UL 181

STANDARD FOR SAFETY

Factory-Made Air Ducts and Air Connectors

UL Standard for Safety for Factory-Made Air Ducts and Connectors, UL 181

Eleventh Edition, Dated July 25, 2013

Summary of Topics

This revision of ANSI/UL 181 dated December 29, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated November 5, 2021.

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UL 181

Standard for Factory-Made Air Ducts and Air Connectors

The first through the fourth editions were titled "Air Ducts."
The fifth edition was title "Factory-Made Air Duct Materials and Air Duct Connectors."
The sixth edition was titled "Factory-Made Air Ducts and Connectors."

Fifth Edition – April, 1974
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Eleventh Edition

July 25, 2013

This ANSI/UL Standard for Safety consists of the Eleventh Edition including revisions through December 29, 2021.

The most recent designation of ANSI/UL 181 as a Reaffirmed American National Standard (ANS) occurred on December 29, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 181 on July 20, 1994. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to materials for the fabrication of air duct and air connector systems for use in accordance with the International Mechanical Code (IMC), International Residential Code (IRC), and Uniform Mechanical Code (UMC), Standards of the National Fire Protection Association for the Installation of Air-Conditioning and Ventilating Systems, NFPA No. 90A, and the Installation of Warm Air Heating and Air-Conditioning Systems, NFPA No. 90B.

1.2 The air ducts and air connectors covered by these requirements include preformed lengths of flexible or rigid ducts, materials in the form of boards for field fabrication of lengths of rigid ducts, and preformed flexible air connectors.

1.3 For the purpose of these requirements, air ducts and air connectors are classified as follows:

Class 0 – Air ducts and air connectors having surface burning characteristics of zero.

Class 1 – Air ducts and air connectors having a flame-spread index of not over 25 without evidence of continued progressive combustion and a smoke-developed index of not over 50.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

5 Materials

5.1 Metals used in the assembly of air ducts and air connectors shall be resistant to atmospheric corrosion and shall not be used in combinations that results in galvanic action which deteriorates any part of the system formed from such material.

5.2 To comply with 5.1 with respect to resistance to atmospheric corrosion, metals which are not inherently corrosion resistant, such as sheet steel, or steel wire, are to have a corrosion-resistant coating.

5.3 The corrosion-resistant coating shall provide protection against atmospheric corrosion as determined by Section 12, Corrosion Resistance, at least equivalent to steel having a uniform coating of zinc of not less than 0.3 ounce per square foot (91.6 g/m^2) of surface area.

5.4 Materials which have their protective coating damaged or the effectiveness reduced by the manufacturing process are to be tested after being subjected to such process.

PERFORMANCE

6 General

6.1 Table 6.1 indicates the tests applicable to the specific forms of air ducts, air connectors, and joining materials. Additionally, joining materials intended for factory installation are to be evaluated in conjunction with the air duct and air connector tests when specified in the individual sections of this Standard.

Exception: Joining materials which comply with the requirements in the Standard for Closure Systems for Use With Rigid Air Ducts and Air Connectors, UL 181A or the Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors, UL 181B are not required to be evaluated.

Table 6.1
Test program

Tests	Air ducts		Air connectors	Joining materials
	Rigid	Flexible		
Surface Burning Characteristics	X	X	X	–
Flame Resistance	–	–	–	X
Flame Penetration	X	X	–	–
Burning	X	X	X	–
Corrosion[a]	X	X	X	X
Mold Growth and Humidity	X	X	X	X
Temperature	X	X	X	–
Puncture	X	X	–	–
Static Load	X	X[b]	X[b]	–
Impact	X	X	–	–
Erosion	X	X	X	–
Pressure	X	X	X	–
Collapse	X	X	X	–

Table 6.1 Continued on Next Page

Table 6.1 Continued

Tests	Air ducts		Air connectors	Joining materials
	Rigid	Flexible		
Tension	–	X	X	–
Torsion	–	X	X	–
Bending	–	X	X	–
Leakage	X	X	X	–

NOTES

X Test applicable.

– Test not applicable.

[a] Applicable to parts of metals not inherently corrosion resistant.

[b] Test applicable for flexible air ducts and air connectors that incorporate vapor barriers supported by grommets or other means of field support.

7 Tests for Surface Burning Characteristics

7.1 Representative samples of air ducts and air connectors shall be evaluated for surface burning characteristics and classified according to the requirements in 7.2 and 7.3.

7.2 Class 0 material shall have surface burning characteristics of zero (flame spread and smoke developed).

7.3 Class 1 material shall have a flame-spread index of not over 25 without evidence of continued progressive combustion and a smoke-developed index of not over 50.

7.4 Tests for surface burning characteristics are to be conducted as specified in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. For the purpose of establishing the flame spread and smoke developed indices, typically a minimum of three tests are to be conducted.

7.5 Samples are to be positioned in the 25 foot (7.62 m) long fire test chamber specified in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. When the composite duct is rigid, no supplemental supports are to be used. When required, due to unusual characteristics of a composite duct that affects the conduct of the test, 1/4 inch (6.4 mm) diameter steel rods shall be used to support the duct constructions. When supporting rods are used, they are to be spaced between 2 feet and 4 feet (0.6 m and 1.2 m) apart as required for support of the samples.

7.6 When the inside and outside surfaces of an air duct or air connector are of different composition, tests for surface burning characteristics are to be conducted by exposing first one side and then the other to the test conditions, using different samples for each exposure. A third test is then to be conducted on the worse case condition using a different sample for the exposure.

7.7 Fabrics, tapes, or other joining materials field-applied to or forming part of a factory-made air duct, air connector, or other parts identified as a component of the product are to be in place during the tests for surface burning characteristics. When, however, the application of the fabric, tape, or other joining material to the sample is likely to affect the various surface burning characteristic indices, samples are to be tested with and without longitudinal seams or joints, and the higher indices taken.

8 Flame Resistance Test

8.1 Fabrics, tapes, or other joining materials shall be those classified for flammability when, as applied to an air duct or air connector, the material is exposed to the internal air stream.

8.2 Tests of fabrics, tapes, or other joining materials to determine compliance with 8.1 are to be made in accordance with the method described in the Standard Methods of fire Tests for Flame Propagation of Textiles and Films, NFPA 701.

9 Bending Test

9.1 Sections of flexible air ducts and air connectors shall not be damaged when bent through a 180-degree arc over a mandrel having a diameter equal to the inside diameter of the air duct or air connector when tested in accordance with 9.3 – 9.5.

9.2 Sections of flexible air ducts shall maintain minimum insulation and scrim (when applicable) overlaps when tested in accordance with 9.6 – 9.10.

Exception: A flexible air duct whose inner core complies with the Flame Penetration Test without insulation is not required to be tested in accordance with 9.6 – 9.10.

9.3 Previously untested samples are to be tested. Samples, at least 8 feet (2.43 m) long, (are to be specified) in accordance with 17.2. Sections of air ducts and air connectors are to be prepared in accordance with 17.3. Steel collars, when not part of the assembly, are to be attached to each end of the test sample in accordance with the manufacturer's instructions. One end of the test sample is to be retained in place and the sample positioned adjacent to the test mandrel so that the center joint of the sample is not located in the area to be subjected to bending. The sample is to be bent through a 180-degree arc around the test mandrel.

9.4 The test is to be repeated five times, and each time the sample is to be returned to its original position.

9.5 Observations are to be made during and following the test. The sample shall not rupture, break, tear, rip, or separate; any reduction in internal cross-sectional area shall not exceed 20 percent at any time during the test; any joining material shall remain intact; and there shall be no evidence of other damage to the sample which results in it not being suitable for further use.

9.6 To comply with the requirement of 9.2, additional samples of previously untested flexible air ducts are to be tested. Packaged samples of standard length duct, at least 8 feet (2.43 m) long, are to be specified in accordance with 17.2. One end of the test sample is to be retained in place and the sample positioned adjacent to the test mandrel such that the midpoint of the air duct is centered on the test mandrel. The sample is to be positioned such that any insulation/scrim seam is at the outside of the bending radius. The sample is to be bent through a 180-degree arc around the test mandrel.

9.7 The bend is to be repeated five times. Between bends, the sample is to be returned to its original position. Upon completion of the final bend, the sample is to be maintained in the 180-degree bent position.

9.8 The vapor barrier is to be cut around the circumference of the duct at the center point of the duct. The vapor barrier is to be separated at the cut to a distance of 1 inch (25.4 mm). The end point of the insulation and scrim overlap is to be marked on the insulation and scrim. The vapor barrier is to be separated further and the distance from the marks to the end of the insulation and scrim measured.

