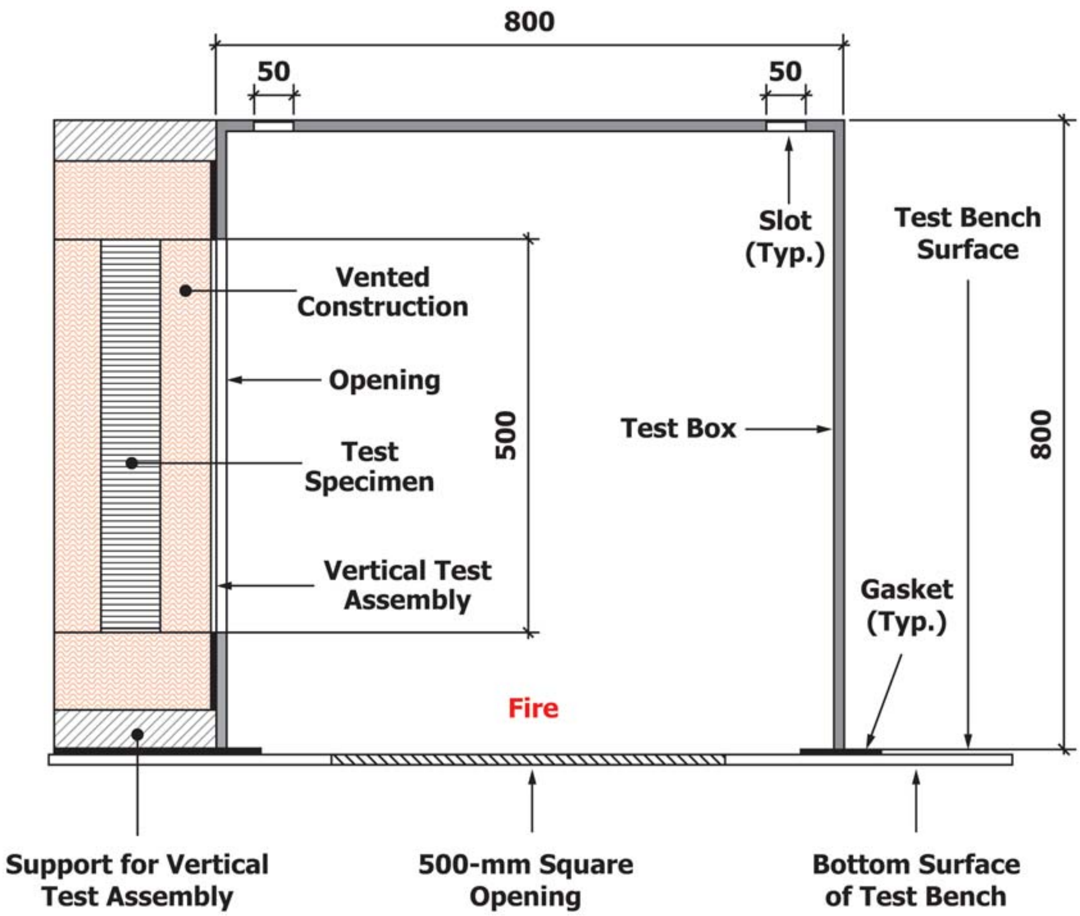

FIG. 16 Test Box with Vertical Test Assembly Shown in Place

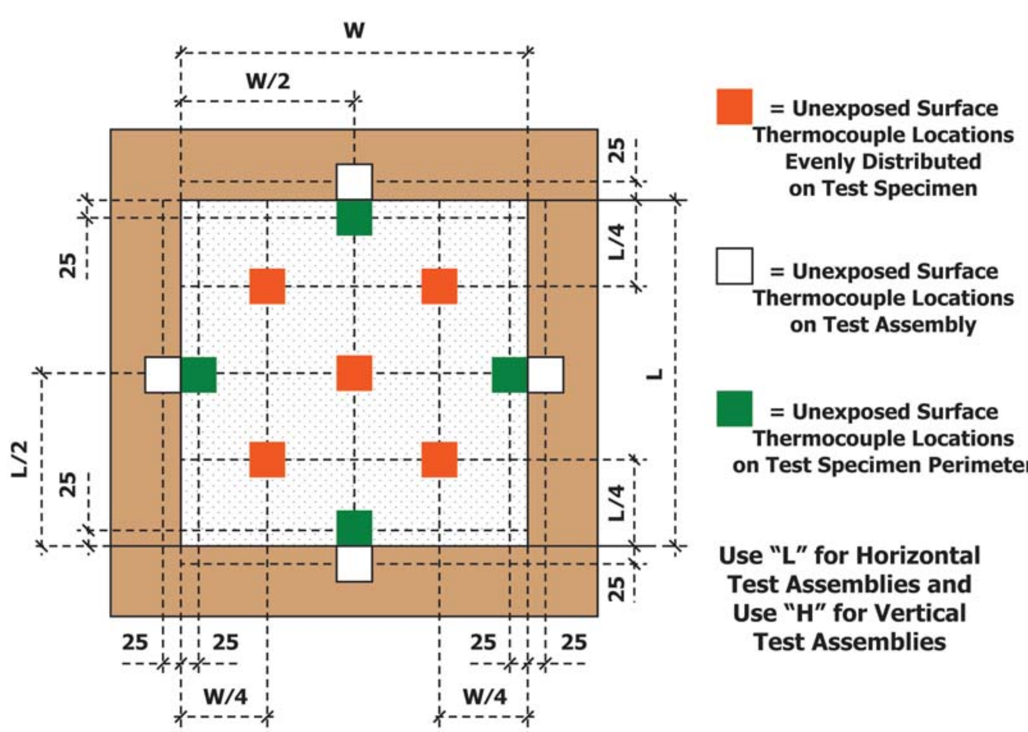

FIG. 17 Thermocouple Locations for