Designation: D5485 – 16

Standard Test Method for
Determining the Corrosive Effect of Combustion Products Using the Cone Corrosimeter[1]

This standard is issued under the fixed designation D5485; 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 measures the corrosive effect by loss of metal from the combustion products of materials, components, or products.

1.2 This test method provides corrosion results of product and material specimens limited to a maximum size of 100 by 100 mm in area and 50 mm thick.

1.3 Additional information regarding the targets, the test conditions, and test limitations is provided in the annex.

1.4 The results of this test method have not been investigated with respect to correlation to actual fires.

1.5 An ISO standard exists, as developed by ISO TC 61 (Plastics), subcommittee 4 (on burning behavior), which is technically very similar to this test method and is designated ISO 11907-4.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. (See SI10)

1.7 *This standard measures and describes 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.*

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

1.9 *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.* For specific hazard statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]
D618 Practice for Conditioning Plastics for Testing
D1711 Terminology Relating to Electrical Insulation
D6113 Test Method for Using a Cone Calorimeter to Determine Fire-Test-Response Characteristics of Insulating Materials Contained in Electrical or Optical Fiber Cables
E176 Terminology of Fire Standards
E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System
2.2 *ISO Standards*[3]
ISO 11907-4 Plastics—Smoke Generation—Determination of the Corrosivity of Fire Effluents—Part 4: Dynamic Decomposition Method Using a Conical Radiant Heater
2.3 *Other Document:*
OSHA 191.1450 Occupational Exposure to Hazard Chemicals in Laboratories[4]

3. Terminology

3.1 *Definitions:*
3.1.1 For definitions of terms used in this test method, refer to Terminologies E176 and D1711.
3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *cone corrosimeter, n*—equipment used to determine corrosion in this test method.

3.2.2 *corrosion-by-metal-loss, n*—loss of metal of a target expressed as reduction of thickness of the target metal.

3.2.3 *exposure chamber, n*—enclosure in which a target is exposed to combustion products.

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[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 International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[4] Available from Occupational Safety and Health Administration (OSHA)/U.S. Departmnet of Labor, 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

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*A Summary of Changes section appears at the end of this standard

3.2.4 *heating flux, n*—incident power per unit area that is imposed externally from the heater on the specimen.

3.2.4.1 *Discussion*—The specimen, once ignited, is also heated by its own flame.

3.2.5 *sustained flaming, n*—existence of flame on or over the surface of the test specimen for periods of 4 s or more.

3.2.5.1 *Discussion*—Flaming ignition of less than 4 s is identified as transitory flaming or flashing.

3.2.6 *target, n*—detector of known electrical resistance which can lose metal through a process of corrosion when it is exposed to combustion products.

3.3 *Symbols Specific to This Standard:*

3.3.1 A_0—initial corrosion instrument reading.

3.3.2 A_1—corrosion instrument reading at the end of 1-h exposure to combustion products.

3.3.3 A_{24}—corrosion instrument reading at the end of 24 h in the environmental chamber.

3.3.4 C—corrosion of a target, nm.

3.3.5 C_1—corrosion at the end of 1-h exposure to combustion products, nm.

3.3.6 C_{24}—corrosion at the end of 24 h in the environmental chamber, nm.

3.3.7 m—specimen mass, g.

3.3.8 m_f—final specimen mass, g.

3.3.9 m_i—initial specimen mass, g.

3.3.10 m_{70}—average 70 % of the total mass loss, g.

3.3.11 t_d—sampling time, s.

3.3.12 T_e—temperature of the gas in the exposure chamber, °C.

3.3.13 V—volumetric sampling rate of combustion products, m^3/s.

4. Summary of Test Method

4.1 In this test method, a specimen is subjected to radiant heat. A spark igniter is used to ignite the combustible vapors. The products of decomposition or combustion are channeled through a funnel. A portion of the products continuously flows through an exposure chamber which holds the corrosion targets until the specimen has lost an average 70 % of the total combustible mass or for a period of 60 min, whichever is less. The corrosion of the target is determined by exposure of the target to combustion products for 1 h, followed by 24-h exposure of the target to a controlled humidity and temperature environment in a separate chamber. The increase in electrical resistance of each target is monitored, and the reduction in thickness of the metal on the target is calculated from the increase in electrical resistance. This reduction in thickness is referred to as corrosion-by-metal-loss.

4.2 This test method involves the use of a cone corrosimeter as described in Section 7 and shown in Fig. 1.

4.3 Alternate equipment found suitable for this test method is the cone calorimeter (see Test Method E1354), with the addition of the gas sampling system described in this test method.

5. Significance and Use

5.1 The metal loss from corrosion is directly related to the increase in electrical resistance of the target due to the decrease in conductive cross-sectional area.
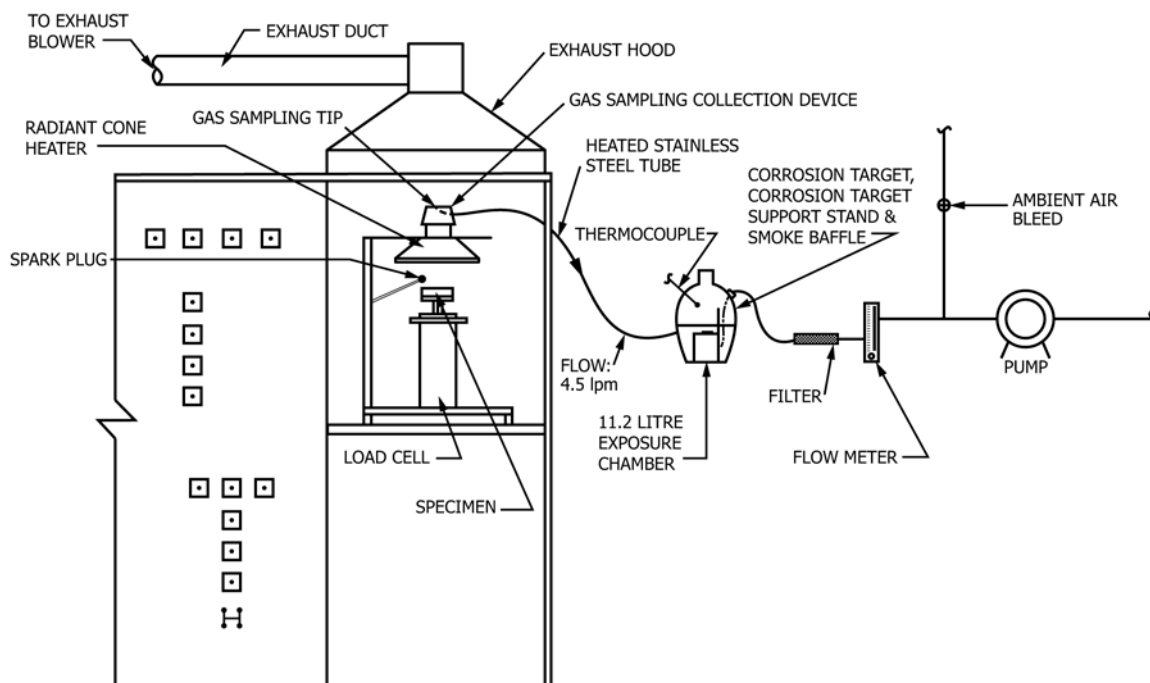

FIG. 1 Cone Corrosimeter

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5.2 The relationship between resistance increase of metallic targets used in this test method and the amount of metal loss as reported by a uniform loss in thickness has not been determined.

5.3 This test method is used to determine the corrosive effect of combustion products from burning electrical insulations or coverings or their constituent materials or components. Corrosion is determined by the reduction of thickness of the metal on standardized targets, as measured by electrical resistance. These targets are not necessarily representative of the intended end use.

5.4 This test method is intended for use in electrical insulations or coverings material and product evaluations, for additional data to assist in design of electrical insulations or coverings products, or for development and research of electrical insulations or coverings products.

