DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. 03–14483, No. 1]

RIN 2127–AH79

Federal Motor Vehicle Safety Standards; Brake Hoses

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Notice of proposed rulemaking.

SUMMARY: Pursuant to the agency's grant of a joint petition from Elf Atochem North America, Inc., Mark IV Industrial/Dayco Eastman, and Parker Hannifin Corporation, NHTSA proposes to update the Federal motor vehicle safety standard on brake hoses to incorporate the substantive specifications of several Society of Automotive Engineers (SAE) Recommended Practices relating to hydraulic brake hoses, vacuum brake hoses, air brake hoses, and plastic air brake tubing.

DATES: Comments must be received on or before July 14, 2003.

ADDRESSES: Comments should refer to the docket number above and be submitted to: Docket Section, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, DC 20590. Alternatively, you may submit your comments electronically by logging onto the Docket Management System (DMS) Web site at *http://dms.dot.gov*. Click on ''Help & Information'' or ''Help/Info'' to view instructions for filing your comments electronically. Regardless of how you submit your comments, you should mention the docket number of this document.

You may call the Docket at 202–366–9324. Docket hours are 9:30 a.m. to 4 p.m., Monday through Friday.

FOR FURTHER INFORMATION CONTACT: For non-legal issues, Mr. Jeffrey Woods, Vehicle Dynamics Division, Office of Vehicle Safety Standards (Telephone: 202–366–6206) (Fax: 202–366–4921). Mr. Woods' mailing address is National Highway Traffic Safety Administration/DOT, NPS–22, 400 Seventh St., SW., Washington, DC 20590.

For legal issues, Mr. George Feygin, Office of the Chief Counsel (Telephone: 202–366–2992) (Fax: 202–366–3820). Mr. Feygin's mailing address is National Highway Traffic Safety Administration, NCC–20, 400 Seventh St., SW., Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

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I. Background

This document responds to a joint petition for rulemaking filed on October 30, 1998, by Elf Atochem North America, Inc., Mark IV Industrial/Dayco Eastman, and Parker Hannifin Corporation, three brake hose manufacturers. The petitioners request that certain requirements relating to brake hoses, brake hose tubing, and brake hose end fittings that are presently administered by the Federal Motor Carrier Safety Administration (FMCSA) be incorporated into the brake hose standard that is currently administered by the National Highway Traffic Safety Administration (''NHTSA'' or the ''agency''). Specifically, the petitioners request incorporation of the requirements in § 393.45 (Brake tubing and hose, adequacy) and § 393.46 (Brake tubing and hose connections) of the Federal Motor Carrier Safety Regulations (FMCSR) into § 571.106 (Brake hoses) of the Federal motor vehicle safety standards (''FMVSS'').

Sections 393.45 and 393.46 of the FMCSRs require that brake hose, tubing, and fittings on ''commercial motor vehicles'' be maintained according to certain specifications adopted by the Society of Automotive Engineers (''SAE''). A ''commercial motor vehicle'' is defined, in § 393.5 of the FMCSRs, as

> any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle—
>
> (1) Has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 4,537 kg (10,001 lbs.) or more; whichever is greater; or
>
> (2) Is designed or used to transport more than 8 passengers (including the driver) for compensation; or
>
> (3) Is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation; or

(4) Is used in transporting material found by the Secretary of Transportation to be hazardous under 49 U.S.C. 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C.[1]

Pursuant to § 393.45, brake tubing and hose on commercial motor vehicles must conform to the following SAE specifications: SAE Recommended Practice J1149 (Metallic Air Brake System Tubing and Pipe—July 1976); SAE Recommended Practice J844 (Nonmetallic Air Brake System Type B—October 1980); SAE Recommended Practice J1402 (Automotive Air Brake Hose and Hose Assemblies—June 1985); SAE Recommended Practice J1401 (Road Vehicle Hydraulic Brake Hose Assemblies for Use with Non Petroleum Base Hydraulic Fluid—June 1985); and SAE Recommended Practice J1403 (Vacuum Brake Hose—June 1985). Under section 393.46, tube fittings on commercial motor vehicles must conform to the requirements of either SAE Standard J512 (Automotive Tube Fittings—October 1980) or SAE J246 (Spherical and Flanged Sleeve (Compression) Tube Fittings—March 1981).

The Federal Highway Administration (''FHWA''), which was responsible for administering the FMCSRs prior to the formation of the Federal Motor Carrier Safety Administration, issued a Notice of Proposed Rulemaking on April 14, 1997 (62 FR 18170). The FHWA proposed amending part 393 of the FMSCRs to, among other things, remove obsolete and redundant regulations and resolve inconsistencies between part 393 and NHTSA's FMVSS. The FHWA stated that because it has no statutory authority to regulate vehicle manufacturers or manufacturers of brake hose, tubing, or fittings, all such regulations should be included in NHTSA's FMVSS rather than in the FMCSRs. The FHWA proposed adopting a requirement that commercial motor vehicles be maintained in compliance with FMVSS No. 106.

Accordingly, FHWA's NPRM included a proposal to delete from §§ 393.45 and 393.46 all but one of the references to SAE specifications applicable to metallic brake tubing, nonmetallic brake tubing, air brake hose, hydraulic brake hose, vacuum brake hose, air brake tube fittings, and spherical and flanged sleeve tube fittings. In place of the SAE specifications, FHWA proposed that § 393.45 state that all brake hose and tubing, brake hose assemblies, and fittings must meet the applicable requirements of FMVSS No. 106. The proposal included retaining one reference to SAE J844 in § 393.45 for coiled nylon brake hose and hose assemblies. Presently, FMVSS No. 106 excludes coiled nylon brake hose/assemblies that comply with FMCSR § 393.45 from certain requirements, namely S7.3.6 (length change), S7.3.10 (tensile strength), and S7.3.11 (tensile strength of an assembly after immersion in water).

FHWA's NPRM aroused concerns. Several brake hose manufacturers and one engineering consultant submitted comments objecting to the proposed deletion of all but one reference to the SAE specifications from §§ 393.45 and 393.46 of the FMCSRs. In addition, a letter signed by 44 Members of Congress was sent to the Secretary of Transportation on November 3, 1997, expressing their concern over FHWA's proposal to repeal its safety standards for commercial motor vehicle brake hose, brake tubing, and fittings.

In response to these concerns, the Department of Transportation held a public meeting on March 24, 1998. In attendance were representatives from FHWA and NHTSA, several brake hose/tubing/fitting manufacturers, a truck manufacturer, a truck manufacturers association, an explosives manufacturer, a truck users association, and United States Congressman Thomas Sawyer (D-Ohio).

At the public meeting, representatives from NHTSA and FHWA said that they favored consolidating all requirements for brake hose, brake tubing, and fittings in FMVSS No. 106, instead of maintaining separate requirements under the jurisdiction of two different agencies. They explained that consolidation of the requirements would, among other things, make them more enforceable. Some of the brake component manufacturers stated their opposition to deleting the SAE specifications for their products. FHWA and NHTSA indicated that anyone opposed to FHWA's proposal was welcome to file a petition for rulemaking requesting that the SAE specifications proposed for deletion for the FMCSRs be incorporated into FMVSS No. 106.

II. Joint Petition for Rulemaking

On October 30, 1998, Elf Atochem North America, Inc., Mark IV Industrial/Dayco Eastman, and Parker Hannifin Corporation jointly submitted a petition for rulemaking asking the agency to incorporate into FMVSS No. 106 the SAE specifications for brake hose, brake tubing, and fittings that FHWA proposed deleting from §§ 393.45 and 393.46 of the FMCSRs. The petition requested that the application of these SAE specifications be limited to hose, tubing, and fittings used on trucks, truck-trailer combinations, and buses with either a GVWR greater than 10,000 lbs. or which are designed to transport 16 or more people, including the driver. In addition, the petitioners requested that the current versions of the SAE specifications be adopted instead of the older versions cited in the FMCSRs.

III. NHTSA's Response to the Joint Petition

NHTSA has decided to grant the joint petition for rulemaking. The agency agrees with the petitioners that there is a safety need to transfer the brake hose, tubing, and fitting requirements currently contained in §§ 393.45 and 393.46 of the FMCSRs to FMVSS No. 106, before those requirements are deleted. NHTSA tentatively concludes that to ensure the continued safety of commercial motor vehicle braking systems, the substantive specifications of the SAE Recommended Practices should be incorporated into FMVSS No. 106, with a few exceptions as noted. This would involve, among other changes, establishing a new category in the standard for plastic air brake tubing, end fittings, and tubing assemblies.

NHTSA's decision to grant the joint petition is also based on the fact that FMVSS No. 106 has not been substantially updated in many years. Revisions over the past 20 years have primarily addressed labeling issues, inclusion of metric-sized brake hoses, updating test fluids to match advances in industry, and minor regulatory revisions to individual test conditions such as the whip test and the adhesion test. The agency notes that most of the substantive requirements currently in Standard 106, other than the labeling requirements, were originally based on SAE standards and American Society for Testing and Materials (ASTM) standards referenced therein. While the SAE and ASTM standards have been modified over time to keep pace with technological developments in the industry, the substantive requirements of FMVSS No. 106 have remained relatively unchanged. Therefore, NHTSA's proposed changes to Standard No. 106 would take into account the substantial technological developments that have occurred and align the

[1] The FMCSRs contain two different definitions of ''commercial motor vehicle'': one in § 393.5 and another in section 382.107. The latter definition is narrower than the former. We note that all references throughout this document to ''commercial motor vehicle'' are to the broader definition found in section 393.5.

standard's requirements with standard industry practices. Incorporating many of the SAE standard's performance requirements is consistent with Office of Management and Budget (OMB) Circular A–119, which directs federal agencies to use and/or develop voluntary consensus industry standards, in accordance with Public Law 104–113, the ''National Technology Transfer and Advancement Act of 1995.''

The agency's proposal differs in a number of respects, however, from that requested by the petitioners—

First, as explained in greater detail below, instead of simply incorporating complete SAE standards by reference as the FMCSRs currently do, NHTSA proposes to incorporate only the specific requirements/specifications of the SAE standards that are either more rigorous than those in Standard No. 106 or are not present at all in FMVSS No. 106.

Second, the agency does not propose to limit the application of those SAE requirements/specifications to brake hose, tubing, and fittings used on commercial motor vehicles. NHTSA tentatively concludes that all brake hose, tubing, and fittings can and should meet the requirements/specifications, regardless of their end use.

Third, although NHTSA agrees with the petitioners that proposed changes to FMVSS No. 106 should be based on the most recent versions of the SAE standards, instead of the older versions cited in the FMCSRs, the agency notes that a number of SAE's standards have been updated since the joint petition was filed. Accordingly, NHTSA proposes to rely on the most recent versions of the SAE standards.

Fourth, the agency does not propose to incorporate SAE standards relating to copper tubing, galvanized steel pipe, or end fittings used with metallic or non-metallic tubing because these materials are occasionally used in chassis plumbing and these products are not considered to be brake hoses, thus it would not be appropriate to include them in FMVSS No. 106.

Fifth, NHTSA is not proposing to incorporate the material and construction specifications for Type A and Type B tubing contained in SAE J844, *Nonmetallic Air Brake System Tubing*, and SAE J1394, *Metric Nonmetallic Air Brake System Tubing* because the agency tentatively concludes that incorporating those material specifications would be design-restrictive.

Sixth, NHTSA does not propose to incorporate the manufacturer identification requirements in SAE J1401, *Hydraulic Brake Hose Assemblies for Use with Nonpetroleum-Base Hydraulic Fluids*, because it tentatively concludes that the manufacturer identification requirements already present in FMVSS No. 106 are sufficient.

IV. Proposed Revisions to FMVSS No. 106

The following sections describe the changes NHTSA proposes to make to Standard No. 106's performance requirements and test procedures relating to: (a) Hydraulic brake hose; (b) air brake hose; (c) vacuum brake hose; (d) plastic air brake tubing; and (e) plastic air brake tubing assemblies and end fittings. Each section contains a table comparing the performance requirements and test procedures of FMVSS No. 106 to the relevant SAE Recommended Practice/Standard and a requirement-by-requirement/procedure-by-procedure explanation of the changes NHTSA is proposing. Generally speaking, whenever an SAE specification is more stringent than the corresponding FMVSS No. 106 requirement/procedure, NHTSA proposes to incorporate the SAE specification.

A. Hydraulic Brake Hoses

NHTSA's performance requirements and test procedures relating to hydraulic brake hoses are located in paragraph S5., *Requirements—Hydraulic brake hose, brake hose assemblies, and brake hose end fittings*, and paragraph S6., *Test procedures—Hydraulic brake hose, brake hose assemblies, and brake hose end fittings* of FMVSS No. 106. The corresponding SAE specifications are contained in SAE Surface Vehicle Standard J1401, *Hydraulic Brake Hose Assemblies for Use with Nonpetroleum-Base Hydraulic Fluids, Rev. September 1999* (SAE J1401).

The performance requirements and test procedures for hydraulic brake hoses in FMVSS No. 106 and SAE J1401 are similar, but not identical. In many cases, the requirements and procedures in SAE J1401 are more stringent than the corresponding requirements and procedures in paragraphs S5 and S6 of FMVSS No. 106. For example, in recognition of the fact that underhood temperatures have increased in modern passenger cars and, therefore, front brake hoses near the engine compartment are subjected to these higher temperatures, SAE J1401 recommends subjecting hydraulic brake hose to a hot impulse test. In contrast, FMVSS No. 106 does not specify a hot impulse test because many of the specifications in the standard originated in the late 1960s, when underhood temperatures were lower.

Generally, in those instances in which the performance requirements and test procedures in SAE J1401 are more rigorous, as with the hot impulse test specification, NHTSA is proposing to incorporate the SAE J1401 requirement/procedure. Where the requirements and procedures of FMVSS No. 106 are either more stringent or are not addressed at all in SAE J1401, however, the agency is proposing to retain the FMVSS No. 106 requirement/procedure.

The agency notes that because the reach of § 393.45 of the FMCSRs is limited to ''commercial motor vehicles,'' the performance requirements and test procedures in SAE J1401 are, at present, only being applied to hydraulic brake hose in use on those vehicles. In contrast, FMVSS No. 106's requirements/procedures apply to all hydraulic brake hoses, regardless of their end use. One question that arises in connection with NHTSA's proposal to incorporate many of SAE J1401's specifications, therefore, is whether to restrict application of those specifications to hydraulic brake hoses designed for use on commercial motor vehicles. NHTSA proposes to apply the specifications of SAE J1401 to all hydraulic brake hoses, regardless of the type of vehicle on which it is installed. The agency does not favor the creation of a separate category of, for example, ''commercial'' hydraulic brake hoses that would include the more severe test conditions only for those particular brake hoses because NHTSA tentatively concludes that all types of brake hoses can and should meet the current SAE J1401 specifications.

Many light vehicles, including passenger cars, are currently manufactured using brake hoses that meet SAE J1401 specifications or other, proprietary standards that are more severe than Standard 106. Although it is not clear whether replacement brake hoses are also designed to meet these more rigorous specifications, NHTSA tentatively concludes that it is in the interest of safety to specify that they do so. From a safety standpoint, if a replacement brake hose which does not meet SAE J1401 specifications were to be installed on a vehicle originally outfitted with hose designed to meet the specifications of SAE J1401 (or another proprietary standard more stringent than FMVSS No. 106), the vehicle brake hose would be more prone to failure. Requiring all hydraulic brake hoses, both original equipment manufacturer (OEM) brake hoses and replacement brake hoses, to meet the current SAE J1401 requirements/specifications

should substantially decrease the likelihood of brake hose failure. NHTSA welcomes comments, however, regarding the appropriateness of applying SAE J1401's requirements/specifications to all hydraulic brake hoses, regardless of their end use or whether they are OEM hoses or replacement hoses.

A detailed discussion of the differences between the hydraulic brake hose performance requirements and test procedures in SAE J1401 and FMVSS No. 106 follows, along with the agency's proposed resolution of those differences.

1. Pressure Test

SAE J1401 specifies a test pressure of 1,500 psi minimum and 2,100 psi maximum for inert gas or air tests and 3,000 psi minimum and 3,500 psi maximum for water and brake fluid tests, with the hose assembly required to sustain these pressures for 10 to 20 seconds, as a preconditioning test for all samples of hose assemblies to be subjected to further test conditions. The burst test (following the expansion test; *see* S5.3.2) specifies a minimum requirement of 4,000 psi plus zero (0) minus 200 psi for 2 minutes, using water or brake fluid, followed by a pressure increase to the point of failure. The minimum failure for ⅛ inch hose is 7,000 psi and for 3⁄16 hose is 5,000 psi. SAE J1401 does not specify test conditions for hose sizes other than ⅛ or 3⁄16 inch.

In contrast, FMVSS No. 106 specifies a water pressure test of 4,000 psi for 2 minutes and 5,000 psi minimum burst strength. The performance requirements and test procedures are similar to those in SAE J1401, although FMVSS No. 106 includes a lower pressure requirement for ⅛ hose (5,000 psi) and includes requirements for hose with inside diameters of ¼ inch or larger.

NHTSA tentatively concludes that a higher, 7,000 psi burst strength requirement should be adopted for ⅛ inch and 3mm hydraulic brake hoses. NHTSA contacted Intertek Testing Services, a company that has performed compliance testing of brake hoses under contract to the agency, to determine if the 7,000-psi pressure has been sustained by brake hoses in past testing. Intertek indicated that it typically will test up to 10,000 psi for all sizes of hydraulic brake hose, and that the hose have consistently been able to sustain this much pressure without bursting. Therefore, NHTSA proposes that the 7,000 psi burst strength requirement from SAE J1401 be adopted into Standard No. 106 for ⅛ inch and 3 mm hydraulic brake hoses.

2. Constriction

SAE J1401's constriction requirement is limited to hydraulic brake hose with an internal hose diameter of ⅛ inch or 3⁄16 inch. SAE J1401 specifies a minimum pass-through diameter of 64 percent of nominal internal hose diameter, which is determined by performing a plug gage test. FMVSS No. 106 contains the same 64 percent of nominal internal hose diameter requirement, but applies it to hose of all sizes, not just hose with an internal hose diameter of ⅛ inch or 3⁄16 inch. Unlike SAE J1401, however, FMVSS No. 106 does not specify a test for determining hose's minimum pass-through diameter. In addition, FMVSS No. 106 explicitly excludes those portions of end fittings that do not contain hose from the constriction test while SAE J1401 does not. NHTSA welcomes comments on the issue of whether the constriction exclusion for portions of end fittings that do not contain hose is still necessary, or if there have been any substantial changes to brake systems which preclude the use of intentionally-restrictive end fittings.

NHTSA proposes retaining the existing constriction performance requirement in FMVSS No. 106 and adding a constriction test procedure. Two different constriction test procedures are available: the drop-ball test and the plug gauge test. In the drop-ball test, a steel ball with a diameter equal to the minimum constriction diameter for a particular hose size is dropped into one end of the hose at its fitting. Gravity is the only downward force acting on the ball, and friction between the hose and ball may not be sufficiently overcome in all tests.

As noted above, SAE J1401 specifies use of a plug gauge test. In the plug gauge test, a cylindrical plug with a small rod handle is inserted into and removed from the hose. NHTSA proposes specifying a plug gauge test because the agency tentatively concludes that the additional weight of the plug gauge may make it less susceptible to friction than the ball used in the drop-ball test. The plug gauge test that NHTSA is proposing, the details of which are contained in paragraph S6.12 of the Proposed Regulatory Text, differs somewhat from the plug gauge test specified in SAE J1401 in two respects. First, the spherical end of the plug gauge must be able to enter the hose or end fitting by applying a force no greater than gravity. Second, the plug gauge must fall under the force of gravity within 3 seconds. The agency welcomes comments both on its proposal to specify a plug gauge test instead of a drop-ball test and on the differences between the plug gauge test specified in SAE J1401 and the one the agency is proposing.

3. Volumetric Expansion

Both SAE J1401 and FMVSS No. 106 have similar requirements/procedures; however, SAE J1401 does not specify tests for hoses other than ⅛ or 3⁄16 inch. FMVSS No. 106 includes requirements for hoses smaller than ⅛ inch, larger than ¼ inch, and also for metric nominal hose sizes. NHTSA does not propose to make any changes to the volumetric expansion requirements/procedures in FMVSS No. 106.

4. Whip Resistance Test

The whip resistance requirements/procedures for hydraulic brake hose in SAE J1401 and FMVSS No. 106 are similar. Both SAE J1401 and FMVSS No. 106 specify that a hydraulic brake hose assembly shall not rupture when run continuously on a flexing machine for 35 hours. The test procedures differ, however, regarding the level of water pressure to be exerted in conducting the whip resistance test. While FMVSS No. 106 specifies a constant minimum water pressure of 235 psi during the test, SAE J1401 specifies a water pressure range of 225 to 250 psi. The agency does not propose any changes to Standard No. 106's existing test procedures for whip resistance because the existing specifications are so close to the upper pressure limit specified in SAE J1401.

5. Tensile Strength

FMVSS No. 106 specifies that a hose assembly shall have a minimum tensile strength of 325 pounds when pulled at a rate of 1 inch per minute. SAE J1401 includes this same specification, but also specifies an additional tensile strength of 370 pounds when pulled at a faster, 2 inches per minute, rate. Therefore, SAE J1401's test environment is more severe than that specified in FMVSS No. 106. NHTSA proposes that the SAE J1401 fast-pull test and 370 pound strength requirement be incorporated into FMVSS No. 106. The agency also proposes to update the ASTM reference for tension testing machines to the latest version of the standard practice.

6. Water Absorption and Pressure Test, Tensile Strength, and Whip Resistance

Both SAE J1401 and FMVSS No. 106 have identical specifications for the conditioning of the hose assembly in water for 70 hours, but the subsequent test conditions (which are also used for non-water conditioned hose) vary, given the aforementioned differences between

the pressure, tensile strength, and whip resistance requirements in SAE J1401 and FMVSS No. 106. NHTSA does not propose any changes to the existing water absorption requirements of FMVSS No. 106 but, as noted above, NHTSA does propose to incorporate SAE J1401's fast-pull test and 370-pound strength requirement into Standard No. 106's tensile strength test procedure. Accordingly, after being conditioned in water for 70 hours, hydraulic brake hose assembly would be required to meet these heightened tensile strength requirements.

7. Low Temperature Resistance Test

Both SAE J1401 and FMVSS No. 106 specify identical test procedures for bending brake hose around a test cylinder after conditioning at minus 40 degrees F. However, SAE J1401 does not include test cylinder dimensions for hoses with inside diameters other than ⅛ inch or 3⁄16 inch, while FMVSS No. 106 includes test cylinder dimensions applicable to all sizes of brake hose. NHTSA does not propose any changes in Standard No. 106's low temperature resistance requirements/procedures.

8. Brake Fluid Compatibility, Constriction, and Burst Strength

FMVSS No. 106 specifies that the hose be conditioned with SAE RM–66–05 Compatibility Fluid at 200 degrees F for 70 hours, and then subjected to constriction and burst strength tests. SAE J1401 specifies that the hose be conditioned using SAE RM–66–03 Compatibility Fluid at 248 +9 −0 degrees F for 70 to 72 hours prior to the constriction and burst strength tests. Thus, when compared to the test procedures specified in Standard No. 106, the SAE J1401 test is run at a higher temperature and uses the older SAE compatibility fluid. Because the RM–66–05 fluid has superceded the RM–66–03 fluid, NHTSA does not propose any change in the type of fluid specified for conditioning the hose. NHTSA does propose, however, to increase the conditioning temperature in FMVSS No. 106 to 248 degrees F.

9. Ozone Resistance

The test cylinder dimensional specifications in SAE J1401 and FMVSS No. 106 are the same, although the test procedures in FMVSS No. 106 account for hose that are not long enough to fit all the way around the test cylinder, while SAE J1401 provides test procedures for hose that exceed the test cylinder circumference and also for hose that collapse when subject to bending. SAE J1401 requires a higher concentration of ozone of 100 parts per million (ppm) compared to FMVSS No. 106, which requires a concentration of 50 ppm.

Both SAE J1401 and FMVSS No. 106 specify a conditioning temperature of 104 degrees F. In addition, both SAE 1401 and FMVSS No. 106 specify that the hose be subjected to ozone for at least 70 hours after which no visible cracks in the hose may be apparent when examined under 7-power magnification. Unlike FMVSS No. 106, however, SAE J1401 includes an additional dynamic ozone test, in which a cut length of hose is mounted in an environmental chamber, exposed to ozone at a 100 ppm concentration, and flexed on a specified apparatus through 3 inches of stroke at 0.3 Hz for 48 hours. SAE J1401 specifies that no cracking of the hose is permissible after 48 hours.