Horizontal and Vertical Test Specimens

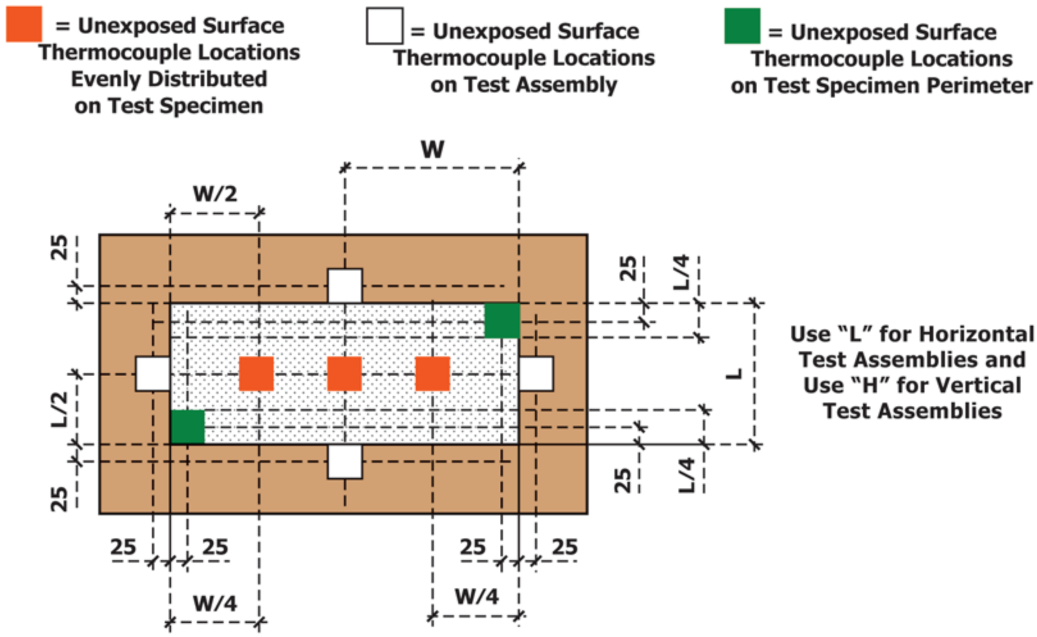

FIG. 18 Thermocouple Locations for Horizontal and Vertical Test Specimens <0.25 m^2 to 0.10 m^2

