# UL 569

## STANDARD FOR SAFETY

# Pigtails and Flexible Hose Connectors for LP-Gas

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UL Standard for Safety for Pigtails and Flexible Hose Connectors for LP-Gas, UL 569

Eighth Edition, Dated November 19, 2013

***Summary of Topics***

***These revisions to ANSI/UL 569 include the following:***

***1. Revision to the moist ammonia-air stress cracking test***

The revised requirements are substantially in accordance with Proposal(s) on this subject dated May 19, 2017.

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# UL 569

## Standard for Pigtails and Flexible Hose Connectors for LP-Gas

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

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## INTRODUCTION

### 1 Scope

1.1 These requirements cover pigtails and flexible hose connectors used in the assembly of fuel-supply systems other than those outlined in 1.3(b) and (c), intended for liquefied petroleum gas (LP-Gas). Low or high pressure flexible hose connectors are also suitable for low pressure (1.0 psig (6.9 kPa) or less) natural gas service. LP-Gas systems use either Department of Transportation (DOT) cylinders or ASME tanks and are intended to be installed in accordance with the Liquified Petroleum Gas Code, NFPA/ANSI 58. Low pressure flexible hose connectors used in natural gas systems are intended to be installed in accordance with the National Fuel Gas Code, NFPA 54/ANSI Z223.1. Pigtails and flexible hose connectors are used to make connection between parts of equipment or between equipment and service piping.

1.2 These requirements also cover hose without end-connection fittings that is used to manufacture flexible hose connectors.

1.3 This Standard does not apply to:

a) Gas appliance connectors for handling fuel gases at 5 psig (34.5 kPa) or less which are investigated under the Standard for Metal Connectors for Gas Appliances, ANSI Z21.24.

b) Flexible hose connectors for engine fuel applications which are investigated under the Outline of Investigation, LP-Gas Fuel Hose and Hose Assemblies for Vehicle Engines, UL 1785.

c) Flexible hose connectors for use in confined areas.

d) Hose connectors which are investigated under the Standard for Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances, ANSI Z21.54.

### 2 General

#### 2.1 Units of measurement

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

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## 2.2 Components

2.2.1 Except as indicated in 2.2.2, a component of a product covered by this standard shall comply with the requirements for that component.

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

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

b) Is superseded by a requirement in this standard.

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

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

## 2.3 Undated references

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

# CONSTRUCTION

## 3 General

3.1 The diameter and length of a pigtail or a flexible hose connector shall be not greater than those specified in 4.1 and 5.1.

3.2 After fabrication of a pigtail, the tubing used in its construction shall be round and without indentations or other imperfections. The passage through the connector shall not be restricted by solder, brazing material, or flux.

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## 4 Flexible Hose Connector

4.1 As used in these requirements, a flexible hose connector is reinforced synthetic-rubber hose that has an inside diameter of 3/16 to 2 inches (4.8 to 50.8 mm) and a length not exceeding 60 inches (1.5 m) and is provided with a connecting fitting on each end. This connector is fabricated in two constructions:

a) Low-pressure type for handling LP-Gas in the gaseous phase at pressures not greater than 1 psig (0.007 MPa), and

b) High-pressure type for handling LP-Gas in the gaseous or liquid phase and having a working pressure of not less than 350 psig (2.4 MPa).

4.2 As used in these requirements, flexible hose connectors covered by this standard are intended for use at temperatures within the range of minus 40 to plus 140°F (minus 40 to plus 60°C).

## 5 Pigtail

5.1 A pigtail is seamless metal tubing that has an outside diameter of 3/16 to 3/8 inch (4.8 to 9.5 mm), a length not exceeding 60 inches (1.5 m), and is provided with a connecting fitting on each end. Pigtails shall have a maximum allowable working pressure not less than 250 psig (1.7 MPa).

## 6 Materials for Pigtails

6.1 Metallic tubing used in the construction of a pigtail shall be of material having characteristics comparable to those of soft-annealed copper tubing.