9.9 The sample is to be removed from the mandrel and overlap measurements are to be made at the quarter points as specified in 9.8.

9.10 Sections of flexible air ducts that incorporate seamed insulation shall maintain a minimum 1 inch (25.4 mm) insulation overlap at each of the points measured in 9.8 and 9.9. When scrim is used as an individual component, it shall also maintain a 1 inch (25.4 mm) overlap.

Exception: Lesser overlaps are capable of being used for constructions that comply with the Flame Penetration Test when such overlaps are directly evaluated. In no case are gaps in the insulation or scrim allowed.

10 Flame Penetration Test

10.1 General

10.1.1 Materials for the fabrication of Class 0 and Class 1 air ducts shall not permit the passage of flame, as described in 10.1.2, for a period of at least 30 minutes when tested in accordance with the method specified in 10.2.1 – 10.5.2.

10.1.2 The sample shall withstand the flame-penetration test without through opening, evidence of perforation to an extent which allows the direct passage of flame or gases, and without ignition occurring on the surface of the sample exterior to the combustion zone of the test furnace.

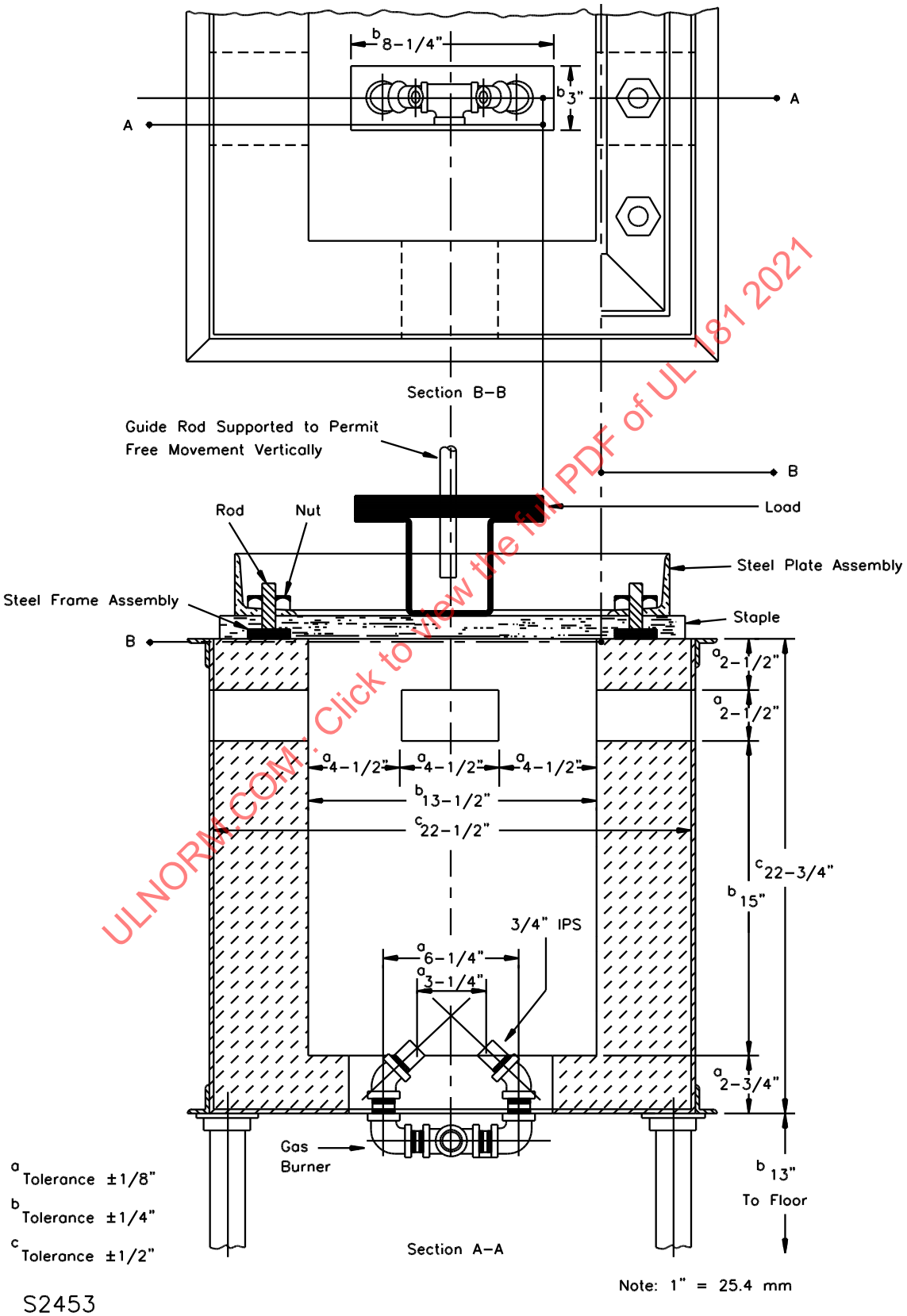
10.1.3 The test series shall consist of a set of three samples.

10.2 Test equipment

10.2.1 Flame-penetration tests are to be conducted using a refractory-lined gas-fired combustion chamber open at the top. The sample to be tested is to form the top of the chamber, thus forming a test furnace as shown in Figure 10.1.

Figure 10.1

Flame penetration test



10.2.2 The furnace is to be equipped with a dual-outlet gas burner composed of pipe fittings as shown in Figure 10.1. The gas burner is not to have any means for premixing of gas and combustion air. The gas burner is to be leveled in both the horizontal and vertical planes.

10.2.3 The furnace is to be vented directly into the room space in which it is located by means of the four vent openings shown. No dampers or regulators are to be employed in openings provided for inlet of combustion air or for venting. The furnace is to be lined as shown with high-duty regular type fireclay brick having a density of 125 – 135 pounds per cubic foot (2002 – 2162 kg/m^3), Standard for Classification of Fireclay and High-Alumina Refractory Brick, ANSI/ASTM C27. (For example, A. P. Green, "Empire DP.") The brick lining is not to incorporate mortar to hold the brick in place.

10.2.4 The furnace is to be equipped with a gas burner as detailed in Figure 10.1. A flanged union incorporating a thin plate orifice sized to be one third of the pipe inside diameter is to be installed in the burner piping located no more than 5 feet (1.5 m) from the gas burner. An adjustable fine tune valve is to be installed no more than 2 feet (0.6 m) upstream of the thin plate orifice for the regulation of gas flow.

10.2.5 The room in which the test furnace is to be located is to be large in relation to the furnace and ventilated to provide adequate air for combustion. Ventilation is to be accomplished without appreciable air movement in the vicinity of the furnace. Controlled ventilation is to be accomplished to maintain constant room temperature and pressure conditions without appreciable air movement around the furnace. (Note: Normal cycling of Heating, Air Conditioning systems may disrupt furnace conditions).

10.2.6 Methane gas or natural gas is to be used for the pre-heat. During stabilization and test periods the gas fuel is to have a heating value of 1000 – 1050 Btu per cubic foot (37,259 – 39,122 KJ/m^3). Methane gas from a compressed gas cylinder is to be commercial grade or purer and is to be regulated to deliver fuel at a constant pressure from the cylinder.

10.2.7 The static load as referenced in 10.5.1 is to be steel (Grade ASTM A36). The static load is to be a 2 pound-mass per square inch (0.14 kg/cm^2) through a bearing surface of 1 by 4 inches (25.4 by 102 mm). The bearing surface is to be 3/16 inch (4.75 mm) thickness and is to have ends with a 5/16 inch (7.9 mm) radius. The weight is to be configured as shown by Figure 10.3 with an open area with a width of 4 inches and a height of 4-3/16 inches (102 by 106 mm). The upper solid mass is to be 5 3/4 inches wide by 4 inches high (146 by 102 mm) with a 3/8 inch (9.5 mm) diameter guide rod extending upward.

10.3 Sample preparation

10.3.1 Samples are to be prepared from previously untested materials. Samples of flexible ducts are to be cut from ducts having an inside diameter of at least 12 inches (305 mm). Rigid duct samples are to be prepared in 24 inch (610 mm) flat squares.

Exception: When a duct at least 12 inches (305 mm) in diameter is not produced, then the largest diameter duct that is produced is to be used for the test.

10.3.2 Materials used in the construction of the sample ducts are to be representative of those used in regular finished production. The air duct components of flexible ducts shall be mounted in the metal frame assembly in the order and orientation that they exist in the duct construction. The material surface identified to be the outside surface of the air duct is to be the surface exposed to the flame during the test. Test samples are to be mounted in a frame fabricated as shown in Figure 10.2. Core wires are to be placed so that they run in the direction from one of the sides of the steel frame assembly (see Figure 10.2) containing hold down nuts to the other side of the steel frame assembly containing hold down nuts. The steel plate is to be tightened against the upper frame by tightening the hold down nuts to 30 ±5 ft-lbs, so that all of the components of the sample are held firmly in place throughout the test duration.

