



Transport Canada
Safety and Security

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Standards and Regulations Division

TECHNICAL STANDARDS DOCUMENT

No. 106, Revision 1

Brake Hoses

The text of this document is based on Federal Motor Vehicle Safety Standard No. 106, *Brake Hoses*, as published in the U.S. *Code of Federal Regulations*, Title 49, Part 571, revised as of October 1, 2006, as well as on the Final Rule published in the *Federal Register* on Tuesday, October 9, 2007 (Vol. 72, No. 194, p. 57450).

Effective Date: November 17, 2007
Mandatory Compliance Date: May 17, 2008

Standards Research and Development Branch
Road Safety and Motor Vehicle Regulation Directorate
TRANSPORT CANADA
Ottawa, Ontario
K1A 0N5

Technical Standards Document Number 106, Revision 1

Brake Hoses

(Ce document est aussi disponible en français.)

Introduction

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(Original signed by)

Director, Standards Research and Development
for the Minister of Transport,
Infrastructure and Communities
Ottawa, Ontario

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BRAKE HOSES

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S1. Scope

This Technical Standards Document (TSD) standard specifies labeling and performance requirements for motor vehicle brake hose, brake hose assemblies, and brake hose end fittings.

S2. Purpose

The purpose of this TSD standard is to reduce deaths and injuries occurring as a result of brake system failure from pressure or vacuum loss due to hose or hose assembly rupture.

S3. Application

[CONTENT DELETED] For applicability, see Schedule III and subsections 106(1) and (2) of Schedule IV to the *Motor Vehicle Safety Regulations*.

S4. Definitions

Armor means protective material installed on a brake hose to increase the resistance of the hose or hose assembly to abrasion or impact damage. (*Armure*)

Brake hose means a flexible conduit, other than a vacuum tubing connector, manufactured for use in a brake system to transmit or contain the fluid pressure or vacuum used to apply force to a vehicle's brakes. For a hose, a dimensional description such as "1/4-inch hose" refers to the nominal inside diameter. For tubing, a dimensional description such as "1/4-in tubing" refers to the nominal outside diameter. (*Boyaux de frein*)

Brake hose assembly means a brake hose, with or without armor, equipped with end fittings for use in a brake system, but does not include an air or vacuum assembly prepared by the owner or operator of a used vehicle, by his employee, or by a repair facility, for installation in that used vehicle. (*Ensemble de boyaux de frein*)

Brake hose end fitting means a coupler, other than a clamp, designed for attachment to the end of a brake hose. (*Raccord d'extrémité de boyaux de frein*)

Free length means the linear measurement of hose exposed between the end fittings of a hose assembly in a straight position. (*Longueur libre*)

Permanently attached end fitting means an end fitting that is attached by deformation of the fitting about the hose by crimping or swaging, or an end fitting that is attached by the use of a sacrificial sleeve or ferrule that requires replacement each time a hose assembly is rebuilt. (*Raccord d'extrémité de boyau fixé en permanence*)

Preformed means a brake hose that is manufactured with permanent bends and is shaped to fit a specific vehicle without further bending. (*Préformé*)

Rupture means any failure that results in the separation of a brake hose from its end fitting or in leakage. (*Rupture*)

Vacuum tubing connector means a flexible conduit of vacuum that (i) connects metal tubing to metal tubing in a brake system, (ii) is attached without end fittings, and (iii) when installed, has an unsupported length less than the total length of those portions that cover the metal tubing. (*Raccord de tuyau à vide*)

S5. Requirements — Hydraulic brake hose, brake hose assemblies, and brake hose end fittings

S5.1 Construction

- (a) Each hydraulic brake hose assembly shall have permanently attached brake hose end fittings which are attached by deformation of the fitting about the hose by crimping or swaging.
- (b) [CONTENT DELETED]

S5.2 Labeling

S5.2.1 [CONTENT DELETED]

S5.2.2 [CONTENT DELETED]

S5.2.3 [CONTENT DELETED]

S5.2.4 [CONTENT DELETED]

S5.2.4.1 At least one end fitting of a hydraulic brake hose assembly shall be etched, stamped or embossed with a designation at least 1.6 mm (one-sixteenth of an inch) high that identifies the manufacturer of the hose assembly ~~and is filed in accordance with S5.2.4(b).~~

S5.3 Test requirements

A hydraulic brake hose assembly or appropriate part thereof shall be capable of meeting any of the requirements set forth under this heading, when tested under the conditions of S13 and the applicable procedures of S6. However, a particular hose assembly or appropriate part thereof need not meet further requirements after having been subjected to and having met the

constriction requirement (S5.3.1) and any one of the requirements specified in S5.3.2 through S5.3.13.

S5.3.1 Constriction. Except for that part of an end fitting which does not contain hose, every inside diameter of any section of a hydraulic brake hose assembly shall be not less than 64 percent of the nominal inside diameter of the brake hose. (S6.12)

S5.3.2 Expansion and burst strength. The maximum expansion of a hydraulic brake hose assembly at 6 895 kPa (1,000 psi), 10 342 kPa (1,500 psi), and 19 995 kPa (2,900 psi) shall not exceed the values specified in Table I (S6.1), except that a brake hose larger than 3/16 inch or 5 mm is not subject to the 19 995 kPa (2,900 psi) expansion test requirements. The hydraulic brake hose assembly shall then withstand water pressure of 27 579 kPa (4,000 psi) for 2 minutes without rupture, and shall not rupture at less than 48 263 kPa (7,000 psi) for a 1/8 inch, 3 mm, or smaller diameter hose, or at less than 34 474 kPa (5,000 psi) for a hose with a diameter larger than 1/8 inch or 3 mm. (S6.2)

Table I — Maximum Expansion of Free Length of Brake Hose, mL/m (cc/ft.)

Hydraulic Brake Hose, Inside Diameter	Test Pressure					
	<u>6 895 kPa</u> (1,000 psi)		<u>10 342 kPa</u> (1,500 psi)		<u>19 995 kPa</u> (2,900 psi)	
	Regular Expansion Hose	Low Expansion Hose	Regular Expansion Hose	Low Expansion Hose	Regular Expansion Hose	Low Expansion Hose
<u>1/8 inch, or 3 mm, or less</u>	<u>2.17</u> (0.66)	<u>1.08</u> (0.33)	<u>2.59</u> (0.79)	<u>1.38</u> (0.42)	<u>3.97</u> (1.21)	<u>2.00</u> (0.61)
<u>> 1/8 inch, or 3 mm, to 3/16 inch, or 5 mm</u>	<u>2.82</u> (0.86)	<u>1.80</u> (0.55)	<u>3.35</u> (1.02)	<u>2.36</u> (0.72)	<u>5.48</u> (1.67)	<u>2.99</u> (0.91)
<u>> 3/16 inch or 5 mm</u>	<u>3.41</u> (1.04)	<u>2.69</u> (0.82)	<u>4.27</u> (1.30)	<u>3.84</u> (1.17)	--	--

S5.3.3 Whip resistance. A hydraulic brake hose assembly shall not rupture when run continuously on a whip test flexing machine for 35 hours. (S6.3)

S5.3.4 Tensile strength. A hydraulic brake hose assembly shall withstand a pull of 1 446 N (325 pounds) without separation of the hose from its end fittings during a slow pull test, and shall withstand a pull of 1 646 N (370 pounds) without separation of the hose from its end fittings during a fast pull test. (S6.4)

S5.3.5 Water absorption and burst strength. A hydraulic brake hose assembly, after immersion in water for 70 hours (S6.5), shall withstand water pressure of 27 579 kPa (4,000 psi) for 2 minutes, and then shall not rupture at less than 34 474 kPa (5,000 psi). (S6.2)

S5.3.6 Water absorption and tensile strength. A hydraulic brake hose assembly, after immersion in water for 70 hours (S6.5), shall withstand a pull of 1 446 N (325 pounds)

without separation of the hose from its end fittings during a slow pull test, and shall withstand a pull of 1 646 N (370 pounds) without separation of the hose from its end fittings during a fast pull test. (S6.4)

S5.3.7 Water absorption and whip resistance. A hydraulic brake hose assembly, after immersion in water for 70 hours (S6.5), shall not rupture when run continuously on a whip test flexing machine for 35 hours. (S6.3)

S5.3.8 Low-temperature resistance. A hydraulic brake hose conditioned at a temperature between -45°C (-49°F) and -48°C (-54°F) for 70 hours shall not show cracks visible without magnification when bent around a cylinder as specified in S6.6. (S6.6)

S5.3.9 Brake fluid compatibility, constriction, and burst strength. Except for brake hose assemblies designed for use with mineral or petroleum-based brake fluids, a hydraulic brake hose assembly shall meet the constriction requirement of S5.3.1 after having been subjected to a temperature of 120°C (248°F) for 70 hours while filled with SAE RM-66-04 Compatibility Fluid, as described in Appendix B of SAE Standard J1703, revised JAN 1995, *Motor Vehicle Brake Fluid*. [SENTENCE DELETED] Copies may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001. [TWO SENTENCES DELETED] It shall then withstand water pressure of 27 579 kPa (4,000 psi) for 2 minutes and thereafter shall not rupture at less than 34 474 kPa (5,000 psi) (S6.2 except all sizes of hose are tested at 34 474 kPa [5,000 psi]).

S5.3.10 Ozone resistance. A hydraulic brake hose shall not show cracks visible under 7-power magnification after exposure to ozone for 70 hours at 40°C (104°F). (S6.8)

S5.3.11 Dynamic ozone test. A hydraulic brake hose shall not show cracks visible without magnification after having been subjected to a 48-hour dynamic ozone test. (S6.9)

S5.3.12 High temperature impulse test. A brake hose assembly tested under the conditions in S6.10:

- (a) Shall withstand pressure cycling for 150 cycles at 146°C (295°F) without leakage;
- (b) Shall not rupture during a 2-minute, 27 579 kPa (4,000 psi) pressure hold test, and;
- (c) Shall not burst at a pressure less than 34 474 kPa (5,000 psi).

S5.3.13 End fitting corrosion resistance. After 24 hours of exposure to salt spray, a hydraulic brake hose end fitting shall show no base metal corrosion on the end fitting surface, except where crimping or the application of labeling information has caused displacement of the protective coating. (S6.11)

S6. Test procedures — Hydraulic brake hose, brake hose assemblies, and brake hose end fittings

S6.1 Expansion test

S6.1.1 Apparatus. Utilize a test apparatus (as shown in Figure 1) which consists of:

- (a) Source for required fluid pressure;
- (b) Test fluid of water without any additives and free of gases;

- (c) Reservoir for test fluid;
- (d) Pressure gauges;
- (e) Brake hose end fittings in which to mount the hose vertically; and
- (f) Graduated burette with 0.05 mL (0.05 cc) increments.

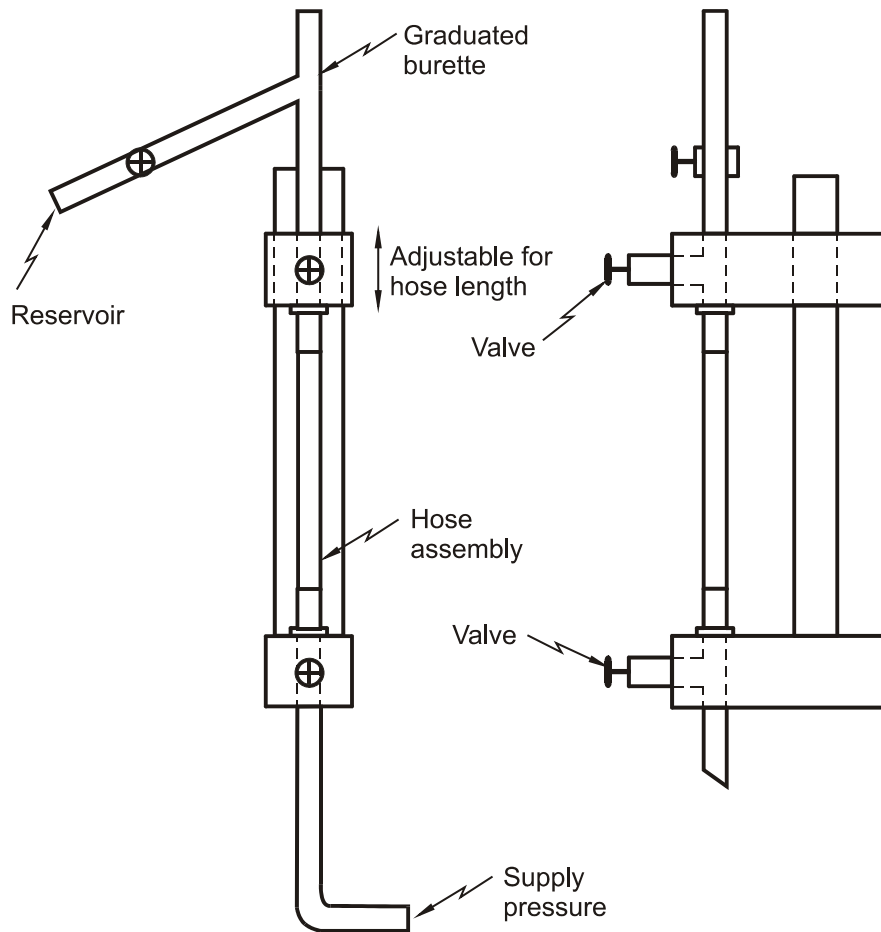


Figure 1 — Expansion Test Apparatus

S6.1.2 Preparation

- (a) Measure the free length of the hose assembly.
- (b) Mount the hose so that it is in a vertical, straight position without tension when pressure is applied.
- (c) Fill the hose with test fluid and bleed all gases from the system.
- (d) Close the valve to the burette and apply 10 342 kPa (1,500 psi) for 10 seconds; then release pressure.

S6.1.3 Calculation of expansion at 6 895 kPa (1,000 psi), 10 342 kPa (1,500 psi), and 19 995 kPa (2,900 psi)

- (a) Adjust the fluid level in the burette to zero.
- (b) Close the valve to the burette, apply pressure at the rate of 103 421 kPa (15,000 psi) per minute, and seal 6 895 kPa (1,000 psi) in the hose (10 342 kPa [1,500 psi] in the second series and 19 995 kPa [2,900 psi] in the third series).
- (c) After 3 seconds, open the valve to the burette for 10 seconds and allow the fluid in the expanded hose to rise into the burette.
- (d) Repeat the procedure in steps (b) and (c) twice. Measure the amount of test fluid which has accumulated in the burette as a result of the three applications of pressure.
- (e) Calculate the volumetric expansion per metre (foot) by dividing the total accumulated test fluid by 3 and further dividing by the free length of the hose in metres (feet).