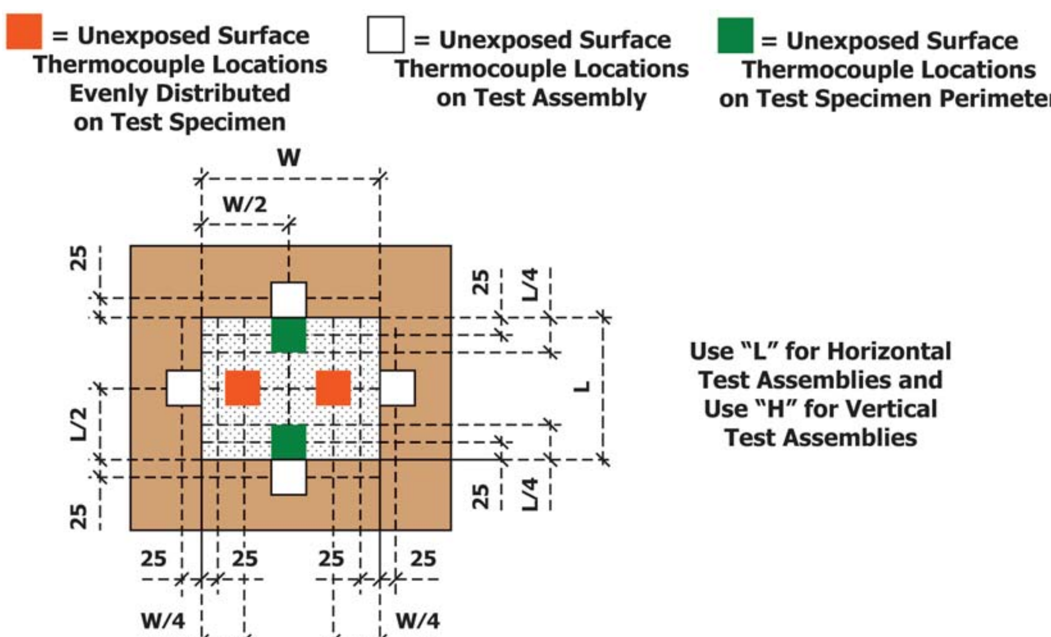

FIG. 19 Thermocouple Locations for Horizontal and Vertical Test Specimens <0.10 m^2 to 0.04 m^2

indication of imminent failure. Employ an unused cotton pad to confirm an integrity failure.

11.3 When possible, photograph the test specimen when any flames occur on its unexposed side or when the cotton pad ignites, or both. Otherwise, refer to the video recording for this information.

12. Insulation Test

12.1 Record the temperatures of all unexposed surface thermocouples for the full duration of the fire test at max 5 s time intervals. Record the time when the unexposed surface thermocouples' average temperature reading on the test specimen exceeds 139°C above the initial average temperature recorded at the start of the fire test.

12.2 Record all unexposed surface temperature readings taken at each individual unexposed surface thermocouple's location.