NHTSA proposes to upgrade FMVSS No. 106's ozone resistance requirements to incorporate the 100–ppm ozone concentration in SAE J1401. The agency also proposes to incorporate the dynamic ozone test in SAE J1401 into Standard No. 106. NHTSA tentatively concludes that such an upgrade is appropriate given the well-documented increase in ground-layer ozone formation and concentration in U.S. cities that has occurred since FMVSS No. 106 was first proposed in 1967. Requiring hydraulic brake hose to sustain increased ozone concentrations should more accurately reflect the present-day operating environments of brake hose and may prevent premature failure of the hose due to ozone exposure.

10. End Fitting Corrosion Resistance

Both SAE J1401 and FMVSS No. 106 specify exposing hydraulic brake hose end fittings to salt spray in a chamber for 24 hours. The salt spray chamber specified in FMVSS No. 106 is based on specifications outlined in ASTM B117–64, while the chamber specifications in SAE J1401 are based on ASTM B 117 Appendix B. NHTSA tentatively concludes these are different versions of the same ASTM Standard Practice B117, which has been revised over time. Instead of referencing either ASTM B117–64 or ASTM B 117 Appendix B, both of which are outdated, NHTSA proposes to change the reference in FMVSS No. 106 to the most recent set of ASTM specifications for salt spray chambers, which are found in ASTM B117–97.

Another difference between the end fitting corrosion resistance specifications in SAE J1401 and FMVSS No. 106 pertains to the mounting angle of the hose. SAE J1401 specifies that the hose shall be mounted at an angle between 15 and 30 degrees from vertical while FMVSS No. 106 specifies an angle of 30 degrees. Most of the end fitting corrosion resistance performance requirements in SAE J1401 and FMVSS No. 106 are similar or identical, with SAE J1401 typically providing tolerances on all parameters. SAE J1401 excludes brass end fittings from testing because apparently SAE deems those end fittings to have adequate corrosion resistance. While the two sets of performance requirements are very similar, Standard No. 106's requirements are somewhat more rigorous and inclusive. Accordingly, with the exception of updating the reference to the most recent set of ASTM specifications for salt spray chambers, NHTSA proposes no changes to the end fitting corrosion resistance requirements/procedures in FMVSS No. 106.

11. High Temperature Impulse Test

SAE J1401 specifies a hot impulse test in which a hose assembly is filled with brake fluid and subjected to 150 cycles of 1600 psi for one minute, then zero pressure for one minute, at an elevated temperature of 259 degrees F. After this test procedure, the hose assembly is cooled and subjected to a burst test with a specified minimum burst pressure of 5,000 psi. FMVSS No. 106 does not include a hot impulse test. Accordingly, NHTSA proposes incorporating the high temperature impulse test from SAE J1401 into FMVSS No. 106.

The table below summarizes the differences between the hydraulic brake hose requirements/procedures of FMVSS No. 106 and SAE J1401 and indicates which requirements/procedures NHTSA proposes incorporating into the standard.

TABLE 1.—COMPARISON OF HYDRAULIC BRAKE HOSE REQUIREMENTS IN FMVSS NO. 106 AND SAE J1401

Requirement/procedure		Existing FMVSS No. 106		SAE J1401
Hydraulic Brake Hoses ''x'' Indicates Requirements/Procedures Proposed To Be Included in FMVSS No. 106				
Pressure Test		5,000 psi burst strength specification, all hoses.	x	7,000 psi specified for ⅛ in. hose, same for 3⁄16 in. hose.
Constriction	1	Similar dimensional specifications	1	Similar, does not specify ¼ in. hose size.
Volumetric Expansion	x	Same		Same.
Whip Test	x	Same		Same.
Tensile Strength		Slow pull rate test	x	Includes slow plus fast pull rate tests.
Water Absorption and Pressure Test	x	Similar, note differences in pressure test		Similar.
Water Absorption and Tensile Strength		Similar, except fast pull rate test not included.	x	Similar, but includes fast pull rate.
Water Absorption and Whip Resistance	x	Similar		Similar.
Low Temperature Resistance Test	x	Same		Same, but does not cover all hose sizes.
Brake Fluid Compatibility, Constriction, and Burst Strength.		Lower conditioning temperature	x	Higher conditioning temperature, older version of test fluid (use RM–66–05 fluid).
Ozone Resistance		Similar, 50 ppm ozone concentration	x	Similar, 100 ppm ozone concentration.
Dynamic Ozone Test		Not included	x	Flex hose in ozone chamber for 48 hours.
End Fitting Corrosion Resistance	x	Similar, 30 degree mounting angle		Similar, 15–30 degree mounting angle, brass material exempt.
High Temperature Impulse Test		Not included	x	Pressure cycling at elevated temperature followed by burst test; does not cover ¼ in. brake hose.

Note 1: Use existing FMVSS No. 106 constriction requirement, propose that J1401 plug gauge test method be adopted in Test Procedure 106, add drop time.

B. Air Brake Hoses

NHTSA's performance requirements and test procedures relating to air brake hose are located in paragraph S7, *Requirements—Air brake hose, brake hose assemblies, and brake hose end fittings,* and paragraph S8, *Test procedures—Air brake hose, brake hose assemblies, and brake hose end fittings,* of FMVSS No. 106. The corresponding SAE requirements/procedures are contained in SAE Surface Vehicle Recommended Practice J1402, *Automotive Air Brake Hose and Hose Assemblies, Rev. June 1985* (SAE J1402).

NHTSA proposes to update FMVSS No. 106 to include performance requirements from SAE Recommended Practice J1402 that are not presently contained in the standard. The agency notes that, as was the case for hydraulic and vacuum brake hoses, air brake hose requirements as originally incorporated in Standard 106 in November of 1973 (38 FR 31302) were based on the substantive requirements in SAE J1402.

NHTSA tentatively concludes that virtually all air-braked vehicles are currently equipped with air brake hoses that meet SAE J1402 because many of these vehicles are used in commercial operations, and therefore are subject to the current FMCSA regulations requiring use of air brake hoses that comply with SAE J1402. While some vehicles equipped with air brake systems may not be operated as commercial vehicles, such as heavy-duty motor homes, the agency tentatively concludes that such vehicle populations are small in comparison to the number of straight trucks, tractors, and air-braked buses. NHTSA tentatively concludes that it is likely that the air brake hose, assemblies, and fittings on these non-commercial vehicles are already compliant with SAE 1402's specifications, however, because SAE 1402-compliant air brake hose products are the most widely available in the United States. Nevertheless, the agency welcomes comments on whether air brake hoses currently in use on commercial and non-commercial vehicles are designed to meet the specifications in SAE J1402.

A detailed discussion of the differences between the air brake hose, assemblies, and end fitting performance requirements and test procedures in SAE J1402 and FMVSS No. 106 follows, along with the agency's proposed resolution of those differences.

1. Dimensional Requirements

FMVSS No. 106 requires that hose constructed of synthetic or natural elastomeric rubber and intended for use with reusable end fittings must conform to the dimensional requirements listed in Table III of paragraph S7.1, *Construction.* Standardized dimensional requirements for hose with reusable end fittings guard against the possibility that replacement hose will not properly fit the end fittings. Table III lists required inside diameter (ID) and outside diameter (OD) dimensions for Type AI and Type AII air brake hose manufactured in fractional-inch sizes.

SAE J1402 includes the same dimensional requirements for AI and AII hose, but also includes dimensions for Type ''A'' hose. Type A air brake hose are primarily used with permanently attached end fittings, unlike Types AI and AII air brake hose, which are used with reusable end fittings. Some Type A hose, specifically ⅜ inch, 7⁄16 inch, and ½ inch ''Special'' hose, may also be fitted with reusable end fittings. SAE J1402's dimensional requirements apply to all Type A hose, regardless of whether they are fitted with permanent or reusable end fittings. With respect to the Type A ⅜-inch and Type A ½-inch ''Special'' hose, the agency notes that there are already corresponding dimensions included in Table III of FMVSS No. 106 with identical dimensions for both Type AI and Type AII hose. Under FMVSS No. 106, a ½-Special or ⅜ brake hose can be labeled to include the ''A,'' ''AI,'' and/or ''AII'' designations, or any combination thereof (*e.g.*, ''AI–AII''), as the hose manufacturer deems appropriate.

Although the petitioners did not specifically request the incorporation of SAE J1402's dimensional requirements for Type A air brake hose into FMVSS No. 106, the agency notes that it once considered whether to do so. In a June 28, 1974, final rule (39 FR 24012, Docket No. 1–5; Notice 11), the agency

decided against including dimensional requirements for Type A air hose in FMVSS No. 106. The agency stated that the primary purpose of the dimensional requirements was to prevent mismatch between reusable end fittings and replacement brake hose. At that time, hose used with permanent end fittings were generally assembled by high volume manufacturers rather than repair operations in the field. The agency did not believe that there was a safety need to provide dimensional requirements for hose assemblies manufactured in such a manner. Accordingly, NHTSA found that including dimensional requirements for air brake hose used with permanent end fittings would amount to ''a design restriction without corresponding safety benefit.''

NHTSA no longer believes that only high-volume brake hose manufacturers are assembling air brake hoses with permanently attached fittings. A review of brake hose manufacturers that are registered with NHTSA indicates that many truck repair facilities are registered, and the agency tentatively concludes that many of these facilities may be capable of assembling brake hoses with permanently attached end fittings as replacement parts. NHTSA does not know the extent to which air brake hose that meets SAE J1402 dimensional requirements for Type A hose is used in such replacement assemblies, but tentatively concludes it is likely that most, if not all, such hose already comply with SAE J1402's dimensional requirements because § 393.45 requires that hoses used on commercial motor vehicles comply with SAE 1402.

NHTSA is not proposing to incorporate into FMVSS No. 106 the dimensional requirements for rubber hose used with permanently attached end fittings found in Table A of SAE J1402. In the case of 7/16-inch hose, which is not currently listed in Table III of FMVSS No. 106, NHTSA proposes to add this hose size to the dimensional tables for Type I and Type II hose, which would have the effect that as indicated in SAE J1402, 7/16-inch hose could be used with either permanent or reusable fittings, as is the case for 3/8-inch and 1/2-inch Special hose as currently included in Table III of FMVSS No. 106. Hose manufacturers would then be able to label 7/16-inch hose with a designation of ''A,'' ''AI,'' and/or ''AII,'' as they deem appropriate. NHTSA welcomes public comments on this proposal, and also requests any dimensional and descriptive information for other sizes of air brake hose that manufacturers may be producing that is not covered under SAE J1402. NHTSA also welcomes public comments on whether FMVSS No. 106 should include dimensional requirements for metric sized hose used with reusable end fittings as Standard No. 106 currently does not provide requirements for such hose. Note that Standard No. 106 does include references to metric sizes of air brake hose that presumably is used with permanently-attached end fittings.

2. Construction and Labeling

Paragraphs S7.1, *Construction,* and S7.2, *Labeling,* both contain references to air brake hoses constructed of synthetic or natural elastomeric rubber to differentiate those hose types from air brake tubing constructed from nylon (plastic), with both rubber hose and nylon tubing currently regulated as air brake hoses under paragraphs S7 and S8. The designation for synthetic or natural elastomeric rubber hoses was added to FMVSS No. 106 in a 1991 final rule (56 FR 7589) so that the dimensions for hoses used with reusable fittings in Table III would not apply to plastic tubing. NHTSA proposes, as discussed in another section below, that plastic air brake tubing be regulated in its own section in FMVSS No. 106 since it differs significantly in construction and material properties from elastomeric rubber hoses. Therefore, NHTSA proposes that any references to synthetic or natural elastomeric rubber be deleted from S7 of FMVSS No. 106 since it will no longer be necessary to differentiate rubber hoses from plastic tubing in S7 and S8. The proposed text in this notice also removes references to ''outside diameter (OD)'' from S7 and S8 of FMVSS No. 106 since OD measurements are generally only applicable to tubing, which NHTSA proposes to address in the new section for plastic tubing.

NHTSA also proposes to specify in S7.2.1(e) of FMVSS No. 106 the labeling scheme that is to be used for air brake hose that meet the dimensional requirements of more than one type of end fitting (A, AI, or AII). The proper labeling of such hose has been addressed in several of the agency's legal interpretation letters and inserting this language in FMVSS No. 106 would serve to minimize confusion on this issue. The proposed text also states that a hose intended for use with more than one type of end fitting may be labeled as such, but is not required to be so labeled. This provides flexibility for hose manufacturers to determine how they intend for their hoses to be used, and would not require them to label hoses for multiple end fitting designations unless they so desire.

3. Manufacturer Identification

While the labeling requirements in FMVSS No. 106 and SAE J1402 differ somewhat, both can be accommodated on a single brake hose. SAE J1402 requires each manufacturer to register the identification of its yarn scheme in accordance with SAE J1401, Appendix B and to label each hose with its manufacturer's identification number. Similarly, FMVSS No. 106 requires that hose manufacturers register with NHTSA and imprint their name or symbol on subject hoses and/or fittings. The agency does not propose to change FMVSS No. 106's manufacturer identification or labeling requirements.

4. Constriction

The constriction requirements relating to air brake hose are found in paragraph S7.3.1 of FMVSS No. 106. Standard No. 106 requires that every inside diameter of any section of each air brake hose assembly shall be not less than 66 percent of the nominal inside diameter of the hose, except for those portions of end fittings that do not contain hose. SAE J1402 also requires air brake hose assembly to meet a 66 percent of nominal inside diameter requirement but, unlike FMVSS No. 106, it does not exclude the portions of end fittings not containing hose. NHTSA proposes to eliminate the exclusion in S7.3.1 for those portions of end fittings which do not contain hose, as the agency does not believe that end fittings for air brake hose include restrictions designed into the fittings, nor are there complex shapes for end fittings as found with some hydraulic brake hoses. NHTSA welcomes public comments on this proposal. NHTSA also proposes that the same test method proposed for testing hydraulic brake hoses for constriction be specified for testing air brake hoses. In addition, noting that the title of paragraph S7.3.1 contains a typographical error, NHTSA proposes to change the title of S7.3.1 from ''Construction'' to ''Constriction.''

5. High Temperature Resistance

FMVSS No. 106 includes a test in which the hose is bent around a test cylinder, conditioned at 212 degrees F for 70 hours, then cooled and straightened. No charring, disintegration, or cracks are permitted. The high temperature test specifications for air brake hose contained in SAE J1402 are similar, but not identical, to those in FMVSS. First, the radii of the test cylinders specified for each hose size are significantly smaller in SAE J1402 than in FMVSS No. 106. Second, unlike FMVSS No. 106, SAE J1402 does

not include test cylinder radii specifications for ⅛-inch ID hose. Third, SAE J1402 does not provide specifications for metric sized hose. Instead, the SAE specification provides only metric conversions for inch sizes of hose. Fourth, unlike FMVSS No. 106, SAE J1402 excludes hose with fabric covering from external inspection for cracks, stating that visual inspection is not practical.

NHTSA proposes that FMVSS No. 106 adopt the smaller radii test cylinders from SAE J1402 and, for ⅛-inch and 3 mm, 4 mm, and 5 mm hose, NHTSA proposes that the test cylinder radius of 1 inch as specified in SAE J1402 for 3⁄16-inch hose also be used for these hose sizes. As currently indicated in Table IV of FMVSS No. 106, the larger metric sizes of hose (6 mm and above) numerically correspond closely to inch sizes of hose, for example, 6 mm (0.236 inch) is very close to ¼ inch (0.250 inch). Accordingly, NHTSA proposes to apply the test cylinder values from SAE J1402 to metric sizes of hose as currently specified in Table IV of FMVSS No. 106. As to SAE J1402's exclusion of fabric-covered air brake hose from the external inspection requirement, NHTSA disagrees that external inspection of such hose is impractical and, therefore, does not propose to incorporate SAE J1402's exclusion.

6. Low Temperature Resistance

FMVSS No. 106 specifies that the hose and test cylinder be conditioned at minus 40 degrees F for 70 hours, followed by bending the hose 180 degrees around the test cylinder. No cracks may be visible on the outside cover of the hose after performing this test. The test procedure in SAE J1402 is similar, including the radii of the test cylinders, except that it does not specify test cylinder radii for ⅛ inch or 3mm hose. SAE J1402 also prohibits cracks on the inside of the hose and, in this respect, the SAE test is more severe than the one specified by FMVSS No. 106. Unlike FMVSS No. 106, however, SAE J1402 excludes the exterior surface of hoses covered with fabric from external inspection.

The agency indicated in a February 26, 1974 final rule (39 FR 7425, Docket No. 1–5, Notice 10) amending FMVSS No. 106 that it would consider specifying inspection of the inner layer of an air brake hose subjected to the low-temperature resistance test at a future date. In addition, the agency notes that the test procedure for Standard No. 106, TP–106, specifies that the same test procedure be used for air brake hose as for hydraulic brake hose, using the test cylinders sized for air brake hose, and does include internal inspection of both types of hoses. NHTSA is now proposing that the internal surface inspection of air brake hose, as specified in SAE J1402, be incorporated into FMVSS No. 106. The agency does not propose, however, to incorporate SAE J1402's exclusion of fabric-covered air brake hose from external inspection.

7. Oil Resistance

Paragraphs S7.3.4, *Oil resistance,* and S8.3, *Oil resistance test,* of FMVSS No. 106 specify that specimens prepared from the inner tube and outer cover of the subject brake hose, when immersed in American Society of Testing and Materials (ASTM) No. 3 oil for 70 hours at 212 degrees F, shall not increase in volume by more than 100 percent. SAE J1402 contains an identical test procedure. As indicated in ASTM D147–98e1, *Standard Test Method for Rubber Property—Effect of Liquids,* ASTM No. 3 oil is no longer commercially available and has been superseded by IRM 903 oil. Accordingly, NHTSA proposes that all references in S7.3.4 and S8.3 to ASTM No. 3 oil be changed to specify IRM 903 oil. The agency does not propose any additional changes to FMVSS No. 106's oil resistance requirements/specifications.

8. Ozone Resistance

FMVSS No. 106's ozone resistance requirements/specifications for air brake hose are the same as those specified for hydraulic brake hose. Standard No. 106 specifies that air brake hose be conditioned in an ozone chamber for 70 hours at 104 degrees F while the hose is secured around a test cylinder. Because the test procedure for air brake hose, S8.4 (*Ozone resistance test*), specifies that the same test procedure for a hydraulic brake hose ozone resistance test be utilized, and because NHTSA is proposing that the ozone concentration for hydraulic brake hose be changed from 50 ppm to 100 ppm, NHTSA proposes to specify the higher ozone concentration (100 ppm) for air brake hose as well. The agency tentatively concludes it is appropriate to specify the same concentration of ozone for testing all types of brake hoses and welcomes public comments on this issue.

9. Length Change

Paragraph S7.3.6, *Length change,* of FMVSS No. 106 requires that air brake hose, when subjected to 200 psi of air pressure, shall not contract more than 7 percent nor elongate more than 5 percent over the length of the hose. The associated test procedure, found in paragraph S8.5, *Length change test,* specifies that the initial length of the hose be measured at a pressure of 10 psi. Coiled nylon tube may alternatively comply with requirements in FMCSR 393.45 (which references J844 for nylon air brake tubing). SAE J1402's length change requirements/procedures are identical to those in FMVSS No. 106. Considering that FMCSA and NHTSA are proposing to consolidate all federal brake hose requirements/procedures into FMVSS No. 106 and because NHTSA is proposing specific requirements/procedures for plastic air brake tubing, the agency proposes to delete the option for coiled nylon tube to comply with FMCSR 393.45 from Standard No. 106. Aside from deleting this reference, the agency does not propose any additional changes to the length change requirements/procedures in FMVSS No. 106.

10. Adhesion

FMVSS No. 106 requires a minimum separation strength of 8 pounds per linear inch for each layer in an air brake hose, except for hose reinforced by wire. SAE J1402 has a similar requirement for non-wire reinforced hose, and a separate test procedure for wire reinforced hose, in which a steel ball is placed inside the hose sample, one end is capped and the other connected to a vacuum source, and the hose is bent 180 degrees around a test cylinder in one direction and then the opposite direction. While still under vacuum, the hose is straightened and the steel ball must be able to roll from one end of the hose to the other. NHTSA proposes to incorporate the SAE J1402 adhesion test for wire-reinforced air brake hose into FMVSS No. 106, with the exception of the steel ball sizes as discussed below.

The table of steel ball sizes for this test procedure in SAE J1402 indicates that for all but the 13⁄32-inch hose sizes, the ball diameter is equal to 75 percent of the nominal hose ID. For the 13⁄32-inch hose size, the specified ball diameter is 73 percent of the nominal hose ID. It appears that the reason for this one difference is that the ball sizes in the table are standard size steel balls measured in 64ths of an inch, thus 75 percent of 13⁄32-inch is slightly larger than 19⁄64-inch and 73 percent of 13⁄32 equals 19⁄64-inch. The table in SAE J1402 also does not provide corresponding steel ball sizes for metric sized hose. Accordingly, to incorporate SAE J1402's specifications into FMVSS No. 106, NHTSA proposes that rather than specifying steel ball diameters for each hose size, the steel ball should be

specified as having a diameter that is 75 percent of the nominal inside diameter of the hose. This would allow for testing of any and all sizes of hose. NHTSA welcomes public comments on this issue.

The agency notes that it is proposing to specify use of a plug gauge rather than a steel ball for constriction testing of other types of hose to which FMVSS No. 106 applies. For the adhesion test, however, it would not be possible to use a plug gauge because the hose is closed off at both ends during the test. Accordingly, NHTSA proposes to specify the use of a steel ball to test air brake hose for adhesion. Finally, the agency proposes to update the ASTM tension testing machine reference in S8.9 from the 1964 version currently in FMVSS No. 106 to the latest revision of that standard, *Standard Practices for Force Verification of Testing Machines,* Designation E4–99.

11. Air Pressure (Leakage)

FMVSS No. 106 specifies that an air brake hose assembly be subjected to a 200-psi pressure test. Once the target pressure is reached, the hose is sealed and the pressure drop over a five-minute period may not exceed 5 psi.

SAE J1402 has two test procedures to evaluate the leakage from air hose assemblies. In the first test, two hose assemblies are tested as follows. One hose assembly is subjected to the high temperature resistance test described above, and is then subjected to a 300-psi pressure test using air or nitrogen, under water, with no visible leakage for 30 seconds. The second hose assembly is subjected to the low temperature resistance test described above, and is then subjected to a 300-psi pressure test using air or nitrogen, under water, with no visible leakage for 30 seconds.

In the second test, a flexure test is performed as follows. A test hose assembly is prepared to the length shown in Figure 2 of that standard. The hose is preconditioned by exposure to a salt spray for 24 hours with the ends sealed, followed by high-temperature aging at 212 degrees F for 70 hours with the ends open and, within 168 hours of completion of the preconditioning, the hose is subjected to the flex test. The hose is mounted on the flex test fixture as described in Figure 2, with the hose being subjected to a 6-inch stroke while the air pressure in the hose is cycled between 0 psi for one minute and 150 psi for one minute. With the flexure machine stroking at 100 cycles per minute, the hose is subjected to 1 million stroke cycles. Upon completion of the 1 million cycles, the hose must be capable of maintaining 150-psi ±10 psi when air is supplied through a 1/16-inch diameter orifice.

The SAE J1402 specifications for hose leakage are more severe than those presently in FMVSS No. 106, and NHTSA proposes incorporating them into Standard 106, with the following modifications. SAE J1402 specifies that upon completion of the high-temperature aging test, the hose assembly must be flex tested within 168 hours. NHTSA tentatively concludes there could be variability introduced in the test results if, for example, the hose was immediately flex tested after the high-temperature test, or if the hose were allowed to cool before being flex tested. Therefore, NHTSA proposes that upon completion of the high-temperature aging test, the hose assembly be cooled at room temperature for two hours, and the flex test then be initiated within 166 hours from that time.

NHTSA also proposes to modify SAE J1402's testing procedures by specifying the thickness of the orifice during the final leak check because the thickness of the orifice, and not only the diameter of the orifice, affects the rate at which air can be supplied to the hose. This would be critical if a small amount of hose leakage is present during the final leakage test. NHTSA proposes specifying an orifice thickness of 0.032 inches (1/32-inch), which is the same thickness specified for the orifice in FMVSS No. 121 S5.3.5, *Control signal pressure differential for converter dollies and trailers designed to tow another vehicle equipped with air brakes.* NHTSA tentatively concludes that this proposed orifice dimension would supply air at a greater rate than any thicker orifice while still providing sufficient mechanical strength to withstand the test conditions. NHTSA welcomes comments on this proposal.

With respect to the amount of leakage that is permitted after the flex test is conducted, SAE J1402 is not absolutely specific. SAE J1402 defines failure as the hose's inability to be repressurized to 150-psi ±10 psi, supplied through the 0.062-inch orifice, within 2 minutes. SAE J1402 specifies that the supply air pressure to the orifice is 150 psi ±10 psi. Accordingly, a hose supplied with up to 160-psi supply air pressure and resulting in 140-psi pressure in the hose assembly could conceivably be construed as passing the test. On the other hand, the specifications could be construed as permitting no leakage, that the pressure in the hose assembly must equal the supply pressure, within a range of 140 psi to 160 psi. If that were the case, however, there would be no need for an orifice to be included in the test apparatus.

