UL 51

STANDARD FOR SAFETY

Power-Operated Pumps and Bypass Valves for Anhydrous Ammonia, LP-Gas, and Propylene

UL Standard for Safety for Power-Operated Pumps and Bypass Valves for Anhydrous Ammonia, LP-Gas, and Propylene, UL 51

Eleventh Edition, Dated May 15, 2023

Summary of Topics

This Eleventh Edition of ANSI/UL 51 dated May 15, 2023 is being issued to update, correct, and clarify requirements.

The requirements are substantially in accordance with Proposal(s) on this subject dated October 7, 2022 and March 17, 2023.

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Standard for Power-Operated Pumps and Bypass Valves for Anhydrous Ammonia, LP-Gas, and Propylene

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

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INTRODUCTION

1 Scope

1.1 These requirements cover power-operated pumps and bypass valves for use in liquid transfer operations in non-refrigerated systems in installations for:

a) Anhydrous ammonia systems installed in accordance with the Safety Requirements for the Storage and Handling of Anhydrous Ammonia, CGA/GAS G-2.1 (ANSI K61.1);

b) Liquefied petroleum gas (LP-Gas) systems installed in accordance with the Liquefied Petroleum Gas Code, NFPA No. 58; and

c) Propylene systems.

1.2 These requirements do not cover:

a) Pumps or compressors intended for handling anhydrous ammonia or LP-Gas or propylene in the gaseous phase and

b) Pumps, compressors or bypass valves for anhydrous ammonia, LP-Gas, or propylene for use in chemical, petro-chemical, petroleum, or utility power plants; nor pipeline or marine terminals; nor related storage facilities at such plants or terminals.

1.3 Equipment covered by these requirements is for use with LP-Gas, propylene, or anhydrous ammonia as covered by the Standards and Codes in 1.1 and shall have a minimum service pressure rating in accordance with Table 1.1.

Exception: A pump without an integral bypass valve with a higher differential pressure obtained in the Differential Pressure Test, Section 20, is permitted to have a lower minimum service pressure rating if it is marked in accordance with 26.2.

Table 1.1
Minimum Service Pressure for Rating Pumps and Bypass Valves

Maximum differential pressure produced when subjected to the Differential Pressure Test, Section 20 psig (kPa)	Anhydrous ammonia and LP-Gas equipment minimum service pressure rating psig (kPa)	Propylene equipment minimum service pressure rating psig (kPa)
≤ 100 (689) Propylene equipment only	Not applicable	350 (2415)
≤ 125 (862)	350 (2415)	375 (2585)
>125 (863) ≤ 150 (1034)	375 (2586)	400 (2758)
>150 (1034) ≤ 200 (1379)	400 (2758)	425 (2930)
≥ 200 (1379)	200 + differential pressure produced (1379 + differential pressure produced)	225 + differential pressure produced (1551 + differential pressure produced)

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex A for a list of standards covering components generally used in the products covered by this standard.

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.

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

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.

2.5 Electrical components, including motors and wiring, when incorporated by a manufacturer in the assembly of a pump for LP-Gas or propylene, and the means provided in the pump assembly for electrical connections, shall comply with the requirements for equipment for use in hazardous locations, Class I, Group D, in the National Electrical Code, NFPA 70, Articles 500 and 501.

2.6 Electrical components, including motors and wiring and connections shall comply with the requirements for equipment for use in hazardous locations, Class I, Group D, in the National Electrical Code, NFPA 70, Articles 500 and 501.

Exception: When incorporated by a manufacturer in the assembly of a pump for anhydrous ammonia, the above described electrical components need only to comply with the requirements for ordinary (nonhazardous) locations or for outdoor use locations, if the assembly is appropriately marked to designate the limitations in location and use involved with the electrical features.

3 Units of Measurement

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

4 Undated References

4.1 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.

5 Glossary

5.1 For the purpose of this standard the following definitions apply.

5.2 BYPASS VALVE – A valve used on the discharge side of a pump which opens automatically at a predetermined differential pressure so as to direct part or all of the pump discharge back to the supply tank. It is either provided as part of a pump assembly (integral bypass valve), or it is a separate valve which is piped into the pump discharge system at the time of installation.

