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INTERNATIONAL
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SURFACE VEHICLE STANDARD

SAE J2027

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Submitted for recognition as an American National Standard

PRELIMINARY STANDARD FOR PROTECTIVE COVERS FOR GASOLINE FUEL LINE TUBING

1. *Scope*—This SAE Standard covers the performance requirements for protective covers for gasoline fuel tubing. The ultimate performance of the protective cover can be highly dependant on the interaction of the fuel line tubing and protective cover. Therefore, it is recommended that specific tubing and cover combinations be tested as an assembly to qualify to this document.

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

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 Documents**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

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

SAE J1960—Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Water-Cooled Xenon-Arc Apparatus
SAE J2027a—Elastomeric Covers
SAE J2027b—Nonelastomeric Covers
SAE J2236—Standard Method for Continuous Upper Temperature Resistance

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2.1.2 ASTM PUBLICATIONS—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

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 3170—Test Method for Chip Resistance of Coatings
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

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 Z1

Z1 = Flexural Modulus, 200 MPa maximum

where:

SAE J2027 = document designation
a = Elastomeric cover
1B = Thermal Resistance, 135 °C minimum continuous service temperature
2C = Flammability, 10 s maximum burn time
4B = Stone Impingement, 3 cycles minimum to wear through
5D = Brittleness Temperature, -34 °C maximum
6E = Formability, 3/4 in minimum bend radius
8A = Burn-Through Resistance, less than 1 min to pressure loss
Z1 = Flexural Modulus, 200 MPa maximum

3.3 See Tables 1 and 2 for performance and classification requirements.

TABLE 1—SAE J2027 PERFORMANCE REQUIREMENTS NONELASTOMERIC COVERS

		A	B	C	D	E
1	Thermal Resistance (Maximum Continuous Exposure Temperature)	121 °C	135 °C	149 °C	177 °C	204 °C
2	Flammability (Maximum Burn Time)	60 s	30 s	10 s	does not support combustion	does not ignite
3	Abrasion Resistance (Cycles to Wear-Through)	1000	3000	5000	8000	10 000
4	Stone Impingement (Cycles to Wear-Through)	2	3	4	5	6
5	Brittleness Temperature (Maximum Temperature With Retention of Impact)	-18 °C	-23 °C	-29 °C	-34 °C	-40 °C
6	Formability (Minimum Bend Radius)	4°	3°	2°	1°	3/4°
7	Springback (Maximum Degree of Relaxation After Thermal Cycling)	30 degrees	15 degrees	10 degrees	5 degrees	2 degrees
8	Burn-Through Resistance (Time to Pressure Loss)	1 min	1 min	2 min	3 min	5 min
9	Chemical Resistance (Maximum % Volume Change w/impact retention) Fluid (Concentration Time, Temperature)					
	1 Aggressive Water (5% 70 h 100 °C)	50	60	70	80	90
	2 Brake Fluid (100% 70 h 100 °C)	50	60	70	80	90
	3 Ethylene Glycol (50% 70 h 100 °C)	50	60	70	80	90
	4 Fuel C (100% 70 h 40 °C)	50	60	70	80	90
	5 #3 Oil (100% 70 h 100 °C)	50	60	70	80	90
	6 Transmission Oil (100% 70 h 100 °C)	50	60	70	80	90
	7 Water (100% 70 h 100 °C)	50	60	70	80	90
	8 Calcium Chloride (10% 70 h 40 °C)	50	60	70	80	90
	9 Ozone (50 pphm 70 h 40 °C)	50	60	70	80	90
	10 Sodium Chloride (10% 70 h 40 °C)	50	60	70	80	90
	11 Zinc Chloride (10% 70 h 40 °C)	50	60	70	80	90
	12 Zinc Chloride (50% 168 h 24 °C)	50	60	70	80	90
10	Insulation (Maximum External Temperature to Maintain 60 °C Internal Temp for 2 h)	66 °C	121 °C	177 °C	260 °C	538 °C
11	Ultraviolet Resistance (Resistance to Outdoor Weathering)	1250 kJ	2500 kJ			
12	Ozone Resistance	PASS				

