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Vacuum oil safety valve for fuel oil tank connections

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Vacuum oil safety valve for fuel oil tank connections

1 Scope

1.1
This document applies to vacuum oil safety valves for fuel oil tank connections (hereinafter referred to as “valve”) intended for installation in the outlet of a fuel oil tank.

1.2
This document applies to valves with an inlet operating pressure range of 0 psi (0 kPa) to 1.75 psi (12.05 kPa).

1.3
This document applies to a valve with an ambient operating temperature range of -13.0 °F to 100.0 °F (-25.00 °C to 38 °C).

1.4
This document applies to a valve with a maximum operating flow of 0.925 gpm (3.50 L/m).

1.5
This document applies to a valve in which the inlet section of the valve is positioned inside the oil tank and the outlet section of the valve is positioned to the exterior of the oil tank to allow connection to the fuel delivery system. The valve may be used on either interior or exterior fuel oil tanks.

1.6
This document applies to a valve not exceeding a size of ½” NPT.

1.7
This document does not apply to gas connectors for appliances. Gas connectors are covered by the Standard for *Connectors for Gas Appliances, ANSI Z21.24 • CSA 6.10*, and the Standard for *Connectors for Moveable Gas Appliances, Z21.69 • CSA 6.16*.

1.8
All references to psi throughout this document are to be considered gauge pressure unless otherwise specified.

1.9
If a value for measurement as given in this document is followed by an equivalent value in other units, the first stated value is to be regarded as the specification.

2 Reference publications

CSA Group
ANSI Z21.15-2009 • CSA 9.1-2009
Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves

CSA B139-2015
Installation code for oil-burning equipment

CSA C22.2, No. 0.15-15
Adhesive Labels

ASME International
ANSI/ASME, B1.20.1-1983(R2006)
Pipe Threads, General Purpose (Inch)

ASME B40.100-2005
Standard for Pressure Gauges and Gauge Attachments

ASTM International
ASTM B117-2011
Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM E84-2013
Test Method for Surface Burning Characteristics of Building Materials

National Fire Protection Association
ANSI/NFPA 31-2011
Standard for the Installation of Oil-Burning Equipment

SAE International
SAE J2494-4-2011
Cartridge Cavity

Underwriters Laboratories, Inc.
UL 404-2010
Gauges, Indicating Pressure, for Compressed Gas Service

UL 842-2007 (R2012)
Valves for Flammable Fluids

3 Definitions

Vacuum oil safety valve – a vacuum operated valve designed to prevent fluid loss from damage or catastrophic failure of lines or equipment downstream of the fuel oil tank.

4 Construction

4.1 Materials

4.1.1
System components shall be constructed entirely of new and unused parts and materials.

4.1.2
Components submitted to the testing agency for examination shall be representative production samples.

4.1.3
The manufacturer shall furnish evidence acceptable to the testing agency concerning the composition and compatibility of the materials used in all components of the system.

4.1.4
The manufacturer shall supply evidence acceptable to the testing agency that all materials have been evaluated and found to be suitable for their intended use. Test data based on ASTM or other appropriate test procedures, certifications or historical data shall be submitted for this purpose. The evidence shall show that the materials have been evaluated, as appropriate, for resistance to moisture, corrosion, the effects of general household chemicals, and the effects of fuel oils and gases, including sulfur compounds, and that non-metallic materials exposed to the atmosphere are suitably resistant to the effects of ozone.

4.1.5
The manufacturer shall provide to the testing agency documented evidence that the valve components have been subjected to the *Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117*, for not less than 96 hours without evidence of pitting, flaking, cracking or signs of corrosion that would prevent the valve from functioning.

4.1.6
The external metal parts of the valve body shall have a melting point of not less than 1000 °F (540 °C).

4.2 General

4.2.1
The construction of parts not specifically covered by this document shall be in accordance with reasonable concepts of safety, substantiality and durability.

All specifications as to construction set forth herein shall be satisfied by the construction actually prescribed or such other construction as will provide at least equivalent performance.

4.2.2
Valves shall be clean and free from dents, flaws or other defects.

4.3 Assembly

The construction of a valve body shall be such that when the turning effort specified in Table 1, Torques for turning effort, is applied across the body parts in a direction that would act to disassemble the valve, the valve body sections shall not start to separate.

Table 1
Torques for turning effort
(See Clauses 4.3, 5.3.1, 5.3.2 and 5.3.3.)

Nominal pipe size		Torque	
Inches	(mm)	Inch-Pounds	(N•m)
⅛	(3.18)	170	(19.2)
¼	(6.35)	220	(24.9)
⅜	(9.53)	280	(31.6)
½	(12.70)	375	(42.4)

4.4 Manual valves

Manual valves shall comply with the Standard for *Valves for Flammable Fluids*, ANSI/UL 842.

4.5 Connections

4.5.1
When pipe threads are used, connections shall be provided with cleanly cut taper pipe threads in accordance with the *Standard for Pipe Threads, General Purpose (Inch) ANSI/ASME B1.20.1.*

4.5.2
Pipe thread length and length to shoulder dimensions shall not be less than that shown in Table 2, Minimum thread length and length to shoulder.

Table 2
Minimum thread length and length to shoulder
(See Clause 4.5.2.)