6.2 Copper tubing used in the construction of a pigtail shall have a wall thickness not less than that specified in Table 6.1.

**Table 6.1**
**Wall thickness of copper tubing**

| Outside diameter of tubing, inch (mm) | | Minimum wall thickness of tubing, inch (mm) | |
|---|---|---|---|
| 3/16 | (4.8) | 0.038 | (0.97) |
| 1/4–3/8 | (6.4–9.5) | 0.045 | (1.14) |

6.3 Aluminum shall not be used in combination with copper or a copper alloy.

6.4 Solder or brazing material used for attachment of end fittings shall have a melting point (solidus temperature) not less than 1000°F (538°C).

6.5 A part made of drawn-brass or machined from brass rod, containing more than 15 percent zinc shall withstand, without cracking, the Moist Ammonia-Air Stress Cracking Test, Section 23.

6.6 End-connecting fittings shall be of corrosion resistant metal or of steel provided with a protective coating having corrosion-resistant qualities at least equivalent to those of the coatings specified in 6.7.

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6.7 Cadmium plating shall be not less than 0.0003 inch (0.008 mm) thick, and zinc plating shall be not less than 0.0005 inch (0.013 mm) thick. However, on parts where threads constitute the major portion of the area, the cadmium or zinc plating shall be not less than 0.00015 inch (0.0038 mm) thick.

## 7 Materials for Flexible Hose Connectors

7.1 The hose used in the construction of a flexible hose connector shall be provided with a reinforced synthetic-rubber inner tube or liner of the oil-resistant type. A rubber cover is not required if the outer braid is impregnated with a rubber cement or compound. A tube or a cover shall be smooth, of uniform thickness, free from pitting, blisters, or other imperfections. Intentional pricking of a cover shall not be considered an imperfection. This requirement does not exclude the use of a corrugated cover.

7.2 Aluminum shall not be used in combination with copper or a copper alloy.

7.3 A part made of drawn-brass or machined from brass rod, containing more than 15 percent zinc shall withstand, without cracking, the Moist Ammonia-Air Stress Cracking Test, Section 23.

7.4 End-connecting fittings shall be of corrosion resistant metal or of steel provided with a protective coating having corrosion-resistant qualities at least equivalent to those of the coatings specified in 7.5.

7.5 Cadmium plating shall be not less than 0.0003 inch (0.008 mm) thick, and zinc plating shall be not less than 0.0005 inch (0.013 mm) thick. However, on parts where threads constitute the major portion of the area, the cadmium or zinc plating shall be not less than 0.00015 inch (0.0038 mm) thick.

## 8 End Connecting Fittings

8.1 Each end of a connector shall be provided with a connecting fitting consistent with the service for which the connector is designed.

8.2 A standard LP-Gas cylinder valve connecting fitting shall comply with the Standard for Compressed-Gas Cylinder Valve Outlet and Inlet Connections, ANSI/CGA V-1-1987.

8.3 A compression-type tubing fitting shall not be used when it utilizes a slip-on ring or sleeve or a fitting requiring the use of a gasket to obtain a gas-tight joint.

*Exception: This requirement is not applicable when a gas-tight joint can be obtained without the use of seal material, as in the case of a gasket or an O-ring used as a secondary seal.*

8.4 Pipe threads shall be in accordance with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1-1983(R92).

8.5 A hose connector or pigtail shall not be constructed with end fittings that would permit the connection of an appliance with a female CGA 600 connection to a LP-Gas cylinder larger than 2 1/2 lb. (1 kg) water capacity.

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## 9 Inside Diameter for Flexible Hose Connectors

9.1 The internal diameter of a hose shall be equal to the nominal diameter ±1/32 inch (0.8 mm) for sizes up to and including 3/4 inch (19.1 mm), and ±1/16 inch (1.6 mm) for larger sizes.