12.3 Record the time at which any individual unexposed surface thermocouple's temperature rise exceeds 181°C.

12.4 Record the time at which each individual unexposed surface thermocouple's temperature reading exceeds 400°C.

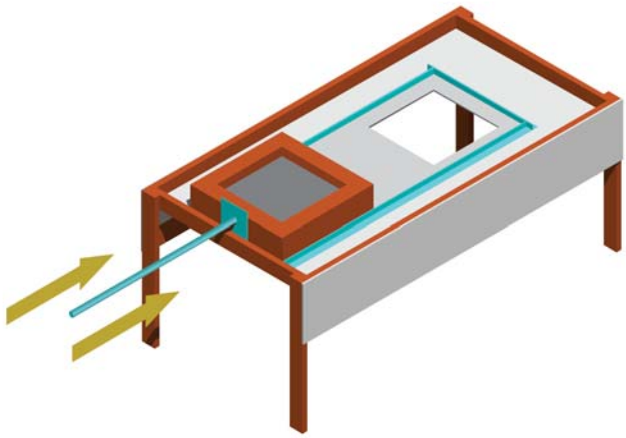

FIG. 20 Example of Horizontal Test Assembly Position before Fire Test Starts

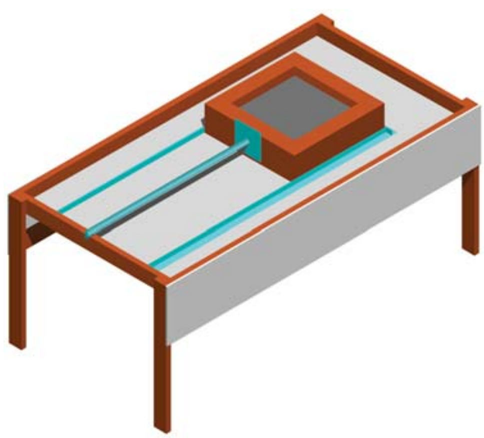

FIG. 21 Example of Horizontal Test Assembly Position after Fire Test Starts

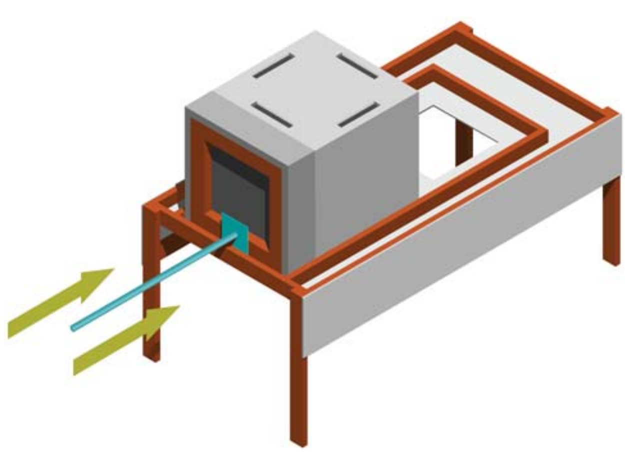

FIG. 22 Example of Vertical Test Assembly Position before Fire Test Starts

NOTE 13—The 400°C temperature information may be helpful in fire modeling and performance based fire safety design as this temperature is discussed in "Unexposed-Face Temperature Criteria in Fire Resistance Tests: A Reappraisal."[5] An excerpt from the Conclusions states, "Thus, the findings indicate that if the hot surface temperature is kept below 400ºC [752°F], ignition will not occur due to thermal transmission across fire-resistive barriers for any goods which may be permissibly stored in normal buildings. Since other criteria of fire resistance tests do not incorporate an explicit, added-on safety factor, for consistency this should also not be done in this case. Expressed as a criterion, failure due to thermal transmission may be presumed to occur when a temperature of 400ºC [752°F] is exceeded. This is a fixed value and not a "temperature rise" value. To obtain the latter, it is appropriate to subtract 20ºC [68°F], thus the temperature rise criterion becomes 380ºC [684°F]. There does not seem to be any technical justification for having a criterion for a single-point rise any higher than the value that corresponds to the lowest relevant hot-surface ignition temperature. Thus, the single-point criterion should also be a temperature rise of 380ºC [684°F]".

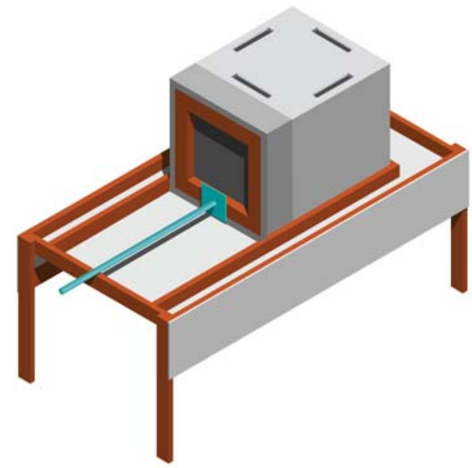

FIG. 23 Example of Vertical Test Assembly Position after Fire Test Starts

12.5 When applicable, separately record the average of the unexposed temperature readings for the vertical unexposed surface thermocouples (designated by the term "cavity wall" to differentiate from other thermocouple locations) on the vertical test assembly containing a horizontal test specimen. Refer to Fig. 12.

13. Report

13.1 Provide the following information in a test report:

13.1.1 Testing laboratory's name and location.

13.1.2 Test report or project number.

13.1.3 Date and signature of testing laboratory's authorized representative.

13.1.4 Test sponsor's name, address, and contact details, such as an email address and telephone and facsimile numbers.

13.1.5 Test specimen's supplier information, including but not limited to, the name and address of the supplier as well as contact information, such as telephone and facsimile numbers as well as a website address and email contact information.

[5] Babrauskas, V., "Unexposed-Face Temperature Criteria in Fire Resistance Tests: A Reappraisal," *Fire Safety Journal*, Volume 44, Issue 6, August 2009, pp. 813–818.

13.1.6 Description of the test specimen and test assembly, including but not limited to, the materials used, the materials' dimensions, the location of the test specimen within the test assembly, whether supports where used, and their material and dimensions.

13.1.7 Include the test specimen's identification number or model, or both.

13.1.8 When tested, describe the splicing method and end sealing used including the test sponsor's instructions and photographic documentation of the installation as prescribed in 7.2.

13.1.9 Include drawings depicting geometry, exact size (length, width, thickness), and the location of materials or devices, or both, constituting the test specimen within the test assembly. Refer to 7.3.

13.1.10 Describe installation procedures provided by the test sponsor. Also include details or drawings and photographs of the test specimen installation procedure as documented in 7.4.

13.1.11 Describe the installed and tested orientation (vertical or horizontal) of the test specimen and test assembly as documented in 7.5.