S6.2 Burst strength test

- (a) Connect the brake hose to a pressure system and fill it completely with water, allowing all gases to escape.
- (b) Apply water pressure of 27 579 kPa (4,000 psi) at a rate of 103 421 kPa (15,000 psi) per minute.
- (c) After 2 minutes at 27 579 kPa (4,000 psi), increase the pressure at the rate of 103 421 kPa (15,000 psi) per minute until the pressure exceeds 34 474 kPa (5,000 psi) for a brake hose larger than $\frac{1}{8}$ inch or 3 mm in diameter, or until the pressure exceeds 48 263 kPa (7,000 psi) for a brake hose of $\frac{1}{8}$ inch, 3 mm, or smaller in diameter.

S6.3 Whip resistance test**S6.3.1 Apparatus.** Utilize a test apparatus that is dynamically balanced and includes:

- (a) A movable header consisting of a horizontal bar equipped with capped end fittings and mounted through bearings at each end to points 101.6 mm (4 inches) from the center of two vertically rotating disks whose edges are in the same vertical plane;
- (b) An adjustable stationary header parallel to the movable header in the same horizontal plane as the centers of the disks, and fitted with open end fittings;
- (c) An elapsed time indicator; and
- (d) A source of water pressure connected to the open end fittings.

S6.3.2 Preparation

- (a) Except for the supplemental support specified in S6.3.2(d), remove all external appendages including, but not limited to, hose armor, chafing collars, mounting brackets, date band, and spring guards.
- (b) Measure the hose free length.

- (c) Mount the hose in the whip test machine, introducing slack as specified in Table II for the size of hose to be tested, measuring the projected length parallel to the axis of the rotating disks. The manufacturer may, at his option, adapt the fitting attachment points to permit the mounting of hose assemblies equipped with angled or other special fittings in the same orientation as hose assemblies equipped with straight fittings.
- (d) In the case of a brake hose assembly equipped with a permanent supplemental support integrally attached to the assembly, the assembly may be mounted using the supplemental support and associated means of simulating its attachment to the vehicle. Mount the supplemental support in the same vertical and horizontal planes as the stationary header end of the whip test fixture described in S6.3.1(b). Mount or attach the supplemental support so that it is positioned in accordance with the recommendation of the assembly manufacturer for attaching the supplemental support on a vehicle.

Table II — Hose Lengths

Free length between end fittings, mm (inches)	Slack, mm (inches)	
	Hose of 3 mm ($\frac{1}{8}$ inch) or less	Hose of more than 3 mm ($\frac{1}{8}$ inch)
203.2 to 393.7 (8 to 15½), inclusive	44.45 (1.75)	
254 to 393.7 (10 to 15½), inclusive		25.4 (1.0)
Over 393.7 to 482.6 (15½ to 19), inclusive	31.75 (1.25)	
Over 482.6 to 609.6 (19 to 24), inclusive	19.05 (0.75)	

S6.3.3 Operation

- (a) Apply 1 620 kPa (235 psi) water pressure and bleed all gases from the system.
- (b) Drive the movable head at 800 rpm.

S6.4 Tensile strength test

Utilize a tension testing machine conforming to the requirements of American Society for Testing and Materials (ASTM) E 4-03, *Standard Practices for Force Verification of Testing Machines*, and provided with a recording device to measure the force applied. [SENTENCE DELETED] Copies may be obtained from the American Society for Testing and Materials (ASTM) International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959. [TWO SENTENCES DELETED]

S6.4.1 Preparation. Mount the hose assembly to ensure a straight, evenly distributed machine pull.

S6.4.2 Operation

- (a) Conduct the slow pull test by applying tension at a rate of 25.4 mm (1 inch) per minute of travel of the moving head until separation occurs.
- (b) Conduct the fast pull test by applying tension at a rate of 50.8 mm (2 inches) per minute of travel of the moving head until separation occurs.

S6.5 Water absorption sequence tests

- (a) Prepare three brake hose assemblies and measure the free length of the hose assemblies.
- (b) Immerse the brake hose assemblies in distilled water at 85°C (185°F) for 70 hours. Remove the brake hose assemblies from the water and condition in air at room temperature for 30 minutes.
- (c) Conduct the tests in S6.2, S6.3, and S6.4 using a different hose for each sequence.

S6.6 Low temperature resistance test**S6.6.1 Preparation**

- (a) Remove hose armor, if any, and condition the hose in a straight position in air at a temperature between -45°C and -48°C (-49°F and -54°F) for 70 hours.
- (b) Condition a cylinder in air at a temperature between -45°C and -48°C (-49°F and -54°F) for 70 hours, using a cylinder of 63.5 mm (2½ inches) in diameter for tests of hose less than ⅛ inch or 3 mm, 76.2 mm (3 inches) in diameter for tests of ⅛-inch or 3-mm hose, 88.9 mm (3½ inches) in diameter for tests of 3/16- to ¼-inch hose or 4-mm to 6-mm hose, and 101.6 mm (4 inches) in diameter for tests of hose greater than ¼ inch or 6 mm in diameter.

S6.6.2 Flexibility testing. Bend the conditioned hose 180 degrees around the conditioned cylinder at a steady rate in a period of 3 to 5 seconds. Examine without magnification for cracks.

S6.7 Brake fluid compatibility test**S6.7.1 Preparation**

- (a) Attach a hose assembly below a 0.473-L (1-pint) reservoir filled with 100 mL of SAE RM-66-04 Compatibility Fluid as shown in Figure 2. [SENTENCE DELETED]
- (b) Fill the hose assembly with brake fluid, seal the lower end, and place the test assembly in an oven in a vertical position.

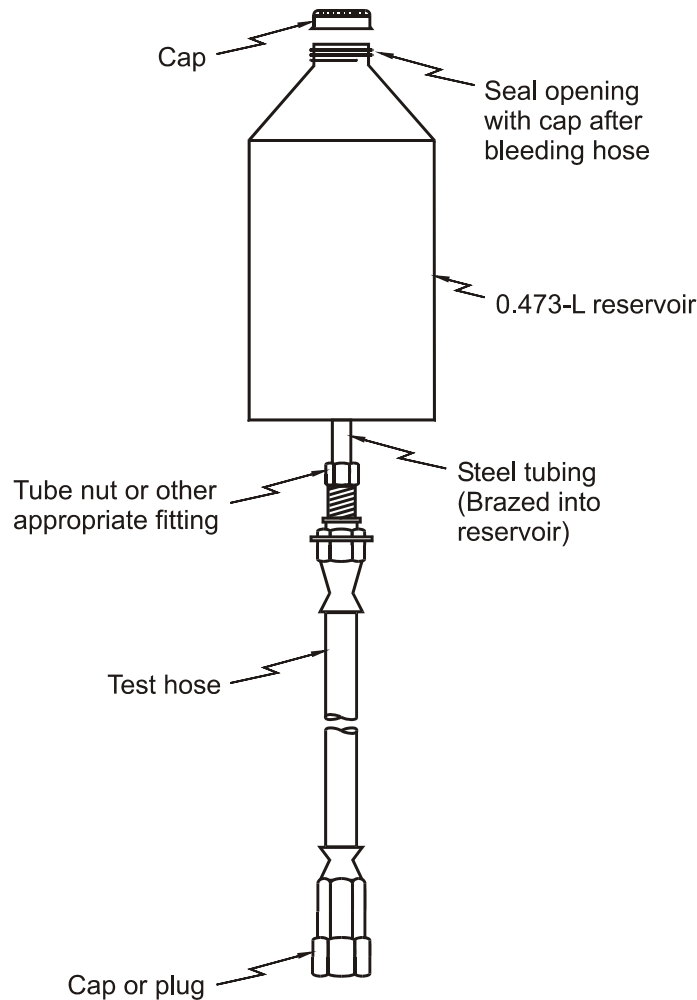


Figure 2 — Brake Fluid Compatibility Apparatus

S6.7.2 Oven treatment

- (a) Condition the hose assembly at 93.3°C (200°F) for 70 hours.
- (b) Cool the hose assembly at room temperature for 30 minutes.
- (c) Drain the brake hose assembly, immediately determine that every inside diameter of any section of the hose assembly, except for that part of an end fitting which does not contain hose, is not less than 64 percent of the nominal inside diameter of the hose, and conduct the test specified in S6.2.

S6.8 Ozone resistance test

Utilize a cylinder with a diameter eight times the nominal outside diameter of the brake hose, excluding armor.

S6.8.1 Preparation. After removing any armor, bind a hydraulic brake hose 360° around the cylinder. In the case of hose shorter than the circumference of the cylinder, bend the hose so that as much of its length as possible is in contact.

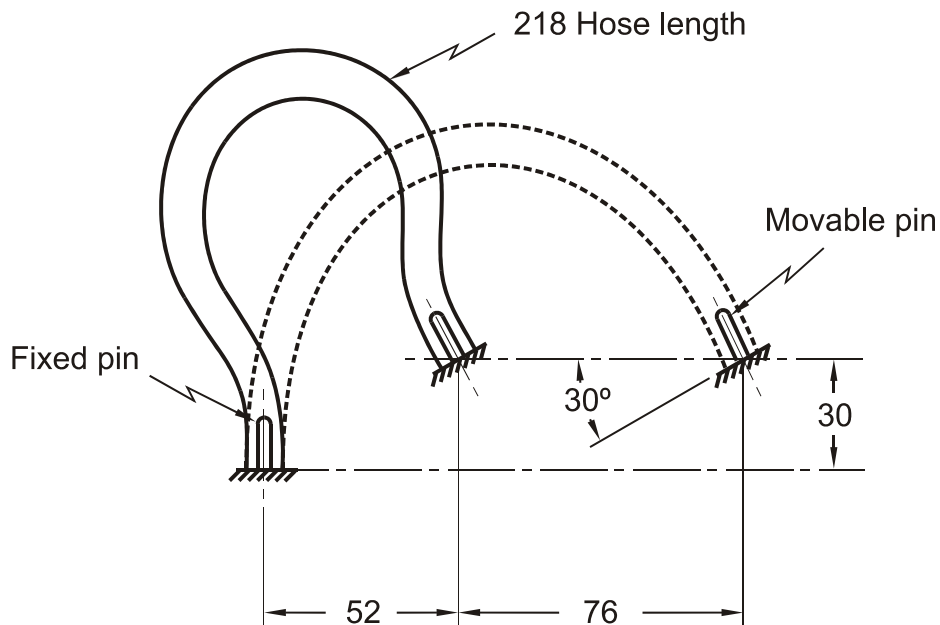
S6.8.2 Exposure to ozone

- (a) Condition the hose on the cylinder in air at room temperature for 24 hours.
- (b) Immediately thereafter, condition the hose on the cylinder for 70 hours in an exposure chamber having an ambient air temperature of 40°C (104°F) during the test and containing air mixed with ozone in the proportion of 100 parts of ozone per 100 million parts of air by volume.
- (c) Examine the hose for cracks under 7-power magnification, ignoring areas immediately adjacent to or within the area covered by binding.

S6.9 Dynamic ozone test

S6.9.1 Apparatus. Utilize a test apparatus shown in Figure 3 which is constructed so that:

- (a) It has a fixed pin with a vertical orientation over which one end of the brake hose is installed.
- (b) It has a movable pin that is oriented 30 degrees from the vertical, with the top of the movable pin angled towards the fixed pin. The movable pin maintains its orientation to the fixed pin throughout its travel in the horizontal plane. The other end of the brake hose is installed on the movable pin.



Notes:

1. Dimensions in mm
2. Not to scale

Figure 3 — Dynamic Ozone Test Apparatus

S6.9.2 Preparation

- (a) Precondition the hose assembly by laying it on a flat surface in an unstressed condition, at room temperature, for 24 hours.
- (b) Cut the brake hose assembly to a length of 218 mm (8.6 inches), such that no end fittings remain on the cut hose.
- (c) Mount the brake hose onto the test fixture by fully inserting the fixture pins into each end of the hose. Secure the hose to the fixture pins using a band clamp at each end of the hose.
- (d) Place the test fixture in an ozone chamber.
- (e) Stabilize the atmosphere in the ozone chamber so that the ambient temperature is 40°C (104°F) and the air mixture contains air mixed with ozone in the proportion of 100 parts of ozone per 100 million parts of air by volume. This atmosphere is to remain stable throughout the remainder of the test.
- (f) Begin cycling the movable pin at a rate of 0.3 Hz. Continue the cycling for 48 hours.
- (g) At the completion of 48 hours of cycling, remove the test fixture from the ozone chamber. Without removing the hose from the test fixture, visually examine the hose for cracks without magnification, ignoring areas immediately adjacent to or within the area covered by the band clamps. Examine the hose with the movable pin at any point along its travel.

S6.10 High temperature impulse test

S6.10.1 Apparatus

- (a) A pressure cycling machine to which one end of the brake hose assembly can be attached, with the entire hose assembly installed vertically inside a circulating air oven. The machine shall be capable of increasing the pressure in the hose from zero kPa (psi) to 11 032 kPa (1,600 psi), and decreasing the pressure in the hose from 11 032 kPa (1,600 psi) to zero kPa (psi), within 2 seconds.
- (b) A circulating air oven that can reach a temperature of 146°C (295°F) within 30 minutes, and that can maintain a constant 146°C (295°F) thereafter, with the brake hose assembly inside the oven and attached to the pressure cycling machine.
- (c) A burst test apparatus to conduct the testing specified in S6.2.

S6.10.2 Preparation

- (a) Connect one end of the hose assembly to the pressure cycling machine and plug the other end of the hose. Fill the pressure cycling machine and hose assembly with SAE RM-66-04 Compatibility Fluid, as described in Appendix B of SAE Standard J1703, revised JAN 1995, *Motor Vehicle Brake Fluid*, and bleed all gases from the system.
- (b) Place the brake hose assembly inside the circulating air oven in a vertical position. Increase the oven temperature to 146°C (295°F) and maintain this temperature throughout the pressure cycling test.