Figure 10.2

Sample holding frame assembly

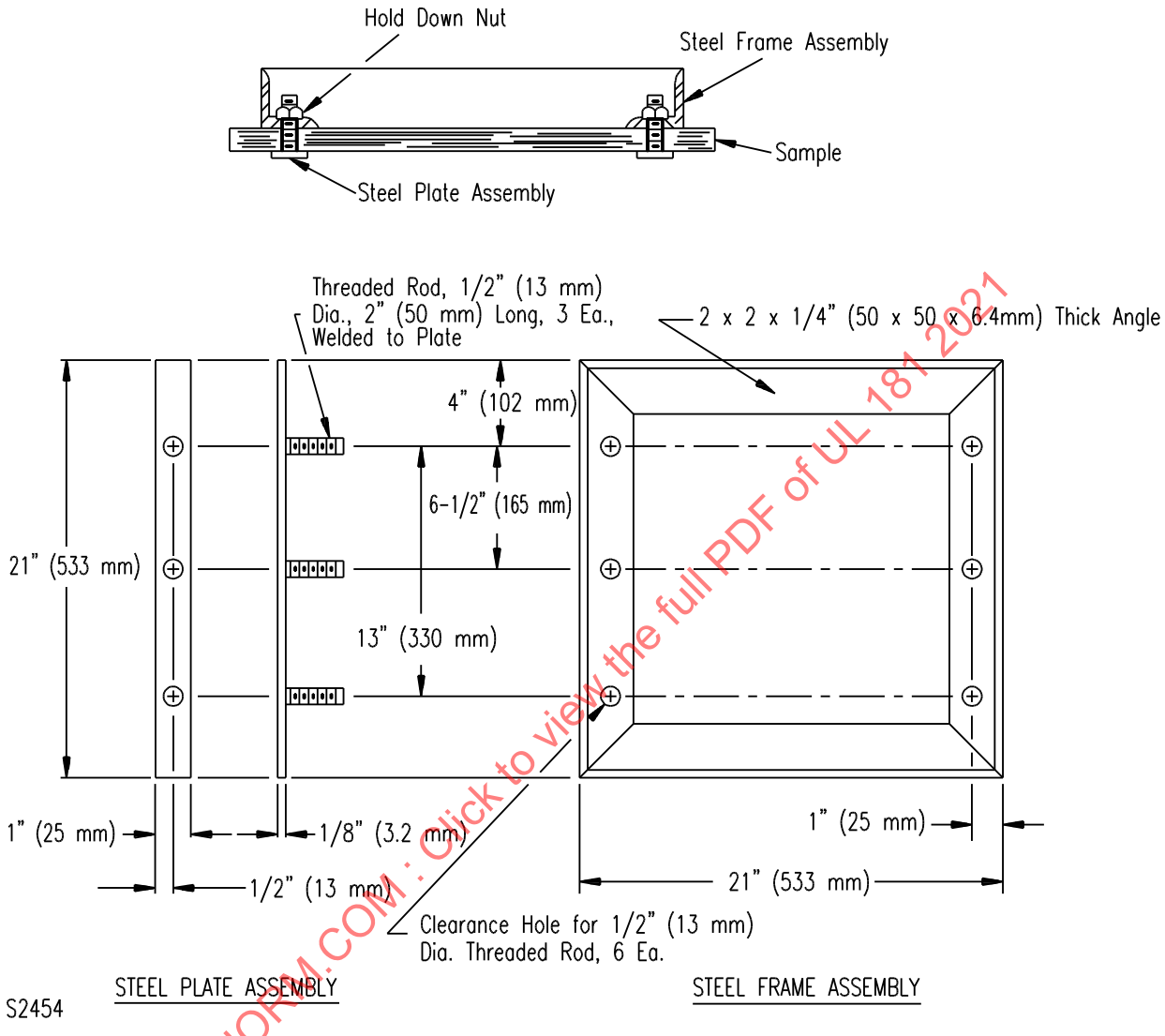
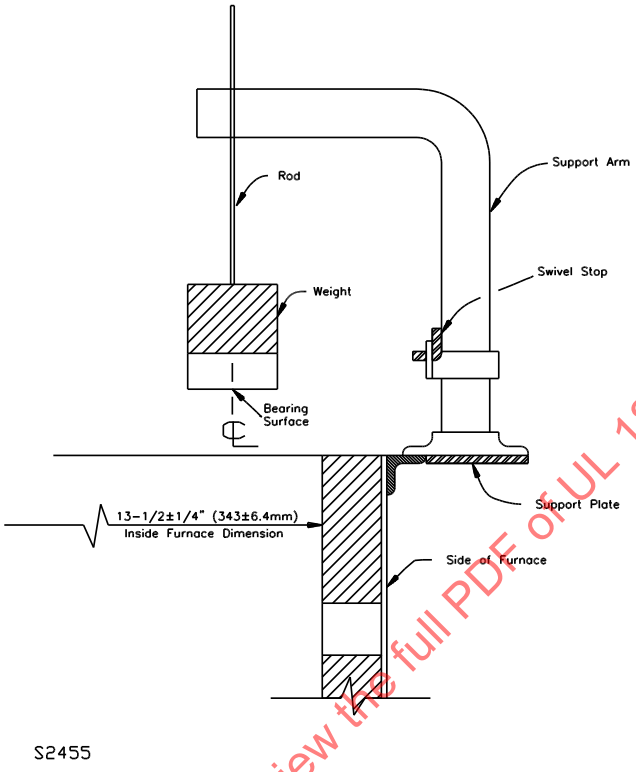


Figure 10.3

Typical support configuration



10.3.3 When the sample is a flexible air duct that incorporates a seam in the insulation, the sample is to be prepared with the seam at the center of the test frame.

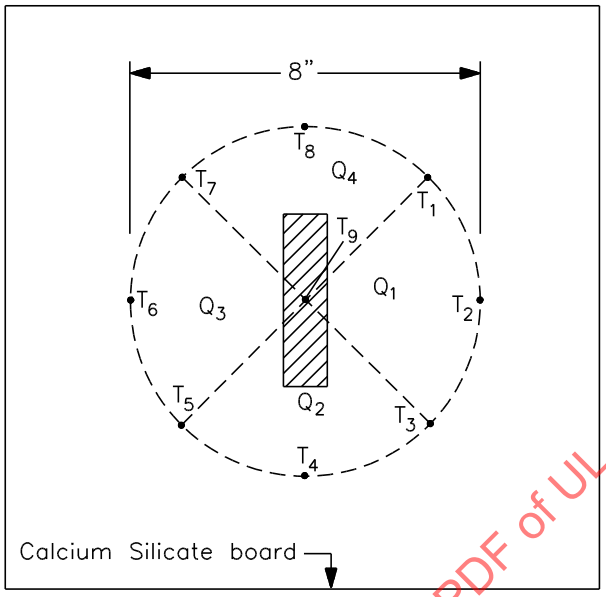
Exception: Flexible air ducts which maintain insulation and seam overlaps of not less than 1-inch (25.4 mm) after being subjected to the Bending Test, Section 9, shall have the sample cut from an area containing no seam.

10.4 Pre-heat and stabilization

10.4.1 At the beginning of the test series, the furnace is to be fired for a minimum 2 hour preheat with the gas pressure maintained at 3.5 ±0.05 inch water gauge as measured upstream of the fine tune valve. The top of the furnace combustion chamber shall be covered by a 1 inch (25.4 mm) thick calcium silicate board that is 18 pounds per cubic feet (288 kg/m^3). The calcium silicate board shall incorporate nine thermocouples of the following type for the measurement of the furnace temperatures: type K, exposed tip, grounded, inconel 600 sheath, with magnesium oxide hard packing (i.e., Omega Part No. KMQIN-125E-6 or equivalent). One of the thermocouples shall be centered over the furnace center point and the remaining eight thermocouples shall be equally spaced to form an 8 ±1/16 inch (20.3 ±0.16 cm) diameter ring concentric with the center point. (See Figure 10.4). The thermocouple tips shall extend 1 ±1/16 inch (2.54 ±0.16 cm) below the bottom of the board surface. The holes for the penetration of the thermocouples shall maintain a tight clearance. The thermocouples shall be connected to an automatic recording device which records the furnace temperature readings every 10 seconds and additionally averages these readings each minute. The averaged temperatures recorded at each minute are processed to develop the individual center temperature, eight individual temperatures for the ring, the average ring temperature, and each average quadrant temperature. (Quadrant temperatures consist of three ring temperatures and the center temperature).