9.2 A tapered plug gauge of wood or metal having a taper of 3/8 in per foot (31.3 mm/m) marked to indicate variation of 1/64 in (0.4 mm) in diameter, a set of wood or metal plug gauges, straight or ball type, in increments of no greater than 0.01 in (0.3 mm) for hoses of nominal size 1 in (25 mm) and less, and in increments no greater than 0.02 in (0.5 mm) for hose of nominal size greater than 1 in (25 mm), or in some cases (see 8.3), an expanding ball gauge and micrometer or other equivalent means to accurately measure the expanded ball, is to be used.

9.3 The end of the hose is to be cut square. When a tapered plug gauge is used, the plug gauge is to be inserted in the hose sample until a close fit is obtained without forcing. The diameter of the gauge at the end of the sample, to the nearest 1/64 inch (0.4 mm), is to be recorded as the internal diameter of the hose. When a set of straight or ball-type plug gauges is used, the diameter of the gauge, which when inserted in the hose sample gives a close fit without forcing, is to be recorded as the internal diameter of the hose. When the end of a wire-braided hose is constricted or flared, the inside diameter is to be measured far enough from the end to be representative of the inside diameter by means of an expanding ball gauge.

## 10 Thickness of Flexible Hose Tube or Cover

10.1 The thickness of the inner tube, and of the cover, when one is used, shall not be less than 0.047 inch (1.19 mm) when determined as described in 10.2 – 10.6.

10.2 A power-driven buffing machine (grinding wheel) or skiving machine outlined in the Practice for Rubber Preparation of Pieces for Test Purposes from Products, ASTM D3183-84, is to be used for buffing off irregularities on specimens. The abrasive wheel of a buffing machine is to be No. 30 – 36 grit; and its diameter and rotary velocity are to be such that the wheel will have a peripheral speed of 4000 ±700 feet per minute (20 ±3.6 m/s). The machine is to be provided with a slow feed to avoid overheating of the specimen.

10.3 A dial micrometer that is graduated to 0.001 inch (0.025 mm) and exerts a load of 80 – 85 grams by means of a weight is to be used. The load is to be applied through a flat contact foot 0.25 ±0.01 inch (6.35 ±0.25 mm) in diameter.

10.4 One piece, 6 – 8 inches in length, taken from the sample selected for physical and detail tests, is to be used in determining the thickness of the lining and cover as specified in 10.5 and 10.6.

10.5 A strip, 6-8 inches (150-200 mm) in length and 1 inch (25.4 mm) in width, or as close to a 1 inch width as possible from small diameter hose, is to be cut from the hose, and the rubber part separated from the plies. When the thickness of the part is not uniform around the circumference of the hose, the strip is to be cut from the thinnest portion of the sample.

10.6 The strip specimen is to be buffed or skived to remove the impressions left by the fabric or braid or other surface irregularities using the buffing or skiving machine described in 10.2. Five thickness measurements are to be taken within the area from which the impressions have been removed, and the maximum reading obtained is to be considered as the thickness of the rubber part.

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## PERFORMANCE

### 11 General

11.1 The number of samples of each type of connector required for tests and the length of the samples are specified in Table 11.1.

**Table 11.1**
**Test samples required**

| | Pigtail | Flexible hose connector | Recommended length of samples, inches (mm) | Remarks |
|---|---|---|---|---|
| Aerostatic Leakage Test | 3 | 3 | 36 (914) | With end fittings |
| Hydrostatic Strength Test | – | – | – | Use above sample |
| Pull Test | 3 | 3 | 12 (305) | With end fittings |
| Bending Test – Tubing | 1 | – | 18–24 (457–610) | Without end fittings |
| Bending Test – Hose | – | 1 | | With end fittings |
| a) Up to 1″ b) 1″ - 2″ | | | 30–40 (762–1016)<br>40–50 (1016–1270) | |
| Low Temperature Test | – | 1 | | Without end fittings |
| a) Up to 1″ b) 1″ - 2″ | | | 18–24 (457–609.6)<br>24–48 (609.6–1219) | |
| Flexible Connector Tests | – | a | b | Without end fittings |
| Moist Ammonia-Air Stress Cracking Test | – | – | – | End fittings, three each, with appropriate companion fittings |

[a] One 30 foot length, or equivalent, of the flexible connector hose, in the largest diameter, will provide material sufficient for all samples required for these tests.
[b] See individual test description.