5.5 A value of the heating flux is selected to be relevant to the fire scenario being investigated (up to 100 kW/m^2). Additional information for testing is given in A1.2.3.

6. Interferences

6.1 Discard the test data if any of the following occur:

6.1.1 Leakage occurs between the sampling point and the exit of the exposure chamber which could cause a dilution of gases.

6.1.2 The specimen swells sufficiently prior to ignition to touch the spark plug or swells into the plane of the heater base plate during combustion.

6.1.3 The specimen drips off the specimen holder or falls out of the specimen holder such that the specimen is not subjected to the test exposure conditions.

6.1.4 There is highly localized corrosion of the target, indicating a defective target.

6.1.5 There is visual degradation of the reference circuit by the attack of combustion products on or under the protective coating.

7. Apparatus

7.1 *General:*

7.1.1 This test method uses the cone corrosimeter described in 7.1.3. Alternatively, the cone calorimeter test equipment is acceptable provided that it is equipped with a gas sampling system as described in 7.8. If the cone calorimeter is used to assess the fire properties of insulating materials contained in electrical or optical fiber cables, the test shall be conducted in accordance with Test Method D6113, which was developed specifically for that purpose.

7.1.2 The dimensions of the cone corrosimeter specimen holder and additional equipment used in collection of gas samples are given in Figs. 1-11 and also stated in the following description.

7.1.3 The cone corrosimeter consists of the following main components: conical-shaped radiant electric heater; temperature controller; load cell; electric ignition spark plug; heat-flux gage; exhaust system; specimen holder; and the gas sampling system. Other essential elements needed to measure corrosion are a corrosion target and a device to measure corrosion (see 7.9). A general view of the cone corrosimeter is shown in Fig. 1.

7.2 *Conical Heater:*

7.2.1 The active element of the heater consists of an electrical heater rod, rated at 5000 W at 240 V, tightly wound into the shape of a truncated cone (Fig. 2). The heater is encased on the outside with a double-wall stainless steel cone, and packed with a refractory fiber material of approximately 100-kg/m^3 density.

7.2.2 The heater is capable of producing heating flux on the surface of the specimen of up to 100 kW/m^2 with a uniformity of ±2 % within the central 50 by 50-mm area of the specimen.

7.2.3 The heating flux from the heater is held at a preset level by means of a temperature controller and three Type K stainless-steel-sheathed thermocouples having an outside diameter of 1.5 to 1.6 mm with an unexposed hot junction.
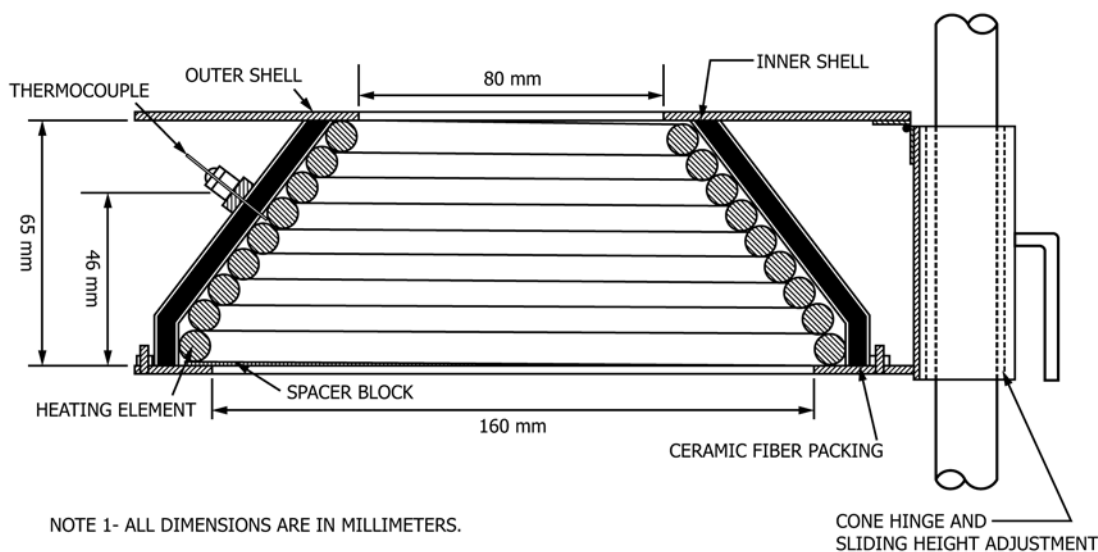

NOTE 1- ALL DIMENSIONS ARE IN MILLIMETERS.

FIG. 2 Cross-Section View Through the Heater

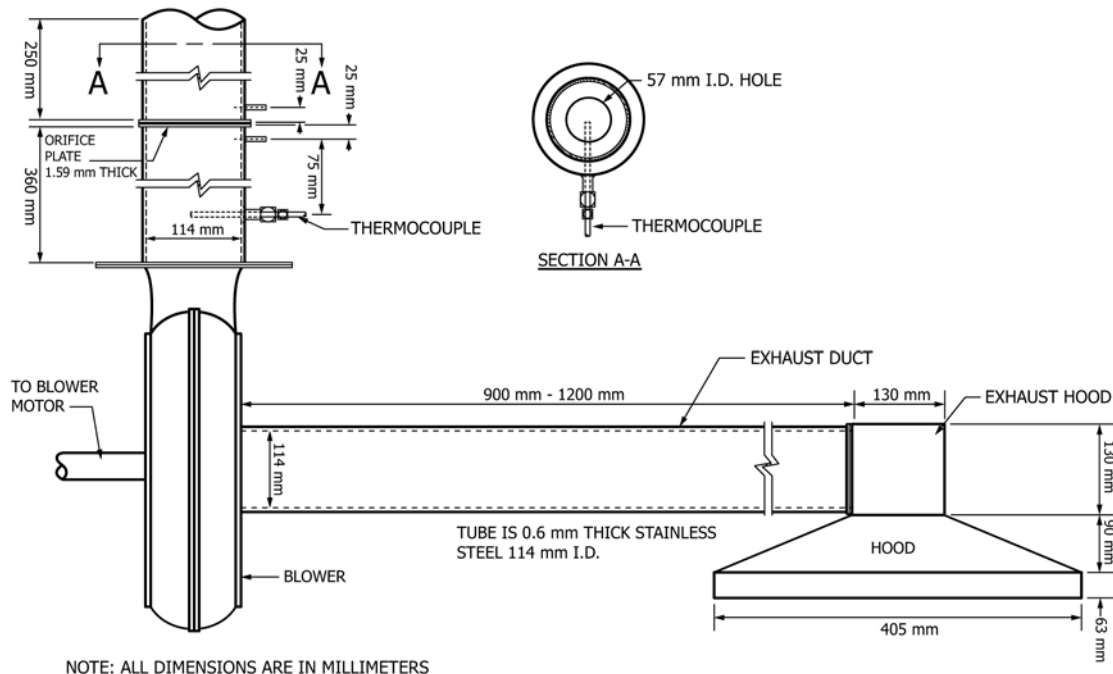NOTE: ALL DIMENSIONS ARE IN MILLIMETERS

FIG. 3 Exhaust System
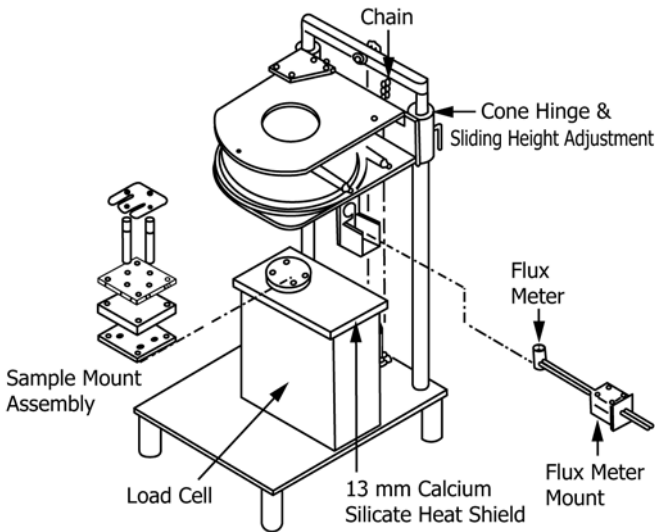
LOAD CELL AND CONE RADIANT HEATER

FIG. 4 Exploded View of Load Cell and Cone Radiant Heater

Alternatively, either 3-mm outside diameter sheathed thermocouples with an exposed hot junction, or 1-mm outside diameter sheathed thermocouples with an unexposed hot junction are suitable. They are symmetrically disposed and in contact with, but not welded to, the heater element (see Fig. 2). The thermocouples are of equal length and wired in parallel to the temperature controller.