Figure 10.4

Thermocouple placement



Note: $Q_{1,2,3,4}$ = Quadrants, consisting of 3 ring TC's plus the center (i.e. $Q_1 = \frac{T_1 + T_2 + T_3 + T_9}{4}$)

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10.4.2 The gas flow shall be adjusted using the fine tune valve to maintain the center temperature in the range of 1425 ±70°F (774 ±39°C) after 45 minutes of the 2 hour preheat period. The gas pressure is to be maintained at 3.5 inch water gauge. After 1-3/4 hours of the pre-heat, the center, individual ring, average ring, and quadrant temperatures are measured until all the following conditions are met for a continuous 15 minute period before the addition of the test sample:

a) Furnace center temperature shall be 1425 ±35°F (774 ±20°C);

b) The average ring temperature and the individual quadrant temperatures shall be at least 90 percent of, but not greater than, the center temperature; and

c) No individual ring temperature shall exceed 100°F (56°C) less than or greater than the average ring temperature.

Adjustments in the gas flow, followed by adjustments in gas pressure, are made during this and any subsequent stabilization period to obtain the required pretest conditions. Any adjustments to gas flow will require a restarting of the 15 minute stabilization period prior to conducting a test. For each succeeding test, the thermocouple grid is to be replaced on the furnace until the stabilization conditions are met for the 15 minute stabilization period.

10.5 Test method

10.5.1 At the end of the pre-heat and stabilization period, the calcium silicate board is to be removed and the air duct test sample substituted in its place within 10 seconds with the sample oriented such that the core wires are parallel to the burners. The test sample is to be subjected during the test to a static load located at the geometric center and rotated to any position determined to be most critical for penetration

on the upper surface of that part of the sample exposed to the flame. See Figure 10.3. The static load is to be gently lowered onto the test sample 3 to 5 seconds after the test sample is in place.

10.5.2 The gas input to the furnace is not to be disturbed during this changeover and any subsequent test period.

10.5.3 The test is to be continued for a period of 30 minutes. The test period is to be measured from the time the static load is applied to the test sample.

11 Burning Test

11.1 Air ducts and air connectors shall not continue to burn progressively, and exterior surfaces of the material shall not drop particles that ignite untreated surgical cotton.

11.2 Representative samples of assembled air duct sections or air connectors are specified for test. When the material is of uniform grade and thickness for all sizes of air ducts and air connectors and of similar cross-sectional shape (rectangular or round), samples are required from the larger and smaller sizes. When the air ducts or air connectors vary in shape or the material varies in grade and thickness with size, additional samples to be representative of the complete line shall be evaluated for testing. The samples selected shall be those expected to burn under the conditions of test.

11.3 Six samples are to be provided for each product required in accordance with 11.2. The samples are to be sections of air duct or air connector 3 feet (0.914 m) long without a transverse joint. Any adhesive or cement is to be allowed to cure for a period of at least 24 hours. Samples are not to be exposed to relative humidity greater than 70 percent during the 24-hour period prior to the test.

11.4 The apparatus to be employed consists of a Bunsen burner with a 3/8-inch (9.5-mm) diameter tube and means for controlling the primary air and gas input, a support for the burner, a stopwatch or other timing device, and a supply of untreated surgical cotton. The Bunsen burner is to be supported and held in place by means of a burner stand, ring stand with clamps or an equivalent type of mechanical support. The gas used is to be a minimum CP grade or purer propane (bottled) gas having a heating value in the range of 2490 – 2510 Btu per cubic foot. The gas bottle is to have a regulator and a valve located between the regulator and the burner. The test stand is to be similar to that illustrated in Figure 11.1. The samples are to be extended to their full length so that all slack is removed. The samples are to be supported by the test stand as illustrated in Figure 11.2 – Figure 11.6. When evaluating the interior surface of the sample in the horizontal and 45 degree orientations, the sample is to be secured to the test stand support rods using three wire ties. The tests are to be conducted in a location free from drafts.