NHTSA proposes to specify a supply pressure of 150 psi and to further specify that the pressure in the hose assembly must reach 140 psi within 2 minutes. NHTSA notes that this is consistent with the existing requirements in FMVSS No. 106, S7.3.8 *Air pressure,* which permits a small amount of leakage in an air brake hose assembly, albeit without prior conditioning. NHTSA welcomes comments on these proposed leakage specifications.

12. Burst Strength

FMVSS No. 106 requires that an air brake hose assembly shall not rupture when subjected to a hydrostatic pressure of 800 psi. SAE J1402 specifies that a hose assembly be first subjected to a 24-hour salt spray test, with no resulting corrosion other than as permitted by that standard, and then shall not burst or separate from an end fitting at a hydrostatic pressure of 900 psi. SAE J1402's burst strength specifications/requirements are more severe than those in FMVSS No. 106. NHTSA proposes to incorporate SAE J1402's burst strength specifications/requirements into Standard No. 106.

13. Tensile Strength

FMVSS No. 106 specifies that a hose assembly for use between either the frame and the axle or between a towed and towing vehicle meet a longitudinal pull test, at a 1 inch per minute force application rate, and not separate from its end fittings at the following force levels: 250 pounds for 1/4 inch or less, or 6mm or less, nominal ID; 325 pounds for more than 1/4 inch or 6mm nominal ID. A hose assembly used in any other application must withstand force levels of: 50 pounds for 1/4 in or less (or 6 mm or less) nominal ID; 150 pounds for 3/8 inch, 1/2 inch, or 10 mm to 12 mm, nominal ID; and 325 pounds if the hose assembly is larger than 1/2 inch (or 12 mm) nominal ID. A coiled nylon tube assembly can either meet these requirements or, alternatively, can meet the requirements in FMCSR § 393.45.

The distinction between a brake hose used between a frame and axle or between a towed and towing unit, and hose used for other purposes, was added to Standard No. 106 on February 26, 1974 (39 FR 7425), in response to petitions for reconsideration of certain brake hose requirements. This distinction was introduced in response to the inclusion of plastic tubing as an air brake hose, and permitted lower tensile strength requirements for plastic tubing used in chassis applications.

Because the agency is now proposing separate requirements for plastic tubing in a new section of FMVSS No. 106, NHTSA proposes to delete the lower tensile strength limits for hose that are used for purposes other than connections between a frame and axle or between a towed and towing unit.

The agency proposes that all rubber brake hose meet the requirements for hose that is used between a frame and axle or between a towed and towing unit. NHTSA tentatively concludes that rubber hoses are no longer used extensively for other purposes on heavy vehicles, as plastic tubing is used for most chassis plumbing of air systems. An example of a chassis plumbing use for rubber hose is to connect an air dryer to the wet tank, although here again many vehicles use plastic tubing in this application. NHTSA tentatively concludes that these rubber hoses are of sufficient diameter to have the mechanical strength to meet the higher, frame-to-axle tensile strength requirements. These requirements are similar to the ones originally proposed for FMVSS No. 106 prior to the accommodation of plastic tubing strength requirements. In addition, these tensile strength requirements are currently specified in SAE J1402, which does not distinguish based on the application of the hose and includes the higher force specification. SAE J1402 does not specify a stand-alone tensile strength test, but does specify a water absorption test followed by a tensile strength test, described below. NHTSA welcomes comments on the proposed tensile strength requirements and information on any alternate tensile strength requirements that might be appropriate for rubber hose.

NHTSA also proposes to delete the reference to FMCSR § 393.45 in paragraph S7.3.10 because NHTSA is proposing to incorporate into FMVSS No. 106 many of the SAE requirements referenced in § 393.45 for plastic air brake tubing.

14. Water Absorption and Tensile Strength

FMVSS No. 106 specifies that a hose assembly be immersed in distilled water for 70 hours at room temperature and, within 30 minutes of being removed from the water, be subjected to the tensile strength test and requirements described above. A coiled nylon tube assembly can either meet these specifications/requirements or, alternatively, the requirements in FMCSR § 393.45.

SAE J1402 specifies bending a hose assembly around a test cylinder and, with its ends capped, immersed in tap water at room temperature for 168 hours. Following this, the hose assembly is subjected to a tensile pull test, with the following force levels specified to be achieved without separation or rupture: 250 pounds for hose of ¼ inch, or 6.4 mm, or less, nominal ID; 325 pounds for hose larger than ¼ inch or 6.4 mm. Thus, the tensile strength required in SAE J1402 is similar to that in FMVSS No. 106 for a hose used between a frame and axle, or between a towed and towing vehicle. SAE J1402 does not, however, include lower tensile strength values for hoses that are used between components that do not experience substantial relative motion and it also does not address plastic tubing.

Although the SAE J1402 test specifies a longer water conditioning period than FMVSS No. 106, which would make those specifications more severe, FMVSS No. 106 specifies that the ends of the hose assembly be left open thereby exposing the inside of the hose to water. SAE J1402 also specifies that tap water rather than distilled water (as specified in FMVSS No. 106) be used in this test, which could introduce variability in test results depending on compounds that are in the tap water at any particular location. On balance, it would be difficult to state which test condition is more severe, but NHTSA proposes that the current requirements in paragraph S7.3.11, *Water absorption and tensile strength,* be retained, except as modified by proposed changes to the stand-alone tensile strength requirements discussed above. NHTSA also proposes to delete the reference to FMCSR § 393.45 in S7.3.11.

15. Zinc Chloride Resistance

Paragraph S7.3.12, *Zinc chloride resistance,* of FMVSS No. 106 requires that a hose assembly be immersed in a 50 percent zinc chloride aqueous solution for 200 hours, with no visible cracks permitted when viewed with 7 power magnification. SAE J1402 does not include a similar requirement. NHTSA does not propose any changes in Standard No. 106's zinc chloride resistance requirements.

16. End Fitting Corrosion Resistance

FMVSS No. 106 requires that air brake hose end fittings meet the same requirements as those specified for hydraulic brake hose end fittings. As is the case for hydraulic brake hoses per SAE J1401, SAE J1402 references the ASTM B117 Method of Salt Spray (Fog) Testing while FMVSS No. 106 references ASTM B117–64. Unlike SAE J1401, SAE J1402 does not exclude brass end fittings from this requirement. While SAE J1402 does not specify the attitude of the brake hose assembly in the chamber, FMVSS No. 106 specifies a 30-degree from vertical angle. Because FMVSS No. 106's end fitting corrosion resistance requirements appear to be more rigorous, NHTSA does not propose any changes to these requirements.

17. Minimum Bend Radius

SAE J1402 specifies minimum bend radius requirements for hose as installed on a vehicle. NHTSA tentatively concludes it would not be appropriate to add these requirements to FMVSS No. 106 because FMVSS No. 106 regulates the properties of brake hoses as stand-alone motor vehicle equipment rather than use requirements.

The table below summarizes the differences between the air brake hose requirements/procedures of FMVSS No. 106 and SAE J1402 and indicates which requirements/procedures NHTSA proposes incorporating into the standard.

TABLE 2.—COMPARISON OF AIR BRAKE HOSE REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J1402

Requirement/procedure		Existing FMVSS No. 106		SAE J1402
Air Brake Hoses ''x'' Indicates Requirements/Procedures Proposed To Be Included in FMVSS No. 106				
Dimensional Specifications	x	Similar, does not include Type A hose		Similar, but includes Type A hose.
Constriction	x	Similar, includes end fittings		Similar but does not include end fittings.
High Temperature Resistance		Similar, but larger test cylinder radii	x	Similar, but smaller test cylinder radii.

TABLE 2.—COMPARISON OF AIR BRAKE HOSE REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J1402—Continued

Requirement/procedure		Existing FMVSS No. 106		SAE J1402
Low Temperature Resistance	1	Similar, excludes interior of hose from inspection.	1	Similar, requires internal inspection, excludes fabric covered hose exterior inspection.
Oil Resistance	x	Same		Same.
Length Change	x	Same; coiled nylon can meet FMCSR § 393.45.		Same.
Adhesion		Same except for wire reinforced hose	x	Same but includes specific test for wire reinforced hose.
Air Pressure (Leakage)		200 psi leak test	x	More test specifications including dynamic flex test.
Burst Strength		800 psi hydrostatic test	x	Salt spray test followed by 900 psi hydrostatic test.
Tensile Strength	x	Specifies longitudinal pull test		No corresponding, stand-alone test. Specifications are in Water Absorption test.
Water Absorption and Tensile Strength	x	70 hour water immersion followed by pull test; coiled.		168 hour water immersion followed by pull test.
Tensile Strength		Nylon can meet FMCSR 393.45		Followed by pull test.
Zinc Chloride Resistance	x	200 hour immersion in zinc chloride		No corresponding test.
End Fitting Corrosion Resistance	x	Similar, specifies angle of hose in test chamber.		Similar, does not specify angle of hose in test chamber.
Ozone Test		No ozone test	2	Hose bent around test cylinder exposed to 50 ppm ozone for 70 hours.
Minimum Bend Radius		None	3	Specifies minimum bend radii for hose as installed on a vehicle.

Note 1: for low temperature resistance, use the most severe requirements from each standard.
Note 2: propose J1402 test, except with 100-ppm ozone concentration.
Note 3: would not be appropriate for FMVSS No. 106.

C. Vacuum Brake Hoses

NHTSA's performance requirements and test procedures relating to vacuum brake hoses are located in paragraph S9., *Requirements—Vacuum brake hose, brake hose assemblies, and brake hose end fittings,* and paragraph S10., *Test procedures—Vacuum brake hose, brake hose assemblies, and brake hose end fittings,* of FMVSS No. 106. The corresponding SAE requirements are contained in SAE Highway Vehicle Standard J1403, *Vacuum Brake Hose, Rev. July 1989.*

When requirements for vacuum brake hoses were originally added to FMVSS No. 106 in November of 1973 (38 FR 31302), the substantive requirements of SAE J1403 were adopted. NHTSA proposes to update FMVSS No. 106 to include performance requirements from the most recent version of SAE J1403 that are not presently contained in the standard.

Again, as with hydraulic brake hoses, the agency tentatively concludes that many light vehicle manufacturers already voluntarily equip their vehicles with vacuum hoses that meet the current version of SAE J1403. Accordingly, NHTSA proposes applying the SAE specifications to all types of vacuum hoses and not just those used on commercial vehicles. The proposed amendments to FMVSS No. 106 represent incrementally more severe performance requirements that the industry has adopted over the past 20 years.

The petitioners requested that the requirements of SAE J1403 be added to FMVSS No. 106 to upgrade the performance requirements for vacuum brake hose. The use of vacuum brake hose in automotive applications is generally for the vacuum hose connecting the power brake booster to the engine manifold, and although there may be other applications for vacuum brake hose, the agency tentatively concludes that vacuum-operated braking systems are no longer being used in the U.S. Although the use of this type of brake hose may be far more limited than it was 40 or 50 years ago, NHTSA tentatively concludes that upgrading the requirements for vacuum brake hose is still warranted given that use of such hose is still widespread.

A detailed discussion of the differences between the vacuum brake hose performance requirements and test procedures in SAE J1403 and FMVSS No. 106 follows, along with the agency's proposed resolution of those differences.

1. Constriction

Paragraph S9.2.1, *Constriction,* of FMVSS No. 106 requires the inside diameter of a heavy duty vacuum hose assembly to be at least 75 percent of the hose's nominal inside diameter. The inside diameter of a light duty vacuum hose assembly is required, by S9.2.1, to be at least 70 percent of the hose's nominal inside diameter. FMVSS No. 106 excludes from these performance requirements those portions of the hose's end fittings that do not contain hose. Constriction testing, as outlined in Testing Procedure 106–08 (TP–106–08), is performed using plug gauges with diameters as specified in TP–106–08.

SAE J1403 does not contain a corresponding set of constriction test requirements/procedures. Accordingly, NHTSA does not propose any changes to Standard No. 106's constriction requirements/procedures for vacuum brake hose. NHTSA does seek public comments, however, on whether to continue to exclude those portions of end fittings that do not contain hose from the standard's constriction requirements.

2. High Temperature Resistance

Paragraph S9.2.2, *High temperature resistance,* of FMVSS No. 106 specifies bending a length of hose around a cylinder of specified diameter and exposing it to air at a temperature of 212 degrees F for 70 hours. After conditioning the hose in this manner, Standard No. 106 specifies that the hose be straightened and cut longitudinally and visually inspected. No visible cracking, charring, or disintegration on the exterior or interior of the hose is permitted.

SAE J1403 has a different test procedure in which a straight length of hose is subjected to a vacuum and conditioned at 257 degrees F for 96 hours. After temperature conditioning, the hose is cooled and bent around a test cylinder, then visibly inspected for degradation. The hose is then subjected to a proof pressure test of 175 psi for one minute. Required performance measures include: not more than 10 percent collapse of the outside diameter (OD) for heavy-wall hose and not more than 15 percent collapse of the OD for light-wall hose after the hot aging test; no visible internal or external embrittlement or degradation; and no leakage during the high-pressure test.

While FMVSS No. 106 specifies test cylinder radii for given sizes of hose (Table V), SAE J1403 simply specifies a test cylinder that is five times the OD of the hose. These test cylinder dimensions cannot be compared based on information in the standards because FMVSS No. 106 does not indicate the OD of the hose.

Nevertheless, the high temperature resistance requirements in SAE J1403 appear to be more rigorous than those in FMVSS No. 106 given that standard's post-test dimensional and burst test specifications. Accordingly, NHTSA proposes to incorporate SAE J1403's high temperature resistance requirements/specifications for vacuum brake hose into FMVSS No. 106.

3. Low Temperature Resistance

Paragraph S9.2.3, *Low temperature resistance*, of FMVSS No. 106 specifies conditioning vacuum brake hose, in a straight configuration, at minus 40 degrees F for 70 hours and then, while still cold, bending the hose 180 degrees around a test cylinder with a radius specified in Table V. After performing this test, S9.2.3 specifies visual inspection of the hose. No visible cracks on the hose are permitted. SAE J1403 has similar provisions, except that after the cold bending test is performed, SAE J1403 specifies subjecting the hose to a 175-psi pressure test at room temperature with no leakage permitted. SAE J1403's low temperature resistance requirements are more rigorous due to the addition of this pressure test. Accordingly, NHTSA proposes to incorporate SAE J1403's pressure test procedure into FMVSS No. 106.

4. Ozone Resistance

Paragraph S9.2.4, *Ozone resistance*, of FMVSS No. 106 specifies subjecting vacuum brake hose to an ozone concentration of 50 ppm for 70 hours. After performing the test, the hose, when visually inspected under 7 power magnification, must reveal no visible cracks. The ozone resistance specifications in SAE J1403 are similar but SAE J1403 specifies an ozone concentration of 100 ppm rather than 50 ppm. The agency tentatively concludes it is appropriate to update the ozone resistance specifications for vacuum brake hose, as it proposes to do for other types of brake hoses. Accordingly, NHTSA proposes to incorporate SAE J1403's 100-ppm ozone concentration specification into FMVSS No. 106.

5. Burst Strength

The burst strength requirements in FMVSS No. 106 and SAE J1403 are nearly identical. Both standards specify a hydrostatic burst test at 350 psi with no hose rupturing allowed under FMVSS No. 106 and no leakage or bursting allowed under SAE J1403. Given the similarities in the two standards, NHTSA does not propose any changes to the vacuum brake hose burst strength requirements/procedures in FMVSS No. 106.

6. Vacuum Deformation

Paragraph S9.2.6, *Vacuum*, of FMVSS No. 106 requires that a vacuum brake hose, when subjected to 26 inches of Hg. for 5 minutes, not collapse more than 1/16-inch as measured on the hose's outside diameter. SAE J1403 does not contain a corresponding, stand-alone test specification, although the collapse of hose as a percentage of OD is measured after performing the high temperature vacuum aging test described above. NHTSA does not propose any changes to the vacuum deformation requirements/procedures in FMVSS No. 106.

7. Bend Test

FMVSS No. 106 requires that a specified length of hose be bent until the ends are touching, with a maximum permissible outside diameter (OD) collapse specified in fractional inches. SAE J1403 has a similar requirement, although the maximum permissible collapse is specified as a percentage of the un-bent OD (*e.g.*, 20 percent, 30 percent). It is difficult to compare the two requirements/procedures because the values presented in Standard No. 106 are not expressed in terms of OD measurement and, therefore, a percentage calculation cannot be made. One difference between the two standards is that SAE J1403 excludes preformed hoses molded to fit specific applications in which no significant additional bending occurs when the hose is installed on a vehicle. Based on the information provided in each standard, it does not appear that either set of requirements/procedures is more stringent than the other. Accordingly, NHTSA does not propose any changes to the bending requirements/procedures in FMVSS No. 106. The agency does propose, however, to incorporate SAE J1403's exclusion of preformed hose and welcomes public comments on this issue.

8. Swell (Fuel Resistance)

FMVSS No. 106 specifies that a brake hose specimen be filled with ASTM Reference Fuel A and conditioned for 48 hours, after which the inside diameter (ID) of the hose is required to be at least 75 percent of nominal ID for heavy-duty hose and 70 percent of nominal ID for light-duty hose. Standard No. 106 specifies use of a plug gauge to measure the hose's inside diameter. Following the swell test, FMVSS No. 106 specifies subjecting the hose to 26 inches of Hg for ten minutes. The hose must then be examined to determine that no leakage or separation of the inner tube from the fabric reinforcement of the hose has occurred.

SAE J1403's swell test requirements/procedures are similar, but not identical. First, SAE J1403 specifies use of Reference Fuel B rather than Reference Fuel A. Second, SAE J1403 specifies that the hose's inside diameter be measured with a drop ball rather than a plug gauge. Third, SAE J1403 specifies a 10-minute vacuum test, followed by a layer adhesion test with an 8 pounds-per-inch minimum separation specification. In contrast, FMVSS No. 106 specifies that the hose show no leakage or separation of the inner tube from the fabric reinforcement of the hose while the 10-minute vacuum test is being performed.

With respect to the difference in specified fuels, as described in ASTM D471–98e1, *Standard Test Method for Rubber Property—Effect of Liquids,* Reference Fuel A is composed of 100 percent isooctane and Reference Fuel B is composed of 70 percent isooctane and 30 percent toluene by volume. Note 2 in the test method states that:

> The ASTM reference fuels in Table 3 have been selected to provide the maximum and minimum swelling effects produced by commercial gasolines. Reference Fuel A has a mild action on rubber vulcanizates and produces results of the same order as low swelling gasolines of the highly paraffinic, straight run type. Reference Fuels B, C [isooctance 50 percent, toluene 50 percent], and D [isooctane 60 percent, toluene 40 percent] simulate the swelling behaviour of the majority of commercial gasolines, with Reference Fuel C producing the highest swelling which is typical of highly aromatic premium grades of automotive gasoline.

NHTSA proposes that Reference Fuel B as specified in SAE J1403 be used for the swell test in FMVSS No. 106. While this fuel would increase the severity of the test, it would not be so severe as using one of the other reference fuels that contain higher concentrations of toluene, nor as severe as some of the other reference fuels that represent ethanol or methanol blends of gasoline (gasohol).

With respect to the difference in measuring instruments used to determine the hose's inside diameter, NHTSA favors use of a plug gauge because plug gauges are somewhat less susceptible to friction than steel drop-balls. Accordingly, NHTSA proposes that the plug gauge method be kept in place in TP–106 for swell testing of vacuum brake hoses, but welcomes comments on the merits of each constriction test procedure as it applies to vacuum brake hose.

Regarding the differences in adhesion testing between the NHTSA and SAE standards during or after the vacuum test, NHTSA tentatively concludes that each standard has its benefits and drawbacks. While the visual check for hose collapse in FMVSS No. 106 is valid for cases in which the entire hose integrity has been compromised during the fuel soak, it is not clear that this visual check would be able to detect separation of multi-layer hose materials if collapse occurs only on the inside tube or layer. On the other hand, the SAE J1403 layer adhesion test does not include a specification that the hose not visibly collapse during the vacuum test. Visible collapse of the hose during the vacuum test indicates a loss of hose integrity, even if the hose layers remain well bonded.

NHTSA proposes that the specifications of these two standards be combined as follows. Following the fuel conditioning using Reference Fuel B and the constriction test, each vacuum hose would be subjected to a vacuum of 26 inches of Hg for ten minutes, with no visible collapse or leakage of the hose permitted (as currently specified by FMVSS No. 106). Then, for hoses constructed of two layers or more, a layer adhesion test would be conducted with a specified performance of 8 pounds-per-inch minimum separation force (as specified by SAE J1403). NHTSA proposes that this adhesion test only be applied to multi-layer hoses for two reasons. First, the agency tentatively concludes that single layer hose cannot be tested easily. Second, NHTSA tentatively concludes that single layer hose that have lost mechanical integrity would not be able to pass the visual collapse or no leakage specification during the vacuum test and, as such, failure would already be detected prior to completion of the vacuum test.

In addition to the foregoing changes to FMVSS No. 106's swell test requirements/procedures, NHTSA also proposes to update the ASTM test procedure referenced in S10.7 for the swell test to the current revision, D471–98e1.

9. Adhesion

FMVSS No. 106 requires that vacuum brake hose, other than wire-reinforced hose, have a minimum layer separation strength of 8 pounds per inch. There are no specifications for wire-reinforced hose. There is a similar, 8-pound-per-inch adhesion requirement in SAE J1403, although the SAE standard specifically identifies the layers as ''the tube from the plies'' and ''the cover from the plies.'' NHTSA tentatively concludes that there are no substantial differences between these two standards. Because NHTSA is proposing to combine the adhesion test with the swell test, however, the agency proposes to delete the stand-alone adhesion test specifications for vacuum brake hose from FMVSS No. 106.

10. Deformation

Paragraph S9.2.10, *Deformation*, of FMVSS No. 106 specifies testing short lengths of hose by compressing (flattening or collapsing) the hose to a specified dimension and then releasing the compression force. After five cycles, the minimum outside diameter (OD) of the hose must be at least a specified percentage of the original OD. SAE J1403 does not contain a similar set of deformation testing specifications. NHTSA does not propose any changes to the vacuum brake hose deformation requirements/specifications in FMVSS No. 106.

11. End Fitting Corrosion Resistance

Paragraph S9.2.11, *End fitting corrosion resistance*, of FMVSS No. 106 requires that vacuum brake hose end fittings show no surface base metal corrosion after being exposed to salt spray for 24 hours. Standard No. 106 provides an exception for that portion of the end fitting where crimping or the application of labeling information has caused displacement of the end fitting's protective coating. SAE J1403 does not contain any corresponding requirements. NHTSA does not propose any changes to Standard No. 106's end fitting corrosion resistance requirements.

The table below summarizes the differences between the vacuum brake hose requirements/procedures of FMVSS No. 106 and SAE J1403 and indicates which requirements/procedures NHTSA proposes incorporating into the standard.

TABLE 3.—COMPARISON OF VACUUM BRAKE HOSE REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J1403

Requirement/Procedure		Existing FMVSS No. 106		SAE J1403
Vacuum Brake Hoses ''x'' Indicates Requirements/Procedures Proposed To Be Included in FMVSS No. 106				
Constriction Test	x	Specifications for constriction at end fittings		No corresponding specifications
High Temperature Resistance		Hose bent and exposed to elevated temperature, less severe than J1403.	x	High temperature conditioning, bend test, pressure test
Low Temperature Resistance		Similar, but does not include pressure test	x	Similar, but also specifies 175 psi pressure test
Ozone Resistance		Similar, 50 ppm ozone concentration	x	Similar, 100 ppm ozone concentration
Burst Strength	x	Same		Same
Vacuum Deformation	x	Limit 1/16 in. collapse of hose OD under vacuum.		No corresponding, stand-alone specification; high temperature test has specifications
Bend Test	x	Similar test, different measurement		Similar test, different measurement
Swell (Fuel Resistance)	1	Similar test, Reference Fuel A, no collapse or leakage permitted.	1	Similar test, Reference Fuel B, layer adhesion test specified
Adhesion		Similar, but is a stand-alone test	x	Similar, but is conducted after swell test fuel soak

TABLE 3.—COMPARISON OF VACUUM BRAKE HOSE REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J1403—Continued

Requirement/Procedure		Existing FMVSS No. 106		SAE J1403
Deformation	x	Compression test	....	No corresponding test
End Fitting Corrosion Resistance hose end fittings.	x	Same as for hydraulic brake hose end fittings.		No corresponding test

Note 1: NHTSA proposes performing layer adhesion test once vacuum hose has been conditioned during swell test. NHTSA considers a stand-alone adhesion test unnecessary.