TABLE 2—SAE J2027 PERFORMANCE REQUIREMENTS ELASTOMERIC AND PLASTIC COVERS

		A	B	C	D	E
1	Thermal Resistance (Maximum Continuous Exposure Temperature)	93 °C	121 °C	135 °C	149 °C	177 °C
2	Flammability (Maximum Burn Time)	60 s	30 s	10 s	does not support combustion	does not ignite
3	Abrasion Resistance (Cycles to Wear-Through)	1000	3000	5000	8000	10 000
4	Stone Impingement (Cycles to Wear-Through)	2	3	4	5	6
5	Brittleness Temperature (Maximum Temperature With Retention of Impact)	-18 °C	-23 °C	-29 °C	-34 °C	-40 °C
6	Formability (Minimum Bend Radius)	4°	3°	2°	1°	3/4°
7	Springback (Maximum Degree of Relaxation After Thermal Cycling)	30 degrees	15 degrees	10 degrees	5 degrees	2 degrees
8	Burn-Through Resistance (Time to Pressure Loss)	1 min	1 min	2 min	3 min	5 min
9	Chemical Resistance (Maximum % Volume Change w/impact retention)					
	Fluid (Concentration Time, Temperature)					
	1 Aggressive Water (5% 70 h 100 °C)	50	30	20	10	5
	2 Brake Fluid (100% 70 h 100 °C)	50	30	20	10	5
	3 Ethylene Glycol (50% 70 h 100 °C)	50	30	20	10	5
	4 Fuel C (100% 70 h 40 °C)	80	60	40	20	5
	5 #3 Oil (100% 70 h 100 °C)	100	50	30	15	5
	6 Transmission Oil (100% 70 h 100 °C)	50	40	30	20	10
	7 Water (100% 70 h 100 °C)	50	30	20	10	5
	8 Calcium Chloride (10% 70 h 40 °C)	must not dissolve cover ->				
	9 Ozone (50 ppm 70 h 40 °C)	no cracking ->				
	10 Sodium Chloride (10% 70 h 40 °C)	no cracking ->				
	11 Zinc Chloride (10% 70 h 40 °C)	no cracking ->				
	12 Zinc Chloride (50% 168 h 24 °C)	no cracking ->				
10	Insulation (Maximum External Temperature to Maintain 60 °C Internal Temp for 2 h)	66 °C	121 °C	177 °C	260 °C	538 °C
11	Ultraviolet Resistance (Resistance to Outdoor Weathering)	1250 kJ	2500 kJ			
12	Ozone Resistance	PASS				

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. Except where otherwise noted, complete fuel line tubing/cover assemblies are required for testing.

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

4.2 In testing wherein 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 Tables 1 and 2 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. 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. Fifty percent of initial ultimate tensile strength and elongation shall be retained after thermal exposure. Dimensional change in specimens shall be less than 1.0% in any direction.

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. Eighty percent of initial tensile strength shall be retained after thermal exposure. Dimensional change in specimens after thermal exposure shall be less than 1.0% in any direction.

5.2.2 FLAMMABILITY [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 exceed 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.

5.2.3 ABRASION RESISTANCE—Cover/tube assemblies shall resist wear-through of the cover for the specified number of cycles when tested in a reciprocating abrasion tester as described as follows:

The cover/tube assemblies shall be mounted in such a manner as to expose the cover to the surface of an abrasive cloth on a reciprocating abrasion tester [Figure 1]. A 200 grit emery cloth and a load of 100 g on the abraser shall be employed. The specimen shall be mounted in the holder and subjected to 1000 cycles of abrasion. A soft brush or compressed air shall be used to remove debris from the specimen, and it shall be visually examined. If the cover material has not worn through to the underlying substrate, the specimen shall be subjected to an additional 1000 cycles, and examined again. This process is repeated until the cover has worn through to the substrate. The value reported shall be the highest number of cycles undergone before wear-through was exhibited.

The load on the abraser shall consist of the weight of the emery cloth holder and any additional weight added to reach the desired levels. A cycle of abrasion shall consist of one full reciprocal move of the abraser [i.e., one full pass in each direction]. Distance of travel for the abraser shall be 4 in total. Test speed is 40 cycles per minute. The emery cloth is to be changed at every 1000 cycle examination point.

Note that many of the covers, especially nonelastomeric covers, may give off harmful dust during testing. The use of a vacuum attachment is strongly advised. Also, care shall be taken to ensure that the abrasive surfaces are kept free of debris during testing.

Elastomeric and nonelastomeric covers are tested in the same manner.

5.2.4 STONE-IMPINGEMENT RESISTANCE [REFERENCE ASTM D 3170]—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 ASTM D 3170, along with the specified 0.375 in/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 70 psi air pressure shall be considered one cycle. Failure is defined as wearing or cracking of the substrate in such a manner as to expose the tubing substrate. Cycles to failure shall be reported.

The gravelometer is to be maintained and testing performed in the conditioning chamber at test temperature. Where this is not possible, impingement is to begin with 15 s of 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.

5.2.5 BRITTLENESS TEMPERATURE—Covers shall not exhibit cracking when cover/tubing assemblies are subjected to a 2.0 ft-lb impact at specified temperature utilizing an impact test apparatus [Figure 2].

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. Where this is not possible, specimens are to be impacted within 15 s of removal from the conditioning chamber. Failure is defined as any through cracking of the cover. Deformation of the cover/tubing assembly is considered acceptable as long as there is no through cracking of the cover.

Assemblies are to be tested at a variety of cold temperatures. The value to be reported is the lowest temperature at which the cover passes the impact test. Elastomeric and nonelastomeric covers are tested in the same manner.