Size thread	**Shoulder distance, in (mm)**			
	Male thread		**Female thread**	
¼ in – 28 NF tapered thread	0.3125	(7.94)	0.3096	(7.864)
⅛ in pipe thread and $^{9}/_{16}$ in – 27 NS tapered thread	0.3750	(9.53)	0.4500	(11.430)
¼ in pipe thread	0.4375	(11.113)	0.4622	(11.740)
⅜ in pipe thread	0.5000	(12.700)	0.6057	(15.385)
½ in pipe thread	0.5625	(14.288)	0.6247	(15.867)

4.5.3
A valve equipped with pipe threads shall be designed to accept a wrench for use in assembly and disassembly to piping.

4.5.4
Outlet fuel oil connections shall be designed so that when a pipe that is threaded two threads beyond standard (for the size in question) is run into the threaded portion of a valve body, it will not adversely affect the operation of the valve.

4.6 Bolts, nuts and screws

Bolts, nuts, machine screws and other threaded parts used in covers, housings, casings and external mounting brackets shall have threads conforming to, as applicable, the *Standard for Unified Inch Screw Threads (UN and UNR Thread Form), ANSI/ASME B1.1*; *International Organization for Standardization Standard for ISO General Purpose Screw Threads – Basic Profile, ISO 68*; or *Standard for ISO General Purpose Metric Screw Threads – General Plan, ISO 261*.

4.7 Seating means

Valves shall be provided with a means, other than gravity, to maintain a continuous seating force greater than the inlet pressure acting against the valve piston and to compensate for manufacturing tolerances, operational variations or displacement of lubricant(s).

4.8 Strainer

Valves shall include a 100 mesh full flow strainer on the inlet opening of the valve.

4.9 Piston and magnet assembly

Valves shall include a piston and adjustable magnet assembly to control the oil flow through the valve. A secondary method of moving the piston will be provided to deactivate the valve when vacuum is not present for operation.

4.10 Instructions

Instructions, including appropriate illustrations, necessary for proper sizing, installation, inspection and repair of the valve shall be provided by the manufacturer.

Included in the instructions shall be statements to the effect that:

a) A warning to the installer that the installation instructions shall be followed as prescribed by the manufacturer.
b) The installation shall be made in accordance with local codes, or, in the absence of local codes, in accordance with the Standard for the *Installation of Oil-Burning Equipment, ANSI/NFPA 31*, CSA-B139, or Authority Having Jurisdiction as applicable.
c) The maximum allowable inlet operating pressure shall be specified by the manufacturer. “The system is for use with fuel oil only and is intended for maximum allowable inlet operating pressures not exceeding 1.750 psi (12.06 kPa).”
d) The operating temperature range.

4.11 Markings

4.11.1

Marking material shall be identified by class number and shall meet the following specifications. All metal marking materials shall be rustproof. All markings shall be suitable for application to surfaces upon which applied and shall demonstrate suitable legibility as specified under Clause 5.7, Marking material adhesion and legibility. The designation of any class of marking shall not preclude the use of marking of a lower number class.

Class I. Integral marking
Marking that is embossed, cast, stamped, or otherwise formed in the part. This includes markings baked into an enameled surface.

Class IIA-1. Permanent plate
Shall be made of metal having a minimum thickness of 0.012 in (0.30 mm), and shall be securely attached by mechanical means and shall comply with Clause 5.7.

Class IIA-2. Permanent plate
Shall be made of metal having a thickness of 0.006 to 0.012 in (0.12 to 0.30 mm), shall have mechanical attachment means at all corners with a maximum spacing of 6 in (152 mm) between mechanical fasteners, and shall comply with Clause 5.7.

Class IIA-3. Permanent plate
Shall be made of metal having a thickness less than 0.006 in (0.05 mm). Such plates shall be attached by means of non-water soluble adhesive that will comply with Clause 5.7.

Class IIA-4. Permanent plate
Shall be made of pressure-sensitive metal foil requiring no solvent or activator, provided such plates comply with Clause 5.7.

Class IIIA-1. Permanent label
Shall be made of material not adversely affected by water, shall be attached by means of non-water soluble adhesive, and shall comply with Clause 5.7.

Class IIIA-2. Permanent label
Shall be made of material not adversely affected by water, shall be attached by means of non-water soluble adhesive, and shall comply with Clause 5.7.

Class IIIB. Waterproof marking
Shall be printed directly on the part with waterproof marking not adversely affected by a temperature of 175 °F (79.5 °C) and shall comply with Clause 5.7.

Class IIIC. Waterproof label
Shall be made of material not soluble in water, and may use water-soluble adhesive for attachment means.

Class IV. Non-waterproof label
Shall be made of material that may be soluble in water, and may use water-soluble adhesive for attachment means.

Class V. Printed marking
Marking shall be clear and prominent and may be applied directly by any printing means.

Class VI. Attached tags

4.11.2
The valve shall be marked with material complying with the Standard for *Adhesive Labels*, CSA C22.2 No. 0.15, the Standard for *Marking and Labeling Systems, ANSI/UL 969*, or tested as specified under Clause 5.7, *Marking Material Adhesion and Legibility*.

4.11.3
Valves shall be permanently marked showing the following information in a form that can be easily understood:
a) Manufacturer's name, trade-mark or symbol;
b) Serial number;
c) Symbol of the organization making the test for compliance with this document;
d) Maximum allowable inlet operating pressure; and
e) The words "Fuel Oil."

5 Performance

5.1 General

Unless otherwise specified, all performance tests shall be conducted with the system maintained at room temperature, i.e., 77 ± 10 °F (25 ± 5.5 °C).

5.2 Leakage test

The valve shall withstand normal operating pressures and temperatures, and shall not leak.