11.2 For the Aerostatic Leakage Test, Section 12, a source of aerostatic pressure such as air or nitrogen is to be used. For the Hydrostatic Strength Test, Section 13, water or other liquids of comparable or lighter viscosity is to be used.

### 12 Aerostatic Leakage Test

12.1 A connector with end fittings that are factory assembled and tightened as intended shall not show evidence of leakage when subjected for 5 minutes to an aerostatic pressure of twice the intended working pressure but not less than 50 psig (0.34 MPa).

12.2 Each of three test samples is to be connected to a source of aerostatic pressure, and the free end is to be closed by the intended companion fitting. A positive shutoff valve and a pressure gauge having a pressure range of not less than 1-1/2 nor more than two times the test pressure are to be installed in the pressure supply piping. The pressure gauge is to be installed in the piping between the shutoff valve and the connector being tested.

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12.3 Each sample is to be immersed in water while lying straight as aerostatic pressure is being applied slowly and in a uniform manner.

## 13 Hydrostatic Strength Test

13.1 A connector, with end fittings that are factory assembled and tightened as intended, shall not rupture when subjected to a hydrostatic pressure of five times the intended working pressure but not less than 500 psig (3.4 MPa).

13.2 The three connectors previously subjected to the aerostatic leakage test are to be used. Each sample is to be connected to a source of hydrostatic pressure. A positive shutoff valve and a pressure gauge having a pressure range of not less than 1-1/2 nor more than two times the test pressure are to be installed in the pressure supply piping. The pressure gauge is to be installed in the piping between the shutoff valve and the connector being tested.

13.3 One end of the sample is to be connected to a source of water pressure, and the fitting at the other end is to be left open while filling each sample with the test liquid to allow air to escape. After all air has been expelled, the fitting is to be capped, and the pressure in the sample is to be increased at a uniform rate of approximately 1000 psig (6900 kPa) per minute until the required test pressure has been reached. Pressure is to be released immediately upon reaching the required test pressure.

## 14 Pull Force Test

14.1 A connector shall withstand the longitudinal pull force specified in Table 14.1.

**Table 14.1**
**Minimum pull force**

| Connector | Tubing OD, hose ID, inch (mm) | Minimum pull force, pounds (N) |
|---|---|---|
| Pigtail | 3/16 (4.8) | 375 (1650) |
| | 1/4 (6.4) | 500 (2200) |
| | 5/16 (7.9) | 625 (2750) |
| | 3/8 (9.5) | 750 (3300) |
| Flexible Hose Connector | | |
| (Low-Pressure Type) | 3/16 to 5/8 (4.8 to 15.9) | 200 (880) |
| | 11/16 to 2 (17.5 to 50.8) | 300 (1320) |
| (High-Pressure Type) | 3/16 to 5/8 (4.8 to 15.9) | 400 (1760) |
| | 11/16 to 2 (17.5 to 50.8) | 750 (3300) |

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14.2 Three samples of the connector are to be subjected to this test. The connecting fitting on each end of the sample is to be assembled with a corresponding companion part and tightened. Next, the connector is to be placed in a tensile testing machine and connected so that both end fittings, fitting joints, and the tubing or hose of the connector are subjected to the pull force. With the testing machine adjusted for a rate of travel of 1/2 inch per minute (0.21 mm per second), the pull force is to be applied until breaking, cracking, or splitting occurs or until the minimum pull force has been attained.

## 15 Bending Test – Metallic Tubing

15.1 Metallic tubing used in the construction of a pigtail shall withstand the test specified in 15.2 – 15.4 without evidence of cracking, splitting, or leakage.