The agency notes that plastic vacuum brake tubing is being used in automotive applications, as it has been requested to issue legal interpretations on the application of requirements in Standard No. 106 to this type of material. This may lead to a situation similar to that for air brake hose, for which both rubber hose and plastic tubing are widely used and the agency is now proposing to create separate requirements for each type of hose. The agency is not aware of an SAE or other industry standard for plastic vacuum brake hose and therefore is not currently proposing any separate requirements for this material. If a suitable industry standard is developed for plastic vacuum brake tubing, the agency may consider adopting those requirements into Standard No. 106 as appropriate, as part of a future rulemaking activity.

D. Plastic Air Brake Tubing

NHTSA's performance requirements and test procedures relating to plastic air brake tubing are located in paragraph S7., *Requirements—Air brake hose, brake hose assemblies, and brake hose end fittings,* and paragraph S8., *Test procedures—Air brake hose, brake hose assemblies, and brake hose end fittings.* The corresponding SAE requirements/procedures are contained in SAE Surface Vehicle Standard J844, *Nonmetallic Air Brake System Tubing, Rev. June 1988* (SAE J844).

Standard No. 106's requirements for plastic air brake tubing are the same as those for rubber air brake tubing. NHTSA tentatively concludes that FMVSS No. 106 does not adequately address the performance requirements for plastic air brake tubing because of the significant difference in the materials, construction, and end fittings of plastic air brake tubing compared with rubber air brake hose. The agency tentatively concludes that due to the current requirements in the FMCSRs, plastic air brake tubing as widely used on air-braked vehicles has been, up until this time, compliant with SAE J844. Therefore, if SAE J844 compliance is no longer required by the FMCSRs, as has been proposed by the FHWA, then the potential exists that the requirements currently in Standard No. 106 will not adequately ensure the continued safe performance of plastic air brake tubing.

NHTSA proposes that the substantive requirements/procedures in SAE J844 be incorporated into FMVSS No. 106, including dimensional specifications, classifications, burst test, moisture absorption test, ultraviolet resistance test, cold temperature flexibility test, heat aging test, resistance to zinc chloride and methyl alcohol tests, boiling water stabilization and burst tests, cold temperature impact test, collapse resistance test, and hot tensile strength test. NHTSA proposes that two performance requirements currently in Standard No. 106 for air brake hoses, ozone resistance and oil resistance, continue to be required for plastic tubing. However, for the oil resistance test, NHTSA proposes a new test procedure consisting of oil conditioning followed by a burst test, rather than the volumetric expansion specification currently in Standard No. 106, as a test condition more appropriate for plastic tubing.

The agency also proposes incorporating the classifications and dimensional specifications from SAE Surface Vehicle Standard J1394, *Metric Nonmetallic Air Brake System Tubing, Rev. April 1991,* into FMVSS No. 106. Although not referenced by the petitioners, this standard contains requirements for plastic air brake tubing manufactured in metric sizes. NHTSA tentatively concludes that it is appropriate to include requirements for both metric and inch sizes of plastic air brake tubing.

Plastic air brake tubing is typically sold separately from the end fittings and therefore it is generally not sold or supplied as an air brake hose assembly, with the exception of coiled hoses used between tractors and trailers which are often pre-assembled using permanently-attached end fittings. In light of this, the SAE has developed separate standards for plastic air brake tubing and plastic air brake tubing assemblies and end fittings. SAE J844 contains performance requirements for plastic air brake tubing, while SAE Surface Vehicle Standard J1131, *Performance Requirements for SAE J844 Nonmetallic Tubing and Fitting Assemblies Used in Automotive Air Brake Systems,* contains performance requirements for plastic air brake tubing assemblies and end fittings.

The requirements in S7 of FMVSS No. 106 were developed for rubber air brake hose that is sized according to internal diameter (ID). Paragraph S7 contains few references to plastic/nylon tubing that, unlike rubber air brake hose, is sized according to outside diameter (OD) and is a significantly different product than rubber hose. Plastic tubing is generally manufactured from nylon but the generic term plastic is used in this notice to account for other types of plastic that may be used for this application. As previously discussed, the applicability of Table III in Standard 106 was amended so that it would only be applicable to brake hoses made from synthetic or natural elastomeric rubber, thus there are no dimensional requirements for plastic tubing in FMVSS No. 106. NHTSA proposes that new dimensional requirements for plastic air brake tubing be included in Standard No. 106 based on the dimensions currently used in SAE J844 (inch units) and SAE J1394 (metric units).

Non-coiled plastic tubing is used for air system plumbing to connect components that maintain a basically fixed relationship during vehicle operation. Coiled plastic tubing is generally used in flexible connections such as between a tractor and a semi-trailer. By coiling a long length of relatively stiff plastic tubing, a flexible coiled arrangement is obtained. Non-coiled tubing differs from conventional rubber hose in that it would not be used between components that experience relative motion, although it would still be subjected to vibration and other loads.

1. Classification

FMVSS No. 106 references Type I and Type II air brake hose and reusable end fittings which are required to be labeled as either ''AI'' or ''AII.'' SAE J844 and SAE J1394 classify plastic tubing as ''A''

for smaller diameter, non-reinforced tubing made from one layer of material, or ''B'' for larger diameter tubing made from two layers of material with a reinforcement braid located at the layer interface. Tubing is sized by the nominal OD of the tubing either in fractions of an inch or in millimeters. These designations are appropriate for plastic tubing but FMVSS No. 106 does not currently contain any references to Type A and B tubing or any dimensional requirements for plastic tubing.

It should be noted that FMCSR § 393.45(b)(ii) specifies that, for plastic tubing used on commercial motor vehicles, the reference to SAE J844 only includes Type B tubing. NHTSA proposes to update FMVSS No. 106 to include requirements for both Types A and B plastic tubing.

2. Dimensions and Tolerances

SAE J844 includes a table (Table 1) that prescribes, for each nominal size of tubing, the ID, OD, minimum wall thickness, and tolerances on the ID and OD. There are no corresponding dimensions in FMVSS No. 106. These dimensions are safety-critical because they ensure that the tubing is compatible with the fittings designed for that tubing. Incompatibility between tubing and end fittings can, among other things, cause the inside diameter of the tubing to collapse. NHTSA agrees with the petitioners that, if there are no requirements for these dimensions, there is the possibility that tubing of improper dimensions could pull out of the end fittings or otherwise prematurely fail at the connections, leak because of improper sealing due to dimensional incompatibility with fittings, or loosen due to thermal expansion and contraction. Accordingly, NHTSA proposes to incorporate into Standard No. 106 the dimension and tolerance requirements contained in SAE J844.

3. One Hundred Percent Leak Test

SAE J844 requires tubing manufacturers to subject all air brake tubing to a 200-psi leak test. The specific testing methods, including test media, rate of application, and required performance measures, are not specified in SAE J844 and are, therefore, determined by the tubing manufacturer.

FMVSS No. 106 does not address the quality control methods that hose manufacturers use to ensure that all hoses installed on motor vehicles will meet the standard. Rather, the manufacturers of such components are required to certify compliance, and each brake hose or assembly is required to meet the standard. NHTSA tentatively concludes that plastic air brake tubing manufacturers will continue to perform quality control tests on their products, but that such requirements should not be included in FMVSS No. 106.

4. Burst Test

SAE J844 specifies that tubing be stabilized at 75 degrees F for a period of 30 minutes to 3 hours. Pressure (of an unidentified medium, assumed to be air) in the tube is increased at a constant rate to reach a specified minimum burst pressure (specified in Table 2) within a time period of 3 to 15 seconds. The tubing must sustain the specified pressure without bursting. FMVSS No. 106 specifies using water as the test media, with a pressure increase rate of approximately 1,000 psi per minute, to a pressure of 800 psi. The specified pressures in Table 2 of SAE J844 range from 1000 to 1200 psi for Type A tubing and 800 psi to 1400 psi for Type B tubing (each size of tubing has one specific burst pressure). Therefore, the pressure requirements in SAE J844 are equal to or higher than those in FMVSS No. 106. While the performance differences of the different test media have not been measured, it would appear that using air would be more appropriate for air brake tubing than using water. NHTSA welcomes comments on the use of air versus water as the test medium.

In NHTSA' judgment, the greater pressure requirements in SAE J844 are more rigorous than existing requirements in FMVSS No. 106. NHTSA proposes changing the burst strength requirements in FMVSS No. 106 to the higher values in SAE J844, and specifying air as the test medium rather than water. NHTSA proposes that the pressure in the tubing be increased in a period of 5 seconds because using the range of 3 to 15 seconds in SAE J844 would specify testing at both 3 and 15 seconds and therefore would be too broad of a specification for use in FMVSS No. 106. NHTSA welcomes comments on the use of air versus water as the test medium.

5. Moisture Absorption

SAE J844 specifies that a tubing specimen be conditioned for 24 hours at 230 degrees F, immediately weighed, and then subjected to 100 percent relative humidity for 100 hours at 75 degrees F. Within five minutes of removal from the humidity chamber, surface moisture is wiped from all surfaces of the tubing and the tubing is weighed. The moisture absorption shall not exceed 2 percent by weight. FMVSS No. 106 does not have a corresponding test. NHTSA proposes incorporating the moisture absorption specification from SAE J844 into FMVSS No. 106.

6. Ultraviolet Resistance

SAE J844 specifies that the tubing be placed in a Q-Panel QUV test apparatus equipped with Philips Type UVS–340 bulbs. If the test apparatus is equipped with a ''Solar Eye,'' the bulbs need not be rotated and the irradiance should be set at 0.85; however, all bulbs should be discarded after 4800 hours maximum or if they fall below the 0.85 irradiance level, whichever occurs first. If the test apparatus is not equipped with a ''Solar Eye,'' the bulbs must be rotated every 400 hours maximum, per the apparatus manufacturer and ASTM G 53. Bulbs used in such an apparatus must be discarded after 1600 hours of use.

The samples are placed in the sample racks of the test apparatus and are exposed for 300 hours at a temperature of 113 degrees F, with the surface of the specimen mounting plate located no more than 2 inches from the bulbs. The samples are rotated according to ASTM D 4329 except the rotation is each 96 hours rather than weekly. No humidity other than ambient is introduced. Immediately after the samples are removed from the ultraviolet light test apparatus, they are subjected to an impact test using a device depicted in Figure 1 of SAE J844. The tubing samples are then cooled to 75 degrees F and subjected to a burst test, with a minimum burst pressure that is at least 80 percent of the value assigned to the tubing based on the tubing's outside diameter as indicated in Figure 2 of SAE J844.

NHTSA notes that in November 1973 (38 FR 31302), NHTSA deleted the ultraviolet light resistance tests for air brake hoses in Standard No. 106, stating that sufficient data had not been generated to support a minimum performance requirement. However, NHTSA tentatively concludes that the plastic material used in nylon air brake tubing is significantly different from the materials used in rubber air brake hoses, and that plastic is susceptible to deterioration that can cause embrittlement due to exposure to ultraviolet light. NHTSA also notes that air brake tubing is installed on heavy vehicles in locations that are exposed to naturally-occurring ultraviolet light. Therefore, NHTSA proposes to incorporate SAE J844's ultraviolet resistance test into FMVSS No. 106, although the agency proposes to reference the apparatus specified in ASTM G154–00, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic*

Materials, rather than the one specified in ASTM G53 because ASTM G154–00 is an updated version of ASTM G53. NHTSA also proposes to reference two additional ASTM standards: ASTM D4329–99, *Standard Practice for Fluorescent UV Exposure of Plastics,* which is currently referenced in SAE J844, and ASTM G151–97, *Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources,* which is not currently referenced in SAE J844, but may provide useful guidance for conducting UV testing.

7. Cold Temperature Flexibility

SAE J844 specifies tubing to be conditioned at 230 degrees F for 24 hours. Within 30 minutes of removal from the oven, the tubing is placed in a cold chamber at minus 40 degrees F and conditioned for 4 hours. A test cylinder with a radius equal to 6 times the nominal OD of the tubing is also conditioned at minus 40 degrees F for 4 hours. The tubing and test cylinder are removed from the cold chamber and the tubing is bent 180 degrees around the test cylinder within a period of 4 to 8 seconds. The tubing must show no signs of fracture.

FMVSS No. 106 also contains a low temperature resistance test procedure. The FMVSS No. 106 procedure differs in that the hose is bent around the test cylinder prior to being conditioned in the cold chamber; the cold conditioning is for 70 hours; and there is no high-temperature preconditioning. The table in paragraph S7 (Table IV) includes dimensions for the test cylinder radius for each nominal size of hose. Table IV references hose size by nominal diameter, and does not differentiate between hose, which is sized by inside diameter, and tubing, which is sized by outside diameter. Applying the test cylinder radii in Table IV to the nominal outside diameter of tubing, and then comparing these values to the test cylinder radii in SAE J844, reveals that the test cylinder radii in SAE J844 are smaller and, therefore, SAE J844 provides a more stringent test condition in terms of bend radius than does FMVSS No. 106.

The test conditions of ''cold temperature flexibility'' in SAE J844 do not correspond to the ''low temperature resistance'' test in FMVSS No. 106. SAE J844 is a test to evaluate the crack resistance of tubing, subjected to bending while in a cold state, while the FMVSS No. 106 test condition is an evaluation of pre-bent tubing's resistance to cracking when subjected to cold temperatures. Because SAE J844 is more rigorous, NHTSA proposes substituting it for the current test in FMVSS No. 106. NHTSA tentatively concludes that the time period of 4 to 8 seconds to accomplish the bending of the tubing is appropriate for this test because the bending is done by hand and is therefore subject to some variability. Specifying the 4 to 8 second time period will preclude the need for specialized bending apparatus that can meet a specific timing specification.

8. Heat Aging

SAE J844 includes three different heat aging tests, which specify use of three separate samples of the same tubing. A tubing sample is subjected to one of the aging tests described below, then subjected to the burst test at room temperature, with a minimum burst strength of 80 percent of a specified value.

The first test is to bend a section of tubing 180 degrees around a test cylinder with a diameter equal to two times the tubing's minimum bend radius, as specified in the standard. The tubing and test cylinder are conditioned for 72 hours at 230 degrees F and then removed to cool at 75 degrees F. Within 30 minutes after stabilizing at 75 degrees F, the tubing is straightened within a time period of four seconds. The tubing is then bent 180 degrees in the opposite direction within a time period of 4 to 8 seconds.

The second test is to condition the tubing at 230 degrees F for 72 hours, then remove and cool the tubing to 75 degrees F. Within 30 minutes after stabilizing at 75 degrees F, the tubing is subjected to an impact test as specified in the standard.

The third test involves conditioning the tubing by immersing it in boiling water for 2 hours, then removing and cooling it to 75 degrees F. Within 30 minutes after stabilizing at 75 degrees F, the tubing is subjected to an impact test as specified in the standard.

FMVSS No. 106 does not have corresponding test procedures. The high temperature resistance test (S8.1) evaluates a hose for resistance to visible cracking after being conditioned at 212 degrees F for 70 hours and then straightened. There is no burst (pressure) strength requirement. NHTSA proposes incorporating the SAE J844 test procedures for plastic air brake tubing into FMVSS No. 106.

9. Zinc Chloride Resistance

SAE J844 specifies that tubing be bent around a test cylinder and immersed in a 50 percent by weight (specific gravity of 1.576 or a Baume rating of 53 degrees at 60 degrees F) aqueous solution of zinc chloride for 200 hours at 75 degrees F. After removal from the solution, the tubing must show no evidence of cracking on the outside diameter. FMVSS No. 106 specifies that a hose assembly be immersed in a 50 percent zinc chloride aqueous solution for 200 hours, with no visible cracks permitted when viewed with 7-power magnification. SAE J844's zinc chloride test procedures are more rigorous due to the bending of the tubing during the conditioning. Accordingly, NHTSA proposes to incorporate the zinc chloride resistance performance requirements and test procedures from SAE J844 into FMVSS No. 106.

10. Resistance to Methyl Alcohol Resistance

SAE J844 specifies that the tubing be bent around a test cylinder and then immersed in 95 percent methyl alcohol for 200 hours at 75 degrees F. After removal from the solution, the tubing must show no evidence of cracking. This test ensures that air brake tubing is not susceptible to damage from alcohol that is sometimes introduced into air brake systems during extreme cold weather conditions, or from windshield washer fluid containing alcohol that may spill onto brake tubing. There is no corresponding test procedure/performance requirement in FMVSS No. 106, and NHTSA proposes to incorporate the one specified in SAE J844. NHTSA also welcomes comments on the suitability of adopting this test procedure/performance requirement for rubber air brake hoses, since they are also susceptible to alcohol exposure for the same reasons.

11. Stiffness

SAE J844 specifies that an 11-inch long sample of tubing be slipped over a rod to maintain the hose in a straight position within plus or minus ⅛ inch. The tubing and rod are conditioned at 230 degrees F for 24 hours, then removed and cooled to 75 degrees F. Within 30 minutes after stabilizing at 75 degrees F, the rod is removed and tubing is subjected to a stiffness test as outlined in the standard. The tubing must require no more that the specified amount of force to deflect 2 inches. This test ensures that the flexibility of the tubing is not reduced when the tubing is subjected to elevated temperatures. An increase in stiffness after exposure to elevated temperatures indicates that the tubing is susceptible to kinking or embrittlement under this condition. Because Standard No. 106 does not contain a similar set of procedures/requirements, NHTSA proposes to incorporate the stiffness procedures/

requirements from SAE J844 into FMVSS No. 106.

12. Boiling Water Stabilization and Burst Test

SAE J844 specifies that the tubing be immersed in boiling water for 2 hours. The tubing is then removed from the water and subjected to a burst test at room temperature. The standard specifies a minimum burst strength of 80 percent of the value assigned to the tubing based on the tubing's nominal outside diameter. NHTSA tentatively concludes that this test condition is redundant because a similar boiling water conditioning test, followed by impact and burst tests, is already specified by the third heat aging test, as described above. FMVSS No. 106 has no corresponding test procedure. Because NHTSA is already proposing to incorporate the heat aging test from SAE J844, the agency does not propose to also incorporate SAE J844's stand-alone boiling water stabilization and burst test.

13. Cold Temperature Impact

SAE J844's cold temperature impact test specifies the use of 10 separate samples of air brake tubing. Five samples are conditioned for 24 hours at 230 degrees F, and the other five are conditioned in boiling water for 2 hours. All samples and the impact test apparatus are then conditioned at minus 40 degrees F for 4 hours. Each sample is then subjected to the impact test per Figure 1, with no visible cracks permitted. Each sample is then warmed to 75 degrees F and, within 30 minutes of stabilization at this temperature, a burst test conducted. Each tubing sample must withstand 80 percent of the specified burst strength. If any one of the samples fails these tests, the entire test sequence is repeated using twenty samples. If any one of these twenty samples fails, then the entire manufacturing lot is to be rejected. This test evaluates the resistance of the tubing to cold temperature fracturing. FMVSS No. 106 does not have corresponding test procedures/ performance requirements.

In an August 1970 notice of proposed amendment to FMVSS No. 106 (35 FR 13738), NHTSA's predecessor agency, the National Highway Safety Bureau, addressed the issue of a sampling approach in testing standards. That notice indicated that the SAE approach, which includes testing of several samples and then retesting additional samples if initial failures are found, is not an essential methodology to demonstrate non-compliance. Rather, the agency indicated that it favored testing one brake hose sample to determine compliance. Manufacturers, on the other hand, should or may conduct testing on multiple samples as part of their quality control procedures to determine whether continued failures exist such as to demand rejection of an entire manufacturing lot. NHTSA tentatively concludes that it is still preferable to subject only one sample to a particular set of testing procedures for compliance purposes. Accordingly, the agency proposes that only one plastic brake tubing sample be subjected to the cold impact test procedures contained in SAE J844. With this one modification, NHTSA proposes to incorporate the cold impact test procedures/performance requirements from SAE J844 into FMVSS No. 106.

14. Adhesion Test

SAE J844 specifies that Type B, reinforced tubing, be subjected to an adhesion test. A helical sample ¼ inch wide and with a length equal to five times the circumference of the tubing is cut from the tubing. With the tubing sample at a temperature of 75 degrees F, a knife blade is used to initiate separation at the braid interface. Further attempts to separate the sample must result in no separation over the entire length of the test sample other than at points at which the braid is present. SAE J844 does not include any specifications for Type A, non-reinforced tubing because this type of hose is only manufactured from one layer. Standard No. 106 presently requires that hose have a minimum adhesion strength of 8 pounds per linear inch of hose.

NHTSA tentatively concludes that the ''no separation'' performance requirement in SAE J844 would be unenforceable because during a destructive test the tubing will ultimately fail at some point during the test. NHTSA tentatively concludes that the existing Standard No. 106 minimum adhesion requirement of 8 pounds per linear inch is suitable for rubber air brake hose. Given the SAE J844 ''no separation'' specification for Type B plastic tubing, however, NHTSA proposes that a higher minimum adhesion requirement is appropriate for that type of tubing. NHTSA therefore proposes a minimum separation value of 25 pounds per linear inch for Type B plastic tubing, which the agency tentatively concludes is severe enough to ensure that an adequate bond exists between the tubing layers but not so high as to present enforcement concerns. Accordingly, NHTSA proposes that the adhesion test procedures/performance requirements for Type B tubing in SAE J844 be incorporated into FMVSS No. 106, with a minimum separation strength of 25 pounds per linear inch. Rather than specifying a stand-alone adhesion test, however, NHTSA is proposing to incorporate SAE J844's heat aging adhesion test, which is described below. With respect to Type A tubing, because such tubing is typically manufactured from a single extrusion of nylon with no internal layers, the agency does not believe it is necessary to specify an adhesion test for that type of tubing.

NHTSA proposes to deviate from SAE J844's test procedure because it appears that it would be difficult to mount the test specimen in a tension testing machine if the specimen is cut from a ¼-inch wide helical section of tubing. NHTSA proposes that a 1-inch length of tubing be cut lengthwise and two flaps of material be cut using a sharp knife so that the test sample can be clamped in the machine. The adhesion test for air brake hose that uses a rotating mandrel to support the inner layers of the hose was considered for tubing but does not appear to be practical for tubing since it would be difficult to separate (cut) the outer layer of the tubing from the inner layer with the inner layer of the tubing in an intact, round shape. NHTSA welcomes comments on the proposed adhesion test procedures/performance requirements.

15. Heat Aging and Adhesion Test

SAE J844 specifies that a Type B tubing sample be conditioned in the first heat aging test (bend tubing, heat conditioning, and re-bend tubing after cooling) and then subjected to the adhesion test, detailed above. Type A tubing is not subjected to this test. FMVSS No. 106 does not have a corresponding set of test procedures/ performance requirements. NHTSA proposes to incorporate the heat aging adhesion test procedures from SAE J844, but that the minimum adhesion performance requirement for Type B tubing be raised from 8 pounds per linear inch to 25 pounds per linear inch.

16. Collapse Resistance

SAE J844 specifies that three test samples of specified length be prepared and the minor outside diameter (OD) be measured. The minor OD is the smallest outside diameter of the tubing measured at the center of the sample, typically located 90 degrees from the natural lay line of the tubing. The samples are installed on a specified bend test fixture and, following the natural bend of the tubing, each tube is bent 180 degrees to the minimum kink radius listed in the standard. The samples are conditioned

at 200 degrees F for 24 hours and then cooled to room temperature (75 degrees F) and, while still installed on the bend fixture, the minor OD is measured. The minor OD collapse of the heat-conditioned samples must not exceed 20 percent of the initial minor OD. FMVSS No. 106 does not contain corresponding test procedures/performance requirements.

NHTSA proposes to incorporate the collapse resistance test procedures/performance requirements from SAE J844 into FMVSS No. 106, with two changes. First, the agency proposes to specify that only one sample be tested rather than three. Second, NHTSA notes that the minimum kink radii in Table 3 of SAE J844 represents the minimum unsupported bend radii for tubing as installed on a vehicle while the test bend radii in Table 2 of that standard represent the minimum bend radii for supported tubing during applicable test procedures. NHTSA tentatively concludes that because heavy vehicle manufacturers are aware that such installation criteria are included in SAE J844 there is no need to incorporate them into FMVSS No. 106. NHTSA welcomes public comments on both of these proposed modifications.

17. Oil Resistance

SAE J844 does not include an oil resistance test as specified by FMVSS No. 106. The oil test is used to measure the volumetric expansion of specimens prepared from the inner and outer layers of a hose, after immersion in ASTM No. 3 oil at 212 degrees F for 70 hours, with a maximum permissible volumetric expansion of 100 percent. While such a test is appropriate for the type of materials used in elastomeric, synthetic rubber air brake hoses, NHTSA tentatively concludes that in the case of plastic air brake tubing it would be more appropriate to evaluate a mechanical property of the tubing such as the ability to pass a burst test after conditioning in oil.