7.3 *Temperature Controller:*

7.3.1 The temperature controller for the heater is to hold the element temperature steady to within ±2°C. A suitable temperature controller system is a "3-term" controller

(proportional, integral, and derivative) with a thyristor unit capable of switching currents up to 25 A at 240 V.

7.3.2 The controller has a temperature input range from 0 to 1000°C; a set scale with a resolution of 2°C; and automatic cold junction compensation. The controller is equipped with a safety feature such that in the event of an open circuit in the thermocouple line, it will cause the temperature to fall to near the bottom of its range.

7.3.3 The temperature controller uses a zero-crossing-type thyristor unit.

7.3.4 The heater temperature is monitored by a meter with a resolution of 2°C.

7.4 *Exhaust System:*

7.4.1 The exhaust-gas system consists of a high-temperature centrifugal exhaust blower, a hood, intake and exhaust ducts for the fan, and an orifice plate flowmeter (Fig. 3).

7.4.2 The flow rate is determined by measuring the differential pressure across a sharp-edged orifice (57-mm inside diameter) in the exhaust stack, at least 350 mm downstream from the fan.

7.4.3 In other details, the geometry of the exhaust system is not critical. Where necessary, small deviations from the recommended dimensions given in Fig. 3 are allowed. For example, it is permissible for the inner diameter of the duct and the orifice plate to be slightly different (tolerance: ±2 mm). The location of the fan in Fig. 3 shall be between 900 and 1200 mm downstream of the hood. Flow through the fan ensures adequate mixing, which is essential to the test.

7.5 *Load Cell*—The general arrangement of the load cell with the conical heater is shown in Fig. 4. Use a load cell with an accuracy of 0.1 g, a measuring range of at least 500 g, and a mechanical tare adjustment range of 3.5 kg.

7.6 *Specimen Holder and Mounting:*
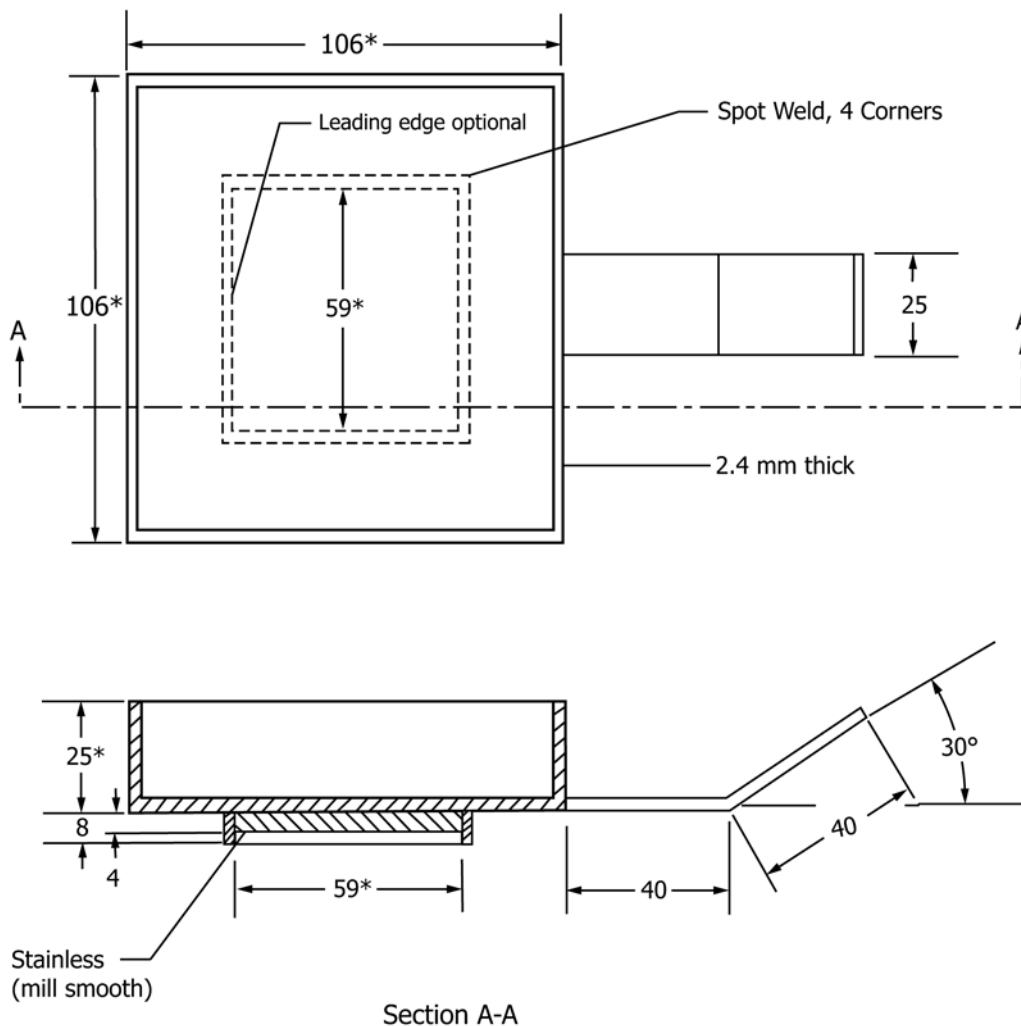
NOTE 1—All dimensions are in millimetres.
NOTE 2—* Indicates a critical dimension.

FIG. 5 First Specimen Holder

7.6.1 Two specimen holders are described, one in 7.6.2 – 7.6.4 and one in 7.6.5.

7.6.2 The first specimen holder is shown in Fig. 5. The bottom is constructed from 2.4-mm nominal stainless steel and has outside dimensions of 106 by 106 by 25-mm height (±2 mm).

7.6.2.1 An open stainless steel square, 59 mm in inside dimensions, shall be spot welded to the underside of the horizontal specimen holder to facilitate the centering of the specimen under the cone heater. The leading edge of the open square underneath the specimen holder, which is the one opposite the handle, is optional. The open square on the bottom of the specimen holder shall be designed to seat with the sample mount assembly located at the top of the load cell, ensuring that the specimen holder is centered with respect to the cone heater.

7.6.2.2 Optionally, use an edge frame and a grid. The optional edge frame (Fig. 6) is constructed from 1.9-mm nominal stainless steel with outside dimensions of 111 by 111 by 54-mm height (±2 mm). The optional grid (Fig. 7) is constructed from 1-mm nominal stainless steel and has dimen-

sions of 109 by 109 mm (±2 mm). The optional grid has 2-mm ribs and the openings in the center are 20 by 20 mm (±1 mm).

7.6.3 The distance between the bottom surface of the cone heater and the top of the specimen shall be adjusted to be 25 ± 1 mm (Fig. 2), except as indicated in 7.6.3.1.

7.6.3.1 The distance between the bottom surface of the cone heater and the top of the specimen shall be adjusted to 60 mm in the case of those dimensionally unstable materials that have the potential to intumesce or deform to such an extent that they are likely to make physical contact with either (*a*) the spark plug before ignition or (*b*) the underside of the cone heater after ignition.