Method of Test
This test shall be conducted at the manufacturer's specified minimum and maximum temperature.

Five new samples of the valve shall be subjected to this test, all of which shall comply.

NOTE: *The five samples may be tested simultaneously by using a common manifold on the inlet connections and a common manifold on the outlet connections of each sample.*

a) A valve shall be completely submerged in a liquid type leak detector such as Propylene Glycol Antifreeze or MS-RC-SNOOP Real Cool liquid leak detector. The liquid type leak detector shall be approved for operation at temperatures below -40 °F (-40 °C) and above the manufacturers specified maximum temperature rating for the "valve." The valve shall be placed in an environmental chamber and heated to the manufacturer's specified maximum temperature ± 5 °F (± 2.8 °C), as indicated by a thermocouple attached to one of the valves. The valve shall be maintained at this temperature for one hour and throughout the remainder of this test.
   With the valve closed and the outlet open, nitrogen gas shall be supplied and maintained at a pressure of 2.0 in wc (498 Pa) until equilibrium conditions are attained, after which the valve(s) shall be checked for evidence of leakage. The pressure shall then be increased slowly to 1.5 times the manufacturer's maximum rated pressure and maintained at that pressure until equilibrium conditions are attained, after which the valve(s) shall be checked for evidence of leakage.
   The above test shall be repeated with the valve open and the outlet sealed.
b) The valve shall remain completely submerged in the liquid type leak detector as tested under item (a) above and cooled to the manufacturer's specified maximum temperature ± 5°F (± 2.8°C), as indicated by a thermocouple attached to one of the valves. The valve shall be maintained at this temperature for one hour and throughout the remainder of this test.
   With the valve closed and the outlet open, nitrogen gas shall be supplied and maintained at a pressure of 2.0 in wc (498 Pa) until equilibrium conditions are attained, after which the

valve shall be checked for evidence of leakage. The pressure shall then be increased slowly to 1.5 times the manufacturer's maximum rated pressure and maintained at that pressure until equilibrium conditions are attained, after that the valve(s) shall be checked for evidence of leakage.

The above test shall be repeated with the valve open and the outlet sealed.

5.3 Strength

5.3.1 Bending moment

A valve shall be capable of operation without cracking, breaking, or leaking while being subjected to a bending moment using the weight specified in Table 3, Load for bending moment, in accordance with the following Method of Test.

This test shall not apply to valves that have outlets threaded for orifice fittings.

Table 3
Load for bending moment
(See Clause 5.3.1.)

Pipe connections			
Nominal pipe size		**Torque**	
Inches	(mm)	Inch-Pounds	(N•m)
1/8	(3.18)	170	(19.2)
¼	(6.35)	220	(24.9)
3/8	(9.53)	280	(31.6)
½	(12.70)	375	(42.4)

Tubing connections			
Inlet tubing O.D.		**Torque**	
inches	(mm)	Inch-Pounds	(N•m)
1/8	(3.18)	38	(4.29)
3/16	(4.76)	75	(8.47)
¼	(6.35)	100	(11.3)
5/16	(7.94)	125	(14.1)
3/8	(9.53)	150	(16.9)
7/16	(11.1)	175	(22.6)
½	(12.70)	200	(33.9)

Method of Test

This test shall be conducted at room temperature. A new sample shall be subjected to the specified test.

a) The inlet and outlet connections of the valve shall be assembled leak tight to the appropriate fittings as described below. The length of the inlet fitting shall be such that, after assembly, the dimension from the valve inlet to the end of the inlet fitting will be 13 in ± ½ in (330 mm ± 12.7 mm). The tightening torque for threaded pipe connections shall be one-half that shown in Table 1, Torques for turning effort.
   i) Pipe threaded connections shall be assembled to Schedule 40 iron pipe, or pipe fitting, using non-Teflon type joint compound.

ii) Connections designed for other than threaded pipe shall be assembled to test fixture(s) representative of the intended connection means.

b) The valve outlet fitting shall be rigidly supported 1 in (25.4 mm) from the valve outlet, unless the following exceptions apply. When the valve has an integral mounting means independent of the inlet and outlet connections, the valve shall be mounted using the integral mounting means as specified by the manufacturer. When the valve is intended to be mounted by either the integral mounting means or the valve outlet, the mounting means that produces the most severe test condition shall be used.

The valve inlet shall be in the horizontal position.

c) With the valve in the closed position, the system shall be pressurized at 21 in wc (5.23 kPa) and the appropriate weight as specified in Table 3, Load for bending moment test, shall then be suspended on the inlet fitting, without shock, 12 in (305 mm) from the inlet of the valve for 15 minutes.

d) The test in sub-clause –c) shall be repeated 3 times with the valve being rotated 90 degrees (1.57 rad) around the horizontal inlet axis between each test. If the application of any bending moment is in a direction that would tend to rotate the valve with respect to the outlet, that bending moment need not be applied. Between tests, the valve shall be cycled on and off 3 times with the weight removed.

At the completion of the above tests, the valve shall be removed and examined for deformation and breakage and then subjected to the leakage test as specified in Clause 5.2, Leakage.

5.3.2 Turning effort

A valve shall be capable of withstanding, without deformation, breakage or leakage, stresses resulting from installation of the valve or device.

Method of Test

These tests shall be conducted at room temperature. A new sample shall be used for each test.

A valve shall be subjected to the following test.