NHTSA is aware of a problem that was encountered several years ago with pre-assembled air brake tubing assemblies used for tractor-trailer connections supplied by one manufacturer. This particular product, when subjected to conditioning in oil, would undergo material property changes that resulted in failure (dissolution) of the tubing. The manufacturer of the tubing assemblies petitioned NHTSA to request that coiled air brake tubing assemblies be exempt from the oil resistance requirements in Standard No. 106. NHTSA ultimately denied this request and stated in the denial (58 FR 38346) that coiled air brake tubing assemblies are subjected to elevated temperatures and exposed to oil. The agency notes that this particular product was not compliant with SAE J844.

NHTSA tentatively concludes it is critical that plastic air brake tubing be resistant to oil exposure. Oil can be introduced into air brake systems due to air compressor leakage, and exposed portions of tubing are subject to oil and grease contamination from sources such as hydraulic work equipment mounted on vocational trucks, axle lubricant leakage, and fifth wheel lubrication. Therefore, NHTSA proposes a test procedure for plastic tubing that combines existing FMVSS No. 106 oil conditioning criteria with the burst strength requirements of SAE J844.

The proposed test procedure involves preparation of a tubing assembly, conditioning it in ASTM IRM 903 oil (which supercedes ASTM No. 3 oil as described in ASTM D471–98e1, *Standard Test Method for Rubber Property-Effect of Liquids*), and then subjecting the tubing to the burst test specified in SAE J844. NHTSA proposes that the tubing not burst at less than 80 percent of the burst pressure listed in Table 2 of SAE J844. This required performance is the same as that specified in SAE J844 for the boiling water stabilization and burst test. NHTSA tentatively concludes that using an 80 percent value for the oil test is appropriate given that the tubing is pre-conditioned in oil, similar to the preconditioning of the boiling water test, and notes that the tubing would not be required to have the 100 percent burst strength required for non-conditioned tubing tested at room temperature. NHTSA welcomes comments on this proposed test procedure in lieu of the existing Standard No. 106 requirement that limits volumetric expansion of the material during oil conditioning.

18. Ozone Resistance

SAE J844 does not include an ozone resistance test as specified by FMVSS No. 106. Standard No. 106 specifies bending a hose around a test cylinder and conditioning it in a test chamber at 50-ppm ozone concentration at 104 degrees F for 70 hours. After performing this test, no visible cracks may be detected when viewed under 7-power magnification. The agency notes that the ozone test for hydraulic brake hose in SAE J1401 specifies an ozone concentration of 100 ppm and that, as noted above, NHTSA is proposing to increase the ozone concentration requirements for all types of brake hose covered by FMVSS No. 106. Accordingly, NHTSA proposes that the ozone test that is currently specified in Standard No. 106 continue to be applied to plastic air brake tubing at the higher ozone concentration level of 100 ppm.

The table below summarizes the differences between the plastic air brake tubing requirements/procedures of FMVSS No. 106 and SAE J844 and indicates which requirements/procedures NHTSA proposes incorporating into the standard.

TABLE 4.—COMPARISON OF NYLON AIR BRAKE TUBING REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J844

Requirement/Procedure		Existing FMVSS No. 106		SAE J844
Plastic Air Brake Tubing				
"x" Indicates Requirements/Procedures Proposed to be Included in FMVSS No. 106. A new section would be added with performance requirements/test procedures for plastic air brake tubing. Some existing requirements/procedures for air brake hose would also apply.				
100 Percent Leak Test	x	Not Specified		Each lot to be tested.
Classification		Type AI or AII air hose	x	Type A or B plastic air brake tubing.
Dimensional Specifications		None	x	J844 (inch) and J1394 (metric) dimensions for plastic tubing.
Burst Test		800 psi requirement	x	Strength based on tubing size and type, minimum is 800 psi.
Moisture Absorption		None	x	Not to exceed 2 percent.
Ultraviolet Resistance		None	x	300 hour exposure followed by impact test.

TABLE 4.—COMPARISON OF NYLON AIR BRAKE TUBING REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J844—Continued

Requirement/Procedure		Existing FMVSS No. 106		SAE J844
Cold Temperature Flexibility		Low temperature resistance but not flexibility.	x	Cold conditioning followed by bending around test cylinder.
Heat Aging		Does not include burst test	x	Three separate test procedures followed by burst test.
Zinc Chloride Resistance		Similar but tubing is not bent during test	x	Similar, tubing is conditioned while bent around test cylinder.
Methyl Alcohol Resistance		None	x	Tubing bent around test cylinder and conditioned in alcohol for 200 hours.
Stiffness		None	x	Stiffness of tubing after conditioning at elevated temperature.
Boiling Water Stablization and Burst Test		None		Considered redundant since more severe test condition included in heat aging test.
Cold Temperature Impact		None	x	Cold conditioning, impact test, and burst test.
Adhesion Test		8 lbs. per linear inch, for any air brake hose.	1	Type B tubing only, no separation permitted.
Heat Aging Adhesion Test		None	1	Type B tubing only, heat aging and adhesion test. No separation permitted.
Collapse Resistance		None	x	Max. 20 percent collapse after high temp. conditioning bent around test cylinder.
Ozone Resistance	2	Same as air brake hose, 50 ppm		None.
Oil Resistance	3	Same as air brake hose	....	None.

Note 1: NHTSA proposes a 25 lbs. per inch adhesion strength instead of ''no separation.''
Note 2: NHTSA proposes 100 ppm ozone concentration.
Note 3: NHTSA proposes an oil soak and burst test for plastic tubing.

E. Plastic Air Brake Tubing Assemblies and End Fittings

NHTSA's performance requirements and test procedures relating to plastic air brake tubing assemblies and end fittings are located in paragraph S7., *Requirements—Air brake hose, brake hose assemblies, and brake hose end fittings*, and paragraph S8., *Test procedures—Air brake hose, brake hose assemblies, and brake hose end fittings*, of FMVSS No. 106. The corresponding SAE performance requirements/test procedures are contained in SAE Surface Vehicle Standard J1131, *Performance Requirements for SAE J844 Nonmetallic Tubing and Fitting Assemblies Used in Automotive Air Brake Systems, Rev. August 1998* (SAE J1131). SAE's end fitting performance requirements/test procedures are located in SAE Surface Vehicle Standard J512, *Automotive Tube Fittings Rev. October 1980* (SAE J512) and SAE Surface Vehicle Standard J246, *Spherical and Flanged Sleeve (Compression) Tube Fittings Rev. March 1981* (SAE J246).

This section addresses performance requirements and test procedures for plastic air brake tubing assemblies and end fittings. The previous section compared FMVSS No. 106 to SAE J844 and only addressed the properties of the tubing and not the properties of tubing assemblies or end fittings. SAE J1131 evaluates the performance of SAE J844 tubing when used in an assembly with either permanently-attached or reusable end fittings.

NHTSA proposes to incorporate the following end fitting performance requirements/test procedures from SAE J1131 into Standard No. 106: the hot tensile strength test, the conditioned pull test, the vibration leak test, the proof and burst test, the fitting compatibility test, and the serviceability test. The serviceability test specifies that an end fitting, after five assembly and disassembly cycles, not leak more than 25 cm^3/min. and NHTSA proposes that this test will only apply to fittings that use a threaded retention nut. Push-to-connect fittings are often believed to result in damage to the tubing upon disassembly and therefore may not be able to meet this specification. When such fittings are disassembled, the end of the tubing can be cut off if there is enough slack in the assembly, or a new section of tubing will need to be fitted for reinstallation.

The agency also proposes specifying constriction testing for plastic air brake tubing assemblies as such testing is already specified for air brake hose assemblies under Standard No. 106.

NHTSA proposes including the current corrosion resistance test in FMVSS No. 106, as applied to all types of brake hose fittings (*i.e.*, hydraulic, vacuum, air), for fittings used with plastic air brake tubing. End fitting corrosion specifications are included in SAE J246 and SAE J512 rather than SAE J1131, and these specifications are different than those currently in FMVSS No. 106, with the SAE test procedures including longer exposure to salt spray but less severe performance requirements for permissible corrosion.

A detailed discussion of the differences between the performance requirements/test procedures of SAE J1131, SAE J246, SAE J512, and FMVSS No. 106 as they relate to plastic air brake tubing assemblies and end fittings follows, along with the agency's proposed resolution of those differences.

1. Tensile Strength

FMVSS No. 106 specifies that an air brake hose assembly for use between either the frame and the axle, or a towing and towed vehicle, meet a longitudinal pull test, at a 1 inch per minute force application rate without separating from its end fittings at the following force levels: 250 pounds for ¼ inch or less, or 6mm or less, nominal ID; 325 pounds for more than ¼ inch or 6mm nominal ID. A hose assembly used in any other application must withstand force levels of: 50 pounds for ¼ in or less, or 6 mm or less, nominal ID; 150 pounds for ⅜ inch, ½ inch, or 10 mm to 12 mm, nominal ID; and 325 pounds if the hose assembly is larger than ½ inch or 12 mm nominal ID. A coiled nylon tube assembly may either meet these requirements or, alternatively,

may meet the requirements in FMCSR 393.45.

While FMVSS No. 106's air brake hose performance requirements and test procedures are currently presented in terms of nominal inside diameter, the agency notes that plastic air brake tubing is sized according to nominal outside diameter. In an August 7, 1974, amendment to FMVSS No. 106 (39 FR 28436), NHTSA responded to a petition from Samuel Moore Company in which the petitioner contended that it was appropriate to base Standard No. 106's tensile strength requirements on the nominal inside diameter of the tubing rather than on the tubing's nominal outside diameter. The petitioner argued that because 3/8-inch nominal OD plastic tubing has an inside diameter of 1/4-inch and provides the same air flow capability as a 1/4-inch nominal ID rubber hose, they should be subject to the same tensile strength requirements. In response to the petition, NHTSA decided to base the tensile strength requirements on the nominal inside diameter of the hose or tubing. Because plastic air brake tubing is labeled according to its nominal outside diameter, however, NHTSA now proposes to specify tensile strength requirements in the same manner to minimize confusion.

Unlike FMVSS No. 106, SAE J1131 does not contain a stand-alone tensile strength test for air brake tubing assemblies. Instead, SAE J1131 specifies tensile strength testing after an air brake tubing assembly has been assembled and pre-conditioned in some manner. The SAE tensile strength performance requirements for pre-conditioned tubing assemblies are not as rigorous as NHTSA's stand-alone requirements. Although the agency proposes to incorporate SAE J1131's tensile strength requirements, NHTSA also proposes to retain the stand-alone tensile strength requirements already present in FMVSS No. 106, with the modifications discussed below.

Standard No. 106's tensile strength requirements provide an alternative set of requirements for coiled nylon tubing. Coiled nylon tubing may either meet the tensile strength requirements in FMVSS No. 106 or, alternatively, may meet the requirements in section 393.45 of the FMCSRs. FMCSR § 393.45, in turn, references the tensile strength requirements of SAE J844. The agency notes, however, that SAE J844 does not contain tensile strength requirements for end fitting retention. The end fitting retention requirements are contained in SAE J1131, which is not referenced in FMCSR § 393.45.

Coiled nylon tubing assemblies, by design, provide that tensile loads on these assemblies are spread out over the long length of the hose in its coiled form, and thus large amounts of relative motion, such as between a tractor and a semi-trailer, are not expected to result in significant tensile load on the end fittings that would pull the tubing out of the fitting. Nevertheless, NHTSA tentatively concludes that the potential exists for the supply and control air lines connecting tractors and semi-trailers to get tangled among themselves, among various components (springs and poles) that are used to support the lines above the truck frame, or with the electrical cord. The agency also notes that these air lines are completely exposed to the elements, are frequently connected and disconnected, and may be subject to various amounts of stretching depending on the physical dimensions of the trailers that are towed.

Despite these potential hazards in the operating environment of coiled nylon tubing, however, FMVSS No. 106, as presently constituted, provides no tensile strength requirements for coiled nylon tubing assemblies if the optional compliance with SAE J844 as referenced in § 393.45 is exercised. In contrast, small, 1/8-inch air brake tubing is essentially prohibited from use in air brake systems because of its inability to meet Standard No. 106's 50-pound tensile strength requirement, even though the application of this tubing would typically be inside the truck cab and routed to protect it from damage. As discussed below, NHTSA proposes to correct this disparity in treatment by requiring coiled nylon tubing to meet SAE J1131's end fitting retention requirements and by lowering the tensile strength requirements for tubing with relatively small nominal outside diameters. The agency proposes to lower the tensile strength requirement for 1/8-inch nominal OD tubing from 50 pounds to 35 pounds and, for 5/32-inch OD tubing, from 50 pounds to 40 pounds.

The agency proposes to retain the existing FMVSS No. 106 tensile strength requirements for air brake tubing assemblies used between a frame and an axle, or between a towed and a towing vehicle, of 250 pounds for a 3/8-inch or less, or 10 mm or less, in nominal outside diameter, and 325 pounds for a tubing assembly larger than 3/8-inch or 10 mm in nominal outside diameter. With respect to plastic air brake tubing assemblies used for any other purpose, the agency proposes to require a tensile strength of: 35 pounds for tubing with a nominal outside diameter of 1/8 inch or less (3 mm or less); 40 pounds for tubing with a nominal outside diameter of 5/32 inch (4 mm); 50 pounds for tubing with a nominal outside diameter between 3/16-inch and 3/8-inch (between 5 mm and 10 mm); 150 pounds for tubing with a nominal outside diameter between 1/2-inch and 5/8-inch (between 11 mm and 16 mm); and 325 pounds for tubing with a nominal outside diameter larger than 5/8-inch (16 mm).

2. Hot Tensile Strength

SAE J1131 specifies that a 6-inch long tubing assembly be placed in a tensile testing machine, with the lower 4 inches of the assembly submerged in boiling water for 5 minutes. The assembly is then pulled at a rate of 1 inch per minute. The required performance is either 50 percent elongation of the hose without end fitting separation or the assembly must sustain a specified tensile load. Standard No. 106 does not have a corresponding test condition. Compared to the tensile strength requirements in FMVSS No. 106, the end fitting separation strength requirements in SAE J1131 are lower, but Standard No. 106's requirements are for non-conditioned tubing assemblies. NHTSA proposes that the hot tensile strength requirement from SAE J1131 be incorporated into FMVSS No. 106. Considering that SAE J1131 does not include tensile loads for metric sized plastic brake tubing, however, the agency proposes to specify tensile load values for metric sized plastic brake tubing.

3. Conditioned Pull Test

SAE J1131 specifies that a tubing assembly undergo four temperature cycles of a minus 40 degree F cold soak for 30 minutes, normalizing at 75 degrees F, immersion in boiling water for 15 minutes and normalizing at 75 degrees F. After four complete cycles of temperature conditioning, the tubing assembly is subjected to a tensile test. The required performance is the same as for the hot tensile strength test above. This test evaluates the tubing's resistance to pulling out of its end fittings when subjected to thermal cycling. Equivalent performance requirements/test procedures are not included in FMVSS No. 106. NHTSA proposes that these performance requirements/test procedures be incorporated into Standard No. 106.

4. Vibration Leak Test

SAE J1131 specifies that an 18-inch long hose assembly be subjected to one million cycles on a vibration machine with one end of the hose fixed and the other end stroked 0.5 inches

perpendicularly to the hose centerline at a rate of 600 cycles per minute, with ½ inch of slack in the hose. The hose is subjected to 120-psi air pressure during the test, and the test chamber temperature is initially 220 degrees F. After 250,000 cycles, the temperature is decreased to minus 40 degrees F. This temperature cycle is repeated after 500,000 cycles. The hose assembly is instrumented to measure leakage during the test. There are two performance requirements. First, the assembly must not leak at a rate greater than 50 cm^3 per minute at minus 40 degrees F or greater than 25 cm^3 per minute at 75 degrees F. Second, the attaching nut at each fitting cannot move when 20 percent of the original tightening torque is re-applied to the nut. FMVSS No. 106 has a leak test (S8.7), but it does not specify preconditioning of the hose by vibration, temperature, or other means, nor does it address fitting tightness after such conditioning. End fitting nut tightness is applicable to end fittings that can be disassembled such that new sections of tubing can be used with the existing fitting components, other than the compression sleeve and the tube support that are renewed when new tubing is installed. Swaged or crimped, permanently-attached fittings which cannot be disassembled for reuse, and push-to-connect fittings which can be reused but do not use a nut to secure the hose or tubing, are exempt from the nut tightness requirement.

The SAE J1131 performance requirements/test procedures ensure adequate end fitting performance to resist vibration and temperature cycling. NHTSA proposes that most of these performance requirements/test procedures be incorporated into FMVSS No. 106.

5. Proof and Burst Test

SAE J1131 specifies proof and burst tests to evaluate end fitting retention. The test apparatus includes a suitable hydraulic pressure source of an unspecified medium. Tubing samples are prepared with 12 inches of free hose length along with the fittings to be evaluated. One end of the assembly is plugged and the other end is attached to the pressure source. At a temperature of 75 degrees F, the pressure is increased to proof pressure and held for 30 seconds. The proof pressure is defined as one-half of the burst pressure specified in SAE J844. Pressure is then increased at a rate such that the specified burst pressure is achieved within 3 to 15 seconds. The fittings must not separate from the tubing and no visible leaks are permitted at less than the specified burst pressure. While FMVSS No. 106 contains leakage and burst performance requirements/test procedures, as detailed above, the burst pressures specified are lower than those in SAE J844 or SAE J1131. NHTSA proposes to incorporate the proof and burst test from SAE J1131 into FMVSS No. 106 so that there will be a specific test to evaluate the performance of end fittings used with plastic tubing. NHTSA proposes that this test be conducted using water, as this is the test fluid used for the burst strength test for air hoses in FMVSS No. 106.

6. Serviceability Test

SAE J1131 specifies a serviceability test to evaluate end fitting performance for reusable fittings after repeated assembly and disassembly. Tubing samples are prepared with 12 inches of free hose length, following the fitting manufacturer's recommendations for assembly of the end fittings. The fittings are then disassembled and reassembled a minimum of five times. The tubing assembly is then subjected to 120 psi of air at 75 degrees F, with resulting leakage not greater than 25 cm^3 per minute.

When flanged-sleeve fittings have been fitted in a plastic tubing assembly that requires replacement, the old tubing is removed by loosening the retaining nut on the fitting. A new section of tubing is cut from a bulk supply of tubing, new ferrules (compression sleeves that fit on the outside of the tubing) and tube supports (internal sleeves that fit inside the tubing) are installed at each end of the replacement tubing, and the new tubing is installed. The other components of the end fittings can be reused. For other types of repairs, such as replacement of a valve to which the tubing is connected, the tubing is disconnected in the same way. The portion of the fitting that threads into the valve can be removed and reinstalled on the replacement valve, and the tubing can then be reinstalled on the new valve using the existing ferrule that remains permanently attached to the tubing. The serviceability performance requirements/test procedures in SAE J1131 are a measure of the fitting's suitability for repeated assembly and disassembly similar to the example of valve replacement when all parts of the end fitting are reused.

Another type of end fitting is the push-to-connect fitting, which when used in an assembly, the end of the tubing is simply pushed into the fitting. To remove the tubing for repair purposes, a ring on the fitting around the outside of the tubing is raised to release the tubing, which can then be pulled out of the fitting. All information the agency has collected on this type of fitting indicates that the tubing may or may not be damaged upon removal from the fitting, depending on such factors as how much air pressure and pulling force the assembly has been subjected to during its use. If the tubing is damaged, a small section cut off for subsequent reassembly if there is a sufficient slack available in the assembly. If there is not enough tubing length to cut the end off for reassembly, then a new section of tubing will need to be installed. If the O-ring in the push-to-connect fitting is also damaged, it may be serviced or the entire fitting will need to be replaced. This would have to be detected by the technician checking for leakage after reassembly.

NHTSA proposes that the serviceability test be included in Standard No. 106 for those fittings that use a threaded retaining nut. This will ensure that the fittings can be separated and reused during servicing of brake system components with minimal likelihood of leakage upon reassembly. NTHSA does not believe the serviceability test could be consistently applied to push-to-connect fittings and therefore does not propose to include them in this test.

7. Fitting Compatibility Test

SAE J1131 specifies that test specimens be prepared according to the fitting manufacturer's recommendations, with 12 inches of free hose length. The assembly is filled with hydraulic fluid at atmospheric pressure and conditioned at 200 degrees F for 24 hours. The pressure is then increased to 450 psi for 5 minutes after which time the pressure is reduced to atmospheric levels and the assembly is cooled to 75 degrees F. Following this, the tubing assembly is cooled to minus 40 degrees F with the fluid at atmospheric pressure for 24 hours after which time the pressure is increased to 450 psi for 5 minutes. The tubing must not rupture or disconnect from the fittings. Standard No. 106 does not have a corresponding set of test procedures/performance requirements. Accordingly, NHTSA proposes to incorporate the fitting compatibility test and performance requirements from SAE J1131 into FMVSS No. 106.

8. Constriction

FMVSS No. 106 requires that each air brake hose assembly shall be not less than 66 percent of the nominal ID of the hose, except for those portions of end fittings that do not contain hose. SAE J1131 does not contain a corresponding requirement. As discussed in greater

detail above, NHTSA is proposing to require that all portions of air brake assemblies, including those portions of end fittings that do not contain hose, meet this requirement. NHTSA proposes to apply the same 66 percent of nominal ID constriction requirement to plastic air brake tubing assemblies. The agency proposes to apply this requirement based on the tubing's nominal inside diameter even though, as noted above, NHTSA is proposing that other requirements relating to air brake tubing be expressed in terms of the tubing's nominal outside diameter.

9. End Fitting Dimensional Requirements

FMVSS No. 106 does not presently contain end fitting dimensional requirements. The petitioners, however, requested incorporation of the requirements of FMCSR § 393.46, which references two SAE standards containing such requirements. FMCSR § 393.46 provides that splices in tubing installed on a vehicle after March 7, 1989, must use fittings that meet the requirements of SAE J512, *Automotive Tube Fittings Rev. October 1980* (SAE J512) or, for air brake systems, SAE J246, *Spherical and Flanged Sleeve (Compression) Tube Fittings Rev. March 1981* (SAE J246).

SAE J512 provides general and dimensional specifications for the various types of tube fittings intended for general application in the automotive, appliance, and allied fields, and includes the following categories of fittings: flare type fittings, inverted flare type fittings, and tapered sleeve compression type fittings intended for use with annealed copper alloy tubing. SAE J512 states that the spherical sleeve compression fitting components in SAE J246 are not to be intermixed with tapered sleeve compression type fitting components in SAE J512. The dimensions of single and double 45 degree flares on tubing used in conjunction with flared and inverted flared fittings in SAE J512 are provided in a different SAE standard, SAE J533.

The application of SAE J512 fittings in automotive braking systems as used in the U.S. is believed to be most commonly associated with inverted double flare hydraulic brake tubing connections, and also for metal tubing that may be used for connecting vacuum booster lines to engine manifolds. NHTSA does not believe that copper tubing is widely used in vehicle braking applications anymore. The agency also does not believe that SAE J512 fittings would be appropriate for use with plastic tubing.

Both SAE J246 and SAE J512 include dimensional requirements for fitting length, concentricity, pipe threads, wrench hexes, ferrule seats, tube support sleeves in the case of plastic tubing fittings, and material properties of brass stock used in fittings and stainless steel stock used in plastic tubing support sleeves. The standards also permit steel to be used if requested by the purchaser.

As already noted above, FMVSS No. 106 does not include any dimensional or material properties specifications for fittings used with brake hose or tubing. NHTSA does not agree with the petitioners that the substantive dimensional and material requirements of SAE J246 and SAE J512 are needed in FMVSS No. 106 for a number of reasons. First, the agency tentatively concludes that fittings that have demonstrated their compatibility with plastic air brake tubing through the testing required by SAE J1131. Second, NHTSA does not favor incorporating the SAE requirements because neither SAE J246 nor SAE J512 provides fitting standards for metric sized plastic tubing. Third, although FMVSS No. 106 does not provide any dimensional specifications for any types of fittings used with other types of brake hose or tubing, the agency is not aware of any field problems associated with these brake products. Fourth, even if FMVSS were to incorporate the dimensional specifications from the SAE standards, at least one of those standards, SAE J246, explicitly states that the standard is not intended to restrict or preclude other designs of a tube fitting for use with SAE J844 air brake tubing.

NHTSA tentatively concludes that the automotive industry generally standardizes, on a voluntary basis, such fittings for compatibility and repair purposes, and has no reason to believe that this will not continue to be the case for plastic air brake tubing fittings. Standard No. 106 currently permits specialized fittings as long as they can meet the specified performance requirements. In a November 13, 1973, final rule (38 FR 31302, Docket No. 1–5; Notice 8), NHTSA declined to adopt any specific standard for end fittings. For the reasons outlined above, NHTSA does not propose to include any dimensional or material properties specifications for end fittings at this time.