Figure 11.1

Burning test stand

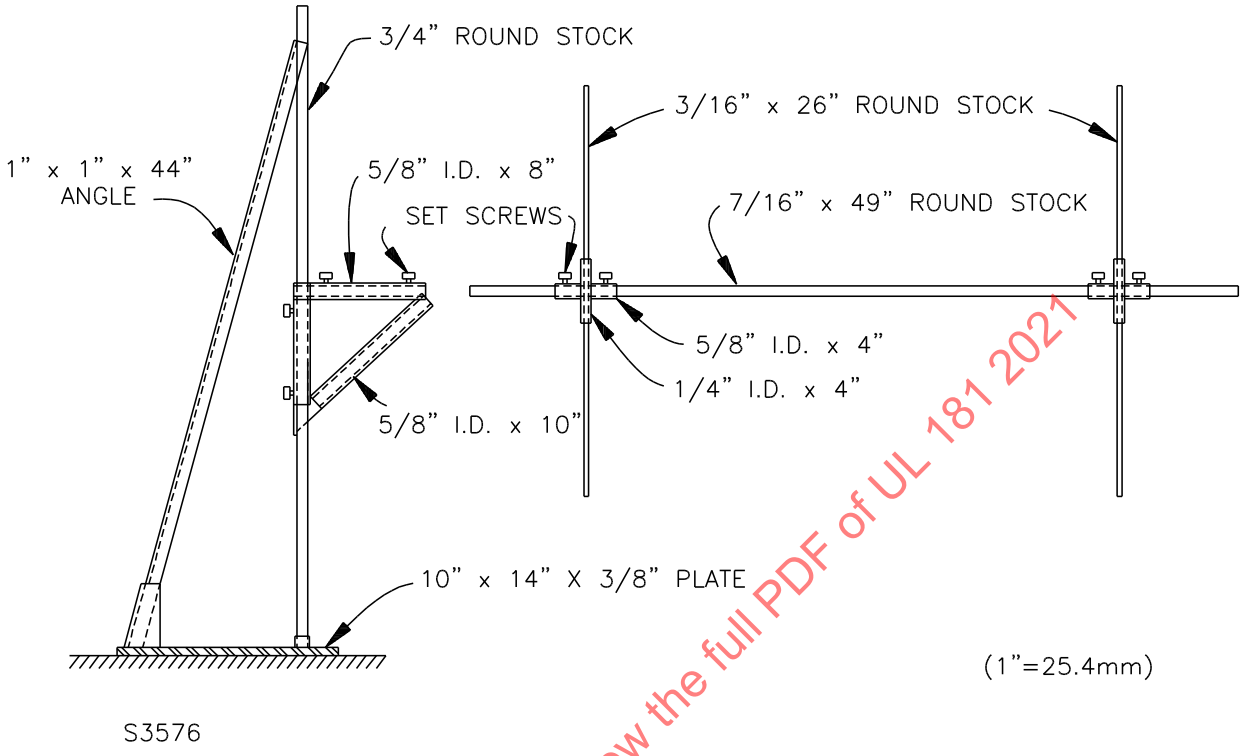


Figure 11.2

Horizontal burning test interior exposure

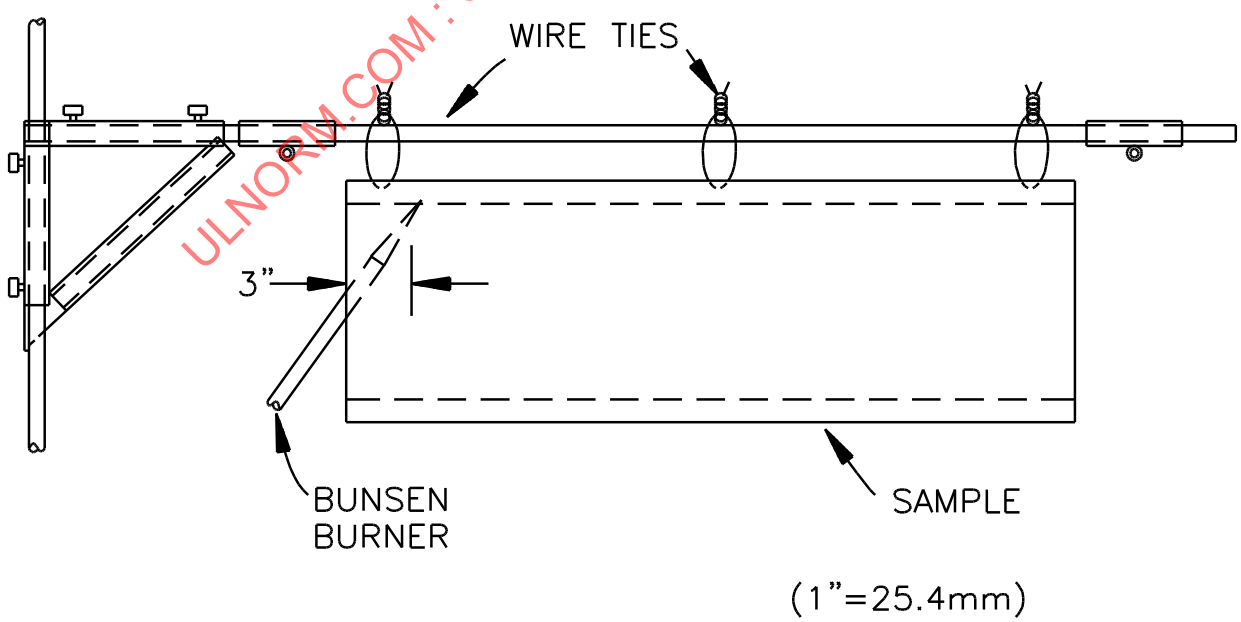


Figure 11.3

Horizontal burning test exterior exposure

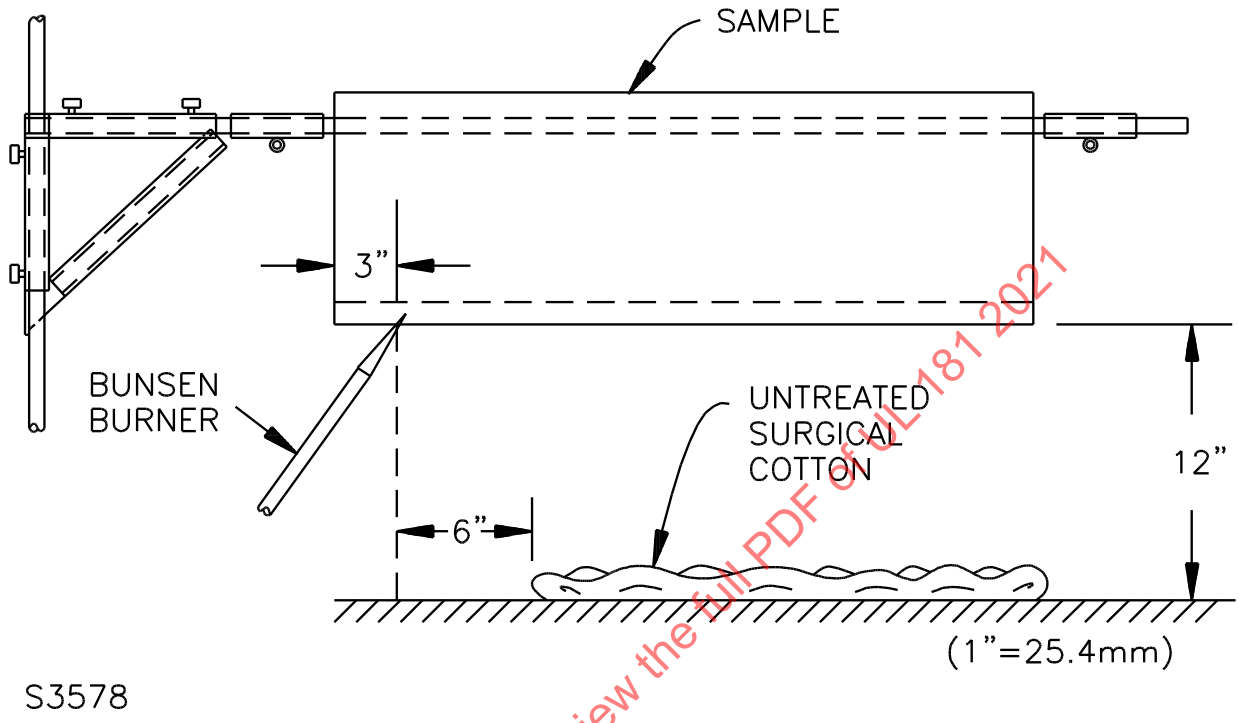


Figure 11.4

Vertical burning test

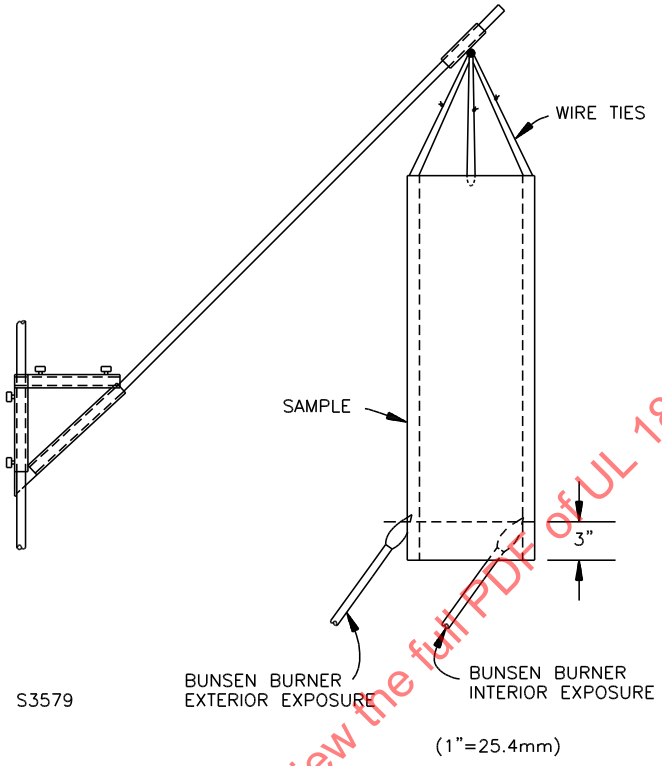
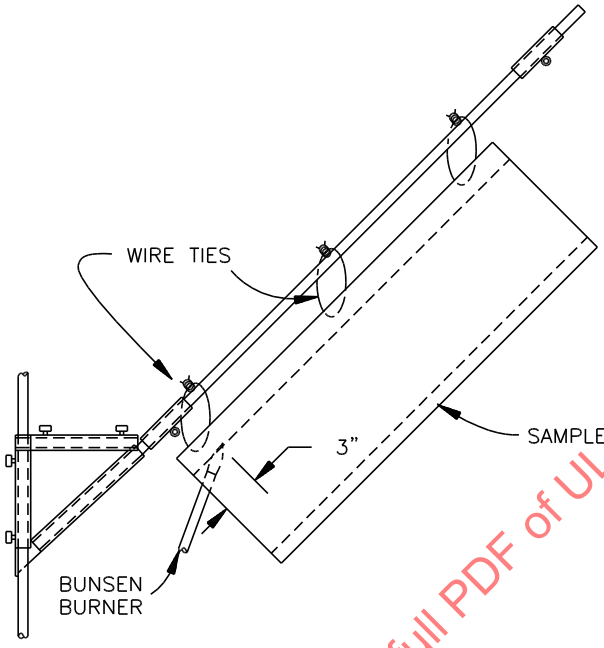


Figure 11.5

45-Degree burning test interior exposure



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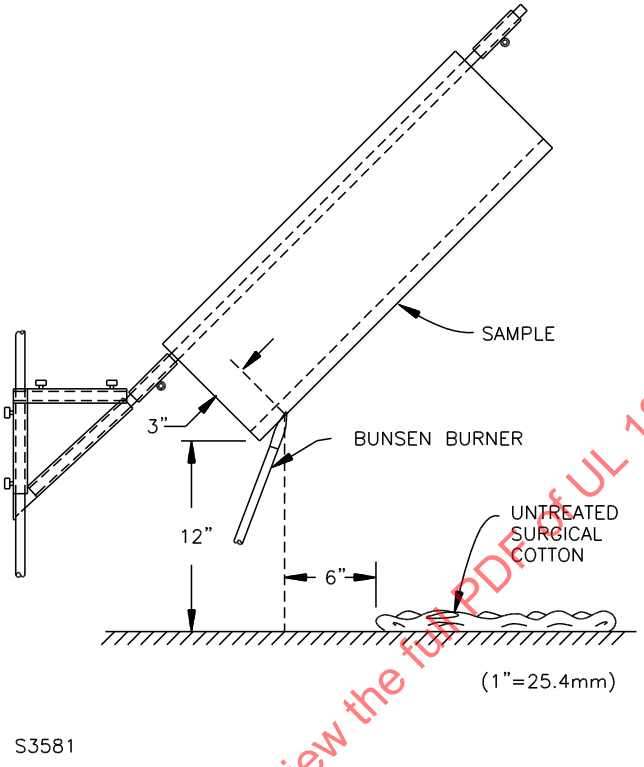
(1"=25.4mm)

Figure 11.6

45-Degree burning test exterior exposure



11.5 The six samples are to be mounted as follows: one in the Interior Horizontal position (see Figure 11.2), one in the Exterior Horizontal position (see Figure 11.3), two in the Vertical position (see Figure 11.4), one in the Interior 45-degree position (see Figure 11.5), and one in the Exterior 45-degree position (see Figure 11.6). Prior to the application of the burner to the sample, the burner is to be adjusted to produce a flame 2-1/2 inches (63.5 mm) high. The air and fuel input are to be adjusted such that the flame has equal parts of blue and yellow. The valve then is to be turned off and the burner positioned such that 1-1/4 inches (31.75 mm) of the test flame impinges the test sample 3 inches (76.2 mm) from the end of the sample. See Figure 11.2 – Figure 11.6. The valve then is to be turned on and the flame ignited.

