SAE International

SURFACE VEHICLE STANDARD

SAE J2027 MAY2013

Issued 1994-06
Stabilized 2013-05

Superseding J2027 JUN1998

Standard for Protective Covers for Gasoline Fuel Line Tubing

RATIONALE

This document has been declared "Stabilized" by the SAE Fuel Systems Standards Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

The Fuel Systems Technical Standard committee which created this document has not further developed this method since the last publication.

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1. ***Scope***—This SAE Standard includes performance requirements for protective covers for flexible, non-metallic fuel tubing. Ultimate performance of the protective cover may be dependent on the interaction of the fuel tubing and protective cover. Therefore, it is recommended that tubing and cover combinations be tested as an assembly, where appropriate, to qualify to this document.

1.1 This document is intended to provide guidance in regard to key performance parameters for protective covers for fuel tubing. This document is designed to allow selection of predetermined performance levels for these parameters.

1.2 The engineer may select a specification by the use of a line call-out designation, which will denote the pertinent characteristics of the cover material and/or the tube/cover assembly and their corresponding performance criteria. The engineer is not required to select every characteristic, but only those deemed important to the application. Characteristics not covered by this document and deemed important to the engineer should be added using "Z" suffixes, with a detailed description for each “Z” on the part drawing.

1.3 This document may involve hazardous materials, operations, and equipment. This document does not address the safety problems associated with its use. It is the responsibility of the user of this document to consult and establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J400—Test for Chip Resistance of Surface Coatings
SAE J1960—Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Water-Cooled Xenon-Arc Apparatus
SAE J2236—Standard Method for Continuous Upper Temperature Resistance
SAE J2260—Non-Metallic Fuel System Tubing with One or More Layers

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 412—Test Methods for Rubber Properties in Tension
ASTM D 471—Test Method for Rubber Property—Effect of Liquids
ASTM D 635—Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM D 638—Test Method for Tensile Properties of Plastics
ASTM D 1149—Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber (Flat Specimens)
ASTM D 1171—Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D 3182—Recommended Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets
ASTM D 3183—Practice for Rubber—Preparation of Pieces for Test Purposes from Products

2.1.3 ISO PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 6495—Rubber hoses—Determination of abrasion resistance of the outer cover

3. Classification

3.1 Type—Protective covers will be classified as either elastomeric or nonelastomeric. Rigid classification criteria are difficult to establish, but classification of most covers will be obvious.

3.1.1 SAE J2027a—ELASTOMERIC COVERS—Normally, covers formed from an organic material with a single continuous structure. An example would be a cover consisting of an extruded tube of rubber or plastic which exhibits elastic characteristics.

3.1.2 SAE J2027b—NONELASTOMERIC COVERS—Normally, covers formed from nonelastic, inorganic materials such as fiberglass, but may be formed from organic fibers. In general, nonelastomeric covers can be distinguished based on a construction of a number of filaments which have been matted, woven, or braided to form the cover. An example would be a braided fiberglass sleeve.

3.1.3 NOTE—If there are both elastomeric and nonelastomeric elements in the cover construction, classification shall be based on the dominant element in the construction.

3.2 Line Call-Outs—A line call-out, which is a specification, shall contain: the document designation, the cover type, the performance characteristics, and the performance requirements. The following is an example of a line call-out:

SAE J2027a 1B 2C 4B 5D 6E 8A

where:

SAE J2027 = document designation
a = Elastomeric cover
1B = Thermal Resistance, 121 °C minimum continuous service temperature
2C = Resistance to Combustion, 10 s maximum burn time
4B = Stone Impingement Resistance, 6 cycles, minimum, to wear through
5D = Cold Temperature Impact, −34 °C maximum
6E = Burn-Through Resistance, 5 min, minimum, to pressure loss
8A = Ultraviolet Resistance, 1250 kJ/m^2 exposure