10. End Fitting Corrosion Resistance

SAE J246 and SAE J512 specify that the external surfaces and threads of carbon steel fittings be subjected to a 72 hour salt spray test per ASTM B117, with no appearance of red rust permitted except for: Internal portions of fittings; edges such as hex points, serrations, or thread crests where there may be mechanical deformation of the plating or coating of mass-produced parts or shipping effects; areas where the plating or coating is subjected to mechanical deformation due to crimping, flaring, bending, or other post plate metal forming operations; or areas where the parts are suspended or affixed in the test chamber where condensate can accumulate. Both standards specify that after January 1, 1997, no parts shall be cadmium plated due to environmental concerns relating to that process.

FMVSS No. 106 specifies that the fittings as installed on a brake hose assembly be subjected to a 24-hour salt spray test, the same test that is specified for hydraulic brake hose, as detailed above. The end fittings must 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. Standard No. 106 specifies that all fittings meet the corrosion test, and does not provide different specifications based on the end fitting's composition (steel, stainless steel, or brass).

The duration of the salt spray test is longer in the SAE standards than in FMVSS No. 106 (72 hours versus 24 hours), but the specified corrosion performance is more rigorous in FMVSS No. 106. The SAE standards specify testing of fittings without any hose attached, while FMVSS No. 106 specifies that the fittings be mounted to a hose for testing. NHTSA tentatively concludes that the existing corrosion resistance requirements in FMVSS No. 106 assure adequate integrity of end fittings, and in one respect is more strenuous than the SAE standards. Accordingly, the agency does not propose to change Standard No. 106's corrosion resistance requirements at this time. Nevertheless, NHTSA welcomes comments on the suitability and need to increase the duration of the salt spray test from the current 24 hours to the 72 hours specified in the SAE standards.

The table below summarizes the differences between the plastic air brake tubing assembly and end fitting performance requirements/test procedures of FMVSS No. 106 and SAE J1131 and indicates which requirements/procedures NHTSA proposes incorporating into the standard.

TABLE 5.—COMPARISON OF PLASTIC AIR BRAKE TUBING ASSEMBLY AND END FITTING REQUIREMENTS/PROCEDURES IN FMVSS NO. 106 AND SAE J1131, SAE J246, AND SAE J512

Requirement/Procedure		Existing FMVSS No. 106		SAE J1131
Fittings for Nylon Air Brake Tubing ''x'' indicates requirements/procedures proposed to be included in FMVSS No. 106. A new section would be added for the performance of these fittings. Existing FMVSS No. 106 requirements/procedures for fittings would also apply.				
Tensile Strength	x	Same as for air brake hose assemblies		No tensile test at ambient conditions.
Hot Tensile Strength		Only at ambient temperature, higher strength specifications.	x	Immersion in boiling water followed by pull test.
Conditioned Pull Test		Only at ambient temperature, higher strength specifications.	x	Four cold soak cycles followed by boiling water, then pull test.
Vibration Leak Test		None	x	Leakage specification after vibration conditioning.
Proof and Burst Test		Burst test, does not specify failure mode	x	No fitting separation during proof and burst tests.
Serviceability Test		None	x	Leakage specifications for flanged-sleeve fittings after five assembly cycles.
Fitting Compatibility Test		None	x	Pressure and temperature cycling to evaluate fitting retention.
Constriction	x	66 percent of nominal inside diameter		None.
End Fitting Dimensional Requirements	x	None		Specified in SAE J246 and SAE J512—variations permitted.
End Fitting Corrosion Resistance	x	Same as for hydraulic brake hose end fittings.		Specified in SAE J246 and SAE J512—similar, exemption for brass fittings.

V. Rulemaking Analyses and Notices

A. Executive Order 12866 and DOT Regulatory Policies and Procedures

Executive Order 12866, ''Regulatory Planning and Review'' (58 FR 51735, October 4, 1993), provides for making determinations whether a regulatory action is ''significant'' and therefore subject to Office of Management and Budget (OMB) review and to the requirements of the Executive Order. The Order defines a ''significant regulatory action'' as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations or recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

This notice was not reviewed under Executive Order 12866. Further, this notice was determined not to be significant within the meaning of the DOT Regulatory Policies and Procedures.

In this document, NHTSA is proposing to incorporate performance requirements and test procedures that are currently contained and/or referenced in the Federal Motor Carrier Safety Regulations. Those performance requirements/test procedures are based on voluntary standards adopted by the Society of Automotive Engineers. Although NHTSA proposes to incorporate the most recent versions of these SAE requirements/procedures and to apply them to brake hoses, tubing, and fittings for all motor vehicles, not just commercial motor vehicles, the agency tentatively concludes that most, if not all, such hoses, tubing, and fittings are already designed to meet the SAE requirements/procedures. However, in the event that there are some brake hose products that would need to be modified to comply with the proposed regulations, the agency (1) estimates that it is a small proportion of brake hose products that would need modification, as most are believed to already comply; and (2) tentatively concludes that the manufacturers of the components used in producing such products are not small businesses.

For air brake hoses, both rubber hose and plastic tubing products, and hydraulic and vacuum brake hoses installed on vehicles that are typically used as commercial motor vehicles such as medium duty trucks, the agency tentatively concludes that all of the brake hose products already comply with the proposed regulations. The largest effect of the proposed regulations would be on the light vehicle sector including passenger cars and light trucks, of which approximately 16 million vehicles are produced each year. As the typical light vehicle is equipped with three to four brake hoses, 48 to 64 million hydraulic brake hose assemblies as installed in new vehicles would be affected, as well as an unknown quantity of replacement brake hoses for light vehicles, but probably a few million. In addition, the agency estimates that approximately 15.5 million vacuum brake hoses and/or assemblies are installed on these vehicles.

Since large quantities of brake hose material are needed to manufacture these brake hoses, the agency believes that there are large manufacturers that produce both hydraulic and vacuum brake hoses in such large quantities. There are many small companies that use the brake hose material and end fitting components to produce brake hose assemblies, but NHTSA does not anticipate that they would be affected by the proposed changes because they simply assemble already-compliant components supplied by the large manufacturers.

The agency does not have data on how many hydraulic and vacuum brake hose assemblies would need to be modified to meet the proposed changes. Based on an informal survey of available hydraulic and vacuum brake hose assemblies, the agency estimates that perhaps as many as 20 percent may need to be modified in some manner to comply with the proposed requirements. Likewise, the agency does not know the cost to modify the manufacturing processes of the brake

hose materials to comply with the proposed changes, but can assume that it would be for improved additives to elastomeric compounds or improved synthetic fibers used as reinforcing materials. Again, the agency does not have any data on the cost of manufacturing such materials, but estimates that the modification of such manufacturing processes would add not more than ten cents to the cost of each brake hose assembly. The highest-cost estimate of the proposed regulations is based on production of 64 million new and replacement hydraulic brake hose assemblies, plus 16 million new and replacement vacuum brake hoses/assemblies, for a total of 80 million total affected brake hoses. If 20 percent of these need to be modified to meet the proposed changes, at a cost of ten cents per hose, the total cost would be $1.6M Therefore, the agency estimates the cost of complying with the proposed changes to FMVSS No. 106 to be between zero and $1.6 M. This potential additional cost would not, however, be expected to have any impact on small businesses, but only on large manufacturers of brake hose materials that are produced in large quantities. Accordingly, the agency does not believe that this proposal would have any significant economic effects. Nevertheless, the agency welcomes comments on the cost of compliance with the proposed requirements.

The DOT's regulatory policies and procedures require the preparation of a full regulatory evaluation, unless the agency finds that the impacts of a rulemaking are so minimal as not to warrant the preparation of a full regulatory evaluation. Since anecdotal evidence suggests that most, if not all, of these hose, tubing, and fittings are already compliant with the minimum performance requirements that the agency is proposing to apply, the agency believes that the impacts of this rulemaking would be minimal. Thus, it has not prepared a full regulatory evaluation.

B. Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996), whenever an agency is required to publish a notice of rulemaking for any proposed or final rule, it must prepare and make available for public comment a regulatory flexibility analysis that describes the effect of the rule on small entities (*i.e.*, small businesses, small organizations, and small governmental jurisdictions). The Small Business Administration's regulations at 13 CFR part 121 define a small business, in part, as a business entity ''which operates primarily within the United States.'' (13 CFR 121.105(a)). No regulatory flexibility analysis is required if the head of an agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. The SBREFA amended the Regulatory Flexibility Act to require Federal agencies to provide a statement of the factual basis for certifying that a rule will not have a significant economic impact on a substantial number of small entities.

NHTSA has considered the effects of this rulemaking action under the Regulatory Flexibility Act. As explained above, NHTSA is proposing to incorporate performance requirements and test procedures that are currently contained or referenced in the Federal Motor Carrier Safety Regulations. Those performance requirements/test procedures are based on voluntary standards adopted by the Society of Automotive Engineers. Although NHTSA proposes to incorporate the most recent versions of these SAE requirements/procedures and to apply them to brake hoses, tubing, and fittings for all motor vehicles, not just commercial motor vehicles, the agency believes that most, if not all, such hoses, tubing, and fittings are already designed to meet the most recent SAE requirements/procedures. For the remaining hoses, tubing, and fittings, estimated at up to 20 percent of all hydraulic and vacuum brake hoses manufactured each year, the agency estimates the cost of complying with these requirements to be $1.6M. Considering that the total number of hydraulic brake hose assemblies and vacuum brake hose/assemblies that would be subject to the proposed requirements is estimated to be approximately 80 million units annually, the agency estimates that the total annual effect of this proposed rule would be between zero and $1.6M. Accordingly, I hereby certify that it would not have a significant economic impact on a substantial number of small entities.

C. National Environmental Policy Act

NHTSA has analyzed this rulemaking action for the purposes of the National Environmental Policy Act. The agency has determined that implementation of this action would not have any significant impact on the quality of the human environment.

D. Executive Order 13132 (Federalism)

Executive Order 13132 requires NHTSA to develop an accountable process to ensure ''meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.'' The Executive Order defines ''policies that have federalism implications'' to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.'' Under Executive Order 13132, NHTSA may not issue a regulation with Federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by State and local governments, the agency consults with State and local governments, or the agency consults with State and local officials early in the process of developing the proposed regulation. NHTSA also may not issue a regulation with Federalism implications and that preempts State law unless the agency consults with State and local officials early in the process of developing the proposed regulation.

NHTSA has analyzed this rulemaking action in accordance with the principles and criteria set forth in Executive Order 13132. The agency has determined that this proposed rule would not have sufficient federalism implications to warrant consultation with State and local officials or the preparation of a federalism summary impact statement. The proposal would not have any substantial effects on the States, or on the current Federal-State relationship, or on the current distribution of power and responsibilities among the various local officials.

E. Civil Justice Reform

This proposed amendment would not have any retroactive effect. Under 49 U.S.C. 30103, whenever a Federal motor vehicle safety standard is in effect, a State may not adopt or maintain a safety standard applicable to the same aspect of performance which is not identical to the Federal standard, except to the extent that the state requirement imposes a higher level of performance and applies only to vehicles procured for the State's use. 49 U.S.C. 30161 sets forth a procedure for judicial review of final rules establishing, amending, or revoking Federal motor vehicle safety standards. That section does not require

submission of a petition for reconsideration or other administrative proceedings before parties may file suit in court.

F. Paperwork Reduction Act

Under the Paperwork Reduction Act of 1995, a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid Office of Management and Budget (OMB) control number. This proposed rule would not require any collections of information as defined by the OMB in 5 CFR part 1320.

G. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Public Law 104–113, section 12(d) (15 U.S.C. 272) directs NHTSA to use voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (*e.g.*, materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies, such as the Society of Automotive Engineers (SAE). The NTTAA directs the agency to provide Congress, through the OMB, explanations when we decide not to use available and applicable voluntary consensus standards.

The proposed changes that NHTSA is proposing are based on voluntary consensus standards adopted by the Society of Automotive Engineers. Accordingly, this proposed rule is in compliance with Section 12(d) of NTTAA.

H. Unfunded Mandates Reform Act

Section 202 of the Unfunded Mandates Reform Act of 1995 (UMRA) requires Federal agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million in any one year (adjusted for inflation with base year of 1995). Before promulgating a rule for which a written statement is needed, section 205 of the UMRA generally requires NHTSA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows NHTSA to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the agency publishes with the final rule an explanation why that alternative was not adopted.

This proposed rule would not result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector of more than $100 million annually. The estimated cost of complying with the proposed requirements is estimated to be between zero and $1.6M annually. Accordingly, the agency has not prepared an Unfunded Mandates assessment.

I. Plain Language

Executive Order 12866 requires each agency to write all rules in plain language. Application of the principles of plain language includes consideration of the following questions:

—Have we organized the material to suit the public's needs?
—Are the requirements in the rule clearly stated?
—Does the rule contain technical language or jargon that is not clear?
—Would a different format (grouping and order of sections, use of headings, paragraphing) make the rule easier to understand?
—Would more (but shorter) sections be better?
—Could we improve clarity by adding tables, lists, or diagrams?
—What else could we do to make this rulemaking easier to understand?

If you have any responses to these questions, please include them in your comments on this NPRM.

J. Regulation Identifier Number (RIN)

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

K. Comments

How Do I Prepare and Submit Comments?

Your comments must be written and in English. To ensure that your comments are correctly filed in the Docket, please include the docket number of this document in your comments.

Your comments must not be more than 15 pages long. (49 CFR 553.21). We established this limit to encourage you to write your primary comments in a concise fashion. However, you may attach necessary additional documents to your comments. There is no limit on the length of the attachments.

Please submit two copies of your comments, including the attachments, to Docket Management at the address given above under **ADDRESSES**.

You may also submit your comments to the docket electronically by logging onto the Dockets Management System Web site at *http://dms.dot.gov.* Click on ''Help & Information'' or ''Help/Info'' to obtain instructions for filing the document electronically.

How Can I Be Sure That My Comments Were Received?

If you wish Docket Management to notify you upon its receipt of your comments, enclose a self-addressed, stamped postcard in the envelope containing your comments. Upon receiving your comments, Docket Management will return the postcard by mail.

How Do I Submit Confidential Business Information?

If you wish to submit any information under a claim of confidentiality, you should submit three copies of your complete submission, including the information you claim to be confidential business information, to the Chief Counsel, NHTSA, at the address given above under **FOR FURTHER INFORMATION CONTACT**. In addition, you should submit two copies, from which you have deleted the claimed confidential business information, to Docket Management at the address given above under **ADDRESSES.** When you send a comment containing information claimed to be confidential business information, you should include a cover letter setting forth the information specified in our confidential business information regulation. (49 CFR part 512)

Will the Agency Consider Late Comments?

We will consider all comments that Docket Management receives before the close of business on the comment closing date indicated above under **DATES**. To the extent possible, we will also consider comments that Docket Management receives after that date. If Docket Management receives a comment too late for us to consider it in developing a final rule (assuming that one is issued), we will consider that comment as an informal suggestion for future rulemaking action.

How Can I Read the Comments Submitted by Other People?

You may read the comments received by Docket Management at the address given above under **ADDRESSES.** The hours of the Docket are indicated above in the same location.

You may also see the comments on the Internet. To read the comments on the Internet, take the following steps:

1. Go to the Docket Management System (DMS) Web page of the Department of Transportation (*http://dms.dot.gov/*)

2. On that page, click on ''search.''

3. On the next page (*http://dms.dot.gov/search/*), type in the four-digit docket number shown at the beginning of this document. Example: If the docket number were ''NHTSA–1998–1234'', you would type ''1234''. After typing the docket number, click on ''search.''

4. On the next page, which contains docket summary information for the docket you selected, click on the desired comments. You may download the comments. Although the comments are imaged documents, instead of word processing documents, the ''pdf'' versions of the documents are word searchable.

Please note that even after the comment closing date, we will continue to file relevant information in the Docket as it becomes available. Further, some people may submit late comments. Accordingly, we recommend that you periodically check the Docket for new material.

List of Subjects in 49 CFR Part 571

Imports, Motor vehicle safety, Motor vehicles, Rubber and rubber products, and Tires.

In consideration of the foregoing, NHTSA proposes to amend 49 CFR part 571 as follows:

PART 571—FEDERAL MOTOR VEHICLE SAFETY STANDARDS

1. The authority for part 571 would continue to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30166, and 30177; delegation of authority at 49 CFR 1.50.

2. Section 571.106 would be amended by:

a. Adding a new definition to paragraph S4,

b. Revising paragraph (b) of S5.2.2,

c. Revising paragraph (b) of S5.2.4,

d. Revising paragraphs S5.3 through S5.3.5,

e. Revising paragraphs S5.3.9 and S5.3.11,

f. Adding paragraphs S5.3.12 and S5.3.13,

g. Revising paragraph (c) of S6.2,

h. Revising paragraphs S6.4 and S6.4.2,

i. Revising paragraph (b) of S6.8.2,

j. Redesignating paragraphs S6.9, S6.9.1, S6.9.2, and S6.9.3 as paragraphs S6.11, S6.11.1, S6.11.2, and S6.11.3 and revising redesignated paragraph S6.11 and paragraph (c) of redesignated S6.11.3,

k. Adding paragraphs S6.9 through S6.9.2,

l. Adding paragraphs S6.10 through S6.10.2,

m. Adding paragraph S6.12,

n. Revising paragraphs (b), (d), and (e) of S7.2.1,

o. Revising Table III,

p. Revising paragraphs (b) and (d) of S7.2.2,

q. Revising paragraphs S7.3 and S7.3.1,

r. Revising paragraph S7.3.3,

s. Revising Table IV,

t. Revising paragraphs S7.3.6 through S7.3.11,

u. Adding paragraph S7.3.14,

v. Revising paragraphs (c) and (d) of S8.2,

w. Revising paragraph (b) of S8.3.2,

x. Revising the heading of paragraph S8.6,

y. Revising paragraph S8.7,

z. Adding paragraphs S8.7.1 and S8.7.2,

aa. Revising paragraph S8.8,

bb. Revising paragraph S8.9, introductory text,

cc. Adding paragraphs S8.13 through S8.15,

dd. Revising paragraphs S9.2 through S9.2.3,

ee. Revising paragraphs S9.2.7 and S9.2.8,

ff. Removing paragraph S9.2.9,

gg. Redesignating paragraphs S9.2.10 and S9.2.11 as paragraphs S9.2.9 and S9.2.10,

hh. Revising paragraphs S10.1 and S10.2,

ii. Revising paragraphs S10.6(a) and S10.7,

jj. Redesignating Figure 3 as Figure 6,

kk. Removing paragraph S10.8,

ll. Redesignating paragraphs S10.9, S10.9.1, S10.9.2, and S10.10 as paragraphs S10.8, S10.8.1, S10.8.2, and S10.9,

mm. Revising paragraph (b) of newly redesignated paragraph S10.8.2,

nn. Redesignating Figure 4 as Figure 7 and adding it at the end of paragraph S10.8.2(b),

oo. Adding Figure 4,

pp. Adding Figure 5,

qq. Adding Figure 8,

rr. Adding Figure 9,

ss. Adding paragraph S10.10,

tt. Redesignating paragraphs S11, S11.1, S11.2, and S11.3 as paragraphs S13, S13.1, S13.2, and S13.3,

uu. Adding paragraphs S11 through S11.3.24,

vv. Adding paragraphs S12 through S12.27,

ww. Revising newly redesignated paragraphs S13 and S13.2, and

xx. Adding paragraph S13.4.

The additions and revisions to § 571.106 would read as follows:

§ 571.106 Standard No. 106; Brake hoses.

* * * * *

S4. *Definitions.*

* * * * *

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

* * * * *

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

* * * * *

S5.2.2 * * *

* * * * *

(b) A designation that identifies the manufacturer of the hose, which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS–222, National Highway Traffic Safety Administration, 400 Seventh St. S.W., Washington, DC 20590. The marking may consist of a designation other than block capital letters required by S5.2.2.

* * * * *

S5.2.4 * * *

* * * * *

(b) A designation that identifies the manufacturer of the hose assembly, which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS–222, National Highway Traffic Safety Administration, 400 Seventh St. S.W., Washington, DC 20590. The designation may consist of block capital letters, numerals, or a symbol.

* * * * *

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 1,000 psi and 1,500 psi shall not exceed the values specified in Table I (S6.1). The hydraulic brake hose assembly shall then withstand water pressure of 4,000 psi for 2 minutes without rupture, and shall not rupture at less than 7,000 psi for a ⅛ inch, 3 mm, or smaller diameter hose, or at less than 5,000 psi for a 3⁄16 inch, 4 mm, or larger diameter hose (S6.2).

* * * * *

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

S5.3.5 *Water absorption and tensile strength.* A hydraulic brake hose assembly, after immersion in water for 70 hours (S6.5), shall withstand a pull of 325 pounds without separation of the hose from its end fittings during a slow pull test, and shall withstand a pull of 370 pounds without separation of the hose from its end fittings during a fast pull test (S6.4).

* * * * *

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 248 °F for 70 hours while filled with SAE RM–66–05 Compatibility Fluid, as described in Appendix B of SAE Standard J1703 JAN 1995, ''Motor Vehicle Brake Fluid.'' It shall then withstand water pressure of 4,000 psi for 2 minutes and thereafter shall not rupture at less than 5,000 psi (S6.2).

* * * * *

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 295 °F without leakage;

(b) shall not leak during a 2-minute, 4,000 psi pressure hold test, and;

(c) shall not burst at a pressure less than 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.*

* * * * *

S6.2 *Burst strength test.* (a) * * *

(c) After 2 minutes at 4,000 psi, increase the pressure at the rate of 15,000 psi per minute until the pressure exceeds 5,000 psi for a hose of 3⁄16, 4 mm, or larger diameter, or 7,000 psi for a hose of ⅛ inch, 3 mm, or smaller diameter.

* * * * *

S6.4 *Tensile strength test.* Utilize a tension testing machine conforming to the requirements of American Society for Testing and Materials (ASTM) Standard Practices for Force Verification of Testing Machines, Designation E4–99, and provided with a recording device to give the total pull in pounds.

* * * * *

S6.4.2 *Operation.*

(a) Conduct the slow pull test by applying tension at a rate of 1 inch per minute travel of the moving head until separation occurs.

(b) Conduct the fast pull test by applying tension at a rate of 2 inches per minute travel of the moving head until separation occurs.

* * * * *

S6.8.2 *Exposure to ozone.* (a) * * *

(b) Immediately thereafter, condition the hose on the cylinder for 70 hours in an exposure chamber having an ambient air temperature of 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.

* * * * *

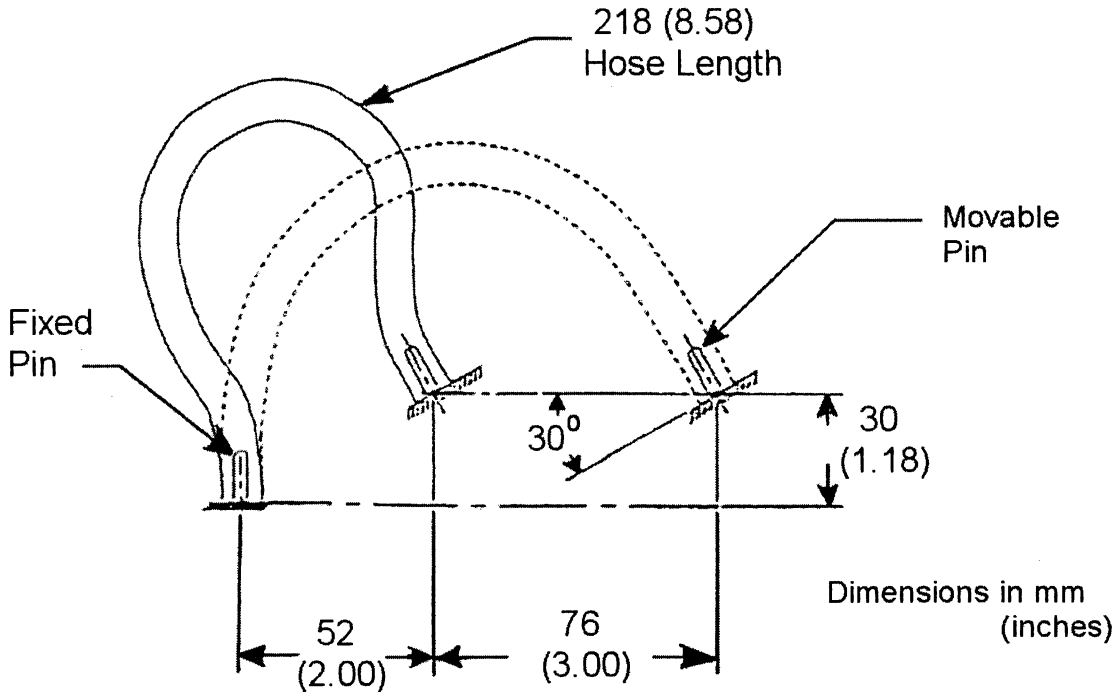
S6.9 *Dynamic Ozone Test.*

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 vertical, with the top of the movable pin angled towards the fixed pin. The moveable 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.