13.1.12 Report whether the test specimen or test assembly, or both, was symmetrical or assymetrical. Refer to information in 7.5.

13.1.13 When only one side of an asymmetrical test assembly is tested, report which side was exposed to fire as documented in 7.5 and 7.6.

13.1.14 When both sides of an asymmetrical test assembly were tested, report the information for each side separately as documented in 7.5 and 7.6.

13.1.15 The drying time for the test assembly as documented in 9.1, and whether accelerated drying techniques were used as documented in 9.2.

13.1.16 Ambient air temperature, air velocity, and relative humidity at the start of the fire test as documented in 10.2.

13.1.17 Photographs of the specimen before, during, and after the fire test as required in 10.4, 10.5, 10.7, and 10.9.

13.1.18 Include observations related to the behavior of the test specimen during the fire test and for 10 min after termination of the fire test as documented in 10.8, 10.12 and 10.14. These observations shall include, but are not limited to, cracks, deformation, flaming, and smoke issuance on the unexposed surface of the test specimen and continued burning or glowing within the test specimen.

13.1.19 All information (time and charring) related to flaming and the presence of hot gases and radiation in 10.13, 11.1 and 11.2, respectively, including the reason for terminating the fire test. Report the information to the nearest integral second. Refer to the archived video recording for evidence.

13.1.20 *Temperatures & Time*—Report times at the minute and 5 s interval. Report temperatures in 5 s intervals.

13.1.20.1 Time when average unexposed surface temperatures exceeded 139°C above initial temperature recorded in 12.1.

13.1.20.2 Time when any individual unexposed surface temperature exceeded the 181°C increase recorded in 12.3.

13.1.20.3 Time when any individual unexposed surface temperature exceeded the 400°C temperature limit recorded in 12.4.

13.1.20.4 All unexposed surface temperatures recorded in 12.2.

13.1.21 Report all other information recorded, observed, and documented.

14. Precision and Bias

14.1 *Precision*—No information can be presented on the precision of the procedure in this Test Method.

14.2 *Bias*—No information can be presented on the bias of the procedure in this Test Method.

15. Keywords

15.1 closed state; damper; fire; fire-test-response characteristic; gap; insulation; integrity; non-mechanical fire damper; open state; open state fire performance; opening; splice; vent; vented construction; void

ANNEXES

(Mandatory Information)

A1. COTTON PAD TEST MATERIALS AND EQUIPMENT

A1.1 Where required by the conditions of acceptance in other sections of this standard to determine that the test specimen has not allowed the passage of gases or radiation hot enough to ignite a cotton pad, the cotton pad test shall be conducted in accordance with Annex A2 during the fire-resistance test whenever a crack, hole, opened joint, or other similar void or defect through which hot gases are capable of passing is observed in the unexposed surface of the test specimen.

A1.2 The cotton pad test shall be conducted using a cotton pad as described in A1.3 and A1.4 in a wire frame provided with a handle as described in A1.5.

A1.3 The cotton pad shall comply with the physical characteristics described in A1.3.1 through A1.3.3.

A1.3.1 The cotton pad shall be nominally 100 by 100 mm by 19 mm thick.

A1.3.2 The cotton pad shall consist of new, undyed, soft cotton fibers, without any admixture of artificial fibers.

A1.3.3 The cotton pad shall weigh 3.5 ± 0.5 g.

A1.4 The cotton pad shall be conditioned prior to the test by drying in an oven at 100 ± 5°C for a period of not less than 30 min. Immediately upon removal from the drying oven, the cotton pad shall be stored in a desiccator for a period of not less than 24 h prior to the fire-resistance test.

A1.5 The frame used to hold the cotton pad for the purpose of the cotton waste test shall be constructed using No. 16 AWG 1.3 mm steel wire which has been fastened to a handle that has a length that reaches all points on the unexposed surface of the test specimen. See Fig. A1.1 and Fig. A1.2.