5.3 BYPASS VALVE WITH VARIABLE FLOW CONTROL – A bypass valve incorporating an integral flow control valve section operated by a handle or lever, designed to allow controlled increase of return flow through the bypass valve.

5.4 LIQUEFIED PETROLEUM GAS (LP-GAS OR LPG) – Any material having a vapor pressure not exceeding that allowed for commercial propane, as defined in Standard Specification for Liquefied Petroleum (LP) Gases, ASTM D1835, that is composed predominantly of the following hydrocarbons, either by themselves (excluding propylene) or as mixtures: propane, propylene, butane (normal butane or isobutane) and butylenes.

5.5 RELIEF VALVE – A recirculating valve which opens at a predetermined differential pressure to direct the pump discharge back to the intake side of the pump. When provided, it is included as part of the pump assembly.

CONSTRUCTION

6 Assembly

6.1 The construction of a pump or bypass valve shall be such that parts are capable of being assembled in the required manner after being dismantled to the extent needed for replacement of parts or for other care or servicing.

6.2 Screws or bolts used to attach parts which are detached for care or servicing of the pump or bypass valve shall be capable of holding upon the application of the torques indicated in Table 6.1 after removal and replacement.

Table 6.1
Maximum Torque Requirements for Screws or Bolts

American standard screw					I.S.O. screw		
Screw size,			Torque,		Screw size,	Torque,	
No.	inch	(mm)	lb-in	(N·m)	mm	N·m	(lb-in)
–	–	(–)	–	(–)	4	1.6	(14)
8	–	(4.2)	18	(2.0)	4.5	2.6	(23)
10	–	(4.8)	30	(3.4)	5	4.2	(37)
–	1/4	(6.4)	100	(11.3)	6	8.7	(77)
–	–	(–)	–	(–)	7	15.0	(133)
–	5/16	(7.9)	200	(22.6)	8	23.5	(208)
–	–	(–)	–	(–)	9	33.6	(297)
–	3/8	(9.5)	350	(39.6)	10	45.2	(400)
–	7/16	(11.1)	575	(65.0)	12	81.0	(715)
–	1/2	(12.7)	850	(96.0)	14	128.0	(1130)
–	9/16	(14.3)	1200	(136.0)	–	–	(–)
–	5/8	(15.9)	1600	(181.0)	16	185.0	(1640)

6.3 When a base is furnished as part of a pump assembly, it shall be arranged to permit intended attachment and alignment of mounted parts and for anchoring to a mounting surface by cap screws or bolts.

7 Materials

7.1 A metal part used for bodies or closures shall be inherently resistant to the action of the liquid to be handled. Other parts in contact with the liquid to be handled shall be resistant to the action of such liquid.

7.2 The common metals are not attacked by dry ammonia. Zinc, copper, and copper base alloys, such as brass, are subject to rapid destructive action by ammonia in the presence of water and shall not be used.

7.3 A material used to prevent external leakage, except a seal ring or a gasket, shall have a melting point (solidus temperature) of not less than 940 °C (1724 °F).

7.4 Bodies or closures in contact with the liquid to be handled shall be of material specified in Table 7.1, or what is determined to be the equivalent.

Table 7.1
Materials for Enclosures

Material type	Criteria for determining compliance
Steel	–
Ductile (modular) iron	ASTM A395[a] or A536[b], Grade 60-40-18 or 65-45-12
Malleable iron	ASTM A47/A47M[c]
High strength gray iron	ASTM A48/A48M [d], Class 40B; or ASTM A126[e], Class B or C
Brass or bronze (for use with LP-gas or propylene only)	–

[a] ASTM A395, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

[b] ASTM A536, Standard Specification for Ductile Iron Castings.

[c] ASTM A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.

[d] ASTM A48/A48M, Standard Specification for Gray Iron Castings.