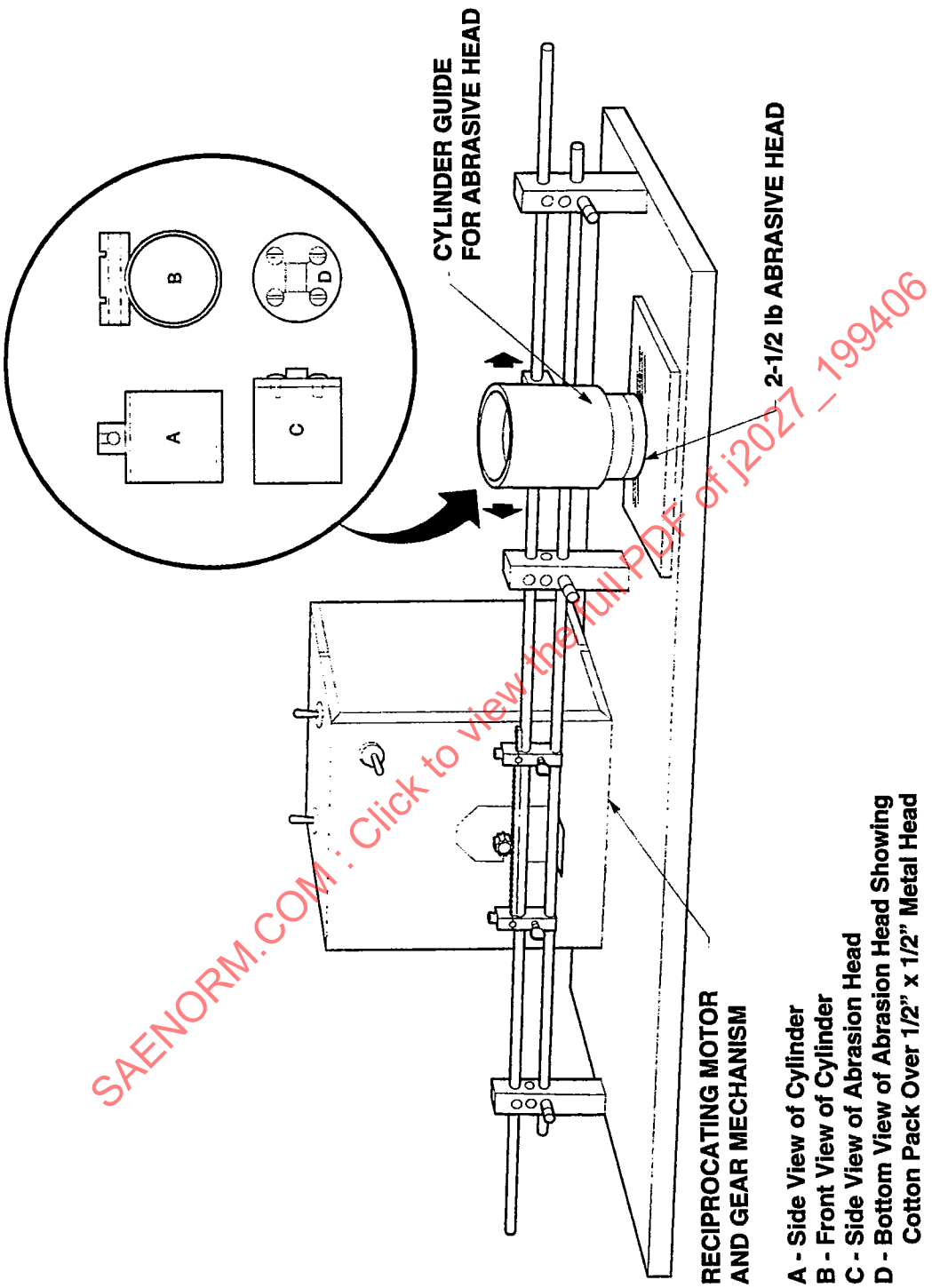

FIGURE 1—RECIPROCATING MOTION ABRASION TESTER

Nominal Tubing O D	W Slot Depth
1/8	0.156
1/4	0.28
5/16	0.343
3/8	0.41
1/2	0.53
5/8	0.66
3/4	0.78