15.2 Both ends of the specimen of metallic tubing are to be cut square and flanged with a 45 degree flaring tool. The flanged portion is to be examined for evidence of cracking or splitting.

15.3 A copper pigtail is to be held by the end fittings and bent 180 degrees around a mandrel having a 4 inch diameter to form a ″U″ and then straightened on a flat work surface. The bending and straightening shall be performed a total of 5 times, except that after the fifth bending the tubing shall remain in the ″U″ shape. The outside surface of the test specimen shall then be examined for evidence of cracking or splitting.

15.4 After the test of 15.3, the copper pigtail shall comply with the Aerostatic Leak Test in Section 12.

## 16 Bending Test – Hose

16.1 A flexible hose connector shall withstand 25,000 continuous cycles of 180-degree bends around a radius of four times the internal diameter of the hose without breakdown of the hose and shall, following the repeated bending, withstand the Aerostatic Leakage Test, Section 12.

16.2 A sample connector that has complied with the requirements of the Aerostatic Leakage Test, Section 11, is to be used in this test.

16.3 Apparatus for this test is to consist of a machine that provides a reciprocating motion over a distance of not less than 12 inches (305 mm). One end of the connector is to be attached to the reciprocating rod or shaft of the machine. From this connection the hose is to be wrapped 180 degrees around a free-running pulley having a pitch radius of four times the inside diameter of the hose. The pitch radius of the pulley is to be on the line of the reciprocating motion.

16.4 The opposite end of the connector is to be attached to a length of flexible cable provided with a weight of 10 pounds (4.5 kg) or more, up to 25 pounds (11.4-kg) as necessary to maintain the hose in contact with the pulley. When the reciprocating motion is horizontal, the cable is to pass over a guide pulley to provide for 180-degree contact of the hose with the pulley used for bending. When the midpoint of the sample hose is on the pulley, the two ends of the hose are to be equidistant from the pulley.

16.5 The reciprocating apparatus is to be adjusted so that the connector is moved alternately over a lineal distance of 12 inches (305 mm). A complete reciprocating cycle is to be recorded as two hose-bending operations. The reciprocating machine is to be adjusted to give 10 to 20 hose-bending operations per minute. If it is necessary to cease the bending operation for a period of time, the weight shall be removed from the hose and placed back in position when bending is to resume.

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## 17 Low Temperature Test

17.1 A flexible hose connector shall not show cracking or other evidence of physical damage when maintained at a temperature of minus 40 ±2°C (minus 40 ±3.6°F) for 24 hours and then bent around a steel mandrel having a diameter of ten times the nominal inside diameter of the hose while at minus 40°C.

17.2 A length of hose of each diameter under investigation is to be subjected to this test. See Table 11.1. The hose samples and the mandrel are to be placed in the cold chamber and allowed to remain for 24 hours. While still in the cold chamber, each length of hose is to be bent around the mandrel in a movement taking 8 to 12 seconds to complete. Test personnel are to wear gloves while handling the hose and the mandrel to reduce the likelihood of heat transfer to the sample. The hose sample is then to be examined for evidence of cracking or other physical damage.

## 18 Tensile Strength and Elongation Tests of Rubber Tube and Cover

### 18.1 General

18.1.1 Rubber tubes and covers for flexible hose connectors shall have the properties specified in 18.2.1, when tested before aging in accordance with the requirements of 18.2.2 – 18.2.11, and the properties specified in 18.3.1, when tested after aging in accordance with the requirements of 18.3.2 and 18.4.1.

### 18.2 Before accelerated air-oven aging

18.2.1 After being exposed to room ambient for at least 30 minutes, samples of tubes and covers shall have the following properties when tested as specified in 18.2.2 – 18.2.11:

a) Minimum tensile strength – 1000 psi (6.9 MPa) for both tubes and covers and

b) Minimum ultimate elongation – 150 percent for tubes and 250 percent for covers.