11.6 The outside surface of three samples oriented in the three positions is to be exposed to the flame for 1 minute and then the flame is to be withdrawn. When flaming or glowing combustion of the sample ceases 60 seconds or less after removal of the test flame, the test flame is to be reapplied at the same place for 1 minute immediately after flaming or glowing combustion of the sample stops. The test flame again is to be withdrawn and the duration of flaming or glowing combustion of the sample noted. During the test of an individual sample, the original size and characteristic of the test flame is not to be changed.

11.7 When particles drop from the sample that is oriented horizontally and 45-degrees from the horizontal during the exterior exposure tests, these particles are to be allowed to fall onto a horizontal plane 1 foot (305 mm) below the nearest part of the test sample. The plane is to be covered with a layer of untreated surgical cotton except for that portion of the area directly below the burner extending for a distance of 6 inches (152.4 mm) measured horizontally in all directions from a vertical axis through the tip of the burner flame.

11.8 Following exposure of the exterior surface of the first three samples, similar tests are also to be conducted on the remaining three samples of the set by applying flame to the inside surface. When required based on size and orientation of the sample, it shall be necessary, in some cases, to cut away

part of the sample in order to apply the test flame to the interior surface. These samples are to be observed for flaming or glowing combustion only and surgical cotton is not to be placed beneath the samples during this test.

11.9 The duration of flaming or glowing of any sample after withdrawal of the test flame is not to exceed 60 seconds; flaming or glowing is not to travel to the end of the sample farthest from the point of application of the test flame; and particles dropped from the exterior surface of the sample during the vertical and 45-degree exterior exposures are not to ignite the surgical cotton.

12 Corrosion Resistance

12.1 Test for zinc-coated steel

12.1.1 To determine compliance with 5.3, the amount of zinc coating shall be determined by the Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ANSI/ASTM A90.

12.1.2 When flaking or cracking of the zinc coating at the outside radius of a bent or formed section is visible at 25 power magnification, or when the coating is scored, the zinc coating is damaged and does not comply.

12.2 Tests for coated steel (other than zinc-coated steel)

12.2.1 General

12.2.1.1 To determine compliance with 5.3, the tests in 12.2.2.1 – 12.2.4.1 are to be conducted on uncoated metals or coated metals other than galvanized steel after the material has been formed for use in the finished product. The tests are to be conducted on samples of the coated material and on zinc-coated steel having the minimum coating of zinc specified in 5.3, and continued until equivalency is demonstrated. The test is to be terminated and equivalency is established when any of the control zinc coated samples demonstrate signs of corrosion sooner than the candidate samples. The test is to be terminated and equivalency is not established when any of the candidate samples demonstrate signs of corrosion sooner than the control zinc coated samples. Signs of corrosion are pitting, cracking, and red discoloration of the metal. Samples having organic coatings are to be tested in the as received condition and also after having been exposed to temperature as encountered in the high-temperature phase of the temperature test, 14.3.1 – 14.3.4.

12.2.2 Salt-spray test

12.2.2.1 The apparatus for salt-spray (fog) testing is to consist of a fog chamber, the inside of which measures 48 by 30 by 36 inches (1219.2 by 762 by 914.4 mm), salt-solution reservoir, a supply of conditioned compressed air, one dispersion tower constructed in accordance with Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117, for producing a salt fog, specimen supports, provision for heating the chamber, and required means of control.

12.2.2.2 The dispersion tower for producing the salt fog is to be located in the center of the chamber and is to be supplied with humidified air at a pressure of 17 to 19 psig (117.2 – 131 kPa) so that the salt solution is aspirated as a fine mist or fog into the interior of the chamber.

12.2.2.3 The salt solution is to consist of 20 percent by weight of common salt (sodium chloride) and distilled water, and the pH value of the collected solution is to be between 6.7 and 7.2 with a specific gravity of 1.126 to 1.157 at 35°C (95°F). The temperature of the chamber is to be maintained at 35 plus 1 or minus 2°C (95 plus 2 or minus 3°F) throughout the test.

12.2.2.4 Drops of solution that accumulate on the ceiling or cover of the chamber are not to be permitted to drop on the specimens, and drops of solution that fall from the specimens are not to be recirculated and are to be removed by drains located at the bottom of the apparatus.

12.2.3 Industrial-atmosphere test

12.2.3.1 The test specimens are to be supported vertically in a closed chamber having openings for gas inlet and outlet.

12.2.3.2 Sulfur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. An amount of sulfur dioxide equivalent to 1 percent of the volume of the test chamber, and an equal volume of carbon dioxide are to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber.

12.2.4 High-temperature and humidity test

12.2.4.1 The test specimens are to be supported vertically in a closed chamber at a constant temperature of 40°C (104°F) and 100 percent relative humidity.

13 Mold Growth and Humidity Test

13.1 Materials for air ducts and air connectors, including any tapes, fabrics, cements, or other materials to be used in assembly during installation shall be resistant to the effects of high humidity under standard atmospheric temperature conditions. The mold shall not spread beyond the inoculated area, and no significant growth of mold is to be observed. Structural material shall not become deformed or delaminated; tapes, casings, and lining shall remain securely in place; and joints shall not open or show evidence of separation.

13.2 Three samples representing typical wall areas of the assembled air ducts or air connectors are to be prepared. Each sample is to be 4 by 4 inches (102 by 102 mm) square and is to include any joining material employed in the installation of duct systems.

13.3 Mold mycelia and spores using Chaetomium Globosium are to be applied to the samples. The samples are to be placed in a closed vessel in which an atmosphere saturated with water vapor is maintained at room temperature and under dark conditions. The samples are to remain in this atmosphere until the extent of growth has been demonstrated or until the mold and spores have disintegrated, and not less than 60 days.

13.4 The samples then are to be examined visually for extent of mold growth and for indications of deterioration in wall structure, exterior casing, inner lining, tapes, and fabrics.

14 Temperature Test

14.1 General

14.1.1 Materials for air ducts and air connectors, including any tapes, fabrics, cements, or other materials intended to be used in assembly during installation, shall be resistant to the effects of the temperatures to which they are exposed in the following tests.

14.2 Low temperature

14.2.1 Structural material shall not become deformed or show delamination; tapes, casings, and lining shall remain securely in place; and joints shall not open or show evidence of separation when a sample is subjected to the test described in 14.2.2 – 14.2.4.

14.2.2 Three samples representing typical wall areas of the assembled product are to be prepared. Each sample is to be 8 by 8 inches (203 by 203 mm) square and is to include joining material, when such is employed in the installation of duct systems.

14.2.3 The samples are to be placed in a closed vessel in which an atmosphere saturated with water vapor is maintained at room temperature for a period of 48 hours. The samples then are to be removed and immediately placed in a refrigerated compartment and maintained at a temperature of minus 17.8°C (0°F) for a period of 24 hours.

14.2.4 The samples shall then be removed from the refrigerated compartment and allowed to be conditioned at 23 ±2°C (73 ±4°F) and 50 ±5 percent relative humidity for at least 24 hours. The samples then are to be examined visually for indications of deterioration in wall structure, exterior casing or interior linings, tapes, fabrics, and cements.

14.3 High temperature

14.3.1 To comply with the requirements of 14.1.1, the exterior and interior surfaces of samples of air duct sections and air connectors are to be simultaneously exposed to air maintained at not less than 51.7°C (125°F) on the exterior and not less than 129.4°C (265°F) on the interior. Any arrangement using samples of air duct sections or air connectors shall be employed. The test arrangement is to provide means for maintaining air at the specified test temperatures in moving contact with the two surfaces of the test samples. As a result of the test described in 14.3.2 – 14.3.4, structural material shall not become deformed or show delamination; tapes, casings, and lining shall remain securely in place; and joints shall not open or show evidence of separation.