- (c) During each pressure cycle, the pressure in the hose is increased from zero kPa (psi) to 11 032 kPa (1,600 psi) and held constant for 1 minute, then the pressure is decreased from 11 032 kPa (1,600 psi) to zero kPa (psi) and held constant for 1 minute. Perform 150 pressure cycles on the brake hose assembly.
- (d) Remove the brake hose assembly from the oven, disconnect it from the pressure cycling machine, and drain the fluid from the hose. Cool the brake hose assembly at room temperature for 45 minutes.
- (e) Wipe the brake hose using acetone to remove residual Compatibility Fluid. Conduct the burst strength test in S6.2, except all sizes of hose are tested at 34 474 kPa (5,000 psi).

S6.11 End fitting corrosion test

Utilize the apparatus described in ASTM B 117-03, *Standard Practice for Operating Salt Spray (Fog) Apparatus*. [SENTENCE DELETED] Copies may be obtained from the American Society for Testing and Materials (ASTM) International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959. [TWO SENTENCES DELETED].

S6.11.1 Construction. Construct the salt spray chamber so that:

- (a) The construction material does not affect the corrosiveness of the fog.
- (b) The hose assembly is supported or suspended 30 degrees from the vertical and parallel to the principal direction of the horizontal flow of fog through the chamber.
- (c) The hose assembly does not contact any metallic material or any material capable of acting as a wick.
- (d) Condensation which falls from the assembly does not return to the solution reservoir for respraying.
- (e) Condensation from any source does not fall on the brake hose assemblies or the solution collectors.
- (f) Spray from the nozzles is not directed onto the hose assembly.

S6.11.2 Preparation

- (a) Plug each end of the hose assembly.
- (b) Mix a salt solution five parts by weight of sodium chloride to 95 parts of distilled water, using sodium chloride substantially free of nickel and copper, and containing on a dry basis not more than 0.1 percent of sodium iodide and not more than 0.3 percent total impurities. Ensure that the solution is free of suspended solids before the solution is atomized.
- (c) After atomization at 35°C (95°F), ensure that the collected solution is in the pH range of 6.5 to 7.2. Make the pH measurements at 28°C (77°F).
- (d) Maintain a compressed air supply to the nozzle or nozzles free of oil and dirt and between 68.9 and 172.4 kPa (10 and 25 psi).

S6.11.3 Operation. Subject the brake hose assembly to the salt spray continuously for 24 hours.

- (a) Regulate the mixture so that each collector will collect from 1 to 2 mL of solution per hour for each 80 cm² of horizontal collecting area.
- (b) Maintain exposure zone temperature at 35°C (95°F).
- (c) Upon completion, remove the salt deposit from the surface of the hose by washing gently or dipping in clean running water not warmer than 38°C (100°F) and then drying immediately.

S6.12 Constriction test

Brake hose constriction test requirements shall be met using at least one of the methods specified in S6.12.1, S6.12.2, or S6.12.3.

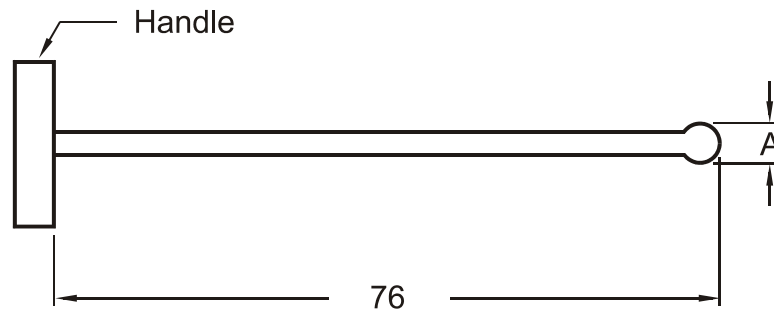
S6.12.1 Plug gauge

- (a) Utilize a plug gauge as shown in Figure 4. Diameter “A” is equal to 64 percent of the nominal inside diameter of the hydraulic brake hose being tested.
- (b) Brake hose assemblies that are to be used for additional testing have constriction testing only at each end fitting. Other brake hose assemblies may be cut into 76.2-mm (3-inch) lengths to permit constriction testing of the entire assembly. Hose assemblies with end fittings that do not permit entry of the gauge (e.g., restrictive orifice or banjo fitting) are cut 76.2 mm (3 inches) from the point at which the hose terminates in the end fitting and then tested from the cut end.
- (c) Hold the brake hose in a straight position and vertical orientation.
- (d) Place the spherical end of the plug gauge just inside the hose or end fitting. If the spherical end will not enter the hose or end fitting using no more force than gravity acting on the plug gauge, this constitutes failure of the constriction test.
- (e) Release the plug gauge. Within 3 seconds, the plug gauge shall fall under the force of gravity alone up to the handle of the gauge. If the plug gauge does not fully enter the hose up to the handle of the gauge within 3 seconds, this constitutes failure of the constriction test.

S6.12.2 Extended plug gauge

- (a) The test in S6.12.1 may be conducted with an extended plug gauge to enable testing of the entire brake hose from one end fitting, without cutting the brake hose. The extended plug gauge ~~mass weight~~ and spherical diameter specifications are as shown in Figure 4, but the handle portion of the gauge may be deleted and the gauge length may be greater than 76.2 mm (3 inches).
- (b) The required performance of the extended plug gauge in S6.12.1(e) is that, after the plug gauge is released, the extended plug gauge shall fall under the force of gravity alone at an average rate of 25.4 mm (1 inch) per second until the spherical diameter of the extended gauge passes through all portions of the brake hose assembly containing hose. If the extended plug gauge does not pass through all portions of the brake hose

assembly containing hose at an average rate of 25.4 mm (1 inch) per second, this constitutes failure of the constriction test.



Notes:

1. Dimension in mm
2. Mass of gauge is 57 g.
3. "A" is the spherical diameter.
4. Not to scale

Figure 4 — Constriction Test Plug Gauge

S6.12.3 Drop ball test

- (a) Utilize a rigid spherical ball with a diameter equal to 64 percent of the nominal inside diameter of the hydraulic brake hose being tested. The mass weight of the spherical ball shall not exceed 57 g (2 ounces).
- (b) Hold the brake hose in a straight position and vertical orientation.
- (c) Hold the ball just above the end fitting.
- (d) Release the ball. The ball shall fall under the force of gravity alone completely through all portions of the brake hose assembly containing hose, at an average rate of 25.4 mm (1 inch) per second. Failure of the ball to pass completely through all portions of the brake hose assembly containing hose, at an average rate of 25.4 mm (1 inch) per second, constitutes failure of the constriction test.

S7. Requirements — Air brake hose, brake hose assemblies, and brake hose end fittings

S7.1 Construction

Each air brake hose assembly shall be equipped with permanently attached brake hose end fittings or reusable brake hose end fittings. Each air brake hose constructed of synthetic or natural elastomeric rubber shall conform to the dimensional requirements specified in Table III, except for brake hose manufactured in metric sizes.

S7.2 Labeling

S7.2.1 [CONTENT DELETED]

S7.2.2 End fittings. Except for an end fitting that is attached by deformation of the fitting about a hose by crimping or swaging, at least one component of each air brake hose fitting shall be etched, embossed, or stamped in block capital letters and numerals at least 1.6 mm (one-sixteenth of an inch) high with the following information:

- (a) ~~The symbol DOT, constituting a certification by the manufacturer of that component that the component conforms to all applicable motor vehicle safety standards.~~
- (b) A designation that identifies the manufacturer of that component of the fitting, ~~which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS-222, National Highway Traffic Safety Administration, 400 Seventh Street, SW., Washington, DC 20590.~~ The designation may consist of block capital letters, numerals, or a symbol.
- (c) The letter “A” shall indicate intended use in air brake systems. In the case of an end fitting intended for use in a reusable assembly with brake hose subject to Table III, “AI” or “AII” shall indicate use with Type I or Type II hose, respectively.
- (d) The nominal inside diameter of the hose to which the fitting is properly attached expressed in inches or fractions of inches or in millimeters. (See examples in S7.2.1(d).)¹ The abbreviation “mm” shall follow hose sizes that are expressed in millimeters.

S7.2.3 [CONTENT DELETED]

S7.2.3.1 At least one end fitting of an air brake hose assembly made with end fittings that are attached by crimping or swaging shall be etched, stamped, or embossed with a designation at least 1.6 mm (one-sixteenth of an inch) high that identifies the manufacturer of the hose assembly ~~and is filed in accordance with S7.2.3(b).~~

¹ Examples are: 3/8, 1/2 (1/2 SP in the case of 1/2-inch special air brake hose), 4 mm, and 6 mm.

Table III — Air Brake Hose Dimensions

Inside Diameter (ID) and Outside Diameter (OD)
Dimensions in mm (inches)

Type A
Hose Size — Nominal Inside Diameter

	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}^1$	$\frac{7}{16}^1$	$\frac{1}{2}$ SP ¹	$\frac{5}{8}$
Minimum I.D.	5.8 (0.227)	7.3 (0.289)	8.9 (0.352)	10.3 (0.407)	11.9 (0.469)	15.1 (0.594)
Maximum I.D.	6.9 (0.273)	8.5 (0.335)	10.1 (0.398)	11.9 (0.469)	13.5 (0.531)	16.7 (0.656)
Minimum O.D.	15.1 (0.594)	16.7 (0.656)	18.3 (0.719)	19.8 (0.781)	21.4 (0.844)	26.2 (1.031)
Maximum O.D.	16.7 (0.656)	18.3 (0.719)	19.8 (0.781)	21.4 (0.843)	23.0 (0.906)	27.8 (1.094)

Type AI²
Hose Size — Nominal Inside Diameter

	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{13}{32}$	$\frac{1}{2}$	$\frac{5}{8}$
Minimum I.D.	4.8 (0.188)	6.4 (0.250)	7.9 (0.312)	10.3 (0.406)	12.7 (0.500)	15.9 (0.625)
Maximum I.D.	5.4 (0.214)	7.1 (0.281)	8.7 (0.343)	11.1 (0.437)	13.7 (0.539)	16.9 (0.667)
Minimum O.D.	12.0 (0.472)	13.6 (0.535)	15.1 (0.598)	18.1 (0.714)	20.5 (0.808)	23.7 (0.933)
Maximum O.D.	13.0 (0.510)	14.6 (0.573)	16.2 (0.636)	19.3 (0.760)	21.7 (0.854)	24.9 (0.979)

Type AII²
Hose Size — Nominal Inside Diameter

	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{13}{32}$	$\frac{1}{2}$	$\frac{5}{8}$
Minimum I.D.	4.8 (0.188)	6.4 (0.250)	7.9 (0.312)	10.3 (0.406)	12.7 (0.500)	15.9 (0.625)
Maximum I.D.	5.4 (0.214)	7.1 (0.281)	8.7 (0.343)	11.1 (0.437)	13.7 (0.539)	16.9 (0.667)
Minimum O.D.	12.7 (0.500)	14.3 (0.562)	16.7 (0.656)	18.8 (0.742)	22.8 (0.898)	26.8 (1.054)
Maximum O.D.	13.7 (0.539)	15.3 (0.602)	17.7 (0.695)	20.1 (0.789)	24.0 (0.945)	27.9 (1.101)

Notes:

¹ Type A, sizes 3/8, 7/16, and 1/2 Special (1/2 SP) can be assembled with reusable end fittings. All Type A break hoses can be assembled using permanently-attached (crimped) end fittings.

² Types AI and AII, all sizes, can be assembled with reusable or permanently-attached (crimped) end fittings.

S7.3 Test requirements

Each air brake hose assembly or appropriate part thereof shall be capable of meeting any of the requirements set forth under this heading, when tested under the conditions of S13 and the applicable procedures of S8. However, a particular hose assembly or appropriate part thereof need not meet further requirements after having met the constriction requirement (S7.3.1) and then having been subjected to any one of the requirements specified in S7.3.2 through S7.3.13.

S7.3.1 Constriction. Every inside diameter of any section of an air brake hose assembly shall not be less than 66 percent of the nominal inside diameter of the brake hose. (S8.14)

S7.3.2 High temperature resistance. An air brake hose shall not show external or internal cracks, charring, or disintegration visible without magnification when straightened after being bent for 70 hours at 100°C (212°F) over a small test cylinder having the radius specified in Table IV for the size of hose being tested. (S8.1)

S7.3.3 Low temperature resistance. The inside and outside surfaces of an air brake hose shall not show cracks as a result of conditioning at -40°C (-40°F) for 70 hours when bent around a large test cylinder having the radius specified in Table IV for the size of hose being tested. (S8.2)

Table IV — Air Brake Hose Diameters and Test Cylinder Radii

Nominal inside diameter of hose in inches ¹	3/16	1/4	5/16	3/8	13/32	7/16, 1/2	5/8
Nominal inside diameter of hose in mm ¹	4.5	6	8	--	10	12	16
Small test cylinder radius in inches ²	1	1½	1¾	1¾	1⅞	2	2½
Small test cylinder radius in mm ²	25	38	45	45	48	51	64
Large test cylinder radius in inches ³	2	2½	3	3½	3½	4	4½
Large test cylinder radius in mm ³	51	64	76	89	89	102	114

¹ These sizes are listed to provide test cylinder radii for brake hoses manufactured in these sizes. They do not represent conversions.

² Small test cylinders are used for the high temperature resistance test.

³ Large test cylinders are used for the low temperature resistance, ozone resistance, and adhesion of wire-reinforced hose tests.