7.6.3.2 If a test is conducted in accordance with the specimen mounting in 7.6.3.1 (a 60 mm distance), the heat flux calibration shall be performed with the heat flux meter positioned 60 mm below the cone heater base plate.

7.6.3.3 If a test has been conducted with a distance of 25 mm and the type of physical contact described in 7.6.3.1 has occurred, that test shall be deemed invalid and the distance shall be adjusted to 60 mm for future tests.
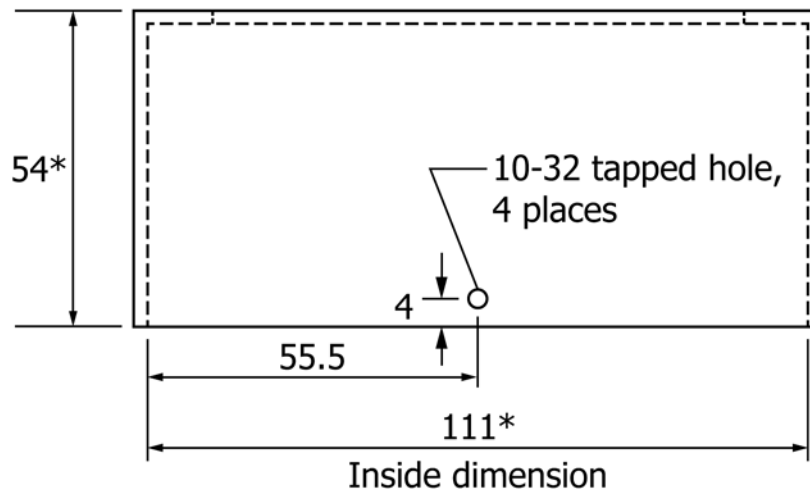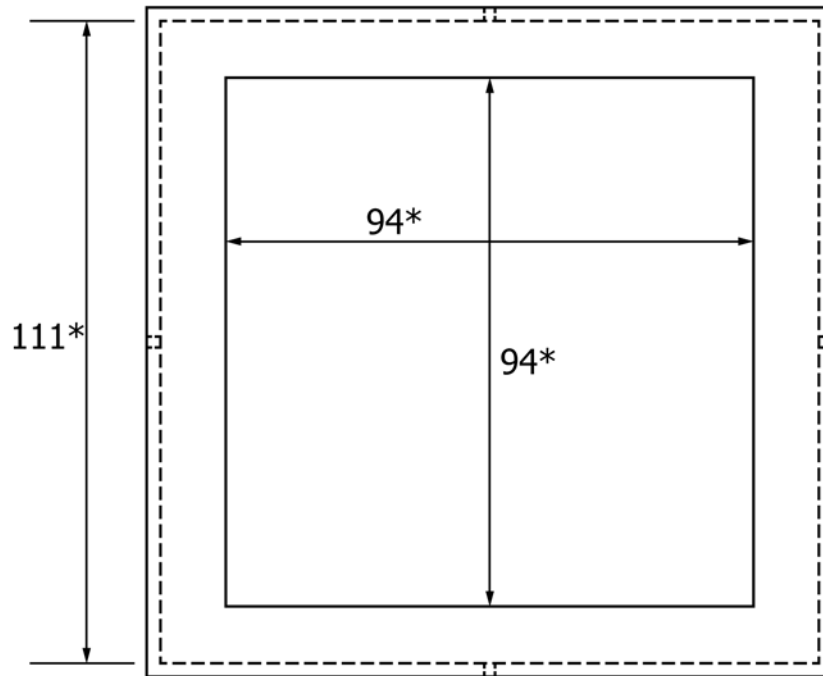
NOTE 1—All dimensions are in millimetres.
NOTE 2—* Indicates a critical dimension.

FIG. 6 Optional Edge Frame

7.6.4 Intumescent materials. The testing technique to be used when testing intumescing specimens in the horizontal orientation shall be documented in the test report. Options include those shown in 7.6.4.1 – 7.6.4.4.
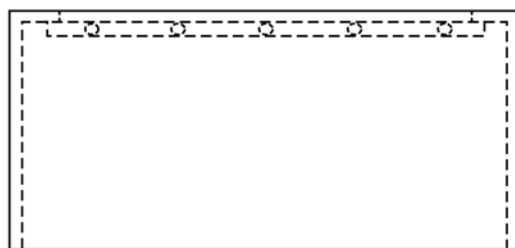
7.6.4.1 Use a retainer frame or edge frame (Fig. 6). The edge frame is used to reduce unrepresentative edge burning of specimens. The edge frame is constructed from 1.9-mm nominal stainless steel with outside dimensions of 111 by 111 by 54-mm height (± 2 mm).
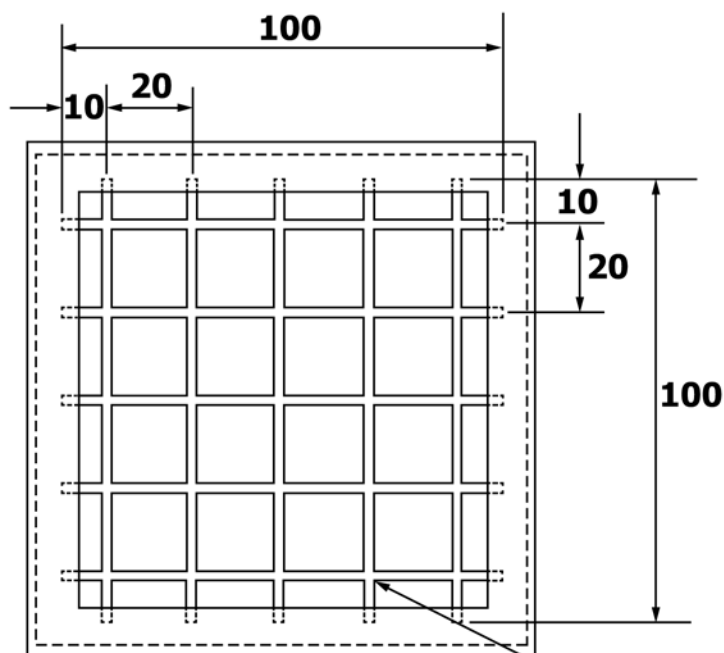
NOTE 1—All dimensions are in millimetres.

FIG. 7 Optional Grid

7.6.4.2 Use a wire grid (Fig. 7). The wire grid is used for retaining specimens prone to delamination and is suitable for several types of intumescent specimens. The grid is con- structed from 1-mm nominal stainless steel and has dimensions of 109 by 109 mm (±2 mm). The grid has 2-mm ribs and the openings in the center are 20 by 20 mm (±1 mm).

7.6.4.3 Use a separation distance between the cone base plate and the upper specimen surface of 60 mm instead of 25 mm. This technique is suitable for those dimensionally un- stable materials that have the potential to intumesce or deform to such an extent that they are likely to make physical contact with either (*a*) the spark plug before ignition or (*b*) the underside of the cone heater after ignition.

7.6.4.4 Use a special mounting procedure suitable for the specimen to be tested.

7.6.5 The second specimen holder is shown in Fig. 8.

7.6.5.1 The second specimen holder consists of the bottom, the edge frame, retaining pins, and wire grid as shown in Fig. 8. The bottom is constructed from 2-mm nominal stainless steel and has outside dimensions of 111 by 111 by 24-mm height (±2 mm). The grid is constructed from 1-mm nominal stainless steel and has dimensions of 109 by 109 mm (±2 mm). The grid has 1-mm ribs and the openings in the center are 19 by 19 mm (±1 mm). The edge frame is constructed from 2-mm nominal stainless steel with outside dimensions of 116 by 116 by 56-mm height (±2 mm). The frame has an 8-mm lip on the top to provide an opening of 100 by 100 mm on the top. There are two 3-mm (±0.5 mm) diameter by 130-mm (±3 mm) long retaining pins to lock the test specimen in the edge frame.