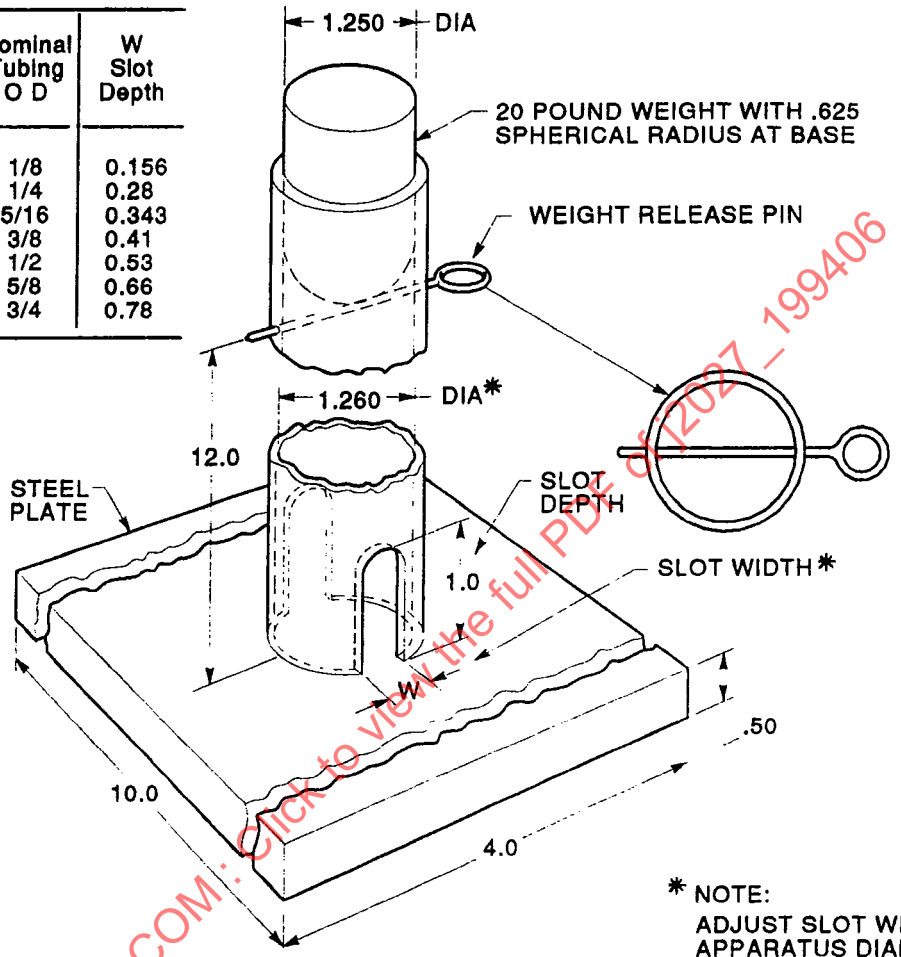

FIGURE 2—IMPACT TEST
2.0 ft-lb = 2.0 lb WEIGHT DROPPED 1 ft

5.2.6 FORMABILITY—Cover/tubing assemblies, when formed into 180 degree bends of the specified radius, shall permit a spherical steel ball of the required size to pass through the assembly. Strict adherence to normal manufacturing procedures must be maintained in forming the bends.

A number of assemblies 45.7 cm (18 in) in length shall be formed into 180 degree bends at the mid-length of the sample. A spherical steel ball with a minimum diameter of 78% of the minimum allowable inside-diameter of the tubing shall then be dropped into one end of the bent assembly. The assembly shall then be rotated in such a manner as to cause the ball to pass through the bend and come out of the other end of the sample. A number of progressively smaller bend radii should be tested. The result reported is the smallest bend radii that allows passage of the steel ball through the bent sample.

Elastomeric and nonelastomeric covers are tested in the same manner.

5.2.7 SPRINGBACK—Tubing/cover assemblies, when formed into a 180 degree bend and subjected to thermal cycling, shall not relax dimensionally by more than the specified number of degrees.

45.7 cm (18 in) long samples of tubing/cover assemblies are to be formed into 180 degree bends at their midpoint, with a bend radius of no greater than 4X the tubing internal diameter. Standard production forming procedures are to be strictly adhered to in forming these bends. Preformed samples, while laying flat and unrestrained, are then to be subjected to a thermal cycle consisting of 2 h at -29 °C, followed by 2 h at 82 °C. This cycle is to be repeated three times on each sample, followed by 24 h at room temperature. Change in bend angle following thermal cycling is to be recorded.

Elastomeric and nonelastomeric covers are tested in the same manner.

5.2.8 BURN-THROUGH RESISTANCE—Cover/tubing assemblies shall maintain internal pressure during flame impingement for the time period specified.

The cover/tubing assembly test specimen shall be mounted into test chamber [Figures 3A, 3B, 3C, 3D, 3E]. 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, and 35 kPa (5 psig) air pressure applied to the tubing. The fuel pan is filled with M85 [an 85/15 volume mixture of absolute methanol and Fuel C] and ignited. The timing device is activated simultaneously with ignition of the methanol. The timing device is stopped when the pressure in the tubing drops, indicating burn-through of the assembly. Extinguish the flames if no pressure loss has occurred after 300 s. The time to pressure loss is recorded.

Elastomeric and nonelastomeric covers are tested in the same manner.

5.2.8.1 Chemical Resistance [elastomeric]—[reference ASTM D 471 and ASTM D 1171]—Cover/tubing assemblies shall not exhibit significant loss of dimensional or mechanical stability when exposed to specified reagents. Dimensional stability is determined by volume expansion, and mechanical stability is determined by impact resistance.

Cover/tube assemblies 15.2 cm (6 in) in length are to be used as test specimens for impact after exposure. Cover stock specimens 2.54 cm in length (1 in) are to be used for volume expansion after exposure. The specimens immersed in the reagent for the specified time and temperature conditions. After the immersion period, the specimens are brought to equilibrium by a brief soak [normally 30 min] in fresh room temperature reagent. [Note—For those materials immersed at room temperature, the 30 min equilabration period is not necessary.] The specimens are then removed, blotted dry with filter paper, placed into the impact test apparatus described in performance test 5 of this document, and subjected to a 2 ft-lb impact at room temperature.