A length of new, clean and properly threaded Schedule 40 iron pipe or pipe fitting, as applicable, whose threads have not been lubricated, shall be threaded to the inlet of the closed test valve with the turning effort specified in Table 1, Torques for turning effort, by gripping the wrench flats on the valve, or any suitable area of the valve if wrench flats are not provided. If wrench flats are provided on both ends of the valve, the inlet end wrench flats shall be used. If wrench flats are not provided, a special tool provided by the valve manufacturer may be used for this test. With the valve in the closed position, the turning effort shall be applied for 15 minutes and then released.

The procedure outlined in Clause 5.3.1-a)-1) shall be repeated for the outlet of the valve using the outlet wrench flats, if provided.

The valve, with the inlet and outlet pipes in place, shall be tested for leakage as specified in Clause 5.2, Leakage, and shall comply. The inlet and outlet pipes shall then be removed and the valve examined for deformation and breakage.

***NOTE**: Any leakage due to dry threads shall be disregarded.*

5.3.3 Impact

A valve shall be capable of withstanding, without cracking or breaking, the applicable impact specified in Table 4, Impact, Inch pounds (J).

Table 4
Impact, Inch-pounds (J)
(See Clause 5.3.3.)

Pipe connections		
Nominal pipe size	**Impact**	
inches	Inch-Pounds	(J)
1/8	2	(2.7)
¼	5	(6.8)
3/8	10	(13.6)
½	15	(20.3)

Method of Test

This test shall be conducted at room temperature.

A new sample shall be subjected to the specified test.

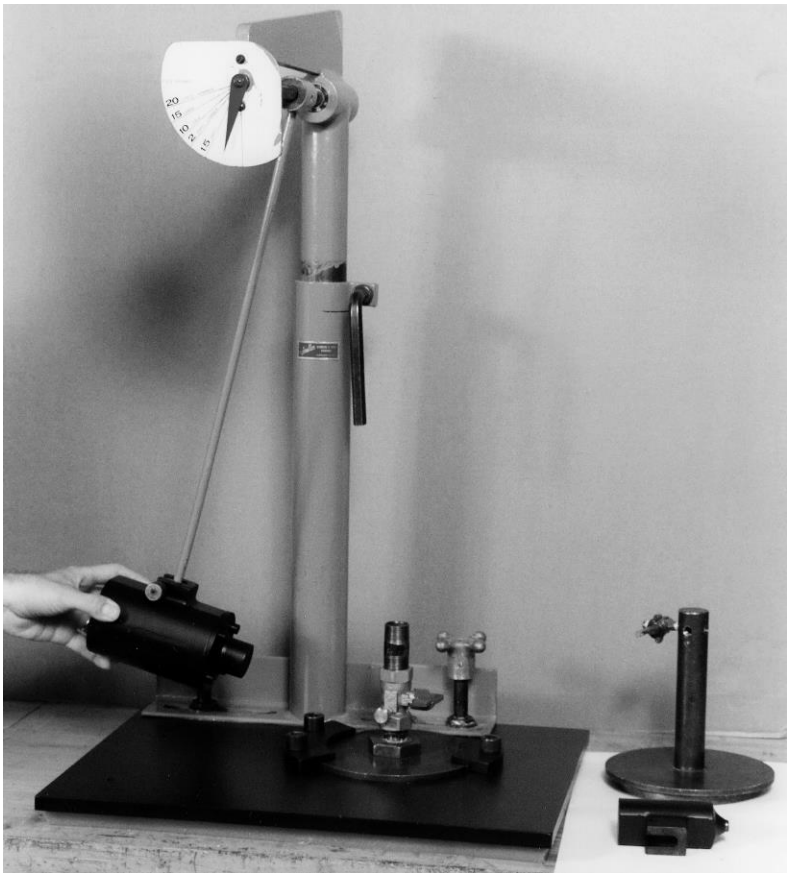
A valve whose inlet is designed for connection to threaded pipe shall be supported by securing its inlet to a close pipe nipple of Schedule 80 iron pipe or a standard-weight pipe coupling mounted on a rigid surface so the free length of the nipple or coupling is not greater than 1 in (25.4 mm). The valve shall be tightened to the support with a turning effort as specified in Table 1, Torques for turning effort.

The outlet end of the valve shall be assembled to a fitting of the type for which designed. The test device shall be arranged so the center line of contact between the striking weight and the valve will be ¼ in (6.4 mm) from the extreme outlet end of the valve.

The valve shall then be struck 4 successive times at right angles to the longitudinal center line of the outlet, with the valve being turned 90 degrees (1.57 rad) between each impact. After each impact, the valve shall be examined visually for cracks or breakage.

A pendulum-type impact machine is shown in Figure 1, Pendulum-type impact machine used for testing valves.

Figure 1
Pendulum-type impact machine used for testing valves
(See Clause 5.3.3.)



At the completion of the above tests, the valve shall be removed and examined for deformation and breakage and then subjected to the leakage test as specified in Clause 5.2, Leakage.

5.4 Flow test

A valve, as received and at the end of this test, shall comply with Clause 5.2, Leakage.

Two of the samples of the valve tested under Clause 5.2 shall be subjected to this test.

Method of Test 1
The valve shall be installed in a sealed container connected to a holding tank filled with colored water. The holding tank shall be positioned a minimum of 3 ft (0.9 m) above the valve. The tubing connecting the holding tank to the test cylinder shall be below the level of the valve. A beaker shall be placed under the outlet of the valve. The valve shall be tested for a period of 30 minutes. Any leakage from the outlet of the valve shall be recorded.