[e] ASTM A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

7.5 A brazing material used in joining liquid-confining parts of a pump or bypass valve for LP-Gas or propylene shall have a melting point (solidus temperature) of not less than 940 °C (1724 °F). Brazing shall not be used on a pump or bypass valve for anhydrous ammonia. See 7.2.

7.6 A body casting of a pump or bypass valve shall be free from porosity leakage, and shall have a wall thickness of not less than that specified in Table 7.2.

Table 7.2
Wall Thickness of Body Castings

Material type	Minimum wall thickness,	
	inch	(mm)
High-strength gray iron	1/4	(6.4)
Malleable iron, ductile iron, or cast steel	3/16	(4.8)
Brass or bronze (for use with LP-Gas or propylene only)	3/16	(4.8)

7.7 When atmospheric corrosion of a part, other than the body, interferes with the required function of a pump, the part shall be of corrosion-resistant material or be provided with a corrosion-resistant protective coating.

7.8 A protective coating shall provide resistance against corrosion to a degree not less than that provided by the protective coatings specified in 7.9 or shall be subjected to the Comparative Corrosion Tests, Section 24.

7.9 Cadmium and nickel plating shall have a thickness of not less than 0.0003 inch (0.008 mm) and zinc plating shall have a thickness of not less than 0.0005 inch (0.013 mm), except on parts where threads constitute the major portion of the area, in which case the thickness of the cadmium or zinc plating shall be not less than 0.00015 inch (0.0038 mm). See 7.2.

7.10 When warping of a casting can affect the tightness of liquid-confining joints, or the necessary fit of parts, the casting shall be stress relieved to reduce to a minimum the possibility of warping.

7.11 A part used to prevent external leakage that is made from a brass material containing more than 15 % zinc shall be subjected to Moist Ammonia Air Stress Cracking Test, Section 22.

8 Bodies, Covers, and Heads

8.1 A pump body assembly or bypass valve body shall comply with the requirements specified in the Deformation Test, Section 16; the Leakage Test, Section 17; and the Hydrostatic Strength Test, Section 21.

8.2 Flanges of parts intended to be clamped together shall have sufficient strength to withstand the stresses imposed by tightening of the clamping bolts or cap screws.

8.3 Plugs and other parts, other than cap screws and bolts threaded into noncorrosion-resistant ferrous parts of the pump or bypass valve, shall be of corrosion-resistant metal or be provided with a protective coating if their function is such that they are required to be removed for adjustment, repair, or other care of the pump or bypass valve.

8.4 A plug, cap, or other part threaded into or on the pump or bypass valve body shall engage with at least four full threads.

8.5 A bolt or a screw hole shall not extend through the outer walls of a pump or bypass valve body into a liquid-handling section.

9 Strainers

9.1 A strainer integral with or provided as part of a pump assembly shall conform to the requirements in 9.2 – 9.4 and the applicable requirements for the Standard for Strainers for Flammable Fluids and Anhydrous Ammonia, UL 331.

9.2 A strainer shall be constructed so that when the screen or filter element is removed for cleaning, all foreign matter (sediment or dirt) is removed without the probability of any of the foreign matter being deposited in the outlet side of the strainer.

9.3 A screen or filter element shall be capable of being removed, cleaned, and readily replaced.

9.4 A cap or cover of a strainer or filter shall be of the bolted type or determined to be of equivalent construction. Repeated removal and replacement of the cap or cover shall permit the joint to be made tight against leakage.

10 Springs

10.1 A spring shall be guided and arranged to minimize binding, buckling, or other interference with its free movement. If necessary, both ends of a spring shall be closed and squared.

11 Pumps and Bypass Valves Pressure Ratings

11.1 A bypass valve or pump shall have a service pressure rating not less than that shown in Table 1.1, in accordance with the differential pressure produced at specific flow capacity through the pump or valve when tested in accordance with the Differential Pressure Test, Section 20.

11.2 A bypass valve shall provide for connection of piping for returning the recirculated liquid back to the supply or storage tank.