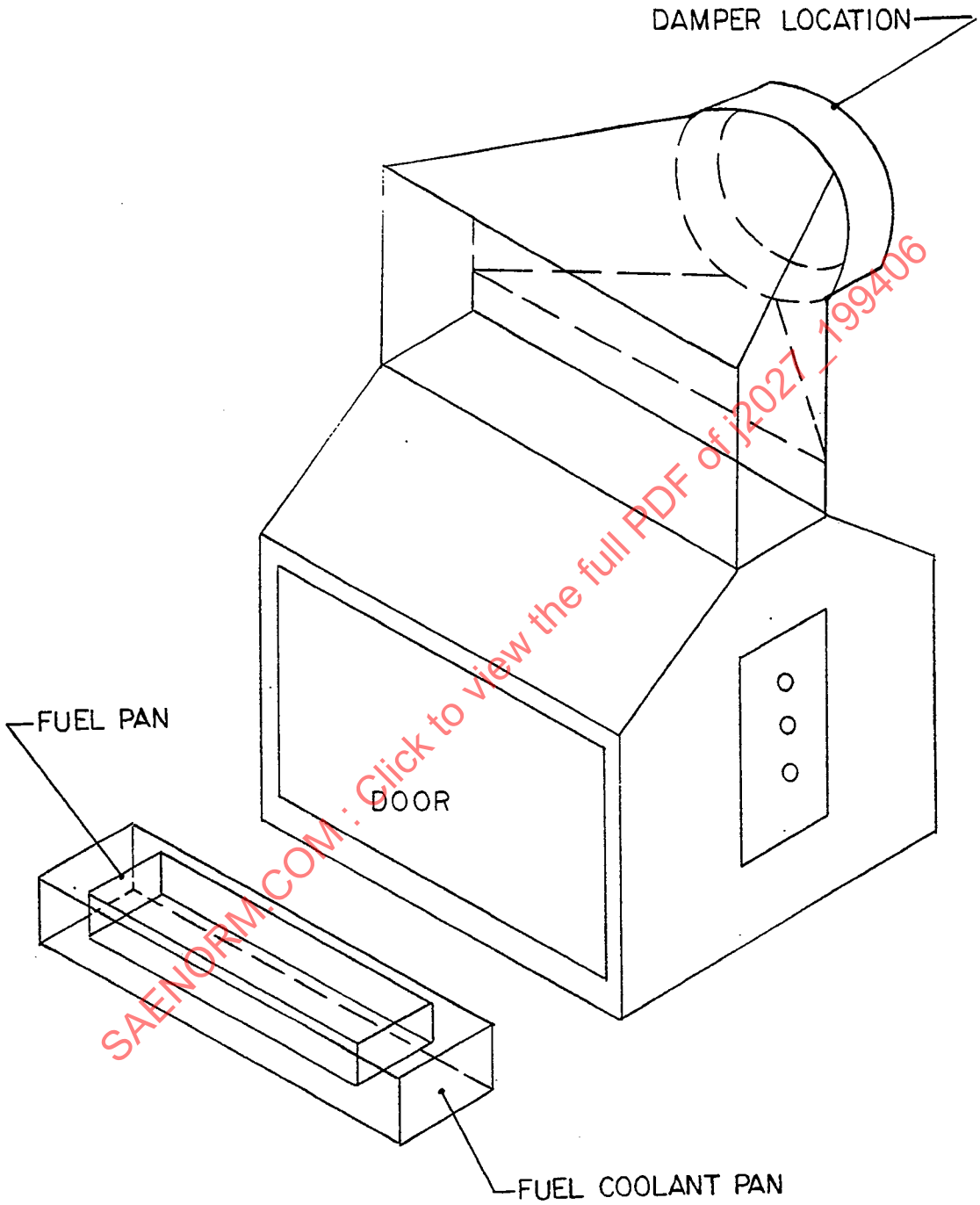

FIGURE 3A—FUEL LINE—FLAME TEST BOOTH

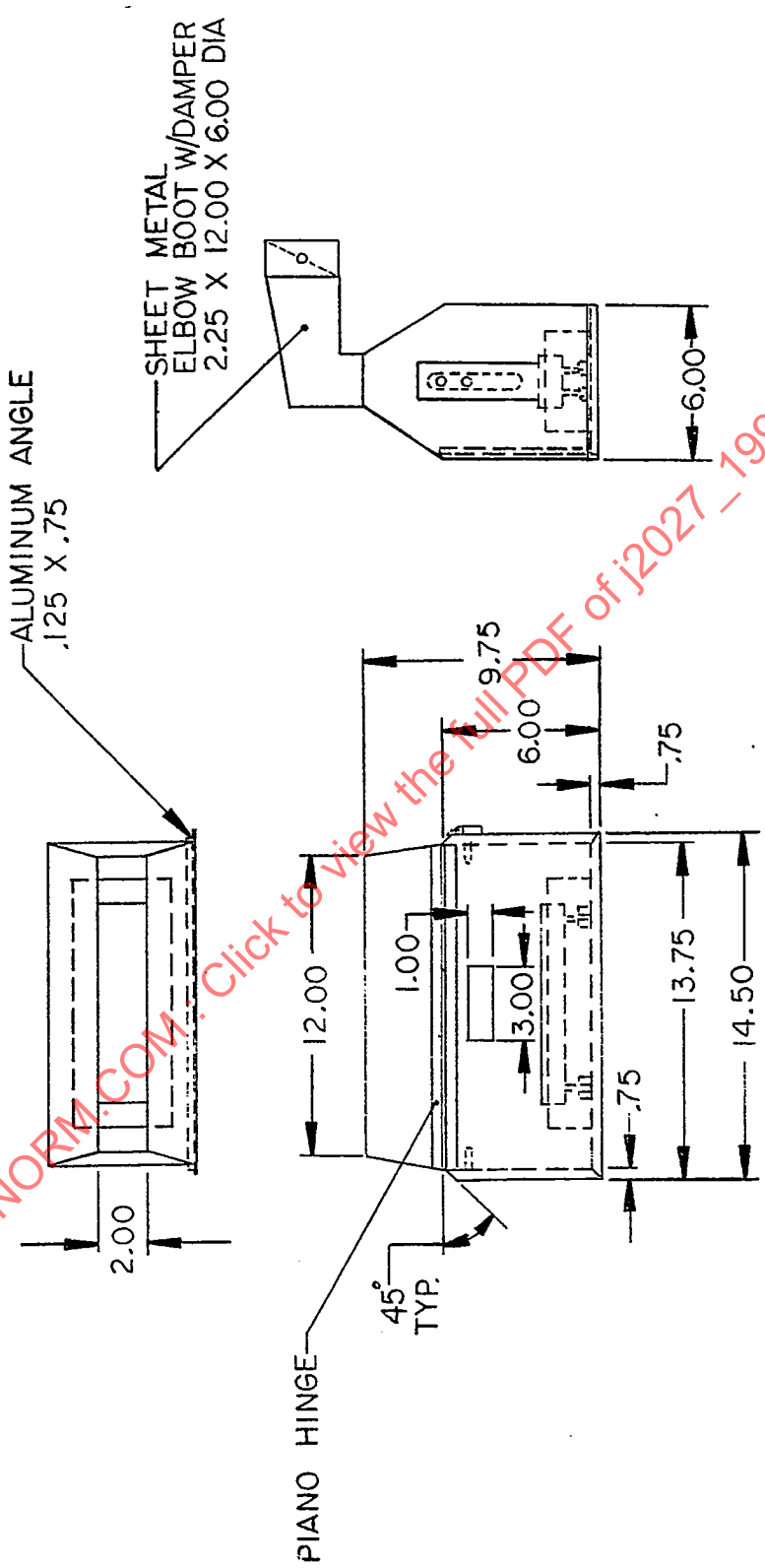