7.6.5.2 The distance between the bottom of the radiant heater and the top of the edge frame is adjusted to 25 ± 1 mm by using a sliding height adjustment (Fig. 2).

MATERIAL:
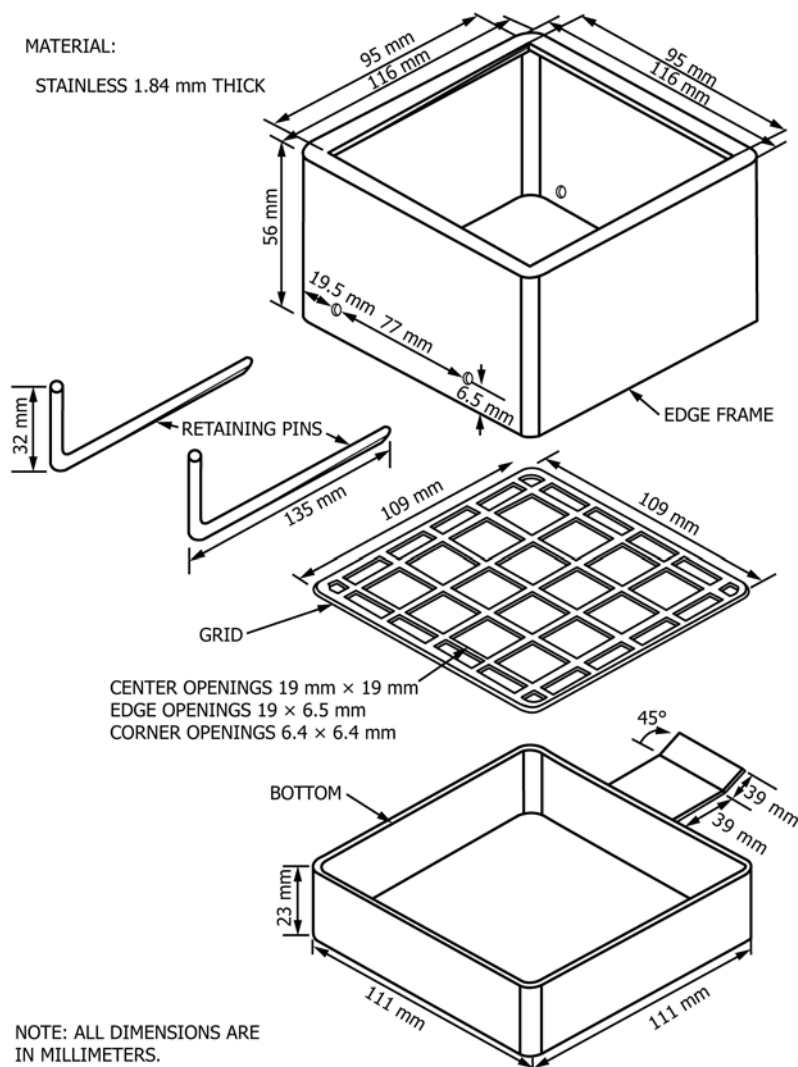STAINLESS 1.84 mm THICK

NOTE: ALL DIMENSIONS ARE
IN MILLIMETERS.

FIG. 8 Second Specimen Holder

7.6.6 The bottom of the specimen holder in 7.6.2 – 7.6.4 or the one in 7.6.5 shall be lined with a layer of a low-density (nominal density 65 kg/m^3) refractory fiber blanket with a thickness of at least 13 mm.

7.7 *Ignition Circuit:*

7.7.1 External ignitor is a spark plug powered from a 10-kV transformer. The spark plug has a gap of 3 mm. The transformer is of a type specifically designed for spark-ignition use. The transformer has an isolated (ungrounded) secondary to minimize interference with the data-transmission lines. The electrode length and location of the spark plug is such that the spark gap is located 13 mm above the center of the specimen.

7.8 *Gas Sampling System:*

7.8.1 The gas sampling system consists of a conical funnel, stainless steel tubing, electric heating tape, silicone rubber tubing, filter, flowmeter, exposure chamber, target support stand, and pump. The general arrangement of the gas sampling system is shown in Fig. 1.

7.8.2 *Funnel*—The funnel is a truncated cone constructed from stainless steel having a larger diameter of 173 ± 5 mm, a smaller diameter of 60 ± 5 mm, and a height of 97 ± 5 mm. It stands on 57 ± 5-mm legs projecting from the larger diameter end. The funnel is shown in Fig. 9.

7.8.3 *Rigid Tubing*—A 6.3-mm (0.25-in.) outside diameter by 675 ± 75-mm long stainless steel tube draws a gas sample from the combustion stream. One end of the tube is bent with the open end of the tube facing away from the specimen surface. The end of the tube is 255 ± 10 mm from the specimen surface. The other end of the rigid tube is connected to flexible tubing. The arrangement of the rigid tube with the funnel is shown in Fig. 9.

7.8.4 *Electric Heating Tape*—Electric heating tape is used to maintain a minimum temperature of the rigid tubing.
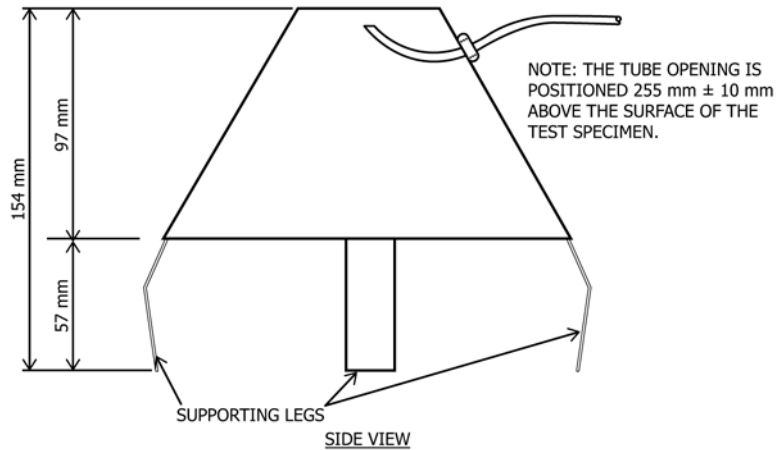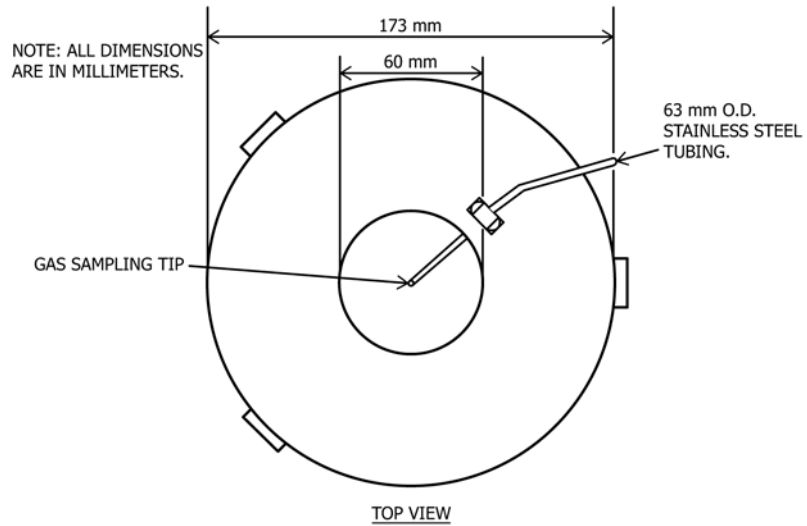
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NOTE: ALL DIMENSIONS
ARE IN MILLIMETERS.

173 mm

60 mm

63 mm O.D.
STAINLESS STEEL
TUBING.