11.3 After the bypass valve is adjusted as intended, it shall be locked or sealed to reduce the risk of tampering; or the adjusting means shall be such that the maximum adjustment obtainable will not permit a differential pressure in excess of the differential at specified flow capacity, and service pressure rating for the valve in accordance with Table 1.1.

11.4 The use of a lock nut on an adjusting screw or a threaded cap over the adjusting screw is judged to be in compliance with the locked or sealed requirement in 11.3.

11.5 A pump shall be marked in accordance with 26.2 when a bypass valve is not provided as part of a pump assembly and the pump is capable of developing a differential pressure in excess of 125 psi (860 kPa) [100 psi (689 kPa) for propylene service].

11.6 When a bypass valve for anhydrous ammonia or LP-Gas has a differential pressure rating in excess of 125 psi (860 kPa), it shall carry a caution tag as outlined by 26.6. When a bypass valve for propylene has a differential pressure rating in excess of 100 psi (689 kPa), it shall carry a caution tag as outlined by 26.6.

12 Relief Valves

12.1 A relief valve when provided shall be an integral part of a pump assembly to reduce the risk of physical damage by the development of excessive pressure under unintended installation conditions or during abnormal operation.

12.2 A relief valve provided as an integral part of a pump assembly shall be tagged to caution the installer or user that it shall not be used in lieu of a bypass valve.

13 Guards

13.1 A gear, belt, pulley, or other rotating part shall be enclosed in a metal guard to reduce the risk of unintentional contact, unless the construction of the part is such that the risk of injury to persons is of a negligible degree, or unless the pump assembly is furnished with an enclosure.

14 Pipe Connections

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

Exception: Pumps and bypass valves intended for use in installations where pipe fittings incorporate other than NPT type threads shall be permitted to be provided with pipe threads complying with a national pipe thread standard compatible with those fittings. The pipe thread type shall be identified in accordance with 26.5.

14.2 Flanges of flange-type pumps or bypass valves shall comply with the respective American National Standard for pipe flanges and flanged fittings covering the material from which they are made.

PERFORMANCE

15 General

15.1 A representative sample of each size and specific design of pump or bypass valve shall be subjected to the tests described in these requirements. Additional samples of parts constructed of nonmetallic materials are generally required for physical and chemical tests.

15.2 Water or other liquid shall be used in developing the required pressure in a leakage or hydrostatic pressure test. All hydrostatic pressures shall be maintained for at least 10 minutes.

15.3 The investigation of a pump or bypass valve shall be limited to the service conditions for which it is recommended, such as speed, maximum differential pressure at specific flow capacity, and liquid to be handled.

15.4 Pressure-measuring devices shall be calibrated over the range that they are used. The test pressure measured shall be not less than 20 % or more than 80 % of the full-scale reading of the device used.

Exception: The test pressure is allowed to be less than 20 % and more than 80 % of the full-scale reading of the measuring device, when calibration indicates that there is no loss of accuracy in the measured value.

16 Deformation Test

16.1 Joints in a pump or bypass valve shall not leak, nor shall there be evidence of damage resulting from the turning effort exerted on pipe-threaded sections when tested as described in 16.2 and 16.3.

16.2 The sample pump or bypass valve, as appropriate, used in this test shall be rigidly anchored or otherwise supported. A length of Schedule 80 pipe shall be connected to a female pipe-threaded section of the body portion, with the male threads having first been lubricated with SAE No. 10 machine oil. The pipe section shall then be tightened to the torque specified in Table 16.1.

16.3 After the torque force has been applied to each connected pipe, the pump or bypass valve, as appropriate, shall be subjected to the Leakage Test, Section 17. If leakage is noted at the threaded joint between the pipe and the body, the joint shall be remade using a pipe joint sealing compound and the sample retested for external leakage.