FIGURE 3B—FUEL LINE—FLAME TEST BOOTH

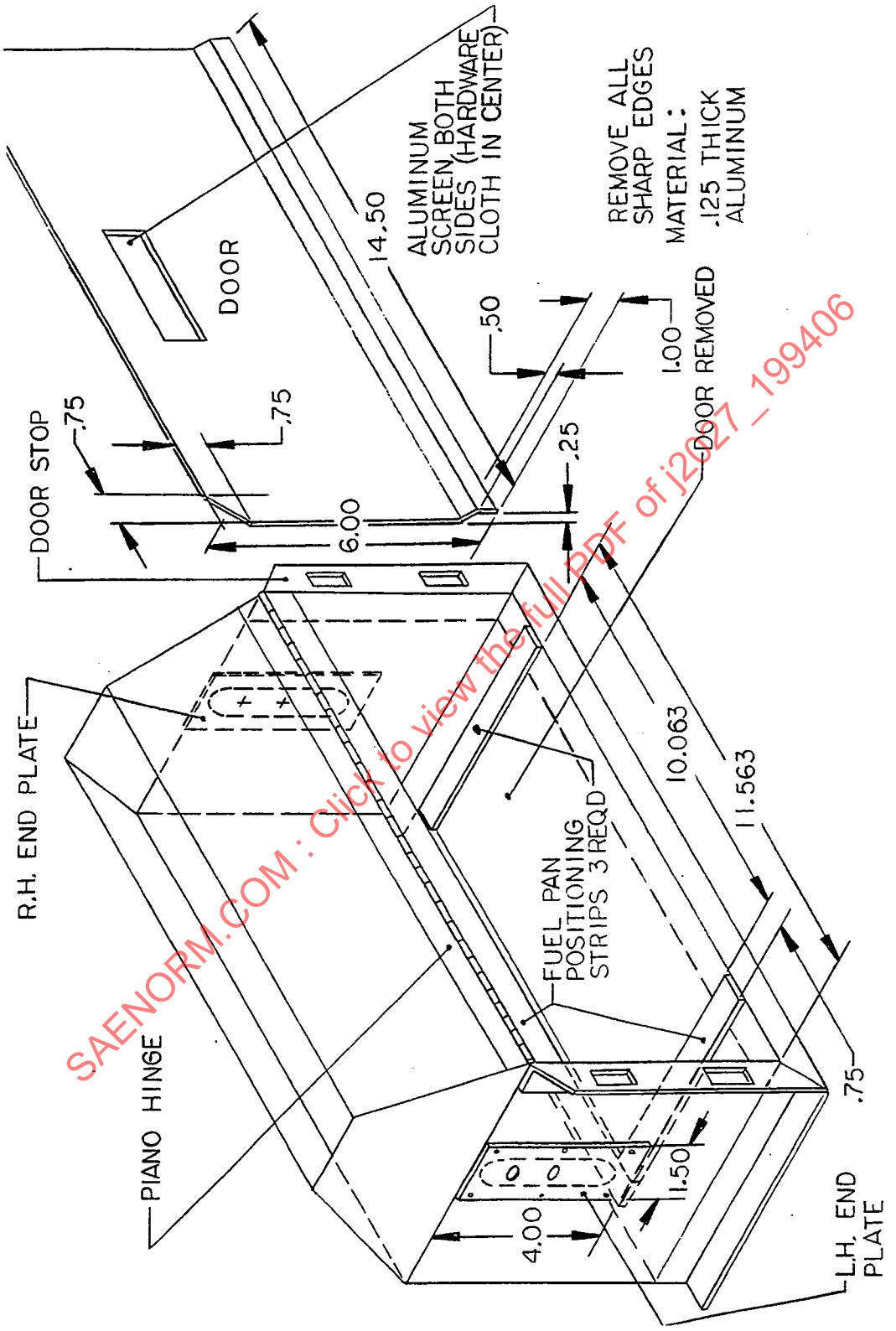