3.3 See Table 1 for performance and classification requirements.

TABLE 1—SAE J2027a/b PERFORMANCE REQUIREMENTS ELASTOMERIC AND NONELASTOMERIC COVERS

	A	B	C	D	E
1 Thermal Resistance (Maximum Continuous Exposure Temperature)					
Nonelastomeric	121 °C	135 °C	149 °C	177 °C	204 °C
Elastomeric	93 °C	121 °C	135 °C	149 °C	176 °C
2 Resistance to Combustion (Maximum Burn Time)	60 s	30 s	10 s	does not support combustion	does not ignite
3 Abrasion Resistance (Minimum cycles to Wear-Through)	100	500	1000	2500	5000
4 Stone Impingement Resistance (Minimum Cycles to Wear-Through)	2	6			
5 Cold Temperature Impact (Minimum Temperature With Retention of Impact)	–18 °C	–23 °C	–29 °C	–34 °C	–40 °C
6 Burn-Through Resistance (Minimum Time to Pressure Loss)	1 min	2 min	3 min	4 min	5 min
7 Chemical Resistance Cold Temperature Impact					
Fluid (Concentration Time, Temperature)					
1 Aggressive Water[1] (100% 70 h 40 °C)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
2 Calcium Chloride (10% 70 h 40 °C)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
3 Sodium Chloride (10% 70 h 40 °C)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
4 Zinc Chloride (50% 168 h 24 °C)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
5 Brake Fluid (100%, 1 h 100 °C, air dry)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
6 Ethylene Glycol (50% 1 h 100 °C, air dry)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
7 Fuel C (100% 1 h 40 °C, air dry)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
8 IRM 903 Oil (100% 1 h, 100 °C, air dry)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
9 Transmission Oil (100% 1 h, 100 °C, air dry)	–13 °C	–18 °C	–23 °C	–29 °C	–34 °C
8 Ultraviolet Resistance (Resistance to Outdoor Weathering)	1250 kJ/m^2	2500 kJ/m^2			
9 Ozone Resistance	50 h	168 h			

1. Aggressive Water is 1.0 L of distilled water with 0.990 g NaCl (600 ppm CL^-), 0.888 g $Na_2SO_4^-$ (600 ppm SO_4^-), and 0.828 g $NaHCO_3^-$ (600 ppm HCO_3^-).

4. ***Sample Preparation***—The preparation of specimens for testing under this document shall conform to the expected procedures for full-scale manufacturing of the fuel line/cover assembly. A sample size of eight is required for each test. Except where otherwise noted, fuel line tubing/cover samples are required for testing.

4.1 Where different methods of manufacture exist (such as co-extrusion versus assembly of individual components), the method of manufacture shall be identified in the specification.

4.2 In testing where the cover is tested separately from the assembly, covers which are crosshead extruded onto the tubing shall be removed from the tubing to provide test specimens. Where this is not possible, or with co-extruded products, an extruded tube of similar size and composition may be utilized as a test specimen.

5. ***Performance Requirements***—The finished tubing/cover assemblies shall satisfactorily meet the performance requirements of the specification based on the following performance tests. Use of standard random sampling techniques is encouraged, where assemblies are in current production. Developmental assemblies shall be prepared based on anticipated production manufacturing techniques. A minimum number of samples shall be examined under each test to meet criteria defined in 5.1, with samples from multiple manufacturing runs encouraged. Refer to Table 1 for details on performance requirements.

5.1 Individual specifiers may request the use of particular statistical methods in sampling and testing, which should be listed under the "Z" section of the specification. Specifiers and testers are encouraged to note any significant factors not covered by this document; an example being the change in properties with humidity exposure of nylon covers.

5.2 Conditioning and test environments are to be 23 °C and 50% relative humidity, unless otherwise specified. Precision of settings and measurements shall conform to normal expectations for that particular procedure.

5.2.1 THERMAL RESISTANCE [REFERENCE SAE J2236]—The cover shall withstand 1008 h of exposure at the rated temperature without significant loss of properties, as defined as follows. Testing shall be performed on cover materials, not tubing/cover assemblies. Thermal exposure shall be accomplished by placing specimens in an air-circulating oven for 1008 h at specified temperature, followed by 72 h conditioning at RT. Reference ASTM D 3182/3183 for specimen preparation procedures.

Elastomeric materials shall be tested for tensile properties under ASTM D 638 or ASTM D 412 both before and after thermal exposure.

a. Acceptance Criteria:

1. Tensile Loss: 50% maximum
2. Elongation Loss: 50% maximum
3. Dimensional Change: 5% maximum

Nonelastomeric material shall be tested for tensile properties both before and after thermal exposure by the accepted tensile testing methods for the particular material or construction involved.

a. Acceptance Criteria:

1. Tensile Loss: 20% maximum
2. Dimensional Change: 5% maximum

5.2.2 RESISTANCE TO COMBUSTION [REFERENCE ASTM D 635]—The cover is to be tested separately from the tube. The cover, when placed horizontally, with one end exposed to flame for 15 s, shall not continue to burn in excess of the specified burn time.