Table 16.1
Torque Requirements for Pipe Connections

Pipe size,	Outside diameter,		Torque,	
nominal inches	inches	(mm)	pound-inches	(N·m)
1/8	0.405	(10.29)	150	(17)
1/4	0.540	(13.72)	250	(28)
3/8	0.675	(17.15)	450	(51)
1/2	0.840	(21.34)	800	(90)
3/4	1.050	(26.67)	1000	(113)
1	1.315	(33.40)	1200	(137)
1-1/4	1.660	(42.16)	1450	(164)
1-1/2	1.900	(48.26)	1550	(175)
2	2.375	(60.33)	1650	(186)
2-1/2	2.875	(73.03)	1750	(198)
3	3.500	(88.90)	1800	(203)
4	4.500	(114.30)	1900	(215)

17 Leakage Test

17.1 Except as provided in 17.2, a pump (before being subjected to the Endurance Test, Section 18), or a bypass valve, shall be capable of withstanding, without leakage, an internal hydrostatic pressure of 1-1/2 times the minimum service pressure rating of the pump or bypass valve in accordance with 1.3.

17.2 When the construction of a pump or bypass valve is such that it is not capable of developing a differential pressure of 125 psi (860 kPa), or 100 psi (689 kPa) for propylene service, the test pressure specified in 17.1 shall be reduced by an amount equal to 1-1/2 times the difference between 125 psi (860 kPa), or 100 psi (689 kPa) for propylene service, and the maximum differential pressure developed.

17.3 During this test, all tapped openings on the body of the pump or bypass valve, as appropriate, shall be plugged. The test sample shall be connected to a source of hydrostatic supply under adequate pressure for the test. A positive shutoff valve and a pressure-measurement device that complies with 15.4, shall be installed in the supply piping. The pressure-measurement device shall be installed in the piping between the shutoff valve and the test sample. While the sample is under the applied test pressure, all joints and body casting surfaces shall be examined for evidence of leakage.

18 Endurance Test – Pump

18.1 A drive shaft seal shall not leak after the pump has been subjected to the endurance test described in 18.2 and 18.3.

18.2 This test shall be conducted on a pump sample previously subjected to the Deformation Test, Section 16, and the Leakage Test, Section 17. The test pump shall be connected to an electric motor of sufficient power rating to permit continuous operation of the pump for a total of 300 hours without causing the motor to overheat as follows:

a) 250 hours at pressure differential of 25 psig (170 kPa) and

b) 50 hours at the maximum pressure differential for which the pump is rated.

18.3 During this test, operating parts of a pump shall be kept "wet" by a continuous flow of a suitable test liquid. Other conditions of the test shall simulate, insofar as practicable, those of actual service.

18.4 A Leakage Test, Section 17, on the drive shaft seal shall be conducted immediately after completion of this endurance test.

19 Endurance Test – By-Pass Valve

19.1 A by-pass valve with a handle or lever shall be capable of complying with the applicable leakage test requirements of Section 17, after being subjected to 6,000 cycles of opening and closing the handle or lever. This test does not need to be performed on the poppet/spring arrangement of a bypass valve. There shall be no sticking of the valve, nor shall the valve become inoperative. Required corrosion protection shall not be impaired.

19.2 The samples used for this test shall have previously been subjected to the Deformation Test, Section 16 and the Leakage Test, Section 17.

19.3 A by-pass valve for use only with LP-Gas that has a pressure rating of 250 psi (1724 kPa) gauge or higher, or one for use with either LP-Gas or anhydrous ammonia, is to be tested with the valve outlet plugged, the valve body filled with n-hexane, and the valve inlet subjected to a pressure of 250 psi (1724 kPa) gauge. If the shutoff valve for LP-Gas service has a rating of 125 psig (860 kPa), the test is conducted with n-hexane and the valve inlet subjected to a pressure of 125 psi (860 kPa) gauge.