FIGURE 3C—FUEL LINE—FLAME TEST BOOTH

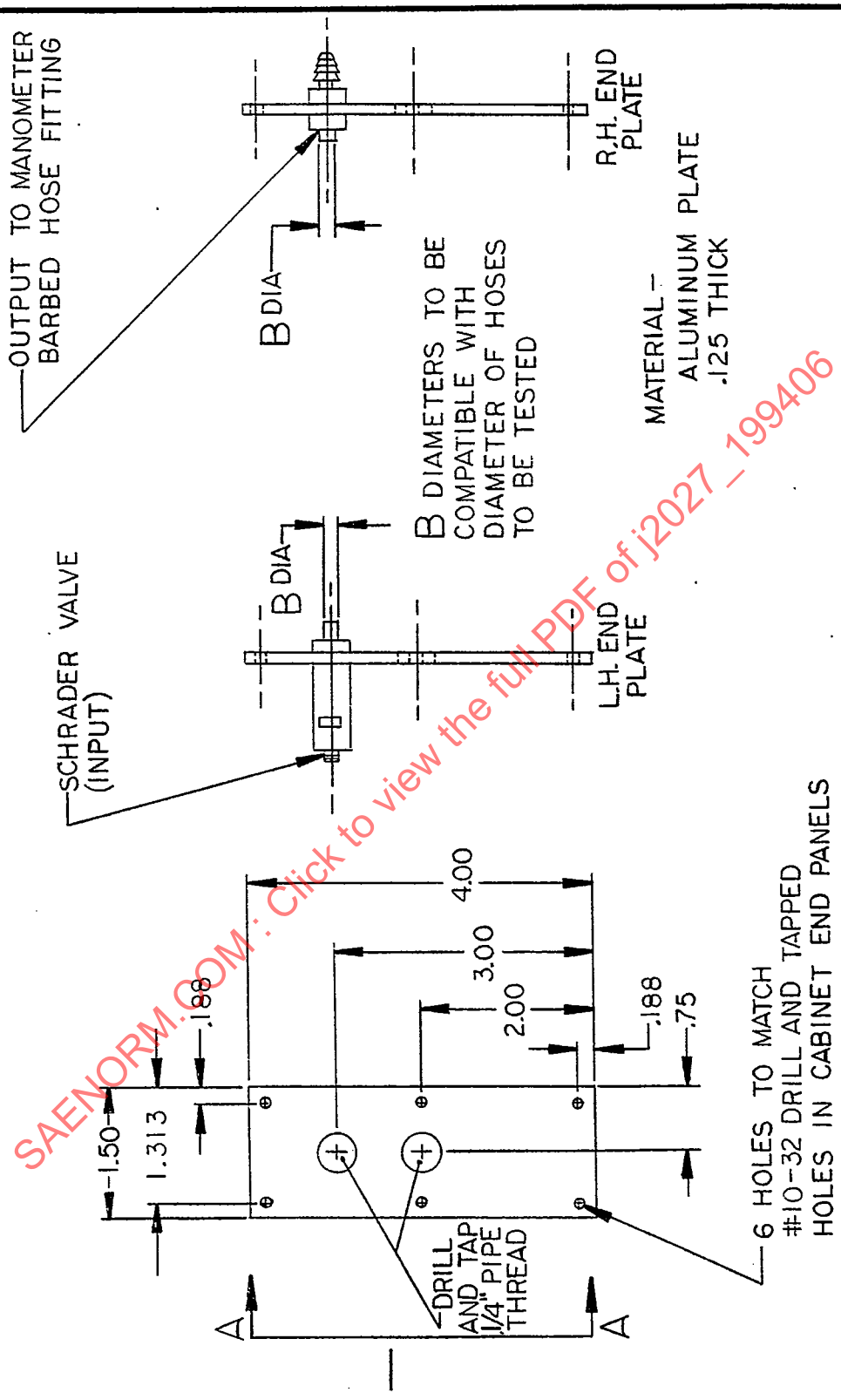

FIGURE 3D—FUEL LINE—FLAME TEST BOOTH END PLATES