18.2.2 Prior to being cut with a die, samples are to be buffed or skived by the equipment specified in 10.2.

18.2.3 The specimens are to be cut using Die C or Die D dumbbell-type, as described in the Tests for Rubber Properties in Tension, ASTM D412-92, and as permitted by sample size and shape. The enlarged ends are to be 1 inch (25.4 mm) wide, when possible. The constricted portion is to be 0.125 inch (3.2 mm) wide and 1.3 inches (33 mm) long (Die D), when cut from hose of 1/4 inch (6.4 mm) diameter or smaller. The constricted portion is to be 1/4 inch wide and 1.3 inches long (Die C), when cut from sizes of hose greater than 1/4 inch.

18.2.4 The specimens are to be cut longitudinally from the sample. Wetting the cutting edges of the die with water is a way to facilitate the cutting operation. The rubber is to rest on a smooth and slightly yielding surface that will not injure the cutting edges of the die such as a piece of belting or light cardboard.

18.2.5 The constricted portion of the specimen is to be buffed or skived to remove fabric impressions or other surface irregularities.

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18.2.6 Three measurements of thickness are to be made with a dial micrometer, in the constricted portion of the specimen. The smallest value obtained is to be used as the thickness of the specimen in calculating the tensile strength.

18.2.7 Two bench marks, 1 inch (25.4 mm) apart, are to be stamped centrally on the constricted portion of each specimen.

18.2.8 Tensile strength and elongation tests are to be made on a power-operated machine as described in the Tests for Rubber Properties in Tension, ASTM D412-92.

18.2.9 The rate of travel of the power-actuated grip is to be 20 ±1 inch per minute (51 ±2.5 cm/min).

18.2.10 The elongation is to be measured by means of a scale or other device, to be used so that it does not touch the specimen and is capable of indicating the elongation with an accuracy of 0.1 inch (2.54 mm).

18.2.11 When a dumbbell-type test specimen breaks outside the bench marks, when a straight specimen breaks at the jaws, or when the result of either the tensile strength or elongation testing is below the requirements, an additional specimen is to be tested, the results of which are to be considered final. Results of tests of dumbbell-type specimen that break in the curved portion just outside the bench marks and of straight specimens that break at the jaws may be acceptable when within the minimum requirements.

### 18.3 After accelerated air-oven aging test

18.3.1 The tensile strength and ultimate elongation of specimens of a rubber tube and a cover that have been heated in air at a temperature of 100 ±2°C (212 ±3.6°F) for 70 ±1/2 hours shall be not less than 80 percent of the tensile strength and 50 percent of the elongation of specimens that have not been heated in air.

18.3.2 The apparatus outlined in the Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method, ASTM D573-88 is to be used for this test.

### 18.4 Method

18.4.1 Three tube and three rubber cover specimens are to be prepared in the same manner as specified in 18.2.2 – 18.4.1 before placing the specimens in the oven. However, in this case the bench marks are to be stamped on the specimens after aging. The exposure is to be conducted in accordance with the test procedures outlined in the Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method, ASTM D573-88. For comparative purposes, three tube and three rubber cover specimens that have not been exposed to air-oven aging are to be subjected to physical tests at the same time that the exposed specimens are tested.

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## 19 Adhesion Test

### 19.1 General

19.1.1 For 3/8-inch (9.5 mm) size hose and smaller, the adhesion between the cover and the reinforcement, between the tube and the fabric reinforcements, and between the plies of fabric reinforcement shall be such that the rate of separation of a ring-shaped specimen, 1 inch (25.4 mm) in width, is not greater than 1 inch per minute (0.42 mm/s) with a weight of 8 pounds (3.6 kg) for the adhesion determinations between the cover and the reinforcements and between the tube and reinforcement and with a weight of 10 pounds (4.5 kg) for the adhesion determination between the plies of reinforcement.