14.3.2 At least two representative samples are to be specified and prepared for this test. When the product is of uniform grade, thickness, and cross section, such as square or round, the samples are to be chosen from the smaller sizes. Square or round sections, varying in grade and thickness with size, may also require samples in other size ranges. Rectangular sections are to be specified on the basis of grade, thickness, and size. Shapes of air duct sections or air connectors which are vulnerable to damage under the conditions of the puncture test are to be tested. See 15.1.

14.3.3 Each sample is to be 3 feet (0.91 m) long and is to be assembled from two sections of air duct or air connector, providing for a joint between sections located 2 feet (0.60 m) from one end or a single piece of material. At least one end of each sample is to be attached to a metal collar in accordance with the manufacturer's instructions.

14.3.4 The conditions of test are to be maintained for a period of 60 days. The samples shall then be removed and conditioned at 23 ±2°C (73 ±4°F) and 50 ±5 percent relative humidity for at least 24 hours. The samples then are to be examined visually for indications of deterioration in wall structure, exterior casings or interior linings, tapes, fabrics, and cements.

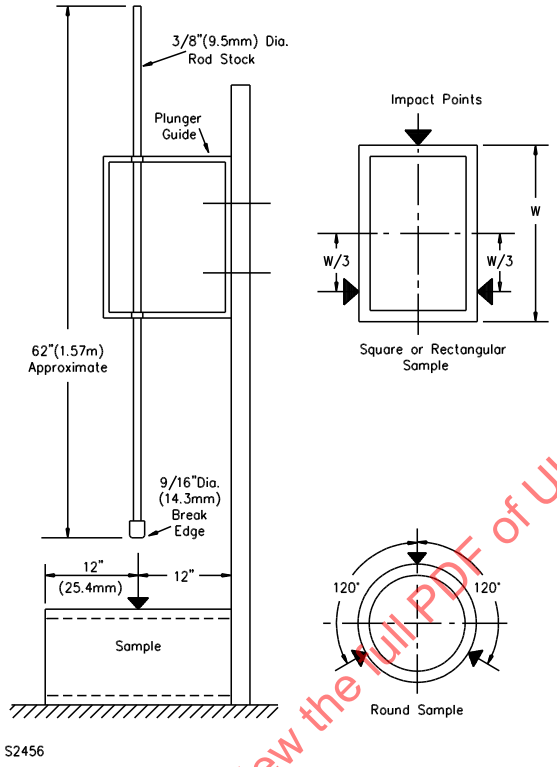
15 Puncture Test

15.1 An air duct shall not be punctured when tested in accordance with these requirements.

15.2 Test apparatus providing for a free fall of a plunger onto the surface of the sample is to be used for this test. The apparatus is to be as illustrated by Figure 15.1.

Figure 15.1

Puncture test



15.3 The plunger is to consist of 3/8-inch (9.52 mm) diameter steel rod having a steel head, 9/16-inch (14.3 mm) diameter, attached to the impact end. The length of the plunger assembly is to provide a 2-pound (0.90 kg) weight. The surfaces of the rod and head are to be smooth. The impact end of the rod is to be formed as shown in Figure 15.1.

15.4 Guides arranged to allow for frictionless fall of the plunger are to be provided. A means for measuring the height of fall is to be provided.

15.5 Pieces, 2 feet (0.60 m) long, are to be taken from duct sections previously subjected to the temperature test, and identical samples prepared from untested product are to be subjected to this test. The samples are to be provided with a firm support below and throughout their length and width. At least three areas of each sample are to receive the impact of the plunger at the approximate center of the test sample along its length and at the impact points around its perimeter as shown in Figure 15.1.

15.6 The samples shall prevent the complete penetration through the wall of the sample of the plunger head falling through a distance of 20 inches (508 mm) as measured to the top surface of the sample.

16 Static Load Test

16.1 General

16.1.1 Sections of rigid air ducts assembled in accordance with the manufacturer's instructions shall not sag, permanently deform, or be damaged as the result of static loading applied according to the requirements of 16.2.1 – 16.2.7. Sections of flexible air ducts and air connectors that incorporate vapor

barriers with integrated mechanical methods of field support shall not be damaged as the result of static loading applied according to 16.3.1 – 16.3.4.

16.2 Tests for rigid air ducts

16.2.1 Following the test, the inner and outer surfaces of the sample shall not be ruptured, broken, torn, ripped, or separated; joints and seams shall remain intact and not be fractured; and there shall be no evidence of other damage to the samples which result in the sample to be unusable.

16.2.2 Previously untested representative samples are to be specified or prepared. When sections are of uniform grade, thickness, and cross section, such as square or round, the samples from the largest and smallest sizes are to be tested. Square or round sections varying in grade and thickness with size also require samples in the intermediate size range. Rectangular sections are to be selected on the basis of grade thickness, and size, as well as the largest ratio of width to depth specified by the manufacturer. Samples of shapes which are vulnerable to damage under the conditions of test are to be specified.

16.2.3 Samples for test are to be at least 2 feet (0.60 m) longer than the maximum distance between supports specified in the manufacturer's instructions for the various sizes, grades, and shapes, and not less than 8 feet (2.43 m) long. Samples are to be assembled to provide for a circumferential joint at the center of the sample, unless supports are specified to be located at each such joint, in which case the manufacturer's instructions are to be followed. When joints are reinforced to the extent that the section shall be more resistant to load than a section without a joint, additional samples of sections without the joint are to be tested. Any adhesives or cements are to be allowed to cure for a period of at least 24 hours. Samples are not to be exposed to relative humidity greater than 70 percent during the 24-hour period prior to the test.

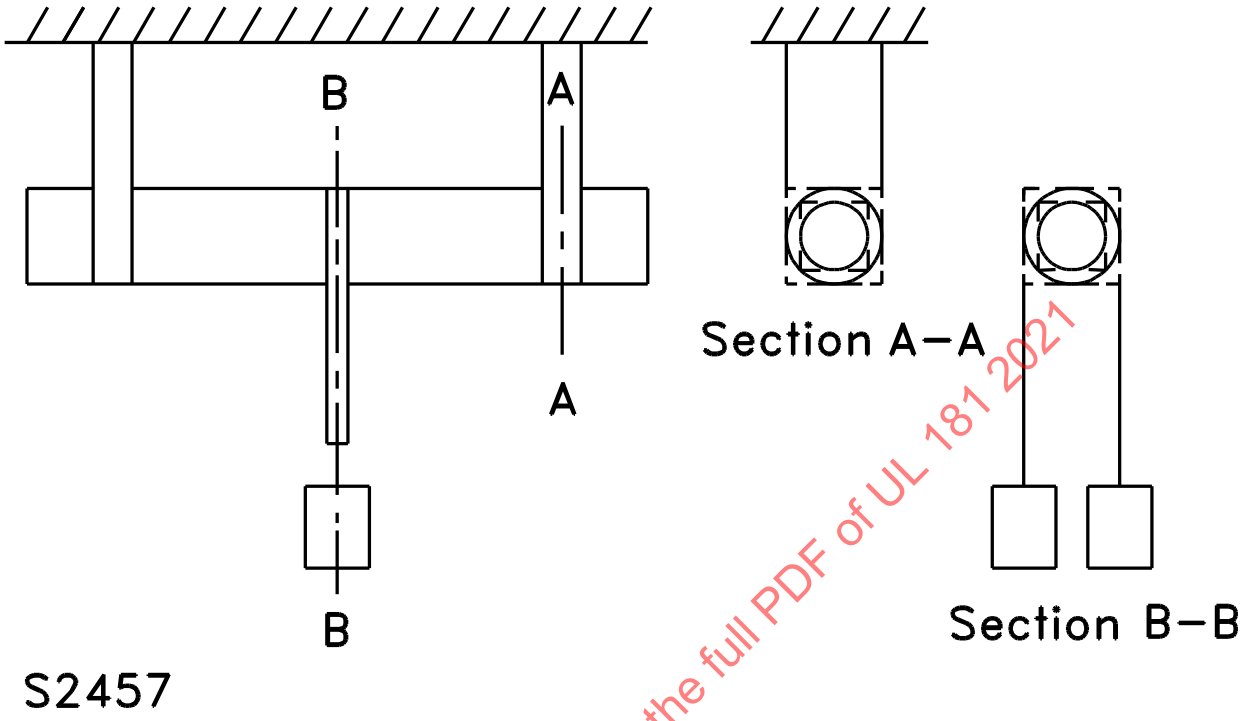
Exception: If the longest section obtainable from the material under test is less than 8 feet, additional pieces shall be joined thereto, so that the longest section is midway between the supports.