Method of Test 2
The valve shall be installed in a sealed container connected to a holding tank filled with colored water. Clear tubing shall be connected to the outlet of the valve. The clear tubing shall empty into a sealed clear container capable of holding a minimum of 1.5 gal (5.7 L), and incrementally

marked at every 0.1 gal (0.5 L). A 6 ft (1.8 m) length of ½ in tubing shall connect the sealed container to a vacuum pump capable of creating a flow of 14 in wc (3.5 kPa). A pressure gauge capable of reading 0.1 in wc (25 Pa) shall be installed on the tubing. Between the gauge and the vacuum pump, a Needle valve shall be installed.

With the Needle valve in the closed position, the vacuum pump shall be started. Open the Needle valve and record the initial pressure reading on the pressure gauge. Maintain the vacuum for a period of 5 minutes, recording the pressure reading every 30 seconds.

Close the Needle valve to stop the vacuum in the line, and record the time needed to stop the flow of liquid through the valve.

Repeat this test for a total of 10 cycles.

Method of Test 3
Using the above test set-up, install the valve with a rubber sleeve covering 90 percent (± 2 percent) of the total mesh filter.

With the Needle valve in the closed position, the vacuum pump shall be started. Open the Needle valve and record the initial pressure reading on the pressure gauge. Maintain the vacuum for a period of 5 minutes, recording the pressure reading every 30 seconds.

Close the Needle valve to stop the vacuum in the line and record the time needed to stop the flow of liquid through the valve.

Repeat this test for a total of 10 cycles.

Following the flow tests, valve leakage shall be determined as specified in Clause 5.2, Leakage test.

Following the tests, any leakage in excess of 1.22 in^3/hr (20 cc/hr), corrected to standard conditions of 30 in Hg column pressure and 60 °F, shall constitute non-compliance.

5.5 Tests of synthetic rubber parts

5.5.1
A synthetic rubber part in contact with fuel oil shall not show change in volume of more than 25 percent swelling or 1 percent shrinkage, or a weight loss (extraction) of more than 10 percent when considered on the basis of its intended function following immersion for 70 hours in IRM 903 oil.

Polymeric parts shall show no evidence of swelling, shrinkage, or weight loss exceeding 3 percent, or other signs of deterioration, warpage, and cracking following the immersion.

These tests shall be conducted in accordance with the *Standard Test Method for Rubber Property – Effect of Liquids, ASTM D471*, with variations as noted.

5.5.2 Volume change test
The test shall be conducted at a temperature of 74 ± 3.6 °F (23 ± 2 °C). Three specimens shall be used in each test. Each specimen shall be placed on a small diameter wire hook. Its volume is then determined by weighing first in air (M_1) and then in water, alcohol or ballast (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, alcohol or ballast (M_4) shall be determined immediately thereafter. Before obtaining the weights in water, alcohol, or ballast (M_2 and M_4), each specimen shall be dipped in ethyl alcohol, and then dipped in water, in order to eliminate surface air bubbles. The change in volume shall be calculated as follows, with the results reported as the average of the three specimens tested.

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

5.5.3 Weight loss test

The test is conducted at the same time and using the same specimens used in Clause 5.6.1, *Volume change test*. For this test, the specimens are each weighed on a balance pan, in air, to the nearest milligram (M_1) prior to immersion in the test liquid. After 70 hours immersion, and following the weight determinations needed for the Clause 5.6.1, the specimens are allowed to reach constant weight by condition in air at a temperature of 73.4 ± 4°F (23 ± 2°C) for a period of at least 70 hours. The specimens shall then be weighed in air (M_2). The loss in weight is calculated as follows, and the results reported as the average of the three specimens tested.

$$Percent\ mass\ change\ = \frac{(M_1 - M_2)}{M_1} \times 100$$

5.5.4 Accelerated aging test

A part made of an elastomer shall not crack or show visible evidence of deterioration following exposure in an air oven for 70 hours at 212 ± 3.6 °F (100 ± 2 °C).

5.6 Resistance to outdoor environment

5.6.1 Resistance to extreme temperature cycles

Valves shall withstand exposure to extreme temperature cycling without evidence of leakage.

Method of Test

Air shall be admitted to the test assembly and maintained at a pressure of 1.5 times the rated pressure throughout the test. Any leaks in the test system or in the connections to the test assembly shall be eliminated prior to beginning the test. A thermocouple shall be attached to the tube fitting on one end of the test assembly to monitor its temperature.

The test assembly shall be mounted in an environmental chamber in the vertical position with the chamber initially at room temperature. The temperature cycling sequence shall be as follows:

a) The chamber temperature shall be established at 50 ± 2 °F (10 ± 1 °C) within a period of 30 minutes. When the test assembly reaches a temperature of 50 ± 2 °F (10 ± 1 °C), as indicated by the thermocouple attached to the tube fitting, it shall be maintained at that temperature for one hour;
b) The chamber temperature shall be increased to 140 ± 2 °F (60 ± 1 °C) within a period of 30 minutes. When the test assembly reaches a temperature of 140 ± 2 °F (60 ± 1 °C), as indicated by the thermocouple attached to the tube fitting, it shall be maintained at that temperature for one hour;

c) The procedure in –a) shall be repeated;
d) The chamber temperature shall be reduced to −40 ± 2 °F (−40 ± 1 °C) within a period of 30 minutes. When the test assembly reaches a temperature of −40 ± 2 °F (−40 ± 1 °C), as indicated by the thermocouple attached to the tube fitting, it shall be maintained at that temperature for one hour.