The cover is to be placed in an appropriate draft-free burn chamber, and secured at one end to the top of a ring stand. The specimen length is to be 460 mm. Adjust height so that approximately 13 mm of the cover is exposed to the burner flame. A Bunsen burner shall then be placed under the cover for 15 s. The timer is started as the burner is removed. Record burn time. Burn time shall be calculated as the time between burner removal and the end of any visible flame, glowing or dripping of the specimen. A specimen, which does not exhibit visible flame when the burner is removed, but which does exhibit glowing, shall be termed "does not support combustion." A specimen which does not exhibit any visible glow or significant material erosion upon burner removal shall be termed "does not ignite."

Elastomeric and nonelastomeric covers are tested in the same manner.

a. Acceptance Criteria: Minimum burn time, per Table 1.

5.2.3 ABRASION RESISTANCE [REFERENCE ISO 6945]—Cover/tube assemblies shall resist wear-through of the cover, when abraded with a 25 N force, per ISO 6945. This test is a comparative analysis and intended to distinguish relative abrasion characteristics of various materials, as opposed to replicating an infinite number of vehicle conditions. Additionally, some material could tear or melt, or tools wear during the test procedure. Therefore, prudent judgement should be exercised to mitigate such conditions. Furthermore, many covers, especially nonelastomeric covers, may generate harmful dust during testing. The use of a vacuum attachment is strongly advised.

Sample configuration: 230 mm long x 7.9 OD tube, and 230 mm long cover. Insert 230 mm long steel rod through tube ID, such that the sample is maintained in a straight and rigid position during testing. Expose sample to abrasion with a 25 N force, per ISO 6945. Abrade sample until 100% wear through of the cover wall is reached. Record the number of cycles.

Elastomeric and nonelastomeric covers are tested in the same manner.

a. Acceptance Criteria: Minimum cycles, per Table 1.

5.2.4 STONE-IMPINGEMENT RESISTANCE [REFERENCE SAE J400]—The cover/tubing assembly shall resist wear-through or cracking of the cover for the specified number of gravelometer cycles.

A gravel-projecting machine as specified in SAE J400, along with the specified 9.53/15.86 mm (0.375/0.575 in) water-eroded alluvial road gravel shall be employed. The specimen shall be mounted to place it at the center of the gravel stream. The impingement of one pint of gravel at 483 kPa (70 psi) air pressure shall be considered one cycle. Failure is defined as wearing or cracking of the cover in such a manner as to expose the tubing substrate.

The gravelometer apparatus is to be maintained and testing performed in the conditioning chamber at test temperature. Where this is not possible, impingement is to begin within 15 s of sample removal from the conditioning chamber. Separate tests shall be performed at –29 °C and 82 °C, and the lowest results reported.

Elastomeric and nonelastomeric covers are tested in the same manner.

a. Acceptance Criteria: Minimum Cycles, per Table 1.

5.2.5 COLD TEMPERATURE IMPACT—Covers/tube assemblies shall not exhibit cracking when assemblies are subjected to a 2.71 N·m (2.0 ft-lb). impact at the specified temperature, per Table 1, utilizing the cold impact test fixture, per SAE J2260.

Cover/tubing assemblies are to be conditioned for 24 h at the specified temperature. Impact tester is to be maintained and testing performed within the conditioning chamber at test temperature, per Table 1. If the impact test cannot be performed inside the cold chamber, utilize SAE J2260, 7.6.2 (cold temperature impact-optional procedure).

Elastomeric and nonelastomeric covers are tested in the same manner.

a. Acceptance Criteria: No cracks through cover (deformation of the cover/tube assemblies is considered acceptable.)

5.2.6 BURN-THROUGH RESISTANCE—Cover/tubing assemblies shall maintain internal pressure during flame impingement for the time period specified, to assess the fire resistance characteristics of non-metallic tubing covers. This test generates time to rupture data, which can provide a comparison between products using a standardized fire. It is not intended to provide quantitative information regarding how an actual tube or assembly will perform in an actual fire.