S7.3.4 Oil resistance. After immersion in ASTM No. 3 oil for 70 hours at 100°C (212°F), the volume of a specimen prepared from the inner tube and cover of an air brake hose shall not increase more than 100 percent. (S8.3)

S7.3.5 Ozone resistance. An air brake hose assembly shall not show cracks visible under 7-power magnification after exposure to ozone for 70 hours at 40°C (104°F) when bent around a test cylinder of the radius specified in Table IV for the size of hose being tested. (S8.4)

S7.3.6 Length change. An air brake hose shall not contract in length more than 7 percent nor elongate more than 5 percent when subjected to air pressure of 1 379 kPa (200 psi). (S8.5)

S7.3.7 Adhesion

(a) Except for hose reinforced by wire, an air brake hose shall withstand a tensile force of 35.6 N (8 pounds) per 25.4 mm (1 inch) of length before separation of adjacent layers. (S8.6)

(b) An air brake hose reinforced by wire shall permit a steel ball to roll freely along the entire length of the inside of the hose when the hose is subjected to a vacuum of 84.6 kPa (25 inches of Hg) and bent around a test cylinder. (S8.13)

S7.3.8 Flex strength and air pressure leakage. An air brake hose assembly of the length specified in the table accompanying Figure 5, when subjected to a flex test and internal

pressure cycling, shall be capable of having its internal pressure increased from zero to 965.3 kPa (140 psi) within 2 minutes with pressurized air supplied through an orifice. (S8.7)

S7.3.9 Corrosion resistance and burst strength. An air brake hose assembly exposed to salt spray shall not rupture when exposed to hydrostatic pressure of 6 205 kPa (900 psi). (S8.8)

S7.3.10 Tensile strength. An air brake hose assembly designed for use between a frame and axle or between a towed and a towing vehicle shall withstand, without separation of the hose from its end fittings, a pull of 1 112 N (250 pounds) if it is $\frac{1}{4}$ inch, or 6 mm, or less in nominal inside diameter, or a pull of 1 446 N (325 pounds) if it is larger than $\frac{1}{4}$ inch, or 6 mm, in nominal inside diameter. An air brake hose assembly designed for use in any other application shall withstand, without separation of the hose from its end fittings, a pull of 222.4 N (50 pounds) if it is $\frac{1}{4}$ inch, or 6 mm, or less in nominal inside diameter, 667 N (150 pounds) if it is larger than $\frac{1}{4}$ inch, or 6 mm, and equal to or smaller than $\frac{1}{2}$ inch, or 12 mm, in nominal inside diameter, or 1 446 N (325 pounds) if it is larger than $\frac{1}{2}$ inch, or 12 mm, in nominal inside diameter. (S8.9)

S7.3.11 Water absorption and tensile strength. After immersion in distilled water for 70 hours, an air brake hose assembly designed for use between a frame and axle or between a towed and a towing vehicle shall withstand, without separation of the hose from its end fittings, a pull of 1 112 N (250 pounds) if it is $\frac{1}{4}$ inch or less or 6 mm or less in nominal inside diameter, or a pull of 1 446 N (325 pounds) if it is larger than $\frac{1}{4}$ inch or 6 mm in nominal inside diameter. After immersion in distilled water for 70 hours, an air brake hose assembly designed for use in any other application shall withstand, without separation of the hose from its end fittings, a pull of 222.4 N (50 pounds) if it is $\frac{1}{4}$ inch or 6 mm or less in nominal inside diameter, 667 N (150 pounds) if it is larger than $\frac{1}{4}$ inch or 6 mm and equal to or smaller than $\frac{1}{2}$ inch or 12 mm in nominal inside diameter, or 1 446 N (325 pounds) if it is larger than $\frac{1}{2}$ inch or 12 mm in nominal inside diameter. (S8.10)

S7.3.12 Zinc chloride resistance. The outer cover of an air brake hose shall not show cracks visible under 7-power magnification after immersion in a 50 percent zinc chloride aqueous solution for 200 hours. (S8.11)

S7.3.13 End fitting corrosion resistance. After 24 hours of exposure to salt spray, air brake hose end fittings shall show no base metal corrosion on the end fitting surface, except where crimping or the application of labeling information causes a displacement of the protective coating. (S8.12)

S8. Test procedures — Air brake hose, brake hose assemblies, and brake hose end fittings

S8.1 High temperature resistance test

- (a) Utilize a small test cylinder with a radius specified in Table IV for the size of hose being tested.
- (b) Bind the hose around the cylinder and condition it in an air oven for 70 hours at 100°C (212°F).
- (c) Cool the hose to room temperature, remove it from the cylinder, and straighten it.

- (d) Without magnification, examine the hose externally and cut the hose lengthwise and examine the inner tube.

S8.2 Low temperature resistance test

- (a) Utilize a large test cylinder with a radius specified in Table IV for the size of hose being tested.
- (b) Condition the cylinder and the brake hose, in a straight position, in a cold box at -40°C (-40°F) for 70 hours.
- (c) With the hose and cylinder at -40°C (-40°F), bend the hose 180 degrees around the cylinder at a steady rate in a period of 3 to 5 seconds. Remove the hose from the test cylinder and visibly examine the exterior of the hose for cracks without magnification.
- (d) Allow the hose to warm at room temperature for 2 hours. All reusable end fittings are removed from the hose. All permanently-attached end fittings are cut away from the hose. Cut through one wall of the hose longitudinally along its entire length. Unfold the hose to permit examination of the interior surface. Visibly examine the interior of the hose for cracks without magnification.

S8.3 Oil resistance test

Utilize three test specimens and average the results.

S8.3.1 Preparation. Fashion a test specimen by cutting a rectangular block 50.8 mm (2 inches) long and not less than 8.47 mm (one-third of an inch) in width, having a thickness of not more than 1.6 mm (one-sixteenth inch), from the brake hose and buff the specimen on both faces to ensure smooth surfaces.

S8.3.2 Measurement

- (a) Weigh each specimen to the nearest milligram in air (W_1) and in distilled water (W_2) at room temperature. If wetting is necessary to remove air bubbles, dip the specimen in acetone and thoroughly rinse it with distilled water.
- (b) Immerse each specimen in ASTM IRM 903 oil for 70 hours at 100°C (212°F) and then cool in ASTM IRM 903 oil at room temperature for 30 to 60 minutes.
- (c) Dip the specimen quickly in acetone and blot it lightly with filter paper.
- (d) Weigh each specimen in a tared weighing bottle (W_3) and in distilled water (W_4) within five minutes of removal from the cooling liquid.
- (e) Calculate the percentage increase in volume follows:

$$\text{Percent of increase} = \frac{(W_3 - W_4) - (W_1 - W_2)}{(W_1 - W_2) \times 100}$$

S8.4 Ozone resistance test

Conduct the test specified in S6.8 using an air brake hose, except use the large test cylinder specified in Table IV for the size of hose being tested.

S8.5 Length change test

- (a) Position a test hose in a straight, horizontal position and apply air pressure of 68.9 kPa (10 psi) thereto.
- (b) Measure the hose to determine its original free length.
- (c) Without releasing the 68.9 kPa (10 psi), raise the air pressure to the test hose to 1 379 kPa (200 psi).
- (d) Measure the hose under 1 379 kPa (200 psi) to determine the final free length. An elongation or contraction is an increase or decrease, respectively, in the final free length from the original free length of the hose.

S8.6 Adhesion test for air brake hose not reinforced by wire

S8.6.1 Apparatus. A tension testing machine that is power-driven and that applies a constant rate of extension is used for measuring the force required to separate the layers of the test specimen. The apparatus is constructed so that:

- (a) The recording head includes a freely rotating form with an outside diameter substantially the same as the inside diameter of the hose specimen to be placed on it.
- (b) The freely rotating form is mounted so that its axis of rotation is in the plane of the ply being separated from the specimen and so that the applied force is perpendicular to the tangent of the specimen circumference at the line of separation.
- (c) The rate of travel of the power-actuated grip is a uniform 25.4 mm (one inch) per minute and the capacity of the machine is such that maximum applied tension during the test is not more than 85 percent nor less than 15 percent of the machine's rated capacity.
- d) The machine produces a chart with separation as one coordinate and applied tension as the other.

S8.6.2 Preparation

- (a) Cut a test specimen of 25.4 mm (1 inch) or more in length from the hose to be tested and cut the layer to be tested of that test specimen longitudinally along its entire length to the level of contact with the adjacent layer.
- (b) Peel the layer to be tested from the adjacent layer to create a flap large enough to permit attachment of the power-actuated clamp of the apparatus.
- (c) Mount the test specimen on the freely rotating form with the separated layer attached to the power-actuated clamp.

S8.6.3 [Reserved]**S8.6.4 Calculations**

- (a) The adhesion value shall be the minimum force recorded on the chart, excluding that portion of the chart which corresponds to the initial and final 20 percent along the displacement axis.
- (b) Express the force in Newtons per metre (pounds per inch) of length.

S8.7 Flex strength and air pressure test

S8.7.1 Apparatus. A flex testing machine with a fixed hose assembly attachment point and a movable hose assembly attachment point, which meets the dimensional requirements of Figure 5 for the size of hose being tested. The attachment points connect to the end fittings on the hose assembly without leakage and, after the hose assembly has been installed for the flex test, are restrained from rotation. The movable end has a linear travel of 152.4 mm (6 inches) and a cycle rate of 100 cycles per minute. The machine is capable of increasing the air pressure in the hose assembly from zero to 1 034 kPa (150 psi) within 2 seconds, and decreasing the air pressure in the hose assembly from 1 034 kPa (150 psi) to zero within 2 seconds.

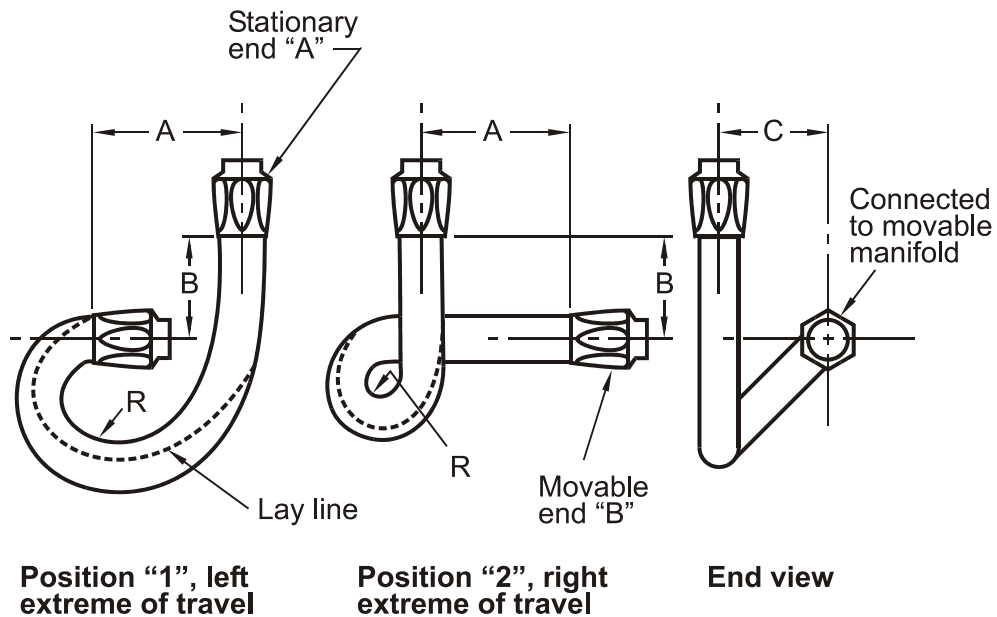


Figure 5 — Flex Test Apparatus

Table Accompanying Figure 5
Dimensions in mm (inches)

Free Length of Hose	Nominal Inside Diameter of Hose	Dimensions							
		Position "1"				Position "2"			
		A	B	C	R ¹	A	B	C	R ¹
254 (10.00)	3/16, 1/4	76 (3.00)	70 (2.75)	95 (3.75)	34 (1.40)	76 (3.00)	70 (2.75)	95 (3.75)	30 (1.20)
279 (11.00)	5/16, 3/8, 13/32	76 (3.00)	89 (3.50)	114 (4.50)	43 (1.70)	76 (3.00)	89 (3.50)	114 (4.50)	33 (1.30)
355 (14.00)	7/16, 1/2, 5/8	76 (3.00)	102 (4.00)	127 (5.00)	56 (2.20)	76 (3.00)	102 (4.00)	127 (5.00)	46 (1.80)

¹ This is an approximate average radius.

S8.7.2 Preparation

- (a) Lay the hose material on a flat surface in an unstressed condition. Apply a permanent marking line along the centerline of the hose on the uppermost surface.
- (b) Prepare the hose assembly with a free length as shown in the table accompanying Figure 5. The end fittings shall be attached according to the end fitting manufacturer's instructions.
- (c) Plug the ends of the hose assembly and conduct the salt spray test in S6.11 using an air brake hose assembly. Remove the plugs from the end fittings.
- (d) Within 168 hours of completion of the salt spray test, expose the hose assembly to an air temperature of 100°C (212°F) for 70 hours, with the hose in a straight position. Remove the hose and cool it at room temperature for 2 hours. Within 166 hours, subject the hose to the flexure test in S8.7.2(e).
- (e) Install the hose assembly on the flex testing machine as follows. With the movable hose attachment point at the midpoint of its travel, attach one end of the hose to the movable attachment point with the marked line on the hose in the uppermost position. Attach the other end of the hose to the fixed attachment point allowing the hose to follow its natural curvature.
- (f) Cycle the air pressure in the hose by increasing the pressure in the hose from zero kPa (psi) to 1 034 kPa (150 psi) and holding constant for one minute, then decreasing the pressure from 1 034 kPa (150 psi) to zero kPa (psi) and holding constant for one minute. Continue the pressure cycling for the duration of the flex testing. Begin the flex testing by cycling the movable attachment point through 152.4 mm (6 inches) of travel at a rate of 100 cycles per minute. Stop the flex testing and pressure cycling after one million flex cycles have been completed.
- (g) Install an orifice with a hole diameter of 1.6 mm (0.0625 inches) and a thickness of 0.8 mm (0.032 inches) in the air pressure supply line to the hose assembly. Provide a

gauge or other means to measure air pressure in the hose assembly. Regulate the supply air pressure to the orifice to 1 034 kPa (150 psi).

- (h) Apply 1 034 kPa (150 psi) air pressure to the orifice. After 2 minutes have elapsed, measure the air pressure in the brake hose assembly, while pressurized air continues to be supplied through the orifice.

S8.8 Corrosion resistance and burst strength test

- (a) Conduct the test specified in S6.11 using an air brake hose assembly. Remove the plugs from the ends of the hose assembly.
- (b) Fill the hose assembly with water, allowing all gases to escape. Apply water pressure at a uniform rate of increase of approximately 6 895 kPa (1,000 psi) per minute until the hose ruptures.

S8.9 Tensile strength test

Utilize a tension testing machine conforming to the requirements of American Society for Testing and Materials (ASTM) E 4-03, *Standard Practices for Force Verification of Testing Machines*, and provided with a recording device to measure the force applied.

- (a) Attach an air brake hose assembly to the testing machine to permit a straight, even machine pull on the hose. Use adapters to mount hose assemblies equipped with angled end fittings so that the hose is in a straight position when installed on the machine.
- (b) Apply tension at a rate of 25.4 mm (1 inch) per minute of travel of the moving head until separation occurs.