19.4 A by-pass valve for use only with anhydrous ammonia shall be tested without a liquid.

19.5 An endurance test shall be conducted at a rate no faster than 10 times per minute.

19.6 The Leakage Test, as described under Section 17, shall be conducted immediately following the Endurance Test.

20 Differential Pressure Test

20.1 This test shall be conducted on a representative sample of each size pump or bypass valve. The test procedure for a pump only, or a pump with integral relief or bypass valve is described in 20.2 and 20.3. The test procedure for a separate bypass valve is described in 20.2 and 20.4. One of the following results shall be obtained:

a) For a pump only, or a pump with integral relief valve:

1) The differential pressure shall not exceed 125 psig (860 kPa) [100 psig (689 kPa) for propylene]; or

2) The pump shall be marked as required by 26.2.

b) For a separate bypass valve, the measured flow capacity shall be equal to or greater than the manufacturer's rated flow capacity for the minimum service pressure and differential pressure rating in accordance with 1.3.

c) For a pump with bypass valve, the differential pressure at specified flow rate shall not exceed the limit for the minimum service pressure of the pump for which it is rated in accordance with 1.3.

20.2 This test shall be conducted with each sample installed in a piping circuit that includes a supply of liquid, pressure gauges, shutoff valve(s), flowmeter, and container(s). The piping system shall be of the same pipe size as the samples being tested. The test shall be conducted with the liquefied gas for which the sample is intended, Stoddard's Solvent, or other suitable liquid.

20.3 The pump sample shall be operating at maximum rated speed throughout this test sequence. A shutoff valve that has been installed on the outlet side of the pump shall be slowly closed. As the valve is closed the differential pressure and corresponding flow rate shall be recorded. The differential pressure shall be determined by subtracting system pressure on the upstream side of the pump from the downstream side pressure. The shutoff valve shall be closed only for the time needed to determine maximum differential pressure at a no-flow condition.

20.4 With the bypass valve sample installed in the piping circuit as described in 20.2, the test shall begin with the valve adjusted to its minimum setting, (adjustment screw turned all the way out). With liquid flowing in the piping system, a shutoff valve is slowly closed that will direct all liquid flow through the bypass valve sample. The pressure across the valve and flow rate shall be measured. The test shall then be repeated with the sample adjusted to the manufacturer's maximum adjusted setting, (adjustment screw locked at a position in accordance with manufacturer's instructions).

21 Hydrostatic Strength Test

21.1 Except as provided in 21.2, liquid-handling parts of a pump or bypass valve shall be capable of withstanding, without rupture or permanent distortion, a hydrostatic pressure of five times the minimum service pressure in accordance with 1.3 for at least 10 minutes.

21.2 When the construction of a pump or bypass valve is such that it is not capable of developing a differential pressure of 125 psig (860 kPa), or 100 psi (689 kPa) for propylene service, the test pressure

specified in 21.1 shall be reduced by an amount equal to five times the difference between 125 psig (860 kPa) and the maximum differential pressure developed.

21.3 The pump or bypass valve sample, as appropriate, previously subjected to the Deformation, Leakage, Endurance, and Differential Pressure Determination Tests, Sections 16, 17, 18, and 20, respectively, shall be connected to a source of hydrostatic pressure. A positive shutoff valve and a pressure-measurement device that complies with 15.4, shall be installed in the hydrostatic pressure supply piping. The pressure-measurement device shall be installed in the piping between the shutoff valve and the sample under test.

21.4 External leakage observed during this test does not constitute a noncompliance when, following the hydrostatic test, the pump or bypass valve, as appropriate, is in compliance with the requirements in the Leakage Test, Section 17.

22 Moist Ammonia Air Stress Cracking Test

22.1 After being subjected to the conditions described in 22.2 – 22.4, a pressure confining brass part containing more than 15 % zinc shall:

a) Show no evidence of cracking, delamination, or degradation or

b) Perform as intended when tested as described in 22.5.

22.2 One test sample of each size shall be subjected to the physical stresses normally imposed on or within a part as the result of assembly with other components. Samples with female tapered pipe threads, intended to be used for installing the product in the field shall have the threads engaged and tightened to the required torque. Samples with female threads other than tapered pipe threads shall be torqued as specified by the manufacturer. Teflon tape or pipe compound shall not be used on any threads. Samples with male threads shall be evaluated as received.