The test is to be conducted in the Fire Test Chamber (see Figures 1A, 1B, 1C, 1D, and 1E) which has been placed into a fireproof chemistry fume hood. During the test, the fume hood door is to be left approximately 20% open and the draught airflow adjusted to 0.5 m/s. If the Fire Test Chamber has a damper on its chimney, the damper is to be set to the fully open position.

The cover/tubing assembly test specimen shall be mounted into the test chamber (see Figures 1A, 1B, 1C, 1D, and 1E). An aluminum support rod of approximately 1/2 of the tubing ID shall be inserted inside the tubing. The assembly should then be checked for pressure leaks using 35 kPa (5 psig) air pressure. Pressurize the assembly to 35 kPa (5 psig) air pressure. The fuel pan is filled with sufficient amount of CM85 to sustain fire for 5 min. Adjust the height of the test sample to 50 mm above the fuel in the pan. The timing device is activate simultaneously with ignition of the methanol. Close the door on the chamber, and close the fume hood door to 20% of its open point. The timing device is stopped and extinguish the fire if necessary when the pressure in the tubing drops, indicating burn-through of the assembly, or the fuel in the chamber is consumed or the fire has burned for 5 min.

Elastomeric and nonelastomeric covers are tested in the same manner.

Acceptance Criteria: Duration to pressure loss, minimum, per Table 1

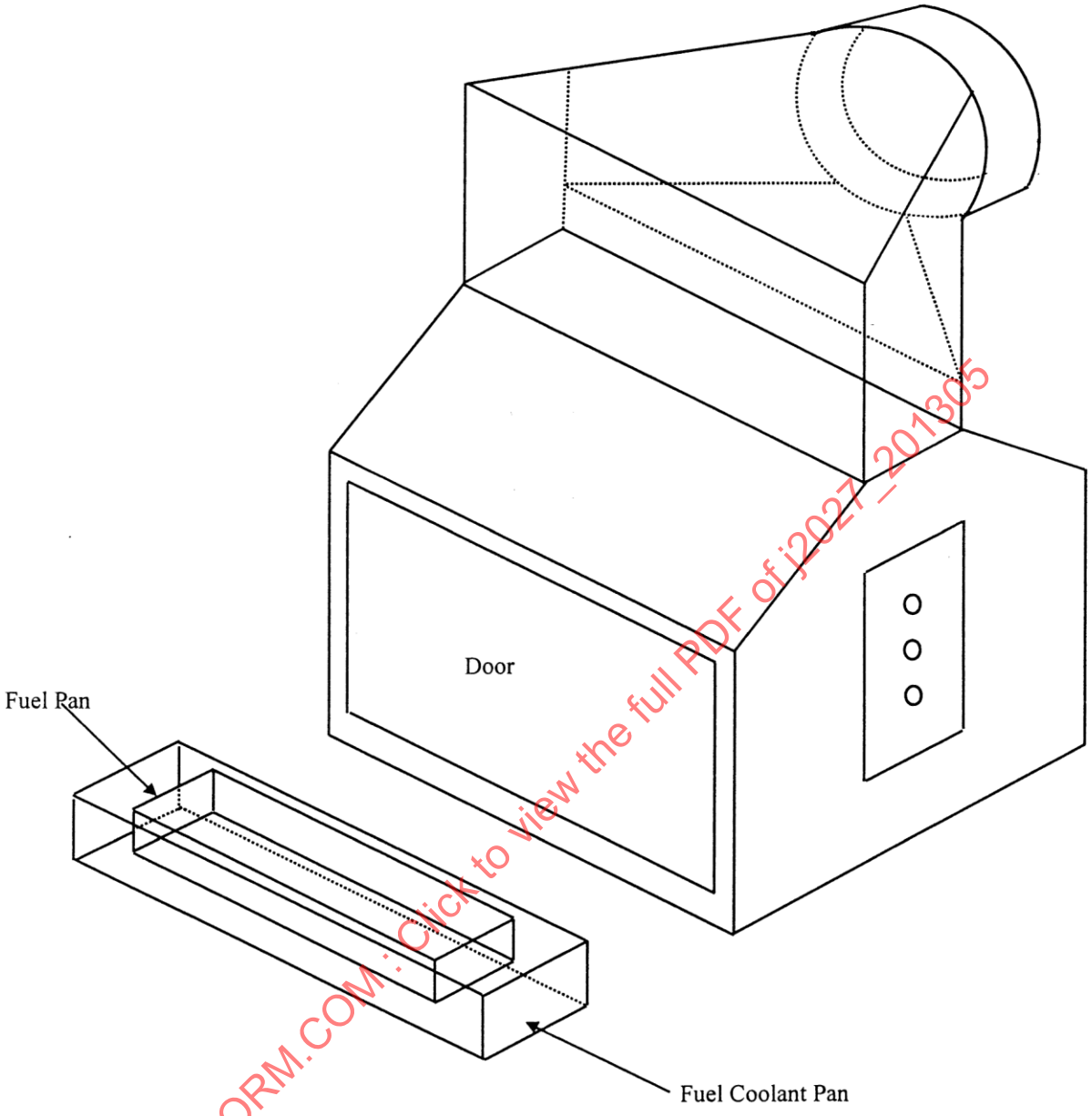

FIGURE 1A—FUEL LINE—FLAME TEST BOOTH

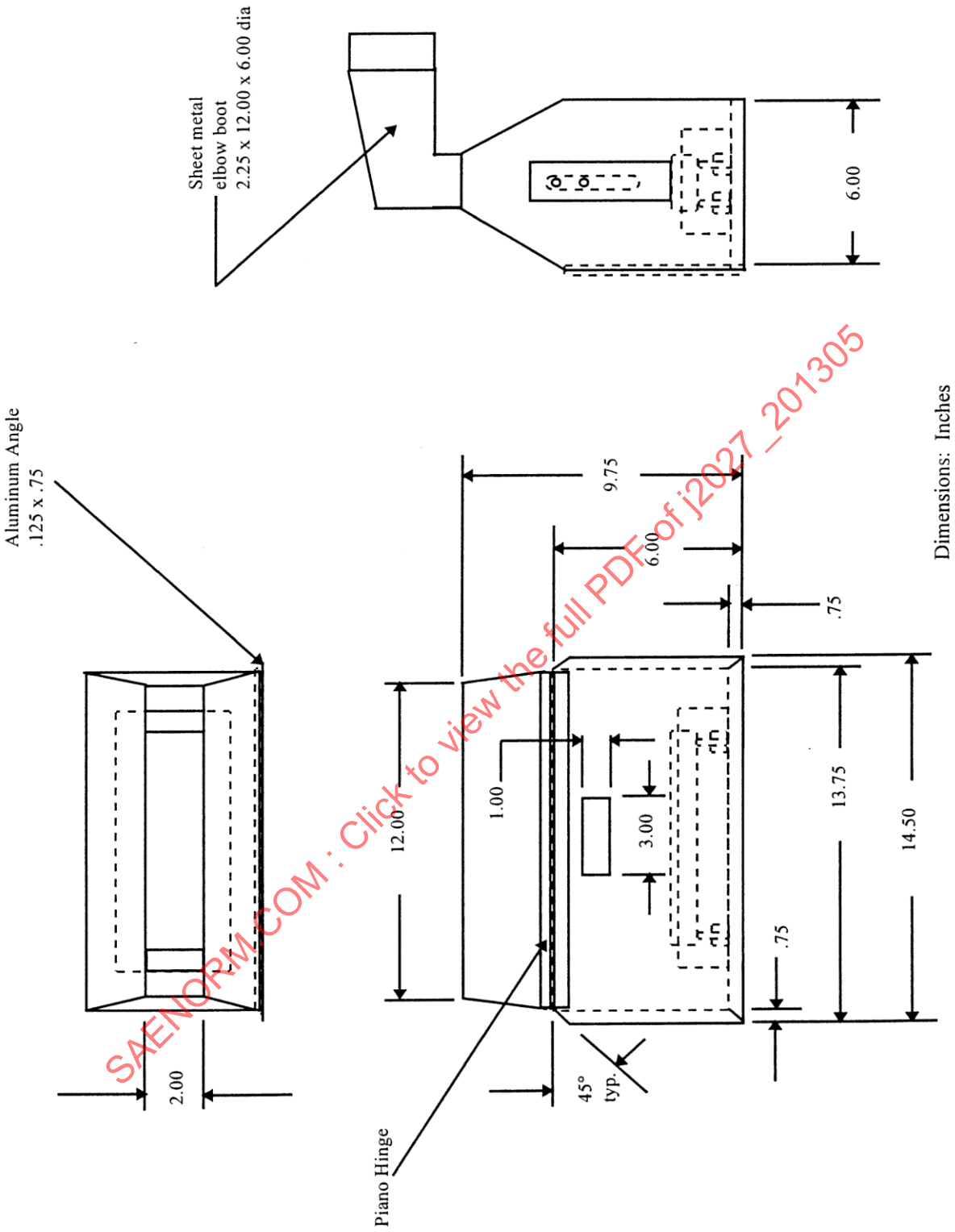

FIGURE 1B—FUEL LINE—FLAME TEST BOOTH

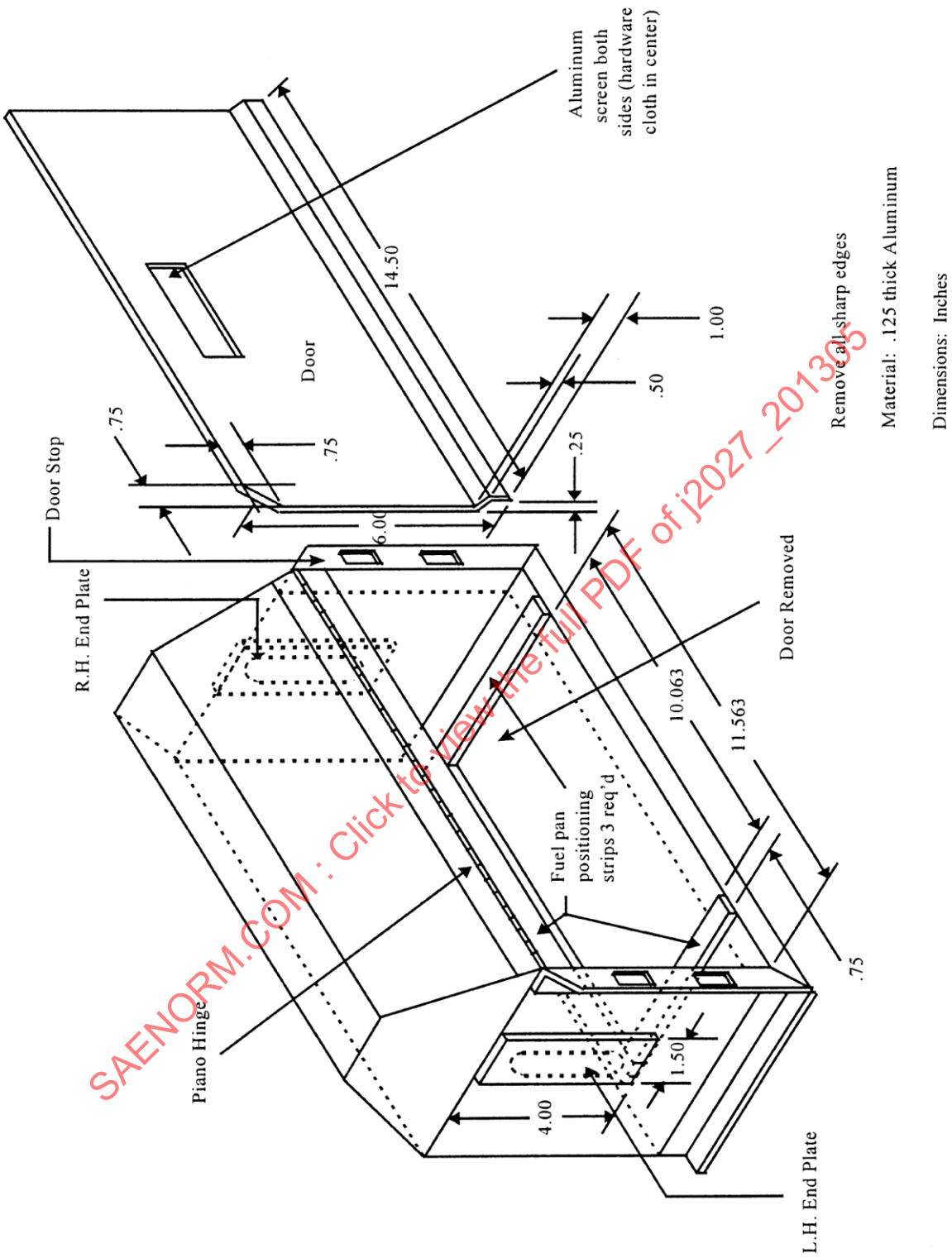

FIGURE 1C—FUEL LINE—FLAME TEST BOOTH

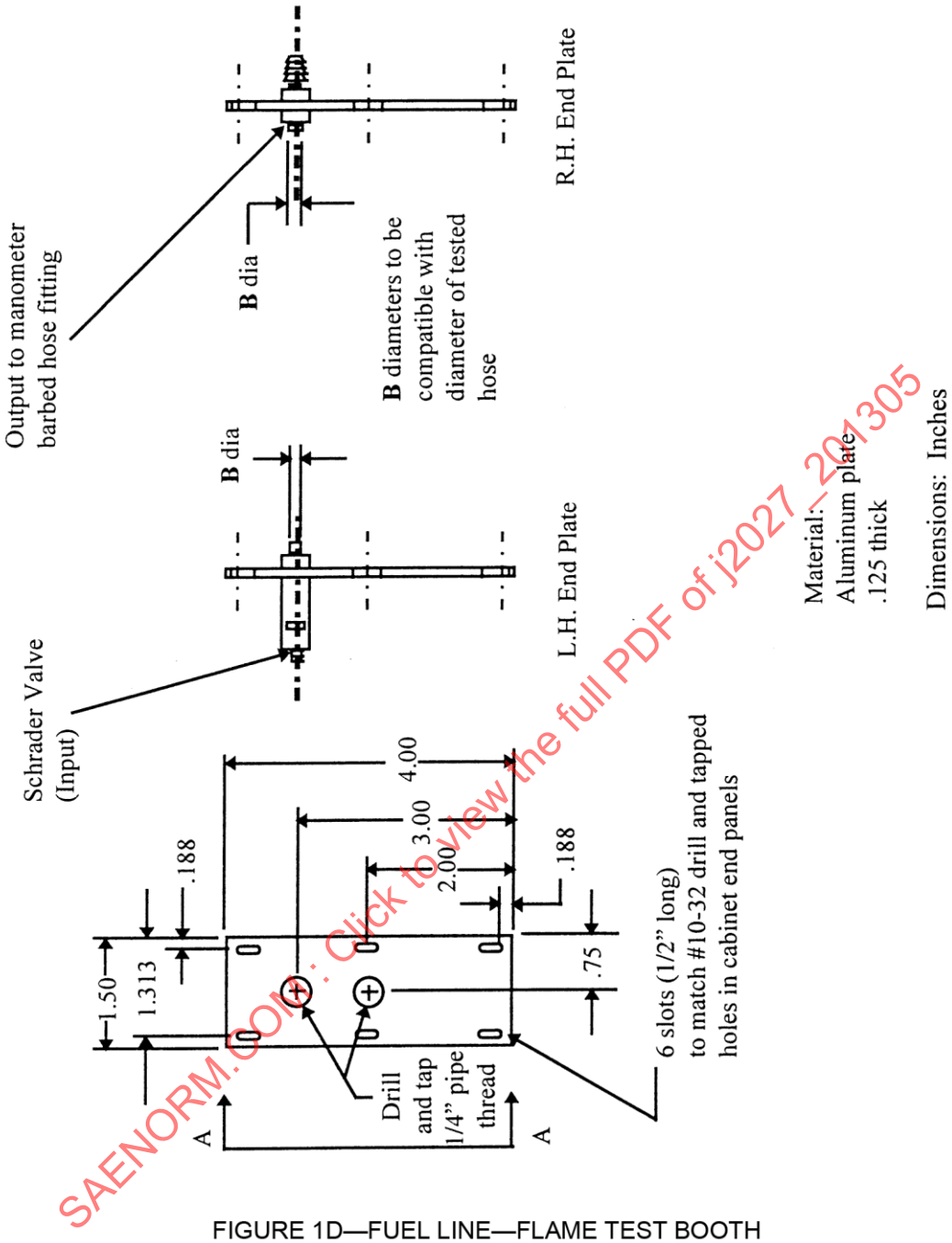

FIGURE 1D—FUEL LINE—FLAME TEST BOOTH END PLATES