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 8.6 inches (218 mm), 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 into an ozone chamber.

(e) Stabilize the atmosphere in the ozone chamber so that the ambient temperature is 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 of a circulating air oven. The machine is capable of increasing the pressure in the hose from zero psi to 1600 psi, and decreasing the pressure in the hose from 1600 psi to zero psi, within 2 seconds.

(b) A circulating air oven that can reach a temperature of 295 °F within 30 minutes, and that can maintain a constant 295 °F thereafter, with the brake hose assembly inside of the oven and attached to the pressure cycling machine.

(c) A burst test apparatus to conduct 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–66–05 Compatibility Fluid, as described in Appendix B of SAE Standard J1703 JAN 1995, and bleed all gases from the system.

(b) Place the brake hose assembly inside of the circulating air oven in a vertical position. Increase the oven temperature to 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 psi to 1600 psi and held constant for 1 minute, then the pressure is decreased from 1600 psi to zero 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.

S6.11 *End fitting corrosion test.* Utilize the apparatus described in ASTM B117–97, ''Standard Practice for Operating Salt Spray (Fog) Apparatus''.

* * * * *

S6.11.3 *Operation.* * * *

* * * * *

(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 100 °F and then drying immediately.

* * * * *

S6.12 *Constriction Test.*

(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.

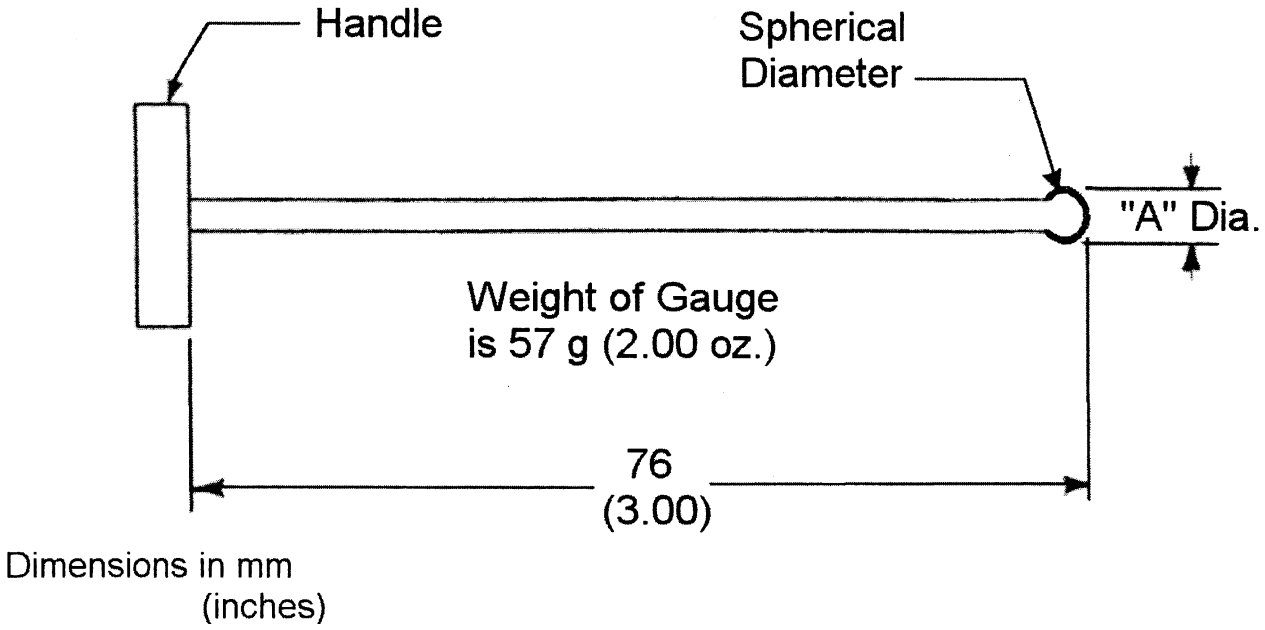
(b) Brake hose assemblies that are to be used for additional testing have constriction testing only at each end fitting. Other brake hose assemblies may be cut into three inch lengths to permit constriction testing of the entire assembly. Hose assemblies with end fittings that do not permit entry of the gauge (*e.g.*, restrictive orifice or banjo fitting) are cut three 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 three 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 three seconds, this constitutes failure of the constriction test.

Figure 4. Constriction Test Plug Gauge



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

* * * * *

S7.2.1 *Hose.* * * *

* * * * *

(b) A designation that identifies the manufacturer of the hose, 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.

* * * * *

(d) The nominal inside diameter of the hose expressed in inches or fractions of inches or in millimeters. The abbreviation ''mm'' shall follow hose sizes that are expressed in millimeters. (Examples: 3/8, 1/2 (1/2SP in the case of 1/2 inch special air brake hose), 4mm, 6mm.)

(e) The letter ''A'' shall indicate intended use in air brake systems. In the case of a hose intended for use in a reusable assembly, ''AI'' or ''AII'' shall indicate Type I or Type II dimensional characteristics of the hose as described in Table III. A hose that is intended to be used with more than one type of end fitting may be labeled with multiple designations. (Examples: AI–AII, AI & AII.)

TABLE III.—AIR BRAKE HOSE DIMENSIONS FOR REUSABLE ASSEMBLIES

Size, inches	Inside diameter tolerance, inches	Type I outside diameter, inches		Type II outside diameter, inches	
		Minimum	Maximum	Minimum	Maximum
3/16	+0.026 −0.000	0.472	0.510	0.500	0.539
1/4	+0.031 −0.000	0.535	0.573	0.562	0.602
5/16	+0.031 −0.000	0.598	0.636	0.656	0.695
3/8	±0.023	0.719	0.781	0.719	0.781
7/16	±0.031	0.781	0.843	0.781	0.843
13/32	+0.031 −0.000	0.714	0.760	0.742	0.789
1/2	+0.039 −0.000	0.808	0.854	0.898	0.945
5/8	+0.042 −0.000	0.933	0.979	1.054	1.101
1/2 special	±0.031	0.844	0.906	0.844	0.906

S7.2.2 *End fittings.* * * *

* * * * *

(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 St. SW., Washington, DC 20590. The designation may consist of block capital letters, numerals, or a symbol.

* * * * *

(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).) The abbreviation ''mm'' shall follow hose sizes that are expressed in millimeters.

* * * * *

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 S7.3.14.

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. (S8.15)

* * * * *

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 minus 40 °F for 70 hours when bent around a cylinder having the radius specified in Table IV for the size of hose tested (S8.2).

TABLE IV.—AIR BRAKE HOSE DIAMETERS AND TEST CYLINDER RADII

Nominal hose diameter, inches [1]	1/8	3/16	1/4	5/16	3/8	13/32	7/16, 1/2	5/8
Nominal hose diameter, millimeters [1]	3	4, 5	6	8	.....	10	12	16
Test cylinder radius for high temperature resistance test and adhesion test for wire reinforced hose, inches (mm)	1 (25)	1 (25)	1½ (38)	1¾ (44)	1¾ (44)	1⅞ (48)	2 (51)	2½ (64)
Test cylinder radius for low temperature resistance test and ozone test, inches (mm)	1½ (38)	2 (51)	2½ (64)	3 (76)	3 (89)	3½ (89)	4 (102)	4½ (114)

[1] These sizes are listed to provide test values for brake hose manufactured in these sizes. They do not represent conversions.

* * * * *

S7.3.6 *Length Change.* An airbrake hose shall not contract in length more than 7 percent nor elongate more than 5 percent when subjected to air pressure of 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 8 pounds per 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 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 Table 5, when subjected to a flex test and internal pressure cycling, shall be capable of having its internal pressure increased from zero to 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 900 psi (S8.8).

S7.3.10 *Tensile strength.* An air brake hose assembly shall withstand, without separation of the hose from its end fittings, a pull of 250 pounds if it is ¼ inch or less or 6 mm or less in nominal inside diameter, or a pull of 325 pounds if it is larger than ¼ inch or 6 mm in nominal inside diameter (S8.9).

S7.3.11 *Water absorption and tensile strength.* After immersion in distilled water for 70 hours (S8.10), an air brake hose assembly shall withstand, without separation of the hose from its end fittings, a pull of 250 pounds if it is ¼ inch or less or 6 mm or less in nominal inside diameter, or a pull of 325 pounds if it is larger than ¼ inch or 6 mm in nominal inside diameter (S8.9).

* * * * *

S7.3.14 *Ozone resistance.* An air brake hose assembly shall not show cracks visible under 7-power magnification after exposure to ozone for 70 hours at 104 °F when bent around a test cylinder of the radius specified in Table IV for the size of hose tested (S8.14).

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

* * * * *

S8.2 *Low temperature resistance test.*

* * * * *

(c) With the hose and cylinder at minus 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.

* * * * *

S8.3.2 *Measurement.*

* * * * *

(b) Immerse each specimen in ASTM IRM 903 oil for 70 hours at 212 °F. and then cool in ASTM IRM 903 oil at room temperature for 30 to 60 minutes.

* * * * *

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

* * * * *

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 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 150 psi within 2 seconds, and decreasing the air pressure

in the hose assembly from 150 to zero psi within 2 seconds.

Figure 5. Flex Test Apparatus

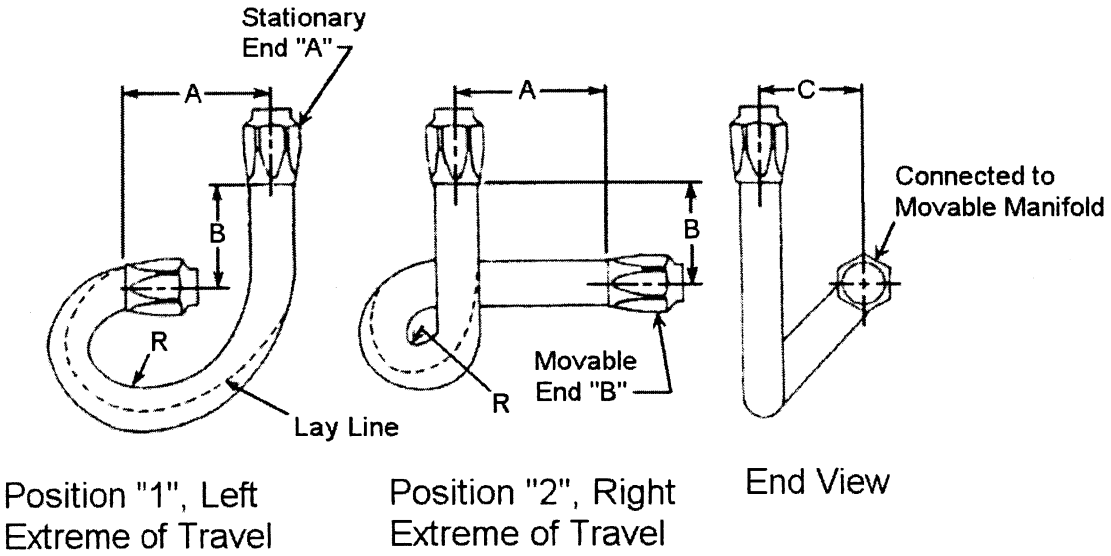


TABLE ACCOMPANYING FIGURE 5

Free hose length 27 (1.6mm)	Hose I.D., in (mm)	Dimensions							
		Position "1"				Position "2"			
		"A"	"B"	"C"	"R"[a]	"A"	"B"	"C"	"R"[a]
10 in (254 mm).	3/16 (4.8); 1/4 (6.3)	3 in (76 mm)	2.75 in (70 mm).	3.75 in (95 mm).	1.4 in (34 mm).	3 in (76 mm)	2.75 in (70 mm).	3.75 in (95 mm).	1.2 in 30 mm).
11 in (279 mm).	5/16 (7.9); 3/8 (9.7); 13/32 (10.4).	3 in (76 mm)	3.5 in (8.9 mm).	4/5 in (114 mm).	1.7 in (43 mm).	3 in (76 mm)	3.5 in (89 mm).	4.5 in (114 mm).	1.3 in (33 mm).
14 in (355 mm).	7/16 (11.2); 1/2 (12.7; (5/8 (16.0).	3 in (76 mm)	4 in (102 mm).	4 in (127 mm).	2.2 in (56 mm).	3 in (76 mm)	4 in (102 mm).	5 in (127 mm).	1.8 in (46 mm).

[a] This is an approximate average radius.

8.7.2 *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 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 S6.9 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 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 (e).

(e) Install the hose assembly on the flex testing machine as follows. With the movable hose attachment point at the mid point 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 psi to 150 psi and holding constant for one minute, then decreasing the pressure from 150 psi to zero 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 6 inches of travel at a rate of 100 cycles per minute. Stop the flex testing and pressure cycling after 1 million flex cycles have been completed.

(g) Install an orifice with a hole diameter of 0.0625 inches and a thickness of 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 150 psi.

(h) Apply 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 S6.9 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 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) Standard Practices for Force Verification of Testing Machines, Designation E4–99, and provided with a recording device to register total pull in pounds.

* * * * *

S8.13 *Adhesion test for air brake hose reinforced by wire.* (a) Place a steel ball with a diameter equal to 75 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 25 inches of Hg for five minutes. With the vacuum still applied to the hose, bend the hose 180 degrees around a test cylinder of the size specified in Table IV for the 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 *Ozone test.* Conduct the test in S6.8 on an air brake hose assembly except use the test cylinder radius specified in Table IV for the size of hose tested.

S8.15 *Constriction test.*

(a) Utilize a plug gauge as shown in Figure 4. Diameter ''A'' shall be equal to 66 percent of the nominal inside diameter of the air brake hose being tested.

(b) Air brake hose assemblies that are to be used for additional testing have constriction testing only at each end fitting. Other hose assemblies may be cut into three inch lengths to permit constriction testing of the entire assembly.

(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 three 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 three seconds, this constitutes failure of the constriction test.

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

* * * * *

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 be not 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 hose if for light duty. (S10.10)

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 °F for 70 hours when bent around a cylinder having the radius specified in Table V for the size hose tested, and;

(b) not leak when subjected to a hydrostatic pressure test.

* * * * *

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 tested. (S10.6).

* * * * *

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 26 inches of Hg for 10 minutes. A vacuum hose that is constructed of two or more layers shall withstand a force of 8 pounds per 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 70 pounds, and the fifth application of force shall reach a peak value of at least 40 pounds. In the case of light duty hose the first application of force shall not exceed a peak value of 50 pounds, and the fifth application of force shall reach a peak value of at least 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. *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 26 inches of Hg at an ambient temperature of 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 test in (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 175 psi within 10 seconds. Maintain an internal hydrostatic pressure of 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 using vacuum brake hose with the cylinder radius specified in Table V for the size of hose tested. Visually inspect the exterior of the hose for cracks without magnification.

(b) Remove the hose from the test cylinder, warm the hose at room temperature for 5 hours, and conduct the hydrostatic pressure test in 10.1(e).

* * * * *

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.

* * * * *

S10.7 *Swell and adhesion test.*

(a) Fill a specimen of vacuum brake hose 12 inches long with ASTM Reference Fuel B as described in ASTM D471–98e1 Standard Test Method for Rubber Property B Effect of Liquids.

(b) Maintain reference fuel in the hose under atmospheric pressure at room temperature for 48 hours.

(c) Remove fuel and determine that every inside diameter of any section of the brake hose is not less than 75 percent of the nominal inside diameter of the hose for heavy-duty hose and 70 percent of the nominal inside diameter of the hose for light-duty hose.

(d) Attach the hose to a source of vacuum and subject it to a vacuum of 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.

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S10.8.2 * * *

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(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 tested.

* * * * *

S10.10 *Constriction test.*

(a) Utilize a plug gauge is shown in Figure 4. Diameter AA'' shall be equal to 75 percent of the nominal inside diameter of the vacuum brake hose being tested if it is heavy duty, or 70 percent of the nominal inside diameter of the vacuum brake hose being tested if it is light duty.

(b) Vacuum brake hose assemblies that are to be used for additional testing have constriction testing only at each end fitting. Other hose assemblies may be cut into three 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) are cut three inches from the point at which the hose terminates in the end fitting and then tested from the cut end.

(c) Hold the vacuum 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 three 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 three seconds, this constitutes failure of the constriction test.

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 brake hose end fittings or reusable brake hose end fittings. Plastic air brake tubing that is constructed of one layer of material shall be designated as Type A tubing and plastic air brake tubing that is constructed of two layers of material with a reinforcing braid between the layers shall be designated as Type B tubing. Plastic air brake tubing shall conform to the dimensional requirements specified in Table VII. (S12.1)

TABLE VII.—PLASTIC AIR BRAKE TUBING DIMENSIONS

Type	Nominal tubing OD	Maximum outside diameter		Minimum outside diameter		Nominal inside diameter		Nominal wall thickness		Wall thickness tolerance	
		mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
A	1/8 inch	3.25	0.128	3.10	0.122	2.01	0.079	0.58	0.023	±0.08	±0.003
A	5/32 inch	4.04	0.159	3.89	0.153	2.34	0.092	0.81	0.032	±0.08	±0.003
A	3/16 inch	4.83	0.190	4.67	0.184	2.97	0.117	0.89	0.035	±0.08	±0.003
A	1/4 inch	6.43	0.253	6.27	0.247	4.32	0.170	1.02	0.040	±0.08	±0.003
A	5/16 inch	8.03	0.316	7.82	0.308	5.89	0.232	1.02	0.040	±0.10	±0.004
B	3/8 inch	9.69	0.379	9.42	0.371	6.38	0.251	1.57	0.062	±0.10	±0.004
B	1/2 inch	12.83	0.505	12.57	0.495	9.55	0.376	1.57	0.062	±0.10	±0.004
B	5/8 inch	16.00	0.630	15.75	0.620	11.20	0.441	2.34	0.092	±0.13	±0.005
B	3/4 inch	19.18	0.755	18.92	0.745	14.38	0.566	2.34	0.092	±0.13	±0.005
A	6 mm	6.10	0.240	5.90	0.232	4.00	0.157	1.00	0.039	±0.10	±0.004
A	8 mm	8.10	0.319	7.90	0.311	6.00	0.236	1.00	0.039	±0.10	±0.004
B	10 mm	10.15	0.399	9.85	0.387	7.00	0.275	1.50	0.059	±0.15	±0.006
B	12 mm	12.15	0.478	11.85	0.466	9.00	0.354	1.50	0.059	±0.15	±0.006
B	16 mm	16.15	0.635	15.85	0.623	12.00	0.472	2.00	0.079	±0.15	±0.006

S11.2 *Labeling.*

S11.2.1 *Plastic Air Brake Tubing.* Plastic air brake tubing shall be labeled, or cut from bulk tubing that is labeled, at intervals of not more than 6 inches, measured from the end of one legend to the beginning of the next, in block capital letters and numerals at least one-eighth of an inch high, with the information listed in paragraphs (a) through (e) of this section. The information need not be present on tubing that is sold as part of a motor vehicle.

(a) The symbol DOT, constituting a certification by the hose manufacturer that the hose conforms to all applicable motor vehicle safety standards.

(b) A designation that identifies the manufacturer of the tubing, which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS–222, National Highway Traffic Safety Administration, 400 Seventh St. S.W., Washington, DC 20590. The designation may consist of block capital letters, numerals, or a symbol.

(c) The month, day, and year, or the month and year, of manufacture, expressed in numerals. For example, 10/1/96 means October 1, 1996.

(d) The nominal outside diameter 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: 3/8 OD, 6 mm OD.)

(e) The letter ''A'' shall indicate intended use in air brake systems.

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 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 St. S.W., 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. (See examples in S11.2.1(d).)

S11.2.3. *Assemblies*. Each plastic air brake tubing assembly made with end fittings that are attached by crimping or swaging, except those sold as part of a motor vehicle, shall be labeled by means of a band around the brake tubing assembly as specified in this paragraph or, at the option of the manufacturer, by means of labeling as specified in S11.2.3.1. The band may at the manufacturer's option be attached so as to move freely along the length of the assembly, as long as it is retained by the end fittings. The band shall be etched, embossed, or stamped in block capital letters, numerals or symbols at least one-eighth of an inch high, with the following information:

(a) The symbol DOT, constituting certification by the tubing assembler that the tubing assembly conforms to all applicable motor vehicle safety standards.

(b) A designation that identifies the manufacturer of the hose assembly, which shall be filed in writing with: Office of Vehicle Safety Compliance, Equipment Division NVS–222, National Highway Traffic Safety Administration, 400 Seventh St. S.W., Washington, DC 20590. The designation may consist of block capital letters, numerals, or a symbol.

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 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.

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 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 *Moisture absorption*. Plastic air brake tubing shall not absorb moisture in a quantity of more than 2 percent by weight after conditioning in air at 230 °F for 24 hours and then conditioning in a 100 percent relative humidity atmosphere at 75 °F for 100 hours. (S12.5)

S11.3.5 *Burst strength*. Plastic air brake tubing shall not rupture or burst when subjected to the burst strength pressure in Table VIII for the size of tubing being tested, when tested at an ambient temperature of 75 °F. (S12.6)

TABLE VIII.—PLASTIC AIR BRAKE TUBING MECHANICAL PROPERTIES

Type	Nominal tubing OD	Burst strength pressure		Stiffness force		Bend radius		Tensile load	
		kPa	psi	N	lbf	mm	inches	N	lbf
A	1/8 inch	6900	1000	4.4	1.0	9.4	0.37	67	15
A	5/32 inch	8300	1200	4.4	1.0	12.7	0.50	178	40
A	3/16 inch	8300	1200	4.4	1.0	19.1	0.75	178	40
A	1/4 inch	8300	1200	8.9	2.0	25.4	1.00	222	50
A	5/16 inch	6900	1000	27.0	6.0	31.8	1.25	334	75
B	3/8 inch	9700	1400	36.0	8.0	38.1	1.50	6671	50
B	1/2 inch	6600	950	89.0	20.0	50.8	2.00	890	200
B	5/8 inch	6200	900	222.0	50.0	63.5	2.50	1446	325
B	3/4 inch	5500	800	356.0	80.0	76.2	3.00	1557	350
A	6 mm	7600	1100	9.0	2.0	20.0	0.75	222	50
A	8 mm	6200	900	27.0	6.0	32.0	1.25	334	75
B	10 mm	8200	1200	36.0	8.0	38.0	1.50	667	150
B	12 mm	6900	1000	90.0	20.0	45.0	1.75	890	200
B	16 mm	6000	875	225.0	50.0	70.0	2.75	1446	325

S11.3.6 *Ultraviolet light 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 being exposed to ultraviolet light for 300 hours and then impacted with a one pound weight dropped from a height of 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 230 °F for 24 hours, and then conditioning in air at minus 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 230 °F for 72 hours while bent 180 degrees around a cylinder having a radius of two times the nominal outside diameter of the tubing; 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 230 °F for 72 hours. (S12.10)

S11.3.10 *High temperature conditioning, 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 230 °F for 24 hours, then conditioned in air at minus 40 °F for 4 hours and impacted with a one pound weight dropped from a height of 12 inches. (S12.11)

S11.3.11 *Boiling water conditioning, 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 boiling water for two hours, then conditioned in air at minus 40 °F for 4 hours, and then impacted with a one pound weight dropped from a height of 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 of two times the nominal outside diameter of the tubing. (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 of two times the nominal outside diameter of the tubing (S12.14)

S11.3.14 *High temperature conditioning and stiffness*. Plastic air brake tubing shall require not more than the stiffness force specified in Table VIII to deflect 2 inches, when tested using the apparatus in Figure 9, after conditioning in air at 230 °F for 24 hours with the tubing supported in a straight position. (S12.15)

S11.3.15 *High temperature conditioning and adhesion*. Type B plastic air brake tubing shall have a tensile strength of 25 pounds per linear inch, measured at the interface of the inner and outer layers, after conditioning as specified in S11.3.8(a) through (c). (S12.16)

S11.3.16 *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 bend radius specified in Table VIII and conditioned in air at 200 °F for 24 hours. (S12.17)

S11.3.17 *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 104 °F. (S12.18)

S11.3.18 *Oil 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 ASTM IRM 903 oil at 212 °F for 70 hours. (S12.19)

S11.3.19 *Tensile strength*. A plastic air brake tubing assembly designed for use between 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 250 pounds if it is ⅜ inch or less or 10 mm or less in nominal outside diameter, or a pull of 325 pounds if it is larger than ⅜ 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 35 pounds if it is ⅛ inch or 3 mm or less in nominal outside diameter, 40 pounds if it is 5⁄32 inch or 4 mm in nominal outside diameter, 50 pounds if it is 3⁄16 to ⅜ inch or 5 mm to 10 mm in nominal outside diameter, 150 pounds if it is ½ to ⅝ inch or 11 mm to 16 mm in nominal outside diameter, or 325 pounds if it is larger than ⅝ inch or 16 mm in nominal outside diameter. (S12.20)

S11.3.20 *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 tensile load in Table VIII without separation from its end fittings, with one end of the assembly conditioned in boiling water for 5 minutes. (S12.21)

S11.3.21 *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 tensile strength in Table VIII without separation from its end fittings after the assembly has been subjected to four cycles of conditioning in air at minus 40 °F for thirty minutes, normalizing at room temperature, conditioning in boiling water for 15 minutes, and normalizing at room temperature. (S12.22)

S11.3.22 *Vibration resistance*. A plastic air brake tubing assembly with an internal air pressure of 120 psi shall not leak more than 50 cm^3 per minute at a temperature of minus 40 °F and 25 cm^3 per minute at a temperature of 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 ½-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 minus 40 °F and 220 °F during the test. (S12.23)

S11.3.23 *End fitting retention*. The end fittings of a plastic air brake tubing assembly shall not separate from the tubing or leak when the assembly is filled with hydraulic fluid and pressurized to the burst strength pressure in Table VIII. (S12.24)

S11.3.24 *Thermal conditioning and end fitting retention*. The end fittings of a plastic air brake tubing assembly shall not separate from the tubing or leak when filled with hydraulic fluid and:

(a) conditioned in air at 200 °F for 24 hours with atmospheric pressure inside the tubing assembly, and;

(b) maintaining an air temperature of 200 °F and increasing the pressure inside the tubing assembly to 450 psi, and holding this pressure for five minutes, and;

(c) reducing the internal tubing assembly pressure to atmospheric and permitting the tubing assembly to cool at 75 NF for 1 hour, and;

(d) conditioning the tubing assembly in air at minus 40 °F for 24 hours with atmospheric pressure inside the tubing assembly, and;

(e) maintaining an air temperature of minus 40 °F and increasing the pressure inside the tubing assembly to 450 psi,

and holding this pressure for five minutes. (S12.25)

S11.3.24 *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. (S12.26)

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 gauge blocks, 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.*

(a) Utilize a plug gauge as shown in Figure 4. Diameter ''A'' shall be equal to 66 percent of the nominal inside diameter of the plastic air brake tubing being tested.