22.3 The samples shall then to be tested in accordance with Apparatus, Reagents and Materials, Test Media, Test Sample Preparation, and Test Procedure of the Standard Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys, ASTM B858-06, except the pH level of the test solution shall be High 10.5 ±0.1 and the exposure temperature shall be 25 ±1 °C.

22.4 After the exposure period, the samples shall be examined for cracks or other signs of stress corrosion using a microscope having a magnification of 25X.

22.5 Pressure-confining exhibiting degradation as indicated in 22.1(a), as a result of the test exposure described in 21.2 and 21.3 shall withstand, without rupture, a hydrostatic test pressure of five times the rated pressure for 10 minutes.

23 Tests for Synthetic Rubber Parts

23.1 General

23.1.1 A synthetic rubber part in contact with one of the liquids indicated in Table 23.1 shall not show excessive volume change or loss of weight, when considered on the basis of its intended function, following immersion, in the specified test liquid. See the volume change test described in 23.2.1 – 23.2.3 and the weight loss test described in 23.3.1 – 23.3.2.

Table 23.1
Test Liquids for Synthetic Rubber Materials

Liquid in contact with part	Test liquid
LP-Gas	n-Hexane
Anhydrous ammonia	Liquid anhydrous ammonia
Propylene	Liquid propylene

23.1.2 A change in volume of not more than 25 % swelling or 1 % shrinkage, and a weight loss (extraction) of not more than 10 % is considered to be in compliance with 23.1.1.

23.1.3 A part made of synthetic rubber shall not crack or show visible evidence of deterioration following exposure for 70 hours to a temperature of 100 ±2 °C (212 ±3.6 °F) in an air-circulating oven.

23.2 Volume change test

23.2.1 The volume change test for synthetic rubber specified in 23.1.1 shall be conducted in a manner similar to that described in the Standard Test Method for Rubber Property – Effect of Liquids, ASTM D471-79 (1991), with variations as noted in 23.2.2 and 23.2.3.

23.2.2 The test using n-hexane shall be conducted at a temperature of 23 ±2 °C (73.4 ±3.6 °F). Three specimens are used in each test. Each specimen shall be placed on a small diameter wire hook. Its volume shall then be determined by weighing first in air (M_1) and then in water (M_2). The specimens shall then be wiped dry and placed in the test liquid. After 70 hours, the specimens shall be removed from the liquid one at a time, immediately wiped dry, and weighed in air while on the same hook (M_3). The weight shall be obtained within 30 seconds after removal from the test liquid. The final weight in water (M_4) is to be determined immediately thereafter. Before obtaining the weights in water (M_2 and M_4), each specimen is to be dipped in ethyl alcohol, then dipped in water, in order to eliminate surface air bubbles. The percent change in volume is to be calculated as follows, with the results reported as the average of the three specimens tested:

$$Percent\ \ Volume\ \ Change = \frac{(M_3 - M_4) - (M_1 - M_2) \times 100}{(M_1 - M_2)}$$

23.2.3 The test using liquid anhydrous ammonia or propylene shall be conducted out-of-doors. The volume of each of three specimens shall be determined by weighing as described in 23.2.2. After weighing, the specimens shall be wiped dry and placed in a closed chamber (bomb) having its inlet connected to a cylinder of anhydrous ammonia. With the discharge valve from the bomb open, liquid anhydrous ammonia is allowed to flow through the bomb until the air is displaced. The discharge valve shall then be closed. With the inlet connection to the cylinder open, exposure shall be continued for 70 hours. The specimens shall then be removed from the bomb and immediately placed in a stoppered flask. The specimens shall be removed one at a time and weighed in air (M_3). The weight shall be obtained within 30 seconds after removal from the flask. The final weight in water (M_4) shall be determined immediately thereafter. The percent change in volume shall be calculated as described in 23.2.2.

23.3 Weight loss test

23.3.1 The weight loss test for synthetic rubber specified in 23.1.1 shall be conducted in a manner similar to that described in the Standard Test Method for Rubber Property – Effect of Liquids, ASTM D471, the standard with variations as noted in 23.3.2.