S8.10 Water absorption and tensile strength test

Immerse an air brake hose assembly in distilled water at room temperature for 70 hours. Thirty minutes after removal from the water, conduct the test specified in S8.9.

S8.11 Zinc chloride resistance test

Immerse an air brake hose in a 50 percent zinc chloride aqueous solution at room temperature for 200 hours. Remove it from the solution and examine it under 7-power magnification for cracks.

S8.12 End fitting corrosion resistance test

Conduct the test specified in S6.11 using an air brake hose assembly.

S8.13 Adhesion test for air brake hose reinforced by wire

- (a) Place a steel ball with a diameter equal to 73 percent of the nominal inside diameter of the hose being tested inside of the hose. Plug one end of the hose. Attach the other end of the hose to a source of vacuum.
- (b) Subject the hose to a vacuum of 84.6 kPa (25 inches of Hg) for five minutes. With the vacuum still applied to the hose, bend the hose 180 degrees around a large test

cylinder with a radius specified in Table IV for the size of hose being tested. At the location of this bend, bend the hose 180 degrees around the test cylinder in the opposite direction.

- (c) With the vacuum still applied to the hose, return the hose to a straight position. Attempt to roll the ball inside the hose using gravity from one end of the hose to the other end.

S8.14 Constriction test

Perform the constriction test in S6.12 using an air brake hose, except that the spherical diameter “A” of the plug gauge in Figure 4, or the diameter of the rigid spherical ball in S6.12.3(a), shall be 66 percent of the nominal inside diameter of the air brake hose being tested.

S9. Requirements — Vacuum brake hose, brake hose assemblies, and brake hose end fittings

S9.1 Labeling

S9.1.1 [CONTENT DELETED]

S9.1.2 End fittings. Except for an end fitting that is attached by heat shrinking or by interference fit with a plastic vacuum hose or that is attached by deformation of the fitting about a hose by crimping or swaging, at least one component of each vacuum brake hose fitting shall be etched, embossed, or stamped in block capital letters and numerals at least 1.6 mm (one-sixteenth of an inch) high with the following information:

- (a) ~~The symbol DOT, constituting a certification by the manufacturer of that component that the component conforms to all applicable motor vehicle safety standards.~~
- (b) A designation that identifies the manufacturer of that component of the fitting, ~~which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS-222, National Highway Traffic Safety Administration, 400 Seventh Street, SW., Washington, DC 20590.~~ The designation may consist of block capital letters, numerals, or a symbol.
- (c) The letters “VL” or “VH” shall indicate that the end fitting is intended for use in a light-duty or heavy-duty vacuum brake system, respectively.
- (d) The nominal inside diameter of the hose to which the fitting is properly attached expressed in inches or fractions of inches or in millimeters, or the outside diameter of the plastic tubing to which the fitting is properly attached expressed in inches or fractions of inches or in millimeters followed by the letters “OD”. (See examples in S9.1.1(d).)² The abbreviation “mm” shall follow hose sizes that are expressed in millimeters.

S9.1.3 [CONTENT DELETED]

² Examples of inside diameters are: 7/32, 1/4, and 4 mm. Examples of outside diameters are: 1/4 OD and 12 mm OD.

S9.1.3.1 At least one end fitting of a vacuum brake hose assembly made with end fittings that are attached by crimping or swaging or of a plastic tubing assembly made with end fittings that are attached by heat shrinking or dimensional interference fit shall be etched, stamped, or embossed with a designation at least 1.6 mm (one-sixteenth of an inch) high that identifies the manufacturer of the hose assembly ~~and is filed in accordance with S9.1.3(b).~~

S9.2 Test requirements

Each vacuum brake hose assembly or appropriate part thereof shall be capable of meeting any of the requirements set forth under this heading, when tested under the conditions of S13 and the applicable procedures of S10. However, a particular hose assembly or appropriate part thereof need not meet further requirements after having met the constriction requirement (S9.2.1) and then having been subjected to any one of the requirements specified in S9.2.2 through S9.2.10.

S9.2.1 Constriction. Except for that part of an end fitting which does not contain hose, every inside diameter of any section of a vacuum brake hose assembly shall not be less than 75 percent of the nominal inside diameter of the hose if for heavy duty, or 70 percent of the nominal inside diameter of the hose if for light duty. (S10.11)

S9.2.2 High temperature resistance. A vacuum brake hose tested under the conditions specified in S10.1:

- (a) Shall not have collapse of the outside diameter exceeding 10 percent of the initial outside diameter for a heavy-duty vacuum brake hose, or exceeding 15 percent of the initial outside diameter for a light-duty vacuum brake hose;
- (b) Shall not show external cracks, charring, or disintegration visible without magnification, and;
- (c) Shall not leak when subjected to a hydrostatic pressure test.

S9.2.3 Low temperature resistance. A vacuum brake hose tested under the conditions specified in S10.2 shall:

- (a) Not show cracks visible without magnification after conditioning at minus -40°C (-40°F) for 70 hours when bent around a cylinder having the radius specified in Table V for the size of hose being tested; and
- (b) Not leak when subjected to a hydrostatic pressure test. (S10.1(e))

S9.2.4 Ozone resistance. A vacuum brake hose shall not show cracks visible under 7-power magnification after exposure to ozone for 70 hours at 40°C (104°F). (S10.3)

S9.2.5 Burst strength. A vacuum brake hose shall not rupture under hydrostatic pressure of 2 413 kPa (350 psi). (S10.4)

S9.2.6 Vacuum. The collapse of the outside diameter of a vacuum brake hose under internal vacuum of 88 kPa (26 inches of Hg) for five minutes shall not exceed 1.6 mm (one-sixteenth of an inch). (S10.5)

S9.2.7 Bend. The collapse of the outside diameter of a vacuum brake hose, other than a preformed vacuum brake hose, at the middle point of the test length, when bent until the ends touch, shall not exceed the values given in Table V for the size of hose being tested. (S10.6)

Table V — Vacuum Brake Hose Test Requirements

Inside Diameter of Hose*		High Temperature Resistance				Low Temperature Resistance			
		Hose Length		Radius of Cylinder		Hose Length		Radius of Cylinder	
<u>mm</u>	inches	<u>mm</u>	inches	<u>mm</u>	inches	<u>mm</u>	inches	<u>mm</u>	inches
5	7/32	203.2	8.0	38.10	1.50	444.5	17.5	76.2	3.0
6	¼	228.6	9.0	38.10	1.50	444.5	17.5	76.2	3.0
	9/32	228.6	9.0	44.45	1.75	482.6	19.0	88.9	3.5
8	11/32	228.6	9.0	44.45	1.75	482.6	19.0	88.9	3.5
10	⅜	254.0	10.0	44.45	1.75	482.6	19.0	88.9	3.5
	7/16	279.4	11.0	50.80	2.00	520.7	20.5	101.6	4.0
	15/32	279.4	11.0	50.80	2.00	520.7	20.5	101.6	4.0
12	½	279.4	11.0	50.80	2.00	520.7	20.5	101.6	4.0
16	⅝	304.8	12.0	57.15	2.25	558.8	22.0	114.3	4.5
	¾	355.6	14.0	63.50	2.50	609.6	24.0	127.0	5.0
	1	406.4	16.0	82.55	3.25	723.9	28.5	165.1	6.5

Inside Diameter of Hose*		Bend Test				Deformation — Collapsed Inside Diameter (Dimension D)	
		Hose Length		Maximum Collapse of Outside Diameter			
mm	inches	mm	inches	mm	inches	mm	inches
5	7/32	177.8	7.0	4.37	11/64	1.19	3/64
6	1/4	203.2	8.0	2.38	3/32	1.59	1/16
	9/32	228.6	9.0	4.76	12/64	1.59	1/16
8	11/32	279.4	11.0	5.16	13/64	1.98	5/64
10	3/8	304.8	12.0	3.97	5/32	2.38	3/32
	7/16	355.6	14.0	6.75	17/64	1.98	5/64
	15/32	355.6	14.0	6.75	17/64	1.98	5/64
12	1/2	406.4	16.0	5.56	7/32	3.18	1/8
16	5/8	558.8	22.0	5.56	7/32	3.97	5/32
	3/4	711.2	28.0	5.56	7/32	4.76	3/16
	1	914.4	36.0	7.14	9/32	6.35	1/4

* These sizes are listed to provide test values for brake hoses manufactured in these sizes. They do not represent conversions.

S9.2.8 Swell and adhesion. Following exposure to Reference Fuel B, every inside diameter of any section of a vacuum brake hose shall not be less than 75 percent of the nominal inside diameter of the hose if for heavy duty, or 70 percent of the nominal inside diameter of the hose if for light duty. The vacuum brake hose shall show no leakage in a vacuum test of 88 kPa (26 inches of Hg) for 10 minutes. A vacuum brake hose that is constructed of two or more layers shall withstand a force of 26.7 N (6 pounds) per 25.4 mm (1 inch) of length before separation of adjacent layers. (S10.7)

S9.2.9 Deformation. A vacuum brake hose shall return to 90 percent of its original outside diameter within 60 seconds after five applications of force as specified in S10.9, except that a wire-reinforced hose need only return to 85 percent of its original outside diameter. In the case of heavy-duty hose, the first application of force shall not exceed a peak value of 311.4 N (70 pounds), and the fifth application of force shall reach a peak value of at least 178 N (40 pounds). In the case of light-duty hose, the first application of force shall not exceed a peak value of 222.4 N (50 pounds), and the fifth application of force shall reach a peak value of at least 89 N (20 pounds). (S10.9)

S9.2.10 End fitting corrosion resistance. After 24 hours of exposure to salt spray, vacuum brake hose end fittings shall show no base metal corrosion of the end fitting surface, except where crimping or the application of labeling information has caused displacement of the protective coating. (S10.10)

S10. Test procedures — Vacuum brake hose, brake hose assemblies, and brake hose end fittings**S10.1 High temperature resistance test**

- (a) Measure the initial outside diameter of the hose.
- (b) Subject the hose to an internal vacuum of 88 kPa (26 inches of Hg) at an ambient temperature of 125°C (257°F) for a period of 96 hours. Remove the hose to room temperature and atmospheric pressure.
- (c) Within 5 minutes of completion of the conditioning in S10.1(b), measure the outside diameter at the point of greatest collapse and calculate the percentage collapse based on the initial outside diameter.
- (d) Cool the hose at room temperature for 5 hours. Bend the hose around a mandrel with a diameter equal to five times the initial outside diameter of the hose. Examine the exterior of the hose for cracks, charring, or disintegration visible without magnification. Remove the hose from the mandrel.
- (e) Fill the hose assembly with water, allowing all gases to escape. Apply water pressure in the hose of 1 207 kPa (175 psi) within 10 seconds. Maintain an internal hydrostatic pressure of 1 207 kPa (175 psi) for one minute and examine the hose for visible leakage.

S10.2 Low temperature resistance test

- (a) Conduct the test specified in S8.2(a) through (c) using a vacuum brake hose with the cylinder radius specified in Table V for the size of hose being tested.
- (b) Remove the hose from the test cylinder, warm the hose at room temperature for 5 hours, and conduct the hydrostatic pressure test in S10.1(e).

S10.3 Ozone resistance test

Conduct the test specified in S6.8 using a vacuum brake hose.

S10.4 Burst strength test

Conduct the test specified in S8.8 using a vacuum brake hose.

S10.5 Vacuum test

Utilize a 305-mm (12-inch) vacuum brake hose assembly sealed at one end.

- (a) Measure the hose's outside diameter.
- (b) Attach the hose to a source of vacuum and subject it to a vacuum of 88 kPa (26 inches of Hg) for 5 minutes.
- (c) Measure the hose to determine the minimum outside diameter while the hose is still subject to vacuum.

S10.6 Bend test

- (a) Bend a vacuum brake hose of the length prescribed in Table V in the direction of its normal curvature until the ends just touch, as shown in Figure 6.
- (b) Measure the outside diameter of the specimen at point A before and after bending.
- (c) The difference between the two measurements is the collapse of the hose's outside diameter on bending.

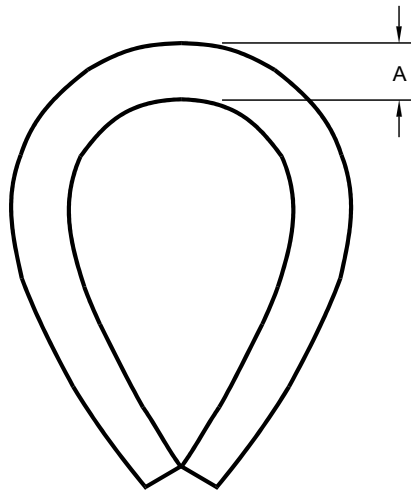


Figure 6 — Bend Test of Vacuum Brake Hose

S10.7 Swell and adhesion test

- (a) Fill a specimen of vacuum brake hose 305 mm (12 inches) long with ASTM Reference Fuel B, as described in ASTM D 471-98^{e1}, *Standard Test Method for Rubber Property—Effect of Liquids*. [SENTENCE DELETED] Copies may be obtained from the American Society for Testing and Materials (ASTM) International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959. [TWO SENTENCES DELETED]
- (b) Maintain reference fuel in the hose under atmospheric pressure at room temperature for 48 hours.
- (c) Remove fuel and conduct the constriction test in S10.11.
- (d) Attach the hose to a source of vacuum and subject it to a vacuum of 88 kPa (26 inches of Hg) for 10 minutes. Remove the hose from the vacuum source.
- (e) For a vacuum brake hose constructed of two or more layers, conduct the test specified in S8.6 using the vacuum brake hose.

S10.8 [Reserved]**S10.9 Deformation test**

Table VI specifies the test specimen dimensions.

S10.9.1 Apparatus. Utilize a compression device equipped to measure force of at least 444.8 N (100 pounds) and feeler gauges of sufficient length to be passed completely through the test specimen.

S10.9.2 Operation

- (a) Position the test specimen longitudinally in the compression device with the fabric laps not in the line of the applied pressure.
- (b) Apply gradually increasing force to the test specimen to compress its inside diameter to that specified in Table VI (dimension D of Figure 7) for the size of hose being tested.
- (c) After 5 seconds, release the force and record the peak load applied.
- (d) Repeat the procedure four times permitting a 10-second recovery period between load applications.