19.1.2 For sizes of hose greater than 3/8 inch (9.5 mm), the adhesion between the cover and the reinforcement, between the tube and the fabric reinforcement, and between the plies of fabric reinforcement shall be such that the rate of separation of a ring-shaped specimen, 1 inch (25.4 mm) in width, is not greater than 1 inch per minute (0.42 mm/s) with a weight of 10 pounds (4.5 kg).

19.1.3 The adhesion between wire reinforcements and between the tube and a wire reinforcement shall be such that adjacent reinforcements, and the tube and the wire reinforcement, adhere firmly to each other by means of a compound impregnated in the reinforcements.

19.1.4 The above adhesion requirement is not intended for light fabric braids imbedded in or vulcanized to the rubber cover or tube for the primary purpose of improving the adhesion between the cover or tube and reinforcement.

### 19.2 Apparatus

19.2.1 Adhesion tests are to be conducted with the type of apparatus described for the Static Mass Method in ASTM D413–82(1993), Test Method Rubber Property–Adhesion to Flexible Substrate.

### 19.3 Method

19.3.1 The tests are to be conducted in accordance with the test methods outlined in ASTM D380–87, Method of Testing Rubber Hose. Adhesion tests are to be conducted on only the cover of wire-reinforced hose. A hack saw with a sharp, fine (24 teeth/inch) blade has been found acceptable for hose having a wire braided reinforcement, but a band saw with a fine blade gives cleaner edges and is preferable for preparing the ring specimens. The adhesion is to be taken as the rate obtained by dividing the total distance separated in inches (mm), to the nearest 1/32 inch (0.8 mm), by the elapsed time in minutes.

19.3.2 When the adhesion of the reinforcement to the tube or cover is such that the parts cannot be separated sufficiently to permit attachment of the clamp, the adhesion is considered to be in compliance with the requirements.

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## 20 Permeation Test

### 20.1 General

20.1.1 When subjected to the permeation test specified in 20.3.1, a high pressure hose shall not exceed a permeation rate of 561 cubic centimeters per meter per hour (171 $cm^3$/ft/hr).

### 20.2 Apparatus

20.2.1 The apparatus for conducting this test shall comply with the requirements outlined in ASTM D3902-90, Method Testing Rubber Hose for the Diffusion of Liquified Petroleum Gas.

### 20.3 Method

20.3.1 A 0.5 meter (1.6 ft) coupled length of hose is to be tested in accordance with the procedure outlined in ASTM D3902-90. The hose is to be tested with LP-Gas in the liquid phase.

## 21 Ozone Exposure Test

21.1 The rubber cover or impregnated outer braid of a flexible hose connector shall show no visible signs of cracking when stressed and then exposed for 70 hours to an atmosphere containing 100 parts per hundred million (pphm) of ozone at a temperature of 40°C (104°F).

21.2 The ozone test chamber for this test is to comply with the requirements outlined in the Method of Test for Accelerated Ozone Cracking of Vulcanized Rubber, ASTM D1149-91. The specimen holder is to comply with the requirements outlined in Procedure B of the Method of Test for Resistance to Surface Cracking of Stretch Rubber Compounds, ASTM D518-86(1991).

21.3 Three specimens, 3-3/4 inches (95.3 mm) long and 1 inch (25.4 mm) wide, are to be cut longitudinally from the rubber cover or impregnated outer braid of the hose sample and mounted in the specimen holder in a looped position, in accordance with the procedures outlined in the Method of Test for Accelerated Ozone Cracking of Vulcanized Rubber, ASTM D518-86(1991), Procedure B. The mounted specimens are to be allowed to remain in an ozone free atmosphere for 24 hours. They are then to be placed in the ozone test chamber, which is to be regulated to produce an ozone concentration of 100 pphm and a constant temperature of 40°C (104°F). The mounted specimens are to remain in the ozone test chamber for 70 hours. After the test exposure, the specimens are to be removed from the test chamber and examined for evidence of cracking with a hand magnifying glass of seven power magnification.

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