GAS SAMPLING TIP

TOP VIEW

97 mm

154 mm

57 mm

NOTE: THE TUBE OPENING IS
POSITIONED 255 mm ± 10 mm
ABOVE THE SURFACE OF THE
TEST SPECIMEN.

SUPPORTING LEGS

SIDE VIEW

FIG. 9 Gas Sampling Collection Device

SILICONE RUBBER
"O" RING SEAL

COMBUSTION
PRODUCTS
OUTLET

COMBUSTION
PRODUCTS
INLET

THERMOCOUPLE

CORROSION
TARGET

SIDE VIEW

CORROSION TARGET SUPPORT STAND &
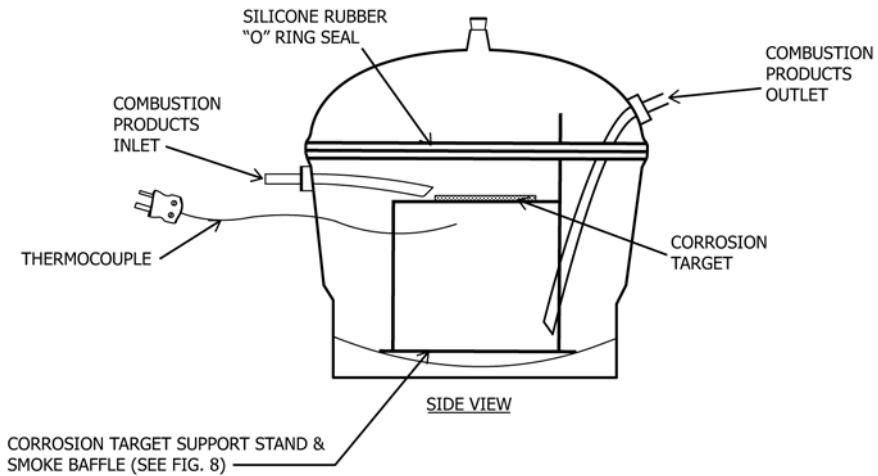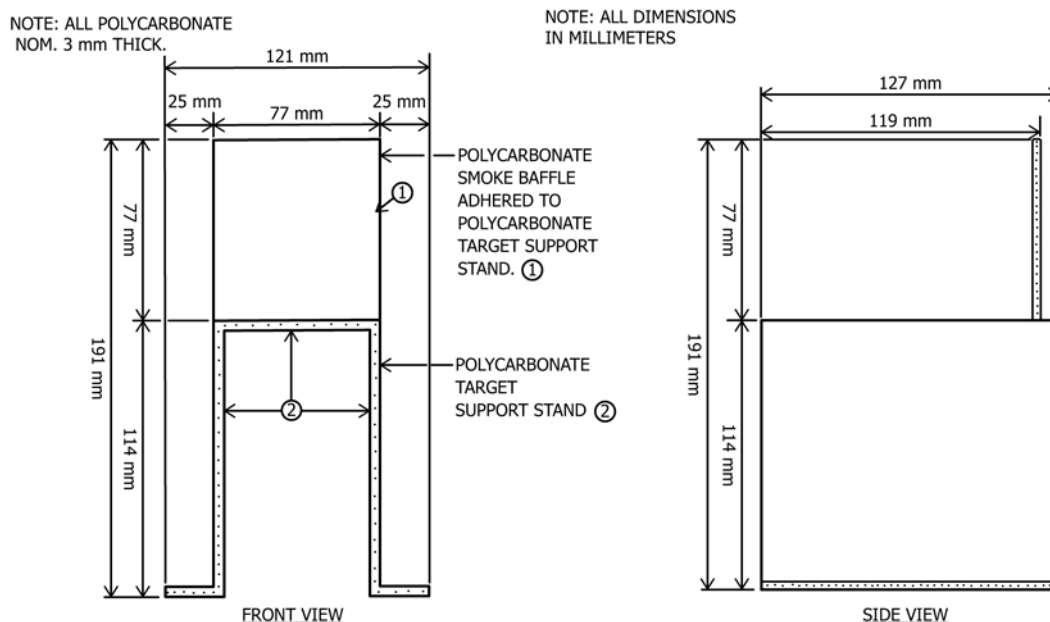SMOKE BAFFLE (SEE FIG. 8)

FIG. 10 11.2-L Exposure Chamber

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FIG. 11 Corrosion Target Support Stand and Smoke Baffle

7.8.5 *Flexible Tubing*—The flexible tubing consists of 6.3-mm inside diameter by 255 ± 10-mm long silicone rubber tube. The flexible tubing is used to connect the rigid tubing to the exposure chamber.

7.8.6 *Exposure Chamber*—The exposure chamber consists of a 0.0112 ± 0.0005-m^3 polycarbonate chamber, a corrosion probe support stand, and smoke baffle. The chamber has an O-ring seal and inlet and outlet ports. The corrosion chamber is shown in Fig. 10.

7.8.7 *Target Support Stand and Smoke Baffle*—The target support stand and smoke baffle (Fig. 11) is fabricated from polycarbonate material 3 mm thick. The bottom component is formed to the dimensions as shown from a single sheet of material. Each of the bottom horizontal flanges, vertical legs, and the horizontal ledge (refer to the front view of Fig. 11) are formed by heating the polycarbonate material and bending the sheet into the geometry as shown. The smoke baffle is cut to the dimensions shown and glued to the bottom with an adhesive.

7.9 *Corrosion Target and Instrumentation:*

7.9.1 *Corrosion Target*—A target is composed of two circuit elements. One circuit element is unprotected and is used for measuring corrosion. The other circuit, with a protective coating, is used as a reference. This compensates for change in electrical resistance due to change in temperature. Both elements of the target are part of a bridge circuit and are exposed to combustion products.

7.9.2 *Corrosion Measuring Instrument*—Use a modified Kelvin Bridge for measurement of change of electrical resistance of targets.[5]

7.10 *Flowmeter*—Use a flowmeter of the range from 0 to 8.33×10^{-5} m^3/s (0 to 5 L/min) with a resolution of 8.33×10^{-6} m^3/s (0.5 L/min) and an accuracy of 2 % of full-scale reading, to monitor and maintain a constant flow throughout the sampling portion of the test.

7.11 *Mass Loss Data Acquisition System*—Use a data acquisition system capable of displaying and recording the sample mass at intervals of 5 s or less during the test.

8. Hazards

8.1 The test procedures involve high temperatures and combustion products. Therefore, conditions exist for burns, ignition of extraneous objects or clothing, and for inhalation of combustion products. Use eye protection and protective gloves

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[5] The sole source of supply of the apparatus known to the committee at this time is Model CK-3 corrosion instrument manufactured by Rohrback Cosasco, which is suitable for measuring the corrosion on the electrical-resistance targets also manufactured by them. This equipment has a resolution equal to target span divided by 1000. The corrosion instrument requires use of cable specific for the target used. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

for insertion and removal of test specimens. Do not touch either the cone heater or the associated fixtures while hot except with the use of protective gloves.

8.2 Vent the combustion products flowing through the exposure chamber through a properly designed exhaust system. Vent the combustion products captured in the exposure chamber during the test through an OSHA-approved smoke hood[6] at the end of this test method.

8.3 Check the exhaust system for proper operation before testing and discharge into a building exhaust system with adequate capacity. Provide for collecting and venting any combustion products that for whatever reason fail to be collected by the normal exhaust system of the apparatus.

9. Test Specimens

9.1 The types of specimens permitted are (*a*) materials in the form of a flat plaque, (*b*) components, or (*c*) an end-use product. If the specimen tested is a material or a component of a product, the specimen shall be 100 by 100 mm in size. If the specimen tested is a product, then fill the specimen holder as completely as possible with the whole product or appropriate product pieces. The thickness of a material specimen shall be 6.3 ± 0.5 mm (0.25 ± 0.02 in.); and the thickness of the component shall be that of its end use.