Table VI — Dimensions of Test Specimen and Feeler Gauge for Deformation Test

Inside Diameter of Hose*		Specimen Dimensions (See Figure 7)				Feeler Gauge Dimensions			
		Depth		Length		Width		Thickness	
mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
5	7/32	1.19	3/64	25.4	1	3.18	1/8	1.19	3/64
6	1/4	1.59	1/16	25.4	1	3.18	1/8	1.59	1/16
	9/32	1.59	1/16	25.4	1	3.18	1/8	1.59	1/16
8	11/32	1.98	5/64	25.4	1	4.76	3/16	1.98	5/64
10	3/8	2.38	3/32	25.4	1	4.76	3/16	2.38	3/32
	7/16	1.98	5/64	25.4	1	6.35	1/4	1.98	5/64
	15/32	1.98	5/64	25.4	1	6.35	1/4	1.98	5/64
12	1/2	3.18	1/8	25.4	1	6.35	1/4	3.18	1/8
16	5/8	3.97	5/32	25.4	1	6.35	1/4	3.97	5/32
	3/4	4.76	3/16	25.4	1	6.35	1/4	4.76	3/16
	1	6.35	1/4	25.4	1	6.35	1/4	6.35	1/4

* These sizes are listed to provide test values for brake hoses manufactured in these sizes. They do not represent conversions.

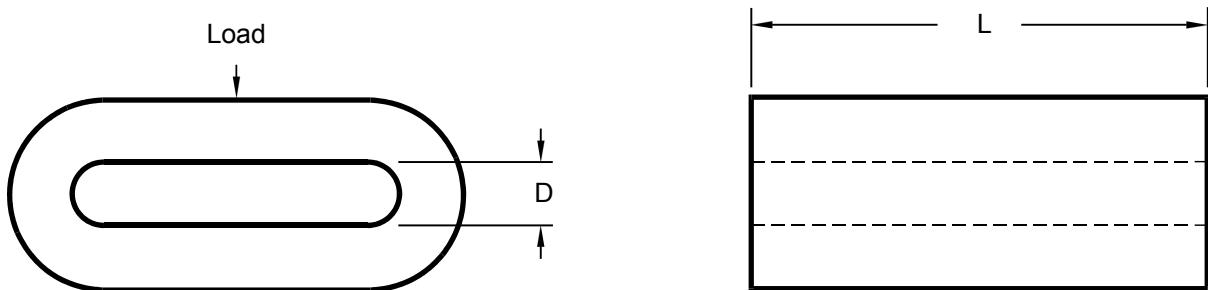


Figure 7 — Deformed Specimen of Vacuum Brake Hose

S10.10 End fitting corrosion resistance test

Conduct the test specified in S6.11 using a vacuum brake hose assembly.

S10.11 Constriction test

Perform the constriction test in S6.12 using a vacuum brake hose, except that the spherical diameter “A” of the plug gauge in Figure 4, or the diameter of the rigid spherical ball in S6.12.3(a), shall be 75 percent of the nominal inside diameter of the vacuum brake hose if it

is heavy duty, or 70 percent of the nominal inside diameter of the vacuum brake hose if it is light duty.

S11. Requirements — Plastic air brake tubing, plastic air brake tubing assemblies, and plastic air brake tubing end fittings

11.1 Construction

Each plastic air brake tubing assembly shall be equipped with permanently attached end fittings or reusable end fittings. Plastic air brake tubing shall conform to the dimensional requirements specified in Table VII. (S12.1)

Table VII — Plastic Air Brake Tubing Dimensions

Nominal Outside Diameter of Tubing	Maximum Outside Diameter		Minimum Outside Diameter		Nominal Inside Diameter		Nominal Wall Thickness		Wall Thickness Tolerance	
	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches
1/8 inch	3.25	0.128	3.10	0.122	2.01	0.079	0.58	0.023	0.08	0.003
5/32 inch	4.04	0.159	3.89	0.153	2.34	0.092	0.81	0.032	0.08	0.003
3/16 inch	4.83	0.190	4.67	0.184	2.97	0.117	0.89	0.035	0.08	0.003
1/4 inch	6.43	0.253	6.27	0.247	4.32	0.170	1.02	0.040	0.08	0.003
5/16 inch	8.03	0.316	7.82	0.308	5.89	0.232	1.02	0.040	0.10	0.004
3/8 inch	9.63	0.379	9.42	0.371	6.38	0.251	1.57	0.062	0.10	0.004
1/2 inch	12.83	0.505	12.57	0.495	9.55	0.376	1.57	0.062	0.10	0.004
5/8 inch	16.00	0.630	15.75	0.620	11.20	0.441	2.34	0.092	0.13	0.005
3/4 inch	19.18	0.755	18.92	0.745	14.38	0.566	2.34	0.092	0.13	0.005
6 mm	6.10	0.240	5.90	0.232	4.00	0.157	1.00	0.039	0.10	0.004
8 mm	8.10	0.319	7.90	0.311	6.00	0.236	1.00	0.039	0.10	0.004
10 mm	10.13	0.399	9.87	0.389	7.00	0.276	1.50	0.059	0.10	0.004
12 mm	12.13	0.478	11.87	0.467	9.00	0.354	1.50	0.059	0.10	0.004
16 mm	16.13	0.635	15.87	0.625	12.00	0.472	2.00	0.079	0.13	0.005

S11.2 Labeling

S11.2.1 [CONTENT DELETED]

S11.2.2 End fittings. Except for an end fitting that is attached by deformation of the fitting about the tubing by crimping or swaging, at least one component of each plastic air brake tubing end fitting shall be etched, embossed, or stamped in block capital letters and numerals at least 1.6 mm (one-sixteenth of an inch) high with the following information:

- (a) ~~The symbol DOT, constituting a certification by the manufacturer that the end fitting conforms to all applicable motor vehicle safety standards.~~
- (b) A designation that identifies the manufacturer of the end fitting, ~~which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS-222, National Highway Traffic Safety Administration, 400 Seventh St., SW., Washington, DC 20590.~~ The designation may consist of block capital letters, numerals, or a symbol.
- (c) The letter “A” shall indicate intended use in air brake systems.
- (d) The nominal outside diameter of the plastic tubing to which the fitting is properly attached expressed in inches or fractions of inches or in millimeters followed by the letters “OD”. The abbreviation “mm” shall follow tubing sizes that are expressed in millimeters. (Examples: $\frac{3}{8}$ OD, 6 mm OD)

S11.2.3 [CONTENT DELETED]

S11.2.3.1 At least one end fitting of a plastic air brake tubing assembly made with end fittings that are attached by crimping or swaging shall be etched, stamped, or embossed with a designation at least 1.6 mm (one-sixteenth of an inch) high that identifies the manufacturer of the tubing assembly ~~and is filed in accordance with S11.2.3(b).~~

S11.3 Test requirements

Each plastic air brake tubing assembly or appropriate part thereof shall be capable of meeting any of the requirements set forth under this heading when tested under the conditions of S13 and the applicable procedures of S12. However, a particular tubing assembly or appropriate part thereof need not meet further requirements after having met the constriction requirement (S11.3.1) and then having been subjected to any one of the requirements specified in S11.3.2 through S11.3.24. Unless otherwise specified, testing is conducted on a sample of tubing 305 mm (12 inches) in length.

S11.3.1 Constriction. Every inside diameter of any section of a plastic air brake tubing assembly shall not be less than 66 percent of the nominal inside diameter of the brake tubing. (S12.2)

S11.3.2 High temperature conditioning and dimensional stability. Plastic air brake tubing shall conform to the dimensions in Table VII after conditioning in air at 110°C (230°F) for four hours. (S12.3)

S11.3.3 Boiling water conditioning and dimensional stability. Plastic air brake tubing shall conform to the dimensions in Table VII after conditioning in boiling water for two hours. (S12.4)

S11.3.4 Burst Strength. Plastic air brake tubing shall not rupture when subjected to the burst strength pressure in Table VIII for the size of tubing being tested. (S12.5)

S11.3.5 Moisture absorption and burst strength. Plastic air brake tubing shall not rupture when subjected to 80 percent of the burst strength pressure in Table VIII, after the tubing has been dried in an oven and then conditioned in a 100 percent relative humidity atmosphere at 24°C (75°F) for 100 hours. (S12.6)

Table VIII — Plastic Air Brake Tubing Mechanical Properties

Nominal Outside Diameter of Tubing	Burst Strength Pressure		Supported Bend Radius ¹		Unsupported Bend Radius ²		Conditioned Tensile Load	
	kPa	psi	mm	inches	mm	inches	N	lbf
1/8 inch	6 900	1,000	9.4	0.37	9.4	0.37	156	35
5/32 inch	8 300	1,200	12.7	0.50	12.7	0.50	178	40
3/16 inch	8 300	1,200	19.1	0.75	19.1	0.75	222	50
1/4 inch	8 300	1,200	25.4	1.00	25.4	1.00	222	50
5/16 inch	6 900	1,000	31.8	1.25	38.1	1.50	334	75
3/8 inch	9 700	1,400	38.1	1.50	38.1	1.50	667	150
1/2 inch	6 600	950	50.8	2.00	63.5	2.50	890	200
5/8 inch	6 200	900	63.5	2.50	76.2	3.00	1 446	325
3/4 inch	5 500	800	76.2	3.00	88.9	3.50	1 557	350
6 mm	7 600	1,100	20.0	0.75	25.4	1.00	222	50
8 mm	6 200	900	31.8	1.25	38.1	1.50	334	75
10 mm	8 200	1,200	38.1	1.50	38.1	1.50	667	150
12 mm	6 900	1,000	44.5	1.75	63.5	2.50	890	200
16 mm	6 000	875	69.9	2.75	76.2	3.00	1 446	325

¹ Supported bend radius for tests specifying cylinders around which the tubing is bent.

² Unsupported bend radius for the collapse resistance test in which the tubing is not supported by a cylinder during bending.

S11.3.6 Ultraviolet light resistance. Plastic air brake tubing shall not rupture when subjected to 80 percent of the burst strength pressure in Table VIII for the size of tubing being tested, after being exposed to ultraviolet light for 300 hours and then impacted with a 0.45-kg (one-pound) weight dropped from a height of 305 mm (12 inches). (S12.7)

S11.3.7 Low temperature flexibility. The outer surface of plastic air brake tubing shall not show cracks visible without magnification as a result of conditioning in air at 110°C (230°F)

for 24 hours, and then conditioning in air at -40°C (-40°F) for four hours, and then bending the tubing 180 degrees around a test cylinder having a radius equal to six times the nominal outside diameter of the tubing. (S12.8)

S11.3.8 High temperature flexibility. Plastic air brake tubing shall not rupture or burst when subjected to 80 percent of the burst strength pressure in Table VIII for the size of tubing being tested, after the tubing has been:

- (a) Conditioned in air at 110°C (230°F) for 72 hours while bent 180 degrees around a cylinder having a radius equal to the supported bend radius in Table VIII for the size of tubing being tested; and
- (b) Cooled to room temperature while remaining on the cylinder, then straightened; and
- (c) Bent 180 degrees around the cylinder in the opposite direction of the first bending. (S12.9)

S11.3.9 High temperature resistance. Plastic air brake tubing shall not rupture or burst when subjected to 80 percent of the burst strength pressure in Table VIII for the size of tubing being tested, after the tubing has been conditioned in air at 110°C (230°F) for 72 hours. (S12.10)

S11.3.10 High temperature conditioning and low temperature impact resistance. Plastic air brake tubing shall not rupture or burst when subjected to 80 percent of the burst strength pressure in Table VIII for the size of tubing being tested, after the tubing has been conditioned in air at 110°C (230°F) for 24 hours, then conditioned in air at -40°C (-40°F) for 4 hours and impacted with a 0.45-kg (one-pound) weight dropped from a height of 305 mm (12 inches). (S12.11)

S11.3.11 Boiling water conditioning and low temperature impact resistance. Plastic air brake tubing shall not rupture when subjected to 80 percent of the burst strength pressure in Table VIII for the size of tubing being tested, after the tubing has been conditioned in boiling water for two hours, then conditioned in air at -40°C (-40°F) for 4 hours, and then impacted with a 0.45-kg (one-pound) weight dropped from a height of 305 mm (12 inches). (S12.12)

S11.3.12 Zinc chloride resistance. The outer surface of plastic air brake tubing shall not show cracks visible under 7-power magnification after immersion in a 50 percent zinc chloride aqueous solution for 200 hours while bent around a cylinder having a radius equal to the supported bend radius in Table VIII for the size of tubing being tested. (S12.13)

S11.3.13 Methyl alcohol resistance. The outer surface of plastic air brake tubing shall not show cracks visible under 7-power magnification after immersion in a 95 percent methyl alcohol aqueous solution for 200 hours while bent around a cylinder having a radius equal to the supported bend radius in Table VIII for the size of tubing being tested. (S12.14)

S11.3.14 High temperature conditioning and collapse resistance. The collapse of the outside diameter of plastic air brake tubing shall not exceed twenty percent of the original outside diameter when bent 180 degrees on a holding fixture to the unsupported bend radius specified in Table VIII and conditioned in air at 93°C (200°F) for 24 hours. (S12.15)

S11.3.15 Ozone resistance. The outer surface of plastic air brake tubing shall not show cracks visible under 7-power magnification after exposure to ozone for 70 hours at 40°C (104°F). (S12.16)

S11.3.16 Oil resistance. Plastic air brake tubing shall not rupture when subjected to 80 percent of the burst strength pressure in Table VIII for the size of tubing being tested, after the tubing has been conditioned in ASTM IRM 903 oil at 100°C (212°F) for 70 hours. (S12.17)

S11.3.17 Tensile strength. A plastic air brake tubing assembly designed for use between a frame and axle or between a towed and a towing vehicle shall withstand, without separation of the tubing from its end fittings, a pull of 1 112 N (250 pounds) if it is $\frac{3}{8}$ inch, 10 mm, or less in nominal outside diameter, or a pull of 1 446 N (325 pounds) if it is larger than $\frac{3}{8}$ inch or 10 mm in nominal outside diameter. A plastic air brake tubing assembly designed for use in any other application shall withstand, without separation of the hose from its end fittings, a pull of 156 N (35 pounds) if it is $\frac{1}{8}$ inch, 3 mm, or less in nominal outside diameter, 178 N (40 pounds) if it is $\frac{5}{32}$ inch or 4 mm in nominal outside diameter, 222.4 N (50 pounds) if it is $\frac{3}{16}$ to $\frac{3}{8}$ inch or 5 mm to 10 mm in nominal outside diameter, 667 N (150 pounds) if it is $\frac{1}{2}$ to $\frac{5}{8}$ inch or 11 mm to 16 mm in nominal outside diameter, or 1 446 N (325 pounds) if it is larger than $\frac{5}{8}$ inch or 16 mm in nominal outside diameter. (S12.18)