The entire sequence described in sub-clauses -a) through -d) shall be repeated continuously for a total of 25 complete cycles.

Leakage, as indicated by the system flow meter, shall be monitored throughout the test. Any leakage in excess of 1.22 in^3/hr (20 cc/hr), corrected to standard conditions of 30 HG column pressure and 60 °F, shall constitute non-compliance with this test.

Following this test, the test assembly shall be subjected to the stress corrosion cracking tests in Clauses 5.6.3-a) and 5.6.3-b), as applicable.

5.6.2 Resistance to freezing and thawing
Valves shall withstand exposure to freezing and thawing without evidence of leakage.

Method of Test
The valve shall be mounted in an environmental chamber in the horizontal position and pressurized at 1.5 times the rated pressure throughout the test.

With the environmental chamber initially at 50 ± 2 °F (10 ± 1 °C), the entire test assembly shall be sprayed for one minute with a fine spray of water. The temperature of the test chamber shall then be reduced to −40 ± 2 °F (−40 ± 1 °C) within a period of 30 minutes following the spraying. The temperature of the test assembly shall be allowed to cool to −40 ± 2 °F (−40 ± 1 °C), as indicated by the thermocouple attached to the tube fitting. After reaching chamber temperature, the test assembly shall be maintained at a temperature of −40 ± 2 °F (−40 ± 1 °C) for one hour, after which the chamber temperature shall be increased to 50 ± 2 °F (10 ± 1 °C) within a period of 30 minutes. The temperature of the test assembly shall then be allowed to warm to 50 ± 2 °F (10 ± 1 °C), and held at that temperature for one hour.

The cycle of spraying, freezing and thawing shall be repeated continuously for a total of 25 cycles. Leakage, as indicated by the system flow meter, shall be monitored throughout the test. Any leakage in excess of 1.22 in^3/hr (20 cc/hr), corrected to standard conditions of 30 in Hg column pressure and 60 °F, shall constitute non-compliance with the test.

5.6.3 Resistance to corrosion
Valves shall withstand exposure to a corrosive environment without evidence of leakage.

The test assembly previously subjected to the procedure in Clause 5.6.1, *Resistance to extreme temperature cycle*, shall be used for this test.

Method of Test
A valve used in Clause 5.6.1, *Resistance to extreme temperature cycle*, shall be retightened to the manufacturer's specifications. The test assembly shall be pressurized at 1.5 times the rated pressure throughout the test. The pressure source shall be isolated with a shutoff valve; and a pressure gauge shall be used to monitor any sudden pressure drop in the test assembly.

If copper alloy fittings are provided with protective coatings, this test shall be conducted with the coating in place.

The test assembly shall be suspended in a sealed plastic vessel containing 250 milliliters of full strength ammonia (28 percent) and 250 milliliters of water. Care shall be taken to prevent the test assembly from coming in contact with the liquid solution at any time.

After 18 hours, the valve shall be tested to Clause 5.4, Flow test, and then Clause 5.2, Leakage.

Following the test, any leakage in excess of 1.22 in^3/hr (20 cc/hr), corrected to standard conditions of 30 in Hg column pressure and 60 °F, shall constitute non-compliance.

5.7 Marking material adhesion and legibility

Marking materials recognized as complying with *Standard for Adhesive Labels, CSA C22.2 No. 0.15*, or *Standard for Marking and Labeling Systems, ANSI/UL 969*, are exempt from this test.

Method of Test

a) Adhesive type marking materials shall be applied to a sample test panel having the particular type of finish used on the valve in production. A sample metal panel of this finish shall be cleaned with a solvent and dried. Half of the panel shall be wiped with a clean cloth lightly oiled with SAE 30 medium machine oil. Two samples of marking material shall be applied to the panel, one on the dry area and one on the oiled area. Test samples shall be applied with firm pressure unless the manufacturer's application instructions specify otherwise. Each sample shall be allowed to set for 24 hours at room temperature.
   Each sample of marking material shall exhibit:
   i) Good adhesion and no curling at edges;
   ii) No illegible or defaced printing when rubbed with thumb or finger pressure; and
   iii) Good adhesion when a dull metal blade (as the back of pocketknife blade) is held at 90 degrees (1.57 rad) to the applied marking and scraped across the edges of the marking.
b) Non-adhesive type marking materials shall exhibit no illegible or defaced printing when rubbed with thumb or finger pressure. Two samples of marking material shall be tested.
c) Samples of both adhesive and non-adhesive type marking materials shall then be placed in an oven for a period of 2 weeks with the oven temperature maintained at:
   i) 350 °F (176.5 °C) for Class IIA1, IIA2, IIA3, IIA4 and IIIA1 marking materials; or
   ii) 250 °F (121 °C) for Class IIIA2 and IIIB marking materials.

Following the oven test, adhesion and legibility of the samples shall be checked again as specified in -a) or -b) above.

Samples shall then be immersed in water for a period of 24 hours, after which adhesion and legibility shall be rechecked as specified in -a) or -b) above.

Good adhesion and legibility qualities shall be obtained for all samples under the above specified test conditions.

Final acceptance of marking materials shall be based on the suitability of the marking material on the valve.

6 Manufacturing and production tests

6.1
The manufacturer shall submit to the testing agency a plan that is mutually acceptable to the manufacturer and the testing agency, which describes the programs, test procedures and the records to be kept by the manufacturer.