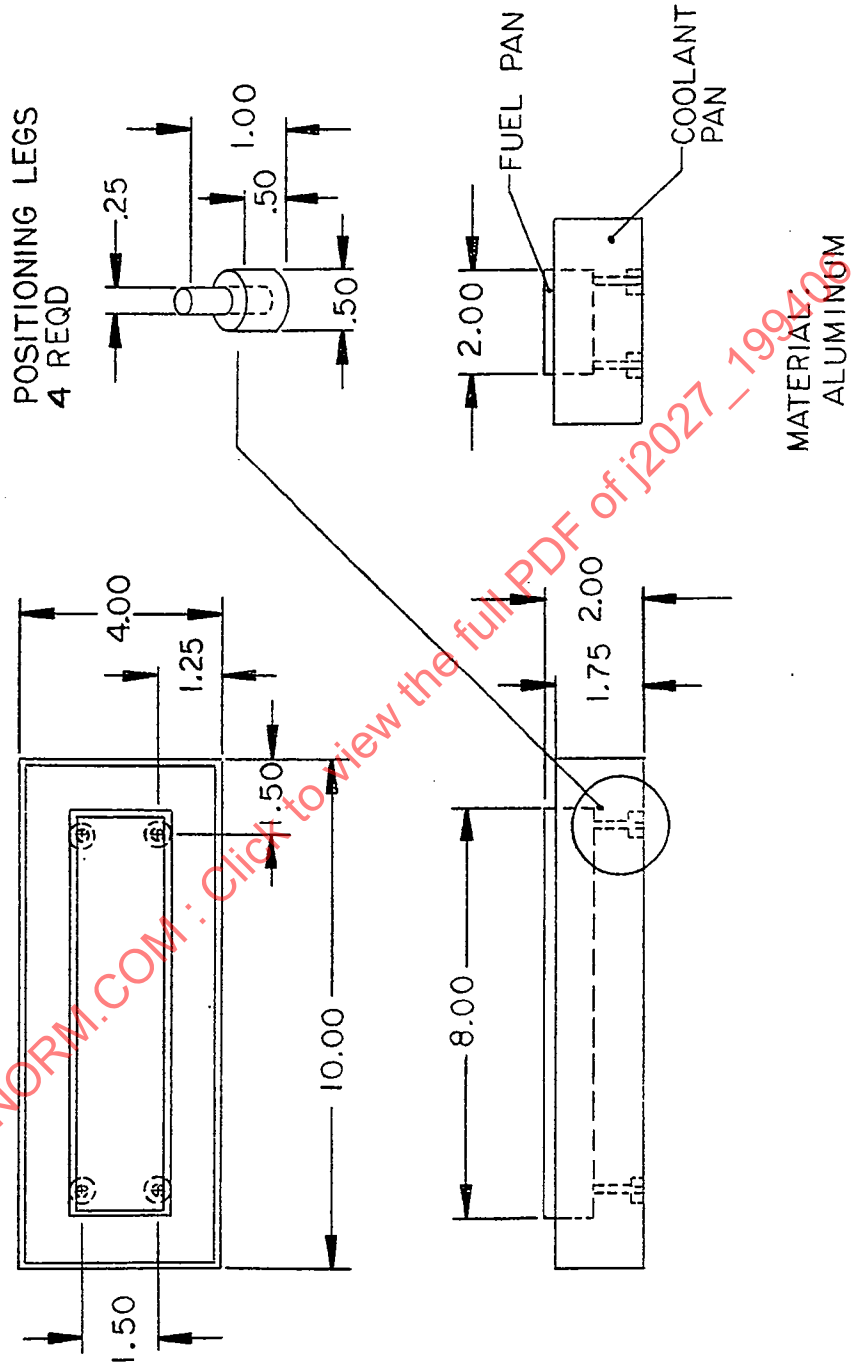

FIGURE 3E—FUEL LINE—FLAME TEST BOOTH
FUEL PAN—COOLANT PAN