16.2.4 The samples are to be placed horizontally on hangers located at the interval specified in the manufacturer's instructions, except that hangers are to be located on centers not less than 16 inches (0.40 m) apart. Rectangular samples are to be placed with the major axis in the horizontal plane. Special bearing blocks, or other reinforcing means, are to be used when supplied as factory-made parts. Steel pipe strap hanger material 1 inch (25.4 mm) wide is to be used to support the test sample, locating each hanger not less than 1 foot (0.30 m) from the end of the sample. When support at intervals less than 6 feet (1.82 m) is specified, additional support straps as needed to support the 8 foot (2.43 m) test sample at the specified interval are to be provided.

16.2.5 The general arrangement for test is to be that illustrated in Figure 16.1.

Figure 16.1

Static load test



16.2.6 With a sample supported as described above, means are to be provided for measuring to the nearest 1/16 inch (1.6 mm) the vertical deflection at the center of the horizontal length. This measurement is to be that taken between the bottom of the sample at the center and the floor or other datum point below the sample. Any deflection due to stretching of the hangers is to be deducted.

16.2.7 A static load is to be applied at the longitudinal center of the sample by suspending two 5-pound (2.26-kg) weights on a 1-inch (25.4-mm) wide pipe strap material as illustrated in Figure 16.1. The maximum vertical deflection measured at the bottom of the test sample, expressed as a percentage of the distance between supports, is not to exceed:

a) 0.7 percent at the end of 5 minutes.

b) 0.8 percent at the end of 1 hour.

c) 1.0 percent at the end of 24 hours.

d) 0.8 percent at the end of 5 minutes after removal of the load.

16.3 Tests for flexible air ducts and air connectors.

16.3.1 After supporting the load for 24 hours, the sample shall not be ruptured, broken, torn, ripped, collapsed, or separated; and there shall be no evidence of other damage to the sample which results in it being unusable.

16.3.2 Previously untested representative samples are to be specified or prepared. Samples of duct sizes that result in the maximum weight intended to be supported by any given grommet size or spacing are to be specified for this test. Samples, 8 feet (2.43 m) long, are to be used.

16.3.3 Any adhesives or cements are to be allowed to cure for a period of at least 24 hours. Samples are not to be exposed to relative humidity greater than 70 percent during the 24-hour period prior to the test.

16.3.4 Samples are to be supported in accordance with the methods and spacings specified by the manufacturer. A load of 2-1/2 times the total weight of the sample is to be uniformly applied to the duct so that it is supported by the support system. When possible, the load is to be applied by laying rods on the inside of the duct. The load shall remain for 24 hours.

17 Impact test

17.1 Sections of air ducts assembled in accordance with the manufacturer's instructions, when tested in accordance with the requirements, shall not be damaged as a result of the impact applied as specified in 17.4 – 17.7. Following the test, the inner and outer surfaces of the samples shall not have ruptured, broken, torn, ripped, collapsed, or separated; and there shall be no evidence of other damage to the sample which results in it being unusable. The average reduction in internal cross-sectional area is to be determined for the three tests. Collapse is defined as an average internal cross-sectional area reduction in excess of 20 percent, or any individual reduction in cross-sectional area in excess of 25 percent.

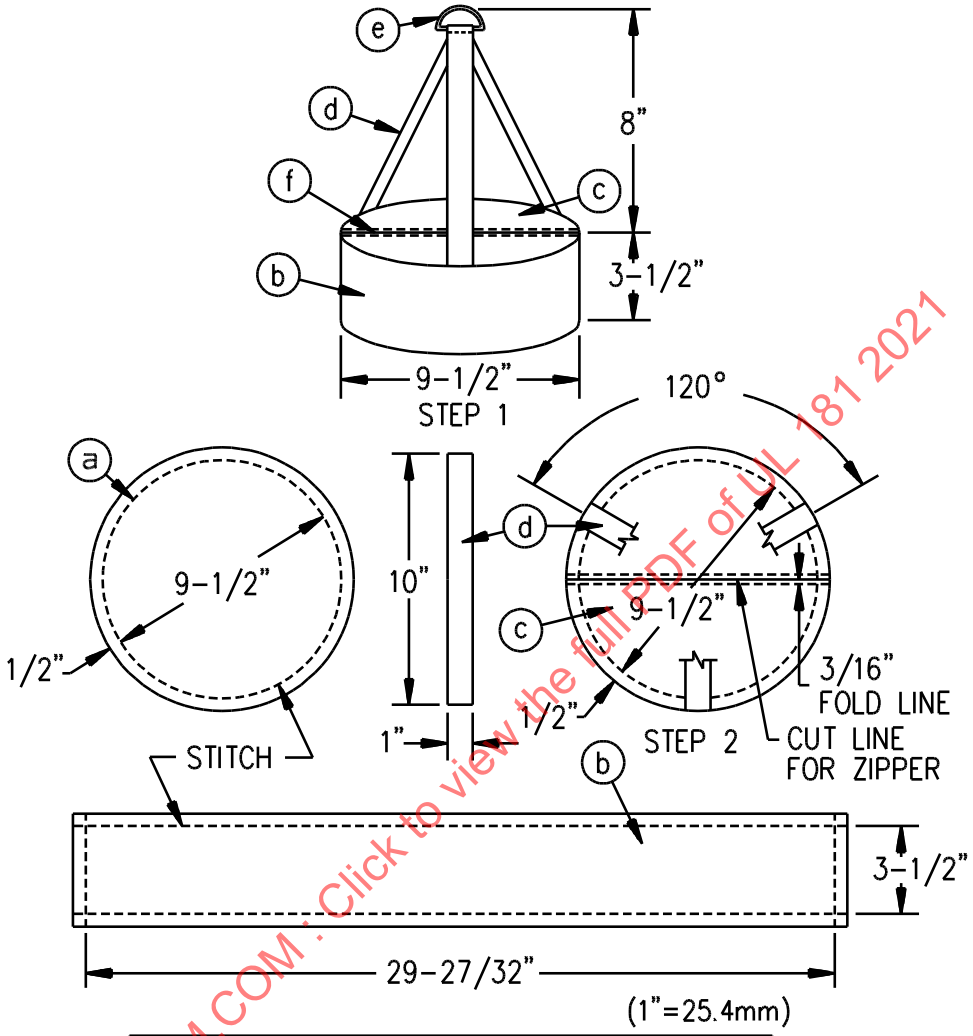
17.2 Previously untested representative samples are to be prepared on the basis of grade, thickness, size, and shape. Consideration is to be given to tested samples which are vulnerable to damage under the conditions of test. Such samples may include air ducts prepared with a representative field splice of a type as specified by the manufacturer. Samples of non-symmetrical cross section are to be evaluated in the orientations identified as being vulnerable under the conditions of test.

17.3 Three samples, each measuring 8 feet (2.43 m) in length, of the finished duct construction are to be assembled for test. In assembling the test samples, all duct materials are to be extended to their full length. Any adhesives or cements are to be allowed to cure for a period of at least 24 hours. Samples are not to be exposed to relative humidity greater than 70 percent during the 24-hour period prior to test.

17.4 An impact test is to be performed on each of the three samples. The impact test is to be performed over a firm rigid flat surface. The impact is to be that of a canvas bag containing sand and weighing 15 pounds (6.8 kg). The bag is to be constructed of nominal 12 ounce (0.33 kg) canvas duck in accordance with Figure 17.1. The test fixture is to incorporate a mechanism which is capable of releasing the bag in a quick and smooth motion which imparts no lateral momentum to the sand bag.

Figure 17.1

Sand bag for the impact test



a	bottom	12 oz. canvas duck
b	side	12 oz. canvas duck
c	top	5 oz. canvas duck
d	strap nylon	1 in. wide
e	D-ring	1-1/2 x 1/4 in.
f	nylon zipper	1-5/8 in. wide x 10-1/2 in. long

1. Cut piece a, b, and c from canvas material.
2. Sew piece b end-to-end with 1/2 inch seam allowance each piece.
3. Sew piece a to piece b as shown with 1/2 inch seam allowance each piece.
4. Cut piece c centerline, fold 3/16 inch each half and sew zipper as shown.
5. Sew nylon straps to piece c, 120° apart as shown in Step 2.
6. With all pieces inside-out sew piece c to piece b opposite piece a. (Note: Insure zipper is unzipped.)
7. Turn bag inside-out to obtain end construction shown in Step 1.
8. Sew 3 strap ends to D-ring leaving 8 inch length from top of D-ring to top of bag measured perpendicularly.

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