6.2
The manufacturer shall use a program to qualify raw materials, parts, assemblies and purchased components.

6.3
The manufacturer shall use a program that includes a mutually acceptable schedule(s) to conduct:

a) Clause 5.4, Flow test;
b) Electronic sensors used for setting up “cracking and run vacuum” shall be calibrated to a known Ultra High Accuracy Testing Vacuum gauge. Electronic sensors to be recalibrated to this gauge every 20 valves;
c) Each valve to be packaged with a certificate showing:
    i) name of manufacturer;
    ii) date when tested;
    iii) graph showing a minimum 4 cycles of the valve;
    iv) temperature value during valve testing;
    v) cracking vacuum value in inches hg or kpa;
    vi) run vacuum value in inches hg or kpa;
    vii) maximum allowed inlet pressure;
    viii) the words “FUEL OIL ONLY”; and
    ix) the serial number of the valve.
    A digital copy of the certificate will be maintained by the manufacturer.
d) Each valve shall be packaged with installation instructions which will include installation directions, warnings, operating pressure and temperature, manufacturer name, model name and certifying agency’s logo;
e) The valve shall be packaged in such a way as to reduce any damage to the valve and the 100 mesh strainer; and
f) Packaging to display the manufacturer name or logo, the valve name, the logo of the certifying agency and the words “FUEL OIL ONLY” and “NON-FIELD ADJUSTABLE”.

Annex A
Table of conversion factors

Note: *This Annex is informative and is not part of the document.*

Quantity	U. S. Unit		Multiplying Factor		SI Units*	
	Name	Symbol	U.S. to SI	SI to U.S.	Symbol	Name
TORQUE	ounce-force-inch	ozf-in	7.061×10^{-3}	141.62	N•m	newton-meter
	pound-force-inch	lbf-in	1.129×10^{-1}	8.85	N•m	newton-meter
	pound-force-foot	lbf-ft	1.355	7.38×10^{-1}	N•m	newton-meter
LENGTH	Inch	in	2.540×10^{-2}	39.37	m	Meter
	inch	in	2.540 x 10	39.37×10^{-3}	mm	millimeter
	foot	ft	3.048×10^{-1}	3.281	m	meter
AREA	Square inch	in^2	6.452×10^{-4}	1550	m^2	square meter
	square inch	in^2	6.452×10^{2}	1550×10^{-6}	mm^2	square millimeter
	square foot	ft^2	9.290×10^{-2}	10.76	m^2	square meter
VOLUME	cubic inch	in^3	1.639×10^{-5}	61.02×10^{3}	m^3	cubic meter
	cubic foot	ft^3	2.832×10^{-2}	35.31	m^3	cubic meter
	cubic foot	ft^3	2.832 x 10	35.31×10^{-3}	l	liter
	gallon	gal	3.785×10^{-3}	264.1	m^3	cubic meter
	gallon	gal	3.785	264.1×10^{-3}	l	liter
VELOCITY	foot/second	ft/s	3.048×10^{-1}	3.281	m/s	meter/second
	foot/minute	ft/min	5.080×10^{-3}	196.8	m/s	meter/second
	mile/hour	m/hr	4.470×10^{-1}	2.236	m/s	meter/second
ACCELERATION	foot/second^2	ft/s^2	3.048×10^{-1}	3.281	m/s^2	meter/second^2
FREQUENCY	cycle/second	c/s	1	1	Hz	hertz
MASS	Ounce	oz	2.835×10^{-2}	35.27	kg	kilogram
	ounce	oz	2.835 x 10	35.27×10^{-3}	g	gram
	pound	lb	4.536×10^{-1}	2.204	kg	kilogram
	grain	gr	6.480×10^{-5}	15.43×10^{-3}	kg	kilogram
MASS PER UNIT AREA	pound/foot^2	lb/ft^2	4.882	2.048×10^{-1}	kg/m^2	kilogram/meter^2
MASS PER UNIT VOLUME	pound/foot^3	lb/ft^3	1.602 x 10	6.243×10^{-2}	kg/m^3	kilogram/meter^3
SPECIFIC VOLUME	foot^3/pound	ft^3/lb	6.243×10^{-2}	1.602 x 10	m^3/kg	meter^3/kilogram
MASS FLOW RATE	pound/hour	lb/hr	1.260×10^{-4}	7.936×10^{3}	kg/s	kilogram/second
	pound/foot^2•hour	lb/ft^2•hr	1.356×10^{-3}	7.374×10^{2}	kg/m^2s	kilogram/meter^2•second
	pound/inch^2•hour	lb/in^2•hr	1.953×10^{-1}	5.120	kg/m^2s	kilogram/meter^2•second
VOLUME FLOW RATE	foot^3/second	ft^3/s	2.832×10^{-2}	35.31	m^3/s	meter^3/second
	foot^3/second	ft^3/s	2.832 x 10	35.31×10^{-3}	l/s	liter/second
	foot^3/minute	ft^3/min.	4.719×10^{-4}	2.119×10^{-3}	m^3/s	meter^3/second
	foot^3/minute	ft^3/min.	4.719×10^{-1}	2.119 x 10	l/s	liter/second
	gallon/minute	gal/min.	6.309×10^{-5}	1.585×10^{4}	m^3/s	meter^3/second
	gallon/minute	gal/min.	6.309×10^{-2}	1.585 x 10	l/s	liter/second
	gallon/hour	gal/hr	1.052×10^{-6}	9.505×10^{5}	m^3/s	meter^3/second
	gallon/hour	gal/hr	1.052×10^{-3}	9.505×10^{2}	l/s	liter/second
PRESSURE	pound force/inch^2	lbf/in^2	6.895×10^{3}	1.450×10^{-4}	Pa	pascal
	pound force/foot^2	lbf/ft^2	4.788 x 10	2.088×10^{-2}	Pa	pascal
		inch H_2O (4°C)	2.491×10^{2}	4.014×10^{-3}	Pa	pascal
	atmosphere		3.386×10^{3}	2.953×10^{-4}	Pa	pascal
		inch Hg (0°C)	1.013×10^{5}	9.871×10^{-6}	Pa	pascal
		atm (std)				
ENERGY, WORK, QUANTITY OF HEAT		Btu	1.055×10^{3}	9.478×10^{-4}	J	joule
		Btu	1.055	9.478×10^{-1}	kJ	kilojoule
	horsepower hour	Hphr	2.685×10^{6}	3.724×10^{-7}	J	joule
	horsepower hour	Hphr	2.685	3.724×10^{-1}	MJ	megajoule
	kilowatt hour	Kwhr	3.6×10^{6}	2.777×10^{-7}	J	joule
	kilowatt hour	Kwhr	3.6	2.777×10^{-1}	MJ	megajoule