9.2 *Conditioning*—Condition the specimen in accordance with Practice D618, to moisture equilibrium (constant weight) at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5 %.

10. Calibration of Apparatus

10.1 *Heater Calibration*—Set the temperature controller to the required flux by using the heat flux meter at the start of the test day, or after changing to a new flux level. Operate the cone heater for at least 10 min and ensure that the controller is within ±5 % of the desired level. During the start up of the heater or when changing the heat flux, place a refractory blanket on the load cell to avoid heating it excessively. Remove the blanket prior to inserting the heat flux meter in the calibration position.

10.2 *Load Cell Calibration*—Calibrate the load cell using standard weights in the range of test specimen weight each day of testing.

10.3 *Corrosion Instrument Calibration*—Calibrate the corrosion instrument each test day in accordance with the manufacturer's procedure.

11. Equipment and Specimen Preparation

11.1 *Equipment Preparation:*

11.1.1 Establish laboratory conditions to be 23 ± 2°C, and relative humidity of 50 ± 5 %.

11.1.2 Put an empty specimen holder (with refractory blanket) in place during warmup and in between tests to avoid excessive heat transmission to the load cell.[7]

11.1.3 Turn on the power to the cone heater and the exhaust blower.

11.1.4 Ensure that the exhaust flow rate is 0.024 ± 0.002 m³/s. (Under room temperature conditions this corresponds to 30 g/s.)

11.1.5 Perform the calibration procedures in accordance with Section 10.

11.1.6 Ensure that the collection device, exposure chamber, all sampling lines, and particulate filter are clean and clear of any residual matter.

11.1.7 Check the sampling system for leaks. This is accomplished with the pump energized and the specific flows established. Pinch off the flexible tubing with a clamp immediately before the exposure chamber. A sealed system is indicated if the flowmeter flow drops to zero. If the flow does not drop to zero, then locate and correct the leaks present in the system.

11.2 *Specimen Preparation:*

11.2.1 For specimens of materials, cut the specimen to a size of 100 by 100 mm. Wrap the specimen in a single layer of aluminum foil. Place the edge frame over the specimen and cut the aluminum foil along the open edges at the top of the edge frame to expose the test specimen. Remove the specimen from the edge frame, place a grid on the exposed face of the specimen, and insert both into the edge frame. If necessary, fill the edge frame below the specimen with refractory blanket to the level of the retaining pins. Lock the assembly with retaining pins and place the assembly on the bottom of the specimen holder.

11.2.2 For components or product greater than 100 by 100-mm size, cut to provide a specimen of 100 by 100 mm. Wrap the specimen in a single layer of aluminum foil. Place the edge frame over the specimen and cut the aluminum foil along the open edges at the tip of the edge frame, place the grid on the exposed face of the specimen and insert both into the edge frame. If necessary, fill the edge frame below the specimen with refractory blanket to the level of the retaining pins. Lock the assembly with retaining pins and place assembly on the bottom of the specimen holder.

11.2.3 For components and products smaller than 100 by 100 mm, place a single layer of aluminum foil on the refractory blanket. Fill the bottom specimen holder as completely as possible with the appropriate specimen pieces. Place the grid on top of the specimens and insert into the edge frame. If necessary, fill the edge frame below the specimen with refractory blanket to the level of the retaining pins. Lock the assembly with retaining pins and place the assembly in the bottom of the specimen holder.

11.2.4 For cables, cut the cables to 100-mm lengths to fill the specimen holder. The number of lengths required equals 100/cable diameter (millimetres). Seal the ends using an

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[6] The smoke hood shall be in compliance with OSHA Regulations for Occupational Exposure to Hazardous Chemicals in Laboratories—191.1450.

[7] Do not turn off the power to the load cell on a daily basis for longevity and stability purposes.

adhesive cement.[8] Apply the adhesive cement to the cable ends such that there are no visible air holes in the coating and the cement overlaps the cable ends by more than 1.6 mm and less than 4.8 mm. The ceramic overlap shall not be visible in the exposed area of the sample frame. Wrap the cable lengths in a single layer of aluminum foil. Place the edge frame over the cable specimens and cut the aluminum foil along the open edges at the tip of the edge frame and expose the specimens. Remove the specimens from the edge frame, place a grid on the exposed face of the specimens, and insert both into the edge frame. If necessary, fill the edge frame below the specimens with refractory blanket to the level of the retaining pins. Lock the assembly with retaining pins and place the assembly on the bottom specimen holder.

12. Procedure

12.1 Measure the initial mass of each of the fire test specimens to be used for the mass loss determination and corrosion tests. Determine the average initial mass of the specimen lot. The initial mass of each specimen shall be within 10 % of the average initial mass. Record the initial mass of each test specimen.

12.2 *Mass Loss Determination Tests:*

12.2.1 To establish mass loss data on each specimen type prior to conducting corrosion tests, conduct two mass-loss determination tests, at the same heating flux level as will be used in the corrosion test, without corrosion gas sampling.

12.2.2 When ready to test, following the stabilization of the heater (see 11.1), first remove the empty specimen holder.

12.2.3 Place the test specimen in the specified holder on the load cell. The specimen holder shall be centered with respect to the cone heater. The specimen holder shall be at room temperature initially.

12.2.3.1 Start the data collection. The data collection intervals shall be 5 s or less.

12.2.4 Record the times when flashing or transitory flaming occurs; when sustained flaming occurs, record the time. Report these events in the test report.

12.2.5 Collect the mass loss data until one of the following occurs: (*a*) the average mass loss over a 1-min period has dropped below 1.5 g; or (*b*) 60 min have elapsed.

12.2.6 Remove the specimen holder.

12.2.7 Repeat the procedures in accordance with 11.2.3 through 11.2.5 for a second specimen.

12.2.8 From the mass-loss data from the two tests, determine the average of 70 % of total mass loss for the corrosion test as follows:

$$m_{70} = 0.5[0.7(m_i - m_f)_1 + 0.7(m_i - m_f)_2] \qquad (1)$$

where subscript 1 denotes the first test, and subscript 2 denotes the second test (see A1.3.1 for discussion).

12.3 *Corrosion Gas Sampling Test:*

12.3.1 For each specimen, conduct three corrosion gas sampling tests in accordance with 12.3.2 to 12.3.14.

12.3.2 Set the minimum temperature of the rigid stainless steel tubing to 105°C.

12.3.3 Record the initial resistance measurement of the corrosion target.

12.3.4 Place the corrosion target in the exposure chamber. Seal the exposure chamber, and check for leakage in accordance with 11.1.7.

12.3.5 Start the gas sampling for corrosion testing and ensure a continuous sampling rate of 7.5×10^{-5} m^3/s (4.5 L/min).

12.3.6 When ready to test, first remove the empty specimen holder.

12.3.7 Place the specimen, held in the appropriate holder, in place and start data collection. The data collection intervals shall be 5 s or less. (The holder must be at room temperature). Start the ignition timer. Move the spark plug into place, and turn on the spark power.

12.3.8 Stop the sampling flow when the specimen has lost mass to the average 70 % point, as determined in 12.2.8, or when 60 min after start of the test have elapsed. Record the sampling time.

12.3.9 *Combustion Product Exposure*—If the sampling time in 12.3.8 is less than 60 min, seal off the inlet and outlet sampling lines of the exposure chamber using clamps, and allow the combustion products to react with the corrosion targets for a total of 60 min as measured from the start of the test.

12.3.10 Once the sampling time in either 12.3.8 or 12.3.9 reaches 60 min, open and vent the exposure chamber under a smoke hood.

12.3.11 Remove the target from the exposure chamber and record the corrosion instrument reading, A_1.

12.3.12 *Post-test Exposure*—Within 10 min of removal from the exposure chamber, place the target in an environmental chamber with a dry bulb temperature of 23 ± 2°C and 75 ± 5 % relative humidity for 24 h. Maintain the relative humidity by using an electro-mechanical conditioning chamber or an equivalent method.