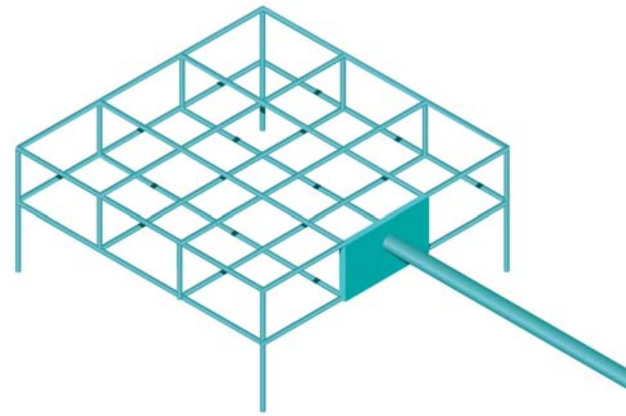

FIG. A1.1 Isometric View

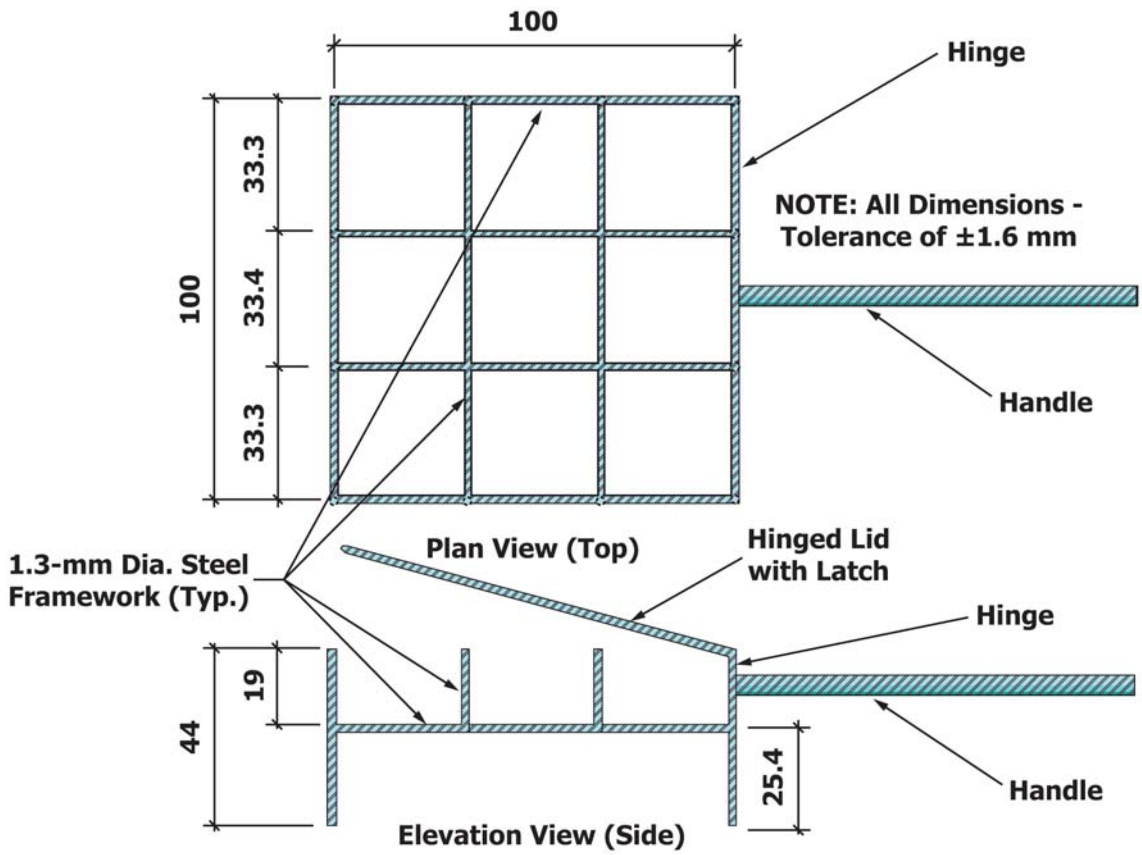

FIG. A1.2 Typical Cotton Pad Holder

A2. IGNITION TEST PROCEDURE

A2.1 Conduct the cotton pad test using an unused cotton pad.

A2.2 Position the cotton pad directly over the observed crack, hole, opened joint, or other similar void or defect in the unexposed surface of the test specimen, approximately 25 ± 3 mm from the surface, for a period of 30 ± 1 s or until ignition of the cotton pad, whichever occurs first.

A2.3 All test locations previously tested in accordance with A2.2 shall be retested as close as practical to the end of the desired fire-resistance period. An unused cotton pad shall be positioned over each previously tested location on the unexposed surface of the test specimen.

A2.4 Ignition of the cotton pad shall be defined as glowing, flaming or smoldering of the cotton pad. Charring of the cotton pad shall not be an indication of ignition.

A2.5 If ignition of the cotton pad occurs, record the time at which ignition occurs, and report the description of the crack, hole, opened joint, or other similar void or defect and the location where it occurs.