(b) Tubing assemblies that are to be used for additional testing shall have constriction testing only at each end fitting. Other tubing assemblies may be cut into three inch lengths to permit constriction testing of the entire assembly.

(c) Hold the tubing in a straight position and vertical orientation.

(d) Place the spherical end of the plug gauge just inside the tubing. If the spherical end will not enter the tubing 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 three 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 tubing up to the handle of the gauge within three seconds, this constitutes failure of the constriction test.

S12.3 *High temperature conditioning and dimensional stability test.*

(a) Condition the tubing at 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 pot constructed of a non-reactive material and fill with distilled water.

(b) Cut the tubing to a length that will fit into the pot without touching any surface of the pot. 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 pot. 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 *Moisture absorption test.*

(a) Prepare a sample of tubing twelve inches in length.

(b) Condition the tubing at 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 weight. The weight shall be measured with a resolution of 0.01g; if the scale has a higher resolution, then values of 0.005g and above shall be rounded to the nearest 0.01g and values below 0.005g 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 75 °F.

(d) Remove the tubing from the chamber within a period of 5 minutes, remove all surface moisture from the tubing using cloth and weigh the tubing to establish the conditioned weight. Weight shall be measured to the nearest 0.01g as in (b) above.

(e) Calculate percentage of moisture absorption as follows:

$$[\text{Conditioned Weight} - \text{Initial Weight}] \div [\text{Initial Weight}] \times 100$$

S12.6 *Burst strength test.*

(a) Utilize an air brake tubing assembly or prepare a 12 inch length of tubing and install end fittings according to the end fitting manufacturer's instructions.

(b) Connect one end of the tubing assembly to a source of air pressure and plug the other end.

(c) Increase the pressure inside the tubing assembly at a constant rate to the burst strength pressure for the size of tubing being tested as specified in Table VIII within a period of 5 seconds.

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) G154–00 Standard Practice for Operating Light Apparatus for UV Exposure of Nonmetallic Materials; ASTM G151–97 Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources, and; ASTM D4329–99 Standard Practice for Fluorescent UV Exposure of Plastics.

(c) *Preparation.*

(i) Utilize a 12 inch length of plastic air brake tubing. Mask 1 inch of each end of the tubing where end fittings will be attached using opaque tape.

(ii) 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 and the longitudinal axis of the tubing is parallel to the fluorescent bulb. (If multiple plastic brake tubing assemblies are tested, then their position in the machine should be rotated according to ASTM D4329–99 S7.4.1, except the rotation is each 96 hours instead of weekly.) The distance from the light bulb to the tubing is approximately 2 inches. Set the UV irradiance to 0.85 W/m^2 @ 340 nm and maintain this level during the testing. Maintain a temperature inside the test chamber of 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.

(iii) Place the tubing inside the impact test apparatus, and drop the impacter onto the tubing from a height of 12 inches.

(iv) 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 S12.6 using 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

Figure 8. Impact Test Apparatus

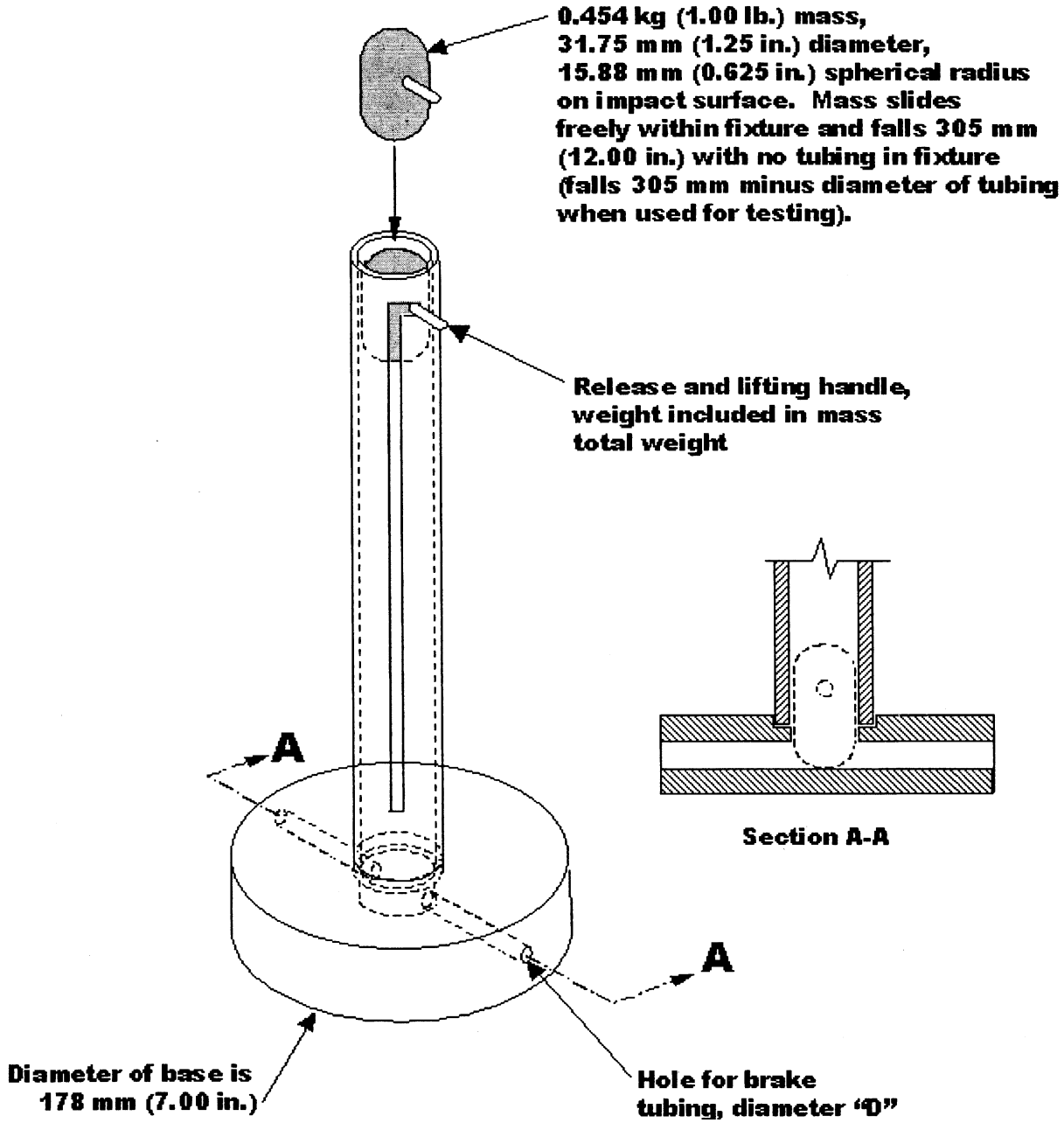


TABLE ACCOMPANYING FIGURE 8

Nominal tube O.D.	Hole DIA D (mm)	Hole DIA D (in)
1/8 in	3.96	0.156
5/32 in	4.75	0.187
3/16 in	5.54	0.218
1/4 in	7.14	0.281
5/16 in	8.71	0.343
3/8 in	10.31	0.406
1/2 in	13.49	0.531
5/8 in	16.66	0.656
3/4 in	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 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 minus 40 °F for four hours.

(d) With the tubing and test cylinder at minus 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 of two times the nominal outside diameter of the tubing.

(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 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 mandrel, at the same point

but in the opposite direction of the bending in (b) above, at a steady rate in a period of 4 to 8 seconds.

(f) Conduct the burst strength test in S12.6 using 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 230 °F for 72 hours. Remove the tubing and allow to cool at room temperature for 30 minutes. Conduct the burst strength test in S12.6 using 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.11 *High temperature conditioning, 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 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 minus 40 °F for 4 hours.

(d) With the tubing and impact test apparatus at minus 40 °F, place the tubing inside the apparatus and drop the impacter onto the tubing from a height of 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 S12.6 using 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII.

S12.12 *Boiling water conditioning, 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).

(c) Condition the tubing and the impact test apparatus in an environmental chamber at minus 40 °F for 4 hours.

(d) With the tubing and impact test apparatus at minus 40 °F, place the tubing inside the apparatus and drop the impacter onto the tubing from a height of 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 S12.6 using 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 of two times the nominal outside diameter of the tubing. The cylinder is constructed of a non-reactive material or coated to prevent chemical reaction with zinc chloride.

(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 of two times the nominal outside diameter of the tubing. 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.

(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 stiffness.*

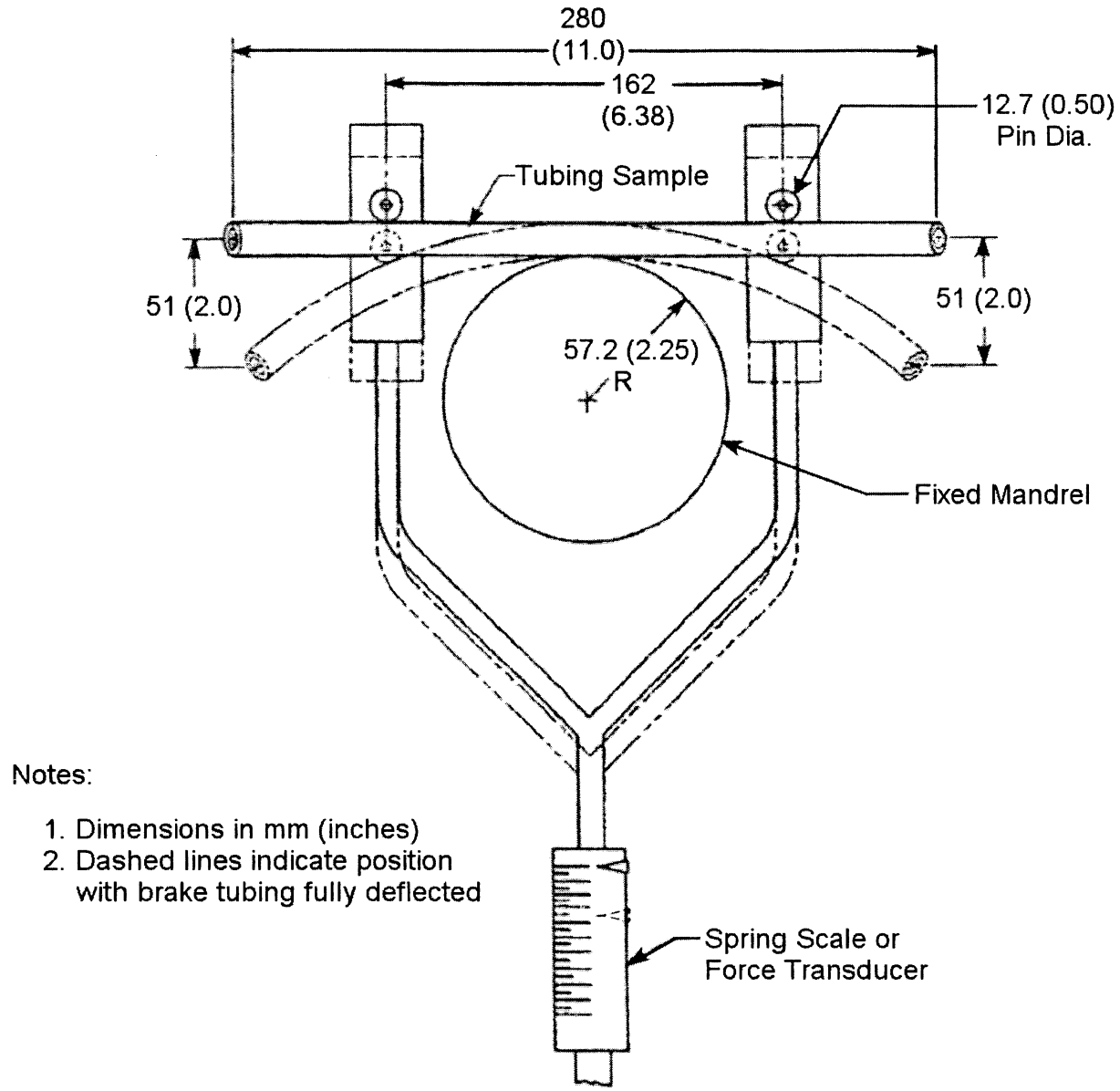
(a) *Apparatus.* Use a flexibility test device shown in Figure 9 with a spring scale or force transducer to measure the force applied to the tubing during bending.

(b) Prepare an 11-inch long length of tubing. Insert a metal rod 12 inches long of suitable diameter to provide a slip fit inside the tubing, and insert it in the tubing to hold it in a straight position within ⅛ inch of true straightness.

(c) Condition the tubing in an air oven at 230 °F for 24 hours. Remove the tubing and allow to cool at room temperature for two hours.

(d) Remove the metal rod from the tubing and place the tubing in the flexibility test device, with the tubing centered on the device and clearance removed between tubing and the pins and cylinder of the test device.. Mark the location of each end of the tubing. Pull on the device until both ends of the tubing have deflected 2 inches from the original position. Record the force applied to the device and verify that it does not exceed the stiffness force in Table VII for the size of tubing being tested.

Figure 9. Stiffness Test Apparatus



S12.16 *High temperature conditioning and adhesion test.*

S12.16.1 *Apparatus.* A tension testing machine that conforms to the requirements of American Society for Testing and Materials (ASTM) Standard Practices for Force Verification of Testing Machines, Designation E4–99. The machine shall have one movable and one fixed jaw suitable for clamping small sections of plastic air brake tubing material. The machine produces a chart or has a recording device providing displacement as one coordinate and tensile force as the other.

S12.16.2 *Preparation.*

(a) Subject the tubing to the bending and temperature conditioning tests specified in S12.9 (a) through (e).

(b) Cut a test specimen of 1 inch in length from a section of tubing that was subjected to bending in (a).

(c) Cut the specimen longitudinally along its entire length so that one wall of the tubing is completely cut through. Along one edge of the specimen resulting from this cut, use a sharp knife and cut the tubing at the interface of the inner and outer layers until two flaps of material are created that are large enough to be clamped in the tension testing machine. One flap consists of material from the inner layer and one flap consists of material from the outer layer.

(d) Mount the specimen in the tension testing machine by clamping one flap in each jaw. Apply a tensile force of 25 pounds to the flaps of the specimen in a period of 5 seconds and maintain this force for the duration of the test. The specimen is permitted to separate a small amount until the inner and outer layer interface becomes fully engaged and a continuous line of reinforcing braid is not present at the layer interface. The layers of the specimen shall not separate thereafter.

S12.17 *High temperature conditioning and collapse resistance test.*

(a) *Apparatus.* A holding device with two vertical pins, the distance between which can be adjusted by moving one or both pins. The bottoms of the pins are attached to the device and remain in a horizontal plane. The diameter of the pins is approximately the same as the inside diameter of the size of tubing to be tested, and is 1 inch in length.

(b) *Preparation.* (i) Use the bend radius for the size of tubing being tested from Table VIII and cut the tubing to the following length:

3.14 × [bend radius]] + [10 × [nominal tubing OD]] + 2 inches

or

[3.14 × [bend radius]] + [10 × [nominal tubing OD]] + 50 mm

(ii) 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 minor diameter as the initial outside diameter.

(iii) Install the tubing completely over the pins of the holding device so that the tubing is bent 180 degrees. Adjust the distance between the pins until the bent radius of the tubing is approximately equal to the bend radius for the size of tubing being tested from Table VIII.

(iv) Condition the holding device and tubing in an air oven at 230 °F for 24 hours. Remove the holding device and tubing and allow to cool at room temperature for thirty minutes.

(v) With the tubing still mounted to the holding device, measure the 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:

[Initial Outside Diameter − Final Outside Diameter] ÷ [Initial Outside Diameter] × 100

S12.18 *Ozone resistance test.* Conduct the test specified in S6.8 using plastic air brake tubing.

S12.19 *Oil resistance test.*

(a) Utilize a plastic air brake tubing assembly or prepare a 12 inch length of tubing and install end fittings according to the end fitting manufacturer's instructions.

(b) Immerse the tubing assembly in ASTM 903 oil at 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) Connect one end of the tubing assembly to a source of air pressure and plug the other end.

(d) Increase the pressure inside the tubing assembly at a constant rate to 80 percent of the burst strength pressure for the size of tubing being tested as specified in Table VIII within a period of 5 seconds.

S12.20 *Tensile strength test.* Conduct the test specified in S6.9 using a plastic air brake tubing assembly or an assembly prepared from a 12 inch length of tubing with the end fittings according to the end fitting manufacturer's instructions.

S12.21 *Boiling water conditioning and tensile strength.*

(a) *Apparatus.* Use the tension testing machine specified in S8.9. Equip the lower attachment point of the machine with a heated, open-top container. The container acts as the lower attachment point for a brake tubing assembly, or it may have a hole in the bottom for the lower attachment point of the machine to pass through the container provided that the hole is sealed water-tight to the machine.

(b) *Preparation.* Prepare an air brake tubing assembly with a free length of six inches in accordance with the end fitting manufacturer's instructions. The free length is measured from the innermost crimp, ferrule, taper, or other mechanical joint that secures the fitting to the tubing and spring guards and other appurtenances are disregarded for measurement purposes. Install the tubing assembly on the tension testing machine with the lower fitting plugged to prevent water from entering the tubing. Fill the container with distilled water so that 4 inches of exposed tubing is submerged. Heat the water until it boils. After the water has boiled continuously for 5 minutes, apply tension to the tubing assembly at a rate of 1 inch per minute travel of the moving head until either the tensile load in Table VIII for the size of tubing being tested is reached or the free length of the tubing assembly reaches 9 inches, whichever occurs first.

S12.22 *Thermal conditioning and tensile strength.*

(a) *Apparatus.* Use the tension testing machine specified in S8.9.

(b) *Preparation.* Prepare an air brake tubing assembly with a free length of six inches in accordance with the end fitting manufacturer's instructions. The free length is measured from the innermost crimp, ferrule, taper, or other mechanical joint that secures the fitting to the tubing and spring guards and other appurtenances are disregarded for measurement purposes. Subject the tubing assembly to four complete cycles of the following sequence:

(i) Condition the tubing assembly in an environmental chamber at minus 40 °F for 30 minutes. Remove from the chamber and allow to warm at room temperature for 30 minutes.

(ii) 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 1 inch per minute travel of the moving head until either the tensile load in Table VIII for the size of tubing being tested is reached or the free length of the tubing assembly reaches 9 inches, whichever occurs first.

S12.23 *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:

(i) 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 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.

(i) The distance between the attachment points is adjustable to compensate for varying lengths of brake tubing assemblies.

(ii) The actuating mechanism for the movable attachment point is balanced to prevent introduction of machine vibration into the brake tubing assembly.

(iii) 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.

(iv) The machine is constructed so that an air brake tubing assembly mounted on it can be conditioned in an environmental test chamber.

(b) *Preparation.* (i) Prepare an air brake tubing assembly with a free length of eighteen inches in accordance with the end fitting manufacturer's instructions. The free length is measured from the innermost crimp, ferrule, taper, or other mechanical joint that secures the fitting to the tubing and spring guards and other appurtenances are disregarded for measurement purposes.

(ii) 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 ½ inch closer together than the distance at which the tubing assembly is taut.

(iii) With the tubing assembly inside the environmental chamber, supply compressed air to the tubing assembly at a pressure of 120 psig and maintain this supply pressure for the duration of the test. Set the temperature of the environmental chamber to 220 °F and initiate cycling of the movable attachment point. After 250,000 cycles,

set the temperature of the environmental chamber to minus 40 °F. After 500,000 cycles, set the temperature of the environmental chamber to 220 °F. After 750,000 cycles, set the temperature of the environmental chamber to minus 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 cm^3 per minute this constitutes failure of the test. Stop the cycling at 1,000,000 cycles and set the environmental chamber temperature to 75 °F, while air pressure is still supplied to the air brake tubing assembly. After 1 hour, measure the compressed air flow rate supplied to the air brake tubing assembly and if the rate exceeds 25 cm^3 per minute this constitutes failure of the test.

(iv) For end fittings that use a threaded retaining nut, apply 20 percent of the original tightening torque as measured in S11.3.22, in the direction of tightening. If the retention nut visibly moves, this constitutes a failure of the test.

S12.24 *End fitting retention test.*

(a) *Apparatus.* A source of hydraulic pressure that includes a pressure gauge or monitoring system, and uses a petroleum-based hydraulic fluid with a pour point of less than minus 40 °F.

(b) *Preparation.* Utilize an air brake tubing assembly or prepare an air brake tubing assembly with a free length of twelve inches in accordance with 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, and fill the assembly with hydraulic fluid and bleed any air from the assembly. Increase the hydraulic pressure inside the tubing assembly at a constant rate to 50 percent of the burst pressure for the size of tubing being tested as specified in Table VIII within a period of 5 seconds, and hold this pressure for 30 seconds. Then increase the hydraulic pressure inside the tubing assembly at a constant rate to the burst pressure for the size of tubing being tested as specified in Table VIII within a period of 5 seconds. Visually inspect the assembly for leakage or separation at the end fittings.

S12.25 *Thermal conditioning and end fitting retention test.*

(a) *Apparatus.* A source of hydraulic pressure that includes a pressure gauge or monitoring system, uses a petroleum-based hydraulic fluid with a pour point of less than minus 40 °F, 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 an air brake tubing assembly with a free length of twelve inches in accordance with 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 hydraulic fluid and bleed any air from the assembly, and place the tubing assembly inside an environment chamber. Conduct the following tests:

(i) With atmospheric pressure applied to the hydraulic fluid inside the tubing assembly, set the environmental chamber temperature to 200 °F and condition the tubing assembly for 24 hours.

(ii) With the temperature maintained at 200 °F, increase the hydraulic pressure inside the tubing assembly at a constant rate to 450 psig within a period of 5 seconds, and hold this pressure for 5 minutes.

(iii) Decrease the pressure inside the tubing assembly to atmospheric and set the temperature of the environmental chamber to 75 °F. Condition the tubing assembly at this temperature for 1 hour.

(iv) Set the temperature of the environmental chamber to minus 40 °F and condition the tubing assembly for 24 hours.

(v) With the temperature maintained at minus 40 °F, increase the hydraulic pressure inside the tubing assembly at a constant rate to 450 psi within a period of 5 seconds, and hold this pressure for 5 minutes. Visually inspect the assembly for leakage or separation at the end fittings.

S12.26. *End fitting serviceability.*

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

(b) *Preparation.* Prepare a 12 inch length of plastic air brake 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, and 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 assembly to a pressure of 120 psi in a period of two seconds. If the end fitting leaks, measure and record the leakage rate using the mass air flow meter.

S12.27 *End fitting corrosion resistance.* Conduct the test specified in S6.9 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 75 °F.

S13.2 Unless otherwise indicated, the test samples are stabilized at test room temperature prior to testing.

S13.3 The brake hoses and brake hose assemblies are at least 24 hours old, and unused.

S13.4. Specified test pressures are gauge pressures (psig).

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