POWER, HEAT FLOW RATE	Btu/hr Btu/hr Hp Hp ton refrigeration (12,000 Btu/hr) ton refrigeration (12,000 Btu/hr) Btu/hour•foot^2 Btu/hr•ft^2		2.931×10^{-1} 2.931×10^{-4} 7.457×10^{2} 7.457×10^{-1} 3.516×10^{3} 3.516 3.155	3.412 3.412×10^{3} 1.341×10^{-3} 1.341 2.844×10^{-4} 2.844×10^{-1} 3.1695×10^{-1}	W kW W kW W kW W/m^2	watt kilowatt watt kilowatt watt kilowatt watt/meter^2
HEAT CAPACITY SPECIFIC HEAT CAPACITY	Btu/degree F Btu/pound•degree F Btu/pound•degree F	Btu/°F Btu/lb•°F Btu/lb•°F	1.899×10^{3} 4.187×10^{3} 4.187	5.265×10^{-4} 2.388×10^{-2} 2.388×10^{-5}	J/°C J/kg•°C kJ/kg•°C	joule/degree Celsius joule/kg□degree Celsius kilojoule/kg□degree Celsius
LATENT HEAT	Btu/pound Btu/pound	Btu/lb Btu/lb	2.326×10^{3} 2.326	4.299×10^{-4} 4.299×10^{-1}	J/kg kJ/kg	joule/kilogram kilojoule/kilogram
VOLUME AT STD. CONDITIONS**	ft^3 (60°F, 30 inches Hg, sat) “ “ “ “ “ “ “ “ “ “ “ “		.9826 .02784 .02832 .02639 .02655	1.0177 35.92 35.31 37.89 37.66	ft^3 (60°F, 30 inches Hg, dry) m^3 (15°C, 760 mm Hg, dry) m^3 (15°C, 760 mm Hg, sat) m^3 (0°C, 760 mm Hg, dry) m^3 (0°C, 760 mm Hg, sat)	

** SI Units (International System of Units) have been adopted by the International Gas Union for use within the gas industry. Where the same quantities have been defined by ISO (International Standards Organization, they are identical to the SI Units.*
Standard cubic foot (SCF) measured @ 60°F and 30 inches Hg, Saturated. (U.S. Conditions)
Standard cubic meter (ms^3) measured @ 15°C and 760 mm Hg, dry. (SI Conditions)
Normal cubic meter (mn^3) measured @ 0°C and 760 mm Hg, dry.

Temperature scales and conversions

The unit of temperature in the International System of Units (SI) is the kelvin (K), but it is generally accepted practice to express temperature differences in terms of degrees Celsius (°C) because the degree intervals are identical. The term “centigrade” was abandoned in 1948 by the General Conference on Weights and Measures but in fact is still in common use. The accepted abbreviation for centigrade is also °C and for all practical purposes the degree intervals of centigrade, Celsius and kelvin, are identical.

Many temperature measurements are still made in terms of degrees Fahrenheit (°F). Although a formal definition of the Fahrenheit scale does not exist, it is based on:

a) The freezing (ice) point of water = 32°F
b) The boiling point of water under standard pressure conditions = 212°F
c) The formula for absolute temperature, 5/9 (°F—32) = °C
d) The formula for “temperature rise,” 5/9 °F = °C

°C	°F	°C	°F	°C	°F
−40	−40	25	77.0	70	158.0
−20	−4	30	86.0	80	176.0
0	32.0	35	95.0	90	194.0
10	50.0	40	104.0	100	212.0
15	59.0	50	122.0	110	230.0
20	68.0	60	140.0	120	248.0

Multiples and submultiples of basic units

Factor by which the unit is multiplied			Prefix	Symbol
1 000 000 000 000	=	10^{12}	Tera	T
1 000 000 000	=	10^{9}	Giga	G
1 000 000	=	10^{6}	mega	G
1 000	=	10^{3}	Kilo	k
100	=	10^{2}	hector	h
10	=	10^{1}	deka	da
0.1	=	10^{-1}	deci	d
0.01	=	10^{-2}	centi	c
0.001	=	10^{-3}	Mili	m
0.000 001	=	10^{-6}	micro	µ
0.000 000 001	=	10^{-6}	nano	n
0.000 000 000 001	=	10^{-12}	Pico	p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