S11.3.18 Boiling water conditioning and tensile strength. A plastic air brake tubing assembly, when subjected to a tensile pull test, shall either elongate 50 percent or withstand the conditioned tensile load in Table VIII without separation from its end fittings, with one end of the assembly conditioned in boiling water for 5 minutes. (S12.19)

S11.3.19 Thermal conditioning and tensile strength. A plastic air brake tubing assembly, when subjected to a tensile pull test, shall either elongate 50 percent or withstand the conditioned tensile load in Table VIII without separation from its end fittings after the assembly has been subjected to four cycles of conditioning in air at -40°C (-40°F) for thirty minutes, normalizing at room temperature, conditioning in boiling water for 15 minutes, and normalizing at room temperature. (S12.20)

S11.3.20 Vibration resistance. A plastic air brake tubing assembly with an internal air pressure of 827 kPa (120 psig) shall not rupture or leak more than 50 cm³ per minute at a temperature of -40°C (-40°F) and 25 cm³ per minute at a temperature of 24°C (75°F), after the assembly has been subjected to 1,000,000 cycles of vibration testing with one end of the assembly fixed and the other end stroked 12.7 mm ($\frac{1}{2}$ inch) at 600 cycles per minute. In addition, end fittings that use a threaded retention nut shall retain at least 20 percent of the original retention nut tightening torque upon completion of the vibration testing. The vibration test shall be conducted in an environmental chamber and the air temperature shall be cycled between -40°C (-40°F) and 104°C (220°F) during the test. (S12.21)

S11.3.21 End fitting retention. The end fittings of a plastic air brake tubing assembly shall not rupture when the assembly is filled with water and pressurized to the burst strength pressure in Table VIII. (S12.22)

S11.3.22 Thermal conditioning and end fitting retention. The end fittings of a plastic air brake tubing assembly shall not rupture when the tubing assembly is filled with ASTM IRM 903 oil and:

- (a) Conditioned in air at 93°C (200°F) for 24 hours with atmospheric pressure inside the tubing assembly; and
- (b) The pressure is increased inside the tubing assembly to 3 103 kPa (450 psi), and this pressure is held for five minutes while maintaining an air temperature of 93°C (200°F);
- (c) The pressure is reduced inside the tubing assembly to atmospheric and the tubing assembly is permitted to cool at 24°C (75°F) for 1 hour;
- (d) The tubing assembly is conditioned in air at -40°C (-40°F) for 24 hours with atmospheric pressure inside the tubing assembly; and
- (e) The pressure is increased inside the tubing assembly to 3 103 kPa (450 psi), and this pressure is held for five minutes while maintaining an air temperature of -40°C (-40°F).

(S12.23)

S11.3.23 End fitting serviceability. A plastic air brake end fitting that uses a threaded retention nut shall not rupture or leak more than 25 cm³ per minute when pressurized to 827 kPa (120 psi) after five assembly cycles. (S12.24)

S11.3.24 End fitting corrosion resistance. After 24 hours of exposure to salt spray, air brake tubing end fittings shall show no base metal corrosion on the end fitting surface, except where crimping or the application of labeling information causes a displacement of the protective coating. (S12.25)

S12. Test procedures — Plastic air brake tubing, plastic air brake tubing assemblies, plastic air brake tubing end fittings

S12.1 Air brake tubing dimensions

Measure the tubing dimensions, including wall thickness, inside diameter, and outside diameter, using appropriate metrology apparatus such as micrometers, dial indicators, and gauges or optical comparators. To account for slight out-of-round conditions, diameter measurements may be calculated using the average of the major and minor diameters.

S12.2 Constriction test

Perform the constriction test in S6.12 using an air brake tubing assembly, except that the spherical diameter “A” of the plug gauge in Figure 4, or the diameter of the rigid spherical ball in S6.12.3(a), shall be 66 percent of the nominal inside diameter of the tubing as specified in Table VII.

S12.3 High temperature conditioning and dimensional stability test

- (a) Condition the tubing at 110°C (230°F) for 4 hours in an air oven.
- (b) Remove the tubing from the oven and allow to cool at room temperature for 30 minutes.
- (c) Measure the dimensions of the tubing using the procedure in S12.1.

S12.4 Boiling water conditioning and dimensional stability test

- (a) Utilize a container constructed of a non-reactive material large enough so that the tubing to be tested does not touch any surface of the container. Fill the container with distilled water.
- (b) Slip the tubing over a stainless steel wire for positioning it in the pot.
- (c) Bring the water to a boil. Place the tubing in the water and position it so that it does not touch the container. Boil the tubing for two hours. Replenish the water as necessary, adding it slowly so that the water in the pot boils continuously.
- (d) Remove the tubing from the water and allow to cool at room temperature for 30 minutes. Wipe off any water that remains on the tubing.
- (e) Measure the dimensions of the tubing using the procedure in S12.1.

S12.5 Burst strength test

- (a) Utilize an air brake tubing assembly or prepare a 305-mm (12-inch) length of tubing and install end fittings according to the end fitting manufacturer's instructions.
- (b) Plug one end of the assembly, fill it with water, and connect the other end to a source of water pressure. Bleed any air from the assembly and water pressure system.
- (c) Increase the water pressure inside the tubing assembly at a rate of 20 684 kPa (3,000 psi) per minute to the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.6 Moisture absorption and burst strength

- (a) Prepare a sample of tubing 305 mm (twelve inches) in length.
- (b) Condition the tubing at 110°C (230°F) for 24 hours in an air oven. Remove the tubing from the oven and, within 30 seconds, weigh it to establish the initial mass weight. The mass weight shall be measured with a resolution of 0.01 g; if the scale has a higher resolution, then values of 0.005 g and above shall be rounded to the nearest 0.01 g and values below 0.005 g shall be truncated.
- (c) Place the tubing in an environmental chamber and condition it for 100 hours at 100 percent relative humidity and a temperature of 24°C (75°F).
- (d) Remove the tubing from the chamber and, within a period of 5 minutes, remove all surface moisture from the tubing using a cloth, and weigh the tubing to establish the conditioned mass weight. Mass Weight shall be measured to the nearest 0.01 g as in S12.6(b).
- (e) Calculate the percentage of moisture absorption as follows:

$$\frac{\text{Conditioned Mass} - \text{Initial Mass}}{\text{Initial Mass}} \times 100$$

- (f) Install end fittings according to the end fitting manufacturer's instructions.

- (g) Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.7 Ultraviolet light resistance test

(a) **Apparatus.** An accelerated weathering test machine for ultraviolet light conditioning of plastic air brake tubing. The machine shall be equipped with fluorescent UVA-340 light bulbs and automatic irradiance control. Also utilize an impact test apparatus as shown in Figure 8.

(b) **Test standards.** The testing is in accordance with American Society for Testing and Materials (ASTM) G 154-00, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*; ASTM G 151-97, *Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources*; and ASTM D 4329-99, *Standard Practice for Fluorescent UV Exposure of Plastics*. [SENTENCE DELETED] Copies may be obtained from the American Society for Testing and Materials (ASTM) International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959. [TWO SENTENCES DELETED]

(c) Preparation

- (1) Utilize a 305-mm (12-inch) length of plastic air brake tubing. Mask 25.4 mm (1 inch) of each end of the tubing where end fittings will be attached using opaque tape.
- (2) Attach the tubing to the test rack of the machine, securing it at the ends along the masked sections. Wipe the outside surface of the tubing with acetone to remove any surface contaminants. Place the tubing and rack in the accelerated weathering test machine so that the center of the tubing assembly is approximately in the center of the UV light exposure area of the test machine. (If multiple plastic brake tubing assemblies are tested, then their position in the machine should be rotated according to ASTM D 4329-99, S7.4.1, except the rotation shall be each 96 hours instead of weekly.) The distance from the light bulb to the tubing shall be approximately 50.8 mm (2 inches). Set the UV irradiance to 0.85 watts per square meter at 340 nm and maintain this level during the testing. Maintain a temperature inside the test chamber of 45°C (113°F), and use only atmospheric humidity. Expose the tubing at this UV irradiance level for 300 hours continuously. Remove the tubing from the test chamber.
- (3) Place the tubing inside the impact test apparatus, and drop the impacter onto the tubing from a height of 305 mm (12 inches).
- (4) Remove the masking material from the ends of the tubing. Install end fittings according to the end fitting manufacturer's instructions. Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

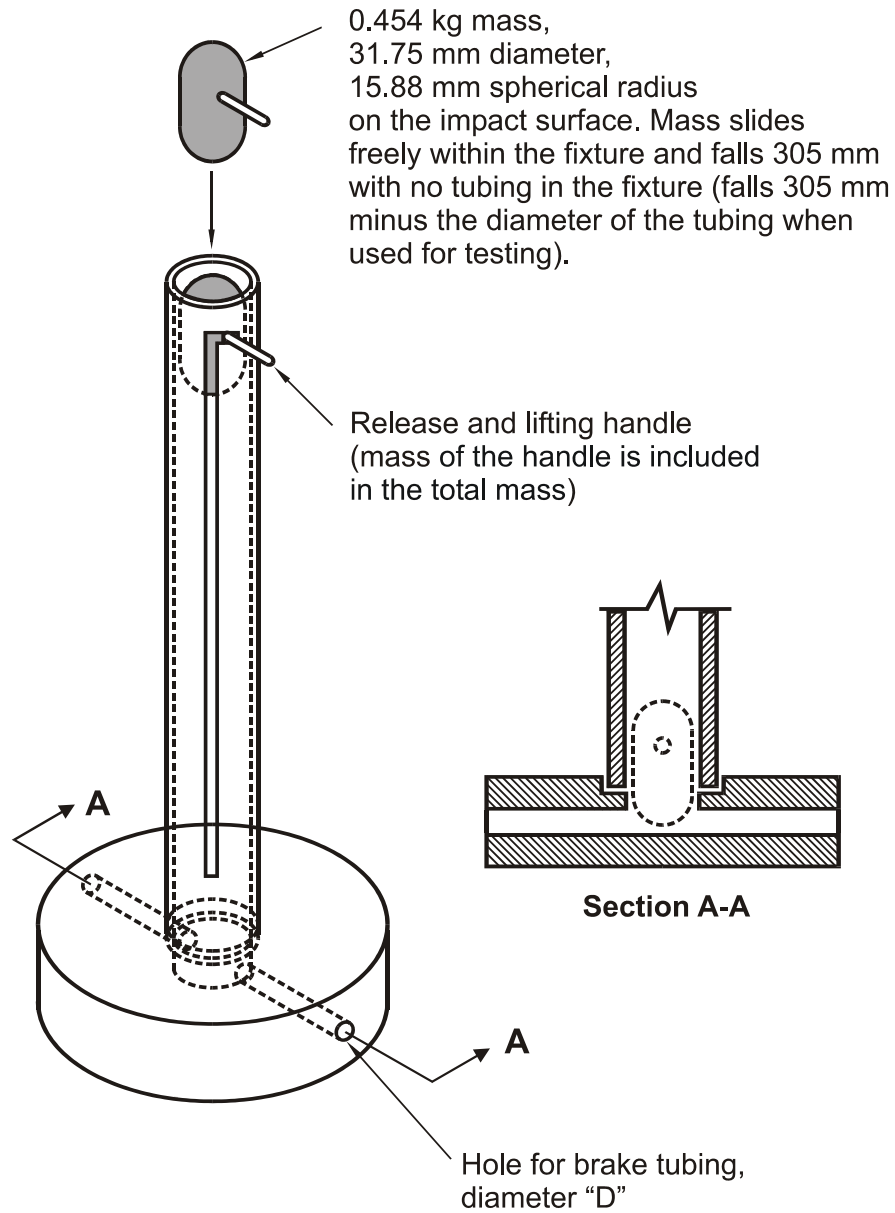


Figure 8 — Impact Test Apparatus

Table Accompanying Figure 8

Nominal Outside Diameter of Tubing	Hole Diameter "D"	
	mm	inches
1/8 inch	3.96	0.156
5/32 inch	4.75	0.187
3/16 inch	5.54	0.218
1/4 inch	7.14	0.281
5/16 inch	8.71	0.343
3/8 inch	10.31	0.406
1/2 inch	13.49	0.531
5/8 inch	16.66	0.656
3/4 inch	20.32	0.800
6 mm	6.80	0.268
8 mm	8.80	0.346
10 mm	10.80	0.425
12 mm	12.80	0.504
16 mm	16.80	0.661

S12.8 Low temperature flexibility test

- (a) Utilize a cylinder having a radius of six times the nominal outside diameter of the tubing.
- (b) Condition the tubing in an air oven at 110°C (230°F) for 24 hours. Remove from the oven and cool at room temperature for 30 minutes.
- (c) Condition the cylinder and the tubing in an environmental chamber at -40°C (-40°F) for four hours.
- (d) With the tubing and test cylinder at -40°C (-40°F), bend the tubing 180 degrees around the cylinder at a steady rate in a period of 4 to 8 seconds.

S12.9 High temperature flexibility test

- (a) Utilize a cylinder having a radius equal to the supported bend radius in Table VIII for the size of tubing being tested.
- (b) Bend the tubing 180 degrees around the cylinder and hold in place with a clamp or other suitable support, applying only enough force on the tubing to hold it in position.