12.3.13 After 24 h in the environmental chamber, remove the target and measure the corrosion with the corrosion instrument, A_{24}.

12.3.14 After the test, using a commercial cleaner, thoroughly clean the exposure chamber, corrosion target support stand and baffle, O-ring seal, and any other components exposed to combustion products. Rinse the components with distilled water, and clean a second time using isopropyl

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[8] The sole source of supply of the apparatus known to the committee at this time is adhesive cement, Sauereisen Insa-Lute from Fischer Scientific Inc., 1600 West Glenlake Ave., Itasca, IL 60143 (Catalog Number 04-760-15). If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

alcohol. Air dry and assemble the components for the next test. Discard the stainless steel and silicone rubber tubes after each specimen run.

13. Calculation

13.1 Use the guidelines set by the manufacturers of the targets and corrosion instrument to determine, in nanometres, the corrosion value of the metal loss at the end of 1-h exposure, and at the end of 24-h post-test exposure.[9]

14. Report

14.1 Report the following information in the units specified for each specimen:

14.1.1 Specimen identification code or number,

14.1.2 Date of test,

14.1.3 Test room temperature (°C) and relative humidity (%),

14.1.4 Composition or generic identification of test specimen,

14.1.5 Specimen size and number of product or product pieces per specimen,

14.1.6 Specimen thickness, mm,

14.1.7 Initial specimen mass, g,

14.1.8 Radiant heat flux kW/m^2,

14.1.9 Corrosion target identification,

14.1.10 Corrosion target span (measuring range, nm),

14.1.11 Volumetric sampling rate, V (m^3/s),

14.1.12 Time to sustained flaming, s,

14.1.13 Mass loss at end of test, g,

14.1.14 Exposure chamber temperature, °C,

14.1.15 Average pretest mass loss, g,

14.1.16 Sampling time, min,

14.1.17 Calculated metal loss at the end of the 1-h exposure for each specimen, nm, and

14.1.18 Calculated metal loss at the end of the 24-h post-test exposure under controlled temperature and humidity conditions for each specimen, nm.

15. Precision and Bias

15.1 The precision of this test method is under consideration and is awaiting evaluation.

15.2 *Bias*—The bias of the procedure is unknown.

16. Keywords

16.1 cone calorimeter; cone corrosimeter; conical heater; corrosion damage; corrosive potency; corrosivity; electrical insulations or coverings; fire; fire test response; ignition; radiant heat; smoke corrosivity

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[9] When the CK-3 corrosion instrument from Rohrback Cosasco is employed to monitor corrosion from the target, then determine the corrosion using the following formulae:

$$C_1 = [(A_1 - A_0)/1000]* \text{ target span}$$
$$C_{24} = [(A_{24} - A_0)/1000]* \text{ target span}$$

ANNEX

(Mandatory Information)

A1. Discussion on the Important Factors in the Measurement of Corrosion Using the Cone Corrosimeter

A1.1 Introduction

A1.1.1 This annex is provided (*1*) to give some insight into the development of the test method; (*2*) to describe the rationale of various features of the gas sampling apparatus; and (*3*) to describe the use of the data.

A1.2 Corrosion Measurements

A1.2.1 The type of corrosion damage identified is an increased electrical resistance from the metal lost by the target exposed to combustion products. For measuring increased electrical resistance due to metal loss, electrical resistance targets have been found to be useful. In these targets, the electrical resistance increases as metal is lost due to corrosion. The increase in electrical resistance is expressed in this test method as metal loss, with the assumption that metal is lost uniformly along the electrical circuit.

A1.2.2 The type of target to be used, in terms of the metal and the range of corrosion, depends upon application. Currently two copper targets from Rohrback Cosasco, have been used to develop some data on corrosivity of combustion products. The Model 610 target has a nominal measuring range from 0 to 250 nm, and has been found to be susceptible to complete corrosion (target goes off-scale) by combustion products of a number of products and materials. To measure corrosion in excess of 250 nm, the Model 030788-SO.35-8061 target with a range of 4500 nm, is recommended in addition to, or instead of the 250-nm target. One study[10] has shown that the Model 610 target metal loss values are different from those of the Model 030788-SO.35-8061 for the same experiment. Data from each target is to be considered separately, and not combined in reporting results for a material or product without appropriate reference to the target used.

A1.2.2.1 The corrosion of targets is influenced by many factors. These include (*1*) composition and concentration of combustion products which is influenced by amount of material consumed during the combustion process; (*2*) exposure time; and (*3*) level of condensation on the target. These factors are important in designing a test since the targets need to be exposed to combustion products for a certain length of time in

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[10] Bennett, J. G., et al., "Corrosivity Test Method for Polymeric Materials, Part 4—Cone Corrosimeter Test Method," presented at the Fire Retardant Chemicals Association Meeting, October, 1992.

order to measure corrosion. An exposure time of 1 h under specified laboratory conditions has been found to be suitable for purposes of this test method.

A1.2.2.2 Transport and decay of corrosion products are important considerations. Smoke particulates are deposited along the walls of the heated stainless steel tube and the exposure chamber. Gaseous products may react with the surfaces of the equipment.

A1.2.2.3 Environmental conditions such as temperature and relative humidity are also important in promoting corrosion. Thus it is desirable to conduct post-test exposure of targets to a high-humidity condition to observe the effect on the target after the combustion products have been vented. This is relevant since actual fires are usually suppressed with water and the resulting post-fire environment is one of "high humidity."

A1.2.3 This test does not prescribe the heating flux levels to be used. This must be determined for each type of electrical insulations or coverings product class and the specific application. Data of total heat flux from the fire scenario consideration and large-scale tests is to be used to guide the user in selection of the heating flux level. Flux levels of 25 and 50 kW/m^2 are consistent with low-intensity and high-intensity flaming fires respectively, as described by the international fire community.

A1.2.4 The size of the test specimen for this test is limited to a maximum of 100 by 100 mm in area and 50-mm thickness. Corrosion results from a specimen that is a mock-up or portion of a product should not be construed as being representative of the product performance without investigating the relationship between the specimen performance and the product performance.

A1.3 Gas Sampling Design

A1.3.1 The gas sampling system has the following salient features: (*1*) location of the sampling point; (*2*) sampling rate; (*3*) exposure chamber volume; and (*4*) gas sampling schedule.

A1.3.1.1 The combustion products are sampled at the small opening of the funnel with the sampling tip facing downstream. The location of the sampling point was selected to avoid the dilution of combustion products by the exhaust flow rate used in the cone corrosimeter. The funnel is used to channel the combustion products to the sampling point.

A1.3.1.2 The ratio of the mass sampling rate to the mass of air in the exposure chamber is one of the design parameters of the gas sampling system. The ratio, known as the time constant of the system, is approximately 150 s for the gas sampling system described.

A1.3.1.3 Based upon analysis of experimentation of various products, the procedure requires sampling the combustion products until 70 % of the total sample mass loss occurred (determined as an average of two tests). This provides a very specific end point for gas sampling and also prevents dilution of combustion products in the exposure chamber.

A1.4 Use of Data

A1.4.1 The corrosion data is provided as metal loss.

A1.4.2 In determining the suitability of the material or product for a specific electrical insulations or coverings application, it is recommended that corrosion data obtained from this test method be used with other fire data such as ignitability, heat release, and smoke release in a fire hazard assessment.

SUMMARY OF CHANGES

Committee D09 has identified the location of selected changes to this standard since the last issue (D5485 – 11) that may impact the use of this standard. (Approved Nov. 1, 2016.)

(*1*) Added new 1.3, 1.5, and 1.7.
(*2*) Removed previous 1.5.1.

(*3*) Added ISO 11907-4 to Referenced Documents 2.2.