- (c) Condition the tubing and cylinder in an air oven at 110°C (230°F) for 72 hours. Remove the tubing and cylinder from the oven and cool at room temperature for two hours.
- (d) Remove the clamps or supports from the tubing and straighten the tubing at a steady rate in a period of 4 to 8 seconds.
- (e) Rebend the tubing 180 degrees around the cylinder, at the same point but in the opposite direction of the bending in S12.9(b), at a steady rate in a period of 4 to 8 seconds.
- (f) Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.10 High temperature resistance test

Condition the tubing in an air oven at 110°C (230°F) for 72 hours. Remove the tubing and allow to cool at room temperature for 30 minutes. Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.11 High temperature conditioning and low temperature impact resistance test

- (a) Apparatus. Utilize an impact test apparatus as shown in Figure 8.
- (b) Condition the tubing in an air oven at 110°C (230°F) for 72 hours. Remove the tubing and allow to cool at room temperature for 30 minutes.
- (c) Condition the tubing and the impact test apparatus in an environmental chamber at -40°C (-40°F) for 4 hours.
- (d) With the tubing and impact test apparatus at -40°C (-40°F), place the tubing inside the apparatus and drop the impacter onto the tubing from a height of 305 mm (12 inches). Remove the tubing from the chamber and allow to warm at room temperature for one hour.
- (e) Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.12 Boiling water conditioning and low temperature impact resistance test

- (a) Apparatus. Utilize an impact test apparatus as shown in Figure 8.
- (b) Condition the tubing in boiling water using the test in S12.4 (a) through (d), except that the length of tubing shall be 305 mm (12 inches).
- (c) Condition the tubing and the impact test apparatus in an environmental chamber at -40°C (-40°F) for 4 hours.
- (d) With the tubing and impact test apparatus at -40°C (-40°F), place the tubing inside the apparatus and drop the impacter onto the tubing from a height of 305 mm (12 inches). Remove the tubing from the chamber and allow to warm at room temperature for one hour.

- (e) Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.13 Zinc chloride resistance test

- (a) Utilize a cylinder having a radius equal to the supported bend radius in Table VIII for the size of tubing being tested. The cylinder is constructed of a non-reactive material or coated to prevent chemical reaction with zinc chloride. The length of the tubing sample is long enough so that its ends will not be submerged during the immersion in zinc chloride, or the ends of the tubing are plugged to keep the zinc chloride from entering the tubing.
- (b) Bend the tubing 180 degrees around the cylinder and hold in place with a clamp or other suitable support constructed of non-reactive materials, applying only enough force on the tubing to hold it in position.
- (c) Immerse the tubing and cylinder in a 50 percent zinc chloride aqueous solution at room temperature for 200 hours.
- (d) Remove the tubing and cylinder from the solution. While still on the test cylinder, inspect the tubing under 7-power magnification for cracks.

S12.14 Methyl alcohol resistance

- (a) Utilize a cylinder having a radius equal to the supported bend radius in Table VIII for the size of tubing being tested. The cylinder is constructed of a non-reactive material or coated to prevent chemical reaction with methyl alcohol.
- (b) Bend the tubing 180 degrees around the cylinder and hold in place with a clamp or other suitable support constructed of non-reactive materials, applying only enough force on the tubing to hold it in position. The ends of the tubing may be shortened so that they will be fully submerged in the methyl alcohol.
- (c) Immerse the tubing and cylinder in a 95 percent methyl alcohol aqueous solution at room temperature for 200 hours.
- (d) Remove the tubing and cylinder from the solution. While still on the test cylinder, inspect the tubing under 7-power magnification for cracks.

S12.15 High temperature conditioning and collapse resistance test

- (a) **Apparatus.** A holding device consisting of two vertical pins affixed to a flat, horizontal plate. Each pin projects 25.4 mm (1 inch) above the top surface of the plate. The diameter of each pin is approximately equal to the inside diameter of the tubing being tested. Using the unsupported bend radius for the size of tubing being tested from Table VIII, the distance between the pin centerlines is equal to:

$$(2 \times \text{Unsupported bend radius}) + (\text{Nominal OD of tubing})$$

- (b) **Preparation**

- (1) Use the unsupported bend radius for the size of tubing being tested from Table VIII and cut the tubing to the following length:

$(3.14 \times \text{Unsupported bend radius}) + (10 \times \text{Nominal tubing OD}) + 2 \text{ inches}$

or

$(3.14 \times \text{Unsupported bend radius}) + (10 \times \text{Nominal tubing OD}) + 50 \text{ mm}$

- (2) Place a reference mark at the center of the sample. At this mark, measure the initial outside diameter of the tubing. If the tubing is slightly out-of-round, use the elliptical minor diameter as the initial outside diameter.
- (3) Install the tubing completely over the pins of the holding device so that the tubing is bent 180 degrees. If the tubing has a natural curvature, the tubing shall be bent in the direction of the natural curvature.
- (4) Condition the holding device and tubing in an air oven at 93°C (200°F) for 24 hours. Remove the holding device and tubing and allow to cool at room temperature for 30 minutes.
- (5) With the tubing still mounted to the holding device, measure the elliptical minor diameter of the tubing at the reference mark to determine the final outside diameter.

(c) Calculation

Calculate the percentage collapse of the outside diameter of the tubing as follows:

$$\frac{\text{Initial Outside Diameter} - \text{Final Outside Diameter}}{\text{Initial Outside Diameter}} \times 100$$

S12.16 Ozone resistance test

Conduct the test specified in S6.8 using plastic air brake tubing.

S12.17 Oil resistance test

- (a) Utilize a plastic air brake tubing assembly or prepare a 305-mm (12-inch) length of tubing and install end fittings according to the end fitting manufacturer's instructions.
- (b) Immerse the tubing in ASTM IRM 903 oil at 100°C (212°F) for 70 hours. Remove and allow to cool at room temperature for 30 minutes. Wipe any excess oil from the tubing assembly.
- (c) Conduct the burst strength test in S12.5, except use 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII and, at the manufacturer's option, oil may be used as the test medium instead of water.

S12.18 Tensile strength test

Conduct the test in S8.9 using a plastic air brake tubing assembly or an assembly prepared from a 305-mm (12-inch) length of air brake tubing with end fittings installed according to the end fitting manufacturer's instructions.

S12.19 Boiling water conditioning and tensile strength

- (a) **Apparatus.** Use a tension testing machine as specified in S8.9. The lower attachment point of the machine is equipped with a heated, open-top container that is water tight.

The inside of the container (lower attachment point) and upper attachment point of the machine have provisions to quickly attach a brake hose assembly for tensile testing.

- (b) Preparation.** Prepare an air brake tubing assembly with a free length of 152.4 mm (6 inches) (152.4 mm [6 inches] of exposed tubing between the end fittings), with the end fittings installed in accordance with the end fitting manufacturer's instructions. If necessary, install adapters on the end fittings to permit quick attachment to the machine, to keep water from entering the tubing assembly, and to ensure that the tubing assembly is in a straight position when installed on the machine. Fill the container with distilled water such that the lower 101.6 mm (4 inches) of exposed tubing will be submerged when the brake tubing assembly is installed on the machine. Heat the water until it boils. Then quickly install the plastic air brake tubing assembly on the machine with the lower end of the tubing assembly in the boiling water. After the water has boiled continuously for 5 minutes, apply tension to the tubing assembly at a rate of 25.4 mm (1 inch) per minute of travel of the moving head until either the conditioned tensile load in Table VIII for the size of tubing being tested is reached or the free length of the tubing assembly reaches 228.6 mm (9 inches), whichever occurs first.

S12.20 Thermal conditioning and tensile strength

- (a) Apparatus.** Use a tension testing machine as specified in S8.9.
- (b) Preparation.** Prepare an air brake tubing assembly with a free length of 152.4 mm (6 inches) (152.4 mm [6 inches] of exposed tubing between the end fittings), with the end fittings installed in accordance with the end fitting manufacturer's instructions. If necessary, install adapters on the end fittings to permit attachment to the machine, to keep water from entering the tubing assembly, and/or to ensure that the tubing assembly is in a straight position when installed on the machine. Subject the tubing assembly to four complete cycles of the following sequence:
- (1) Condition the tubing assembly in an environmental chamber at -40°C (-40°F) for 30 minutes. Remove from the chamber and allow to warm at room temperature for 30 minutes.
 - (2) Condition the tubing assembly by submerging it in boiling water for 15 minutes. Remove and allow to cool at room temperature for 30 minutes. Install the tubing assembly on the tension testing machine and apply tension to the tubing assembly at a rate of 25.4 mm (one inch) per minute of travel of the moving head until either the conditioned tensile load in Table VIII for the size of tubing being tested is reached or the free length of the tubing assembly reaches 228.6 mm (9 inches), whichever occurs first.

S12.21 Vibration resistance test

- (a) Apparatus.** A vibration testing machine that supports a brake tubing assembly by its end fittings in approximately a straight line and includes the following features:
- (1) One tubing assembly attachment point is fixed and the other moves in a plane perpendicular to a line projected between the attachment points. The movable

attachment point moves in a linear direction and travels 12.7 mm (½ inch) total and at its midpoint of travel falls on a line projected between the attachment points. The movable attachment point has a cycle rate of 600 cycles per minute.

- (2) The distance between the attachment points is adjustable to compensate for varying lengths of brake tubing assemblies.
- (3) The actuating mechanism for the movable attachment point is balanced to prevent introduction of machine vibration into the brake tubing assembly.
- (4) The machine has a compressed air supply system that pressurizes the air brake tubing assembly through one fitting while the other fitting is plugged. The machine's compressed air supply system includes a pressure gauge or monitoring system and an air flow meter.
- (5) The machine is constructed so that an air brake tubing assembly mounted on it can be conditioned in an environmental test chamber.

(b) Preparation

- (1) Prepare an air brake tubing assembly with a free length of 457.2 mm (18 inches) (457.2 mm [18 inches] of exposed tubing between the end fittings), with the end fittings installed in accordance with the end fitting manufacturer's instructions. Record the initial tightening torque for an end fitting that uses a threaded retaining nut.
- (2) Install the air brake tubing assembly on the vibration testing machine and, with the movable attachment point at the midpoint of its travel, adjust the distance between the attachment points so that they are 12.7 mm (½ inch) closer together than the distance at which the tubing assembly is taut.
- (3) With the tubing assembly inside the environmental chamber, apply compressed air to the tubing assembly at a regulated pressure of 827 kPa (120 psi) and maintain the supply of air to the tubing assembly for the duration of the test. Set the temperature of the environmental chamber to 104°C (220°F) and initiate cycling of the movable attachment point. After 250,000 cycles, set the temperature of the environmental chamber to -40°C (-40°F). After 500,000 cycles, set the temperature of the environmental chamber to 104°C (220°F). After 750,000 cycles, set the temperature of the environmental chamber to -40°C (-40°F). Measure the air flow rate just prior to 1,000,000 cycles and, if the compressed air flow rate supplied to the air brake tubing assembly exceeds 50 cm³ per minute, this constitutes failure of the test. Stop the cycling at 1,000,000 cycles and set the environmental chamber temperature to 24°C (75°F), while air pressure is still supplied to the air brake tubing assembly. After one hour, measure the compressed air flow rate supplied to the air brake tubing assembly and, if the rate exceeds 25 cm³ per minute, this constitutes failure of the test.
- (4) For end fittings that use a threaded retaining nut, apply 20 percent of the original tightening torque as recorded in S12.21(b)(1). If the retention nut visibly moves, this constitutes a failure of the test.

S12.22 End fitting retention test

- (a) Utilize an air brake tubing assembly or prepare a 305-mm (12-inch) length of tubing and install end fittings according to the end fitting manufacturer's instructions.
- (b) Plug one end of the assembly, fill it with water, and connect the other end to a source of water pressure. Bleed any air from the assembly and water pressure system.
- (c) Increase the pressure inside the tubing assembly at a rate of 20 684 kPa (3,000 psi) per minute to 50 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII. Hold the pressure constant for 30 seconds.
- (d) Increase the pressure inside the tubing assembly at a rate of 20 684 kPa (3,000 psi) per minute to the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.23 Thermal conditioning and end fitting retention test

- (a) **Apparatus.** A source of hydraulic pressure that includes a pressure gauge or monitoring system, uses ASTM IRM 903 oil, and is constructed so that an air brake tubing assembly mounted to it can be conditioned in an environmental test chamber.
- (b) **Preparation.** Utilize an air brake tubing assembly or prepare a 305-mm (12-inch) length of tubing and install end fittings according to the end fitting manufacturer's instructions. Attach one end of the assembly to the hydraulic pressure supply and plug the other end of the assembly, fill the assembly with ASTM IRM 903 oil and bleed any air from the assembly, and place the tubing assembly inside an environmental chamber. Conduct the following tests:
 - (1) With atmospheric pressure applied to the oil inside the tubing assembly, set the environmental chamber temperature to 93°C (200°F) and condition the tubing assembly for 24 hours.
 - (2) With the temperature maintained at 93°C (200°F), increase the oil pressure inside the tubing assembly at a rate of 20 684 kPa (3,000 psi) per minute to 3 103 kPa (450 psi), and hold this pressure for 5 minutes.
 - (3) Decrease the oil pressure inside the tubing assembly at a rate of 20 684 kPa (3,000 psi) per minute to atmospheric pressure and set the temperature of the environmental chamber to 24°C (75°F). Condition the tubing assembly at this temperature for 1 hour.
 - (4) Set the temperature of the environmental chamber to -40°C (-40°F) and condition the tubing assembly for 24 hours.
 - (5) With the temperature maintained at -40°C (-40°F), increase the hydraulic pressure inside the tubing assembly at a rate of 20 684 kPa (3,000 psi) per minute to 3 103 kPa (450 psi), and hold this pressure for 5 minutes.

S12.24 End fitting serviceability

- (a) **Apparatus.** A source of air pressure that includes a pressure gauge or monitoring system and is equipped with a mass air flow meter.

- (b) **Preparation.** Prepare a 305-mm (12-inch) length of tubing and plug one end. Assemble the end fitting with the threaded retention nut on the other end of the tubing according to the end fitting manufacturer's instructions, then disassemble the fitting. Repeat the assembly and disassembly sequence three more times, and then reassemble the end fitting (five total assembly steps).
- (c) Attach the end fitting with the threaded retention nut to the source of air pressure. Pressurize the tubing at a rate of 20 684 kPa (3,000 psi) per minute to a pressure of 827 kPa (120 psi). If the end fitting leaks, measure and record the leakage rate using the mass air flow meter.

S12.25 End fitting corrosion resistance

Utilize an air brake tubing assembly or prepare a 305-mm (12-inch) length of tubing and install end fittings according to the end fitting manufacturer's instructions. Conduct the test specified in S6.11 using a plastic air brake tubing assembly.

S13. Test conditions

Each hose assembly or appropriate part thereof shall be able to meet the requirements of S5, S7, S9, and S11, under the following conditions.

S13.1 The temperature of the testing room is 24°C (75°F).

S13.2 The brake hoses and brake hose assemblies are at least 24 hours old, and unused.

S13.3 Specified test pressures are gauge pressures (psig).