ANSI Z21.41-2014
(reaffirmed 2019) •
CSA 6.9-2014
(reaffirmed 2019)

Quick disconnect devices for use with gas fuel appliances

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Revision History

ANSI Z21.41-2014 • CSA 6.9-2014, Quick disconnect devices for use with gas fuel appliances

Revision from previous edition	Revision symbol (in margin)
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ANSI Z21.41-2014 • CSA 6.9-2014

Quick disconnect devices for use with gas fuel appliances

American National Standards Institute, Inc.

IGAC

Interprovincial Gas Advisory Council

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Preface

This is the fourth edition of ANSI Z21.41 • CSA 6.9, Standard for *Quick disconnect devices for use with gas fuel appliances*. It supersedes the previous editions published in 2011, 2003, 1998.

This Standard was prepared by the Z21/CSA Joint Technical Advisory Group on Standards for Manually Operated Gas Valves, under the jurisdiction of the CSA Technical Committee on Gas Appliances and Related Accessories and Z21/83 Technical Committees on the Performance and Installation of Gas Burning Appliances and Related Accessories and the Strategic Steering Committee on Standards for Gas Appliances and Related Accessories, and had been formally approved by the Technical Committee(s), American National Standards Institute, and the Interprovincial Gas Advisory Council.

Interpretations: The Strategic Steering Committee on Standards for Gas Appliances and Related Accessories has provided the following direction for the interpretation of standards under its jurisdiction: "The literal text shall be used in judging compliance of products with the safety requirements of this Standard. When the literal text cannot be applied to the product, such as for new materials or construction, and when a relevant committee interpretation has not already been published, CSA's procedures for interpretation shall be followed to determine the intended safety principle."

Notes:

1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
2) *This standard contains SI (Metric) corresponding to the yard/pound quantities, the purpose being to allow the standard to be used in SI (Metric) units. (Standard for use of the International System of Units (SI): The Modern Metric System, IEEE/ASTM SI I0 or ISO 80000-1:2009 Quantities and units– Part 1: General are used as a guide in making metric conversion from yard/pound quantities.) If a value for a measurement and a corresponding value in other units are stated, the first stated value is to be regarded as the requirement. The given corresponding value may be approximate. If a value for a measurement and a corresponding value in other units are both specified as a quoted marking requirement, the first stated unit, or both shall be provided.*
3) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
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   d) *Rationale for the change.*
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   b) *Provide an explanation of circumstances surrounding the actual field condition; and*
   c) *Where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.*
   d) *Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.*

History of the development of ANSI Z21.41–2014 • CSA 6.9–2014

Note: *This history is informative and is not part of the standard.*

With the onset of the Free Trade Agreement between the United States and Canada on January 2, 1988, significant attention was given to the harmonization of the United States and Canadian safety standards addressing gas-fired equipment for residential, commercial and industrial applications. It was believed that the elimination of the differences between the standards would remove potential trade barriers and provide an atmosphere in which North American manufacturers could market more freely in the United States and Canada. The harmonization of these standards was also seen as a step toward harmonization with international standards. Joint subcommittees were established to facilitate the standards harmonization process between the United States and Canada.

At its meeting of May 12-13, 1993 the Z21/CGA Joint Subcommittee on Standards for Manually-Operated Valves and Quick-Disconnect Devices passed a motion requesting staff to prepare a draft binational standard for Quick Disconnect Devices For Use With Gas Fuel Appliances for public review and comment.

The first draft harmonized standard was based on the current coverage from American National Standard for Quick-Disconnect Devices For Use With Gas Fuel, ANSI Z21.41-1989, Addenda Z21.41a-1990, and Z21.41b-1992, and the National Standard of Canada for Quick Disconnect Devices For Use With Gas Fuel, CAN1-6.9-M79. The first draft was subsequently issued for public review during September and October of 1995.

Following reconsideration and modification of the proposed draft standard, in light of comments received, the joint manual valves subcommittee, at its March 12-13, 1996 meeting, recommended the proposed draft to the Z21 Committee and the CGA Standards Steering Committee for approval.

The proposed draft of the harmonized Standard for Quick-Disconnect Devices For Use With Gas Fuel Appliances, as modified by the joint subcommittee at its meeting of March 12-13, 1996, was approved by the Z21/83 Committee by letter ballot dated July 30, 1997 and by the CGA Standards Steering Committee on September 16, 1996.

The first edition of the harmonized Z21/CSA Standard for Quick-Disconnect Devices For Use With Gas Fuel Appliances, was approved by the Canadian Interprovincial Gas Advisory Council (IGAC) in December 1996 and by the American National Standards Institute Inc. (ANSI) on January 6, 1998.

Following the procedures outlined above, further revisions to this standard, Z21.41 CSA 6.9, were made in line with industry developments. The second edition of the American National Standard/CSA Standard for Quick Disconnect Devices For Use With Gas Fuel Appliances was approved by the IGAC on November 15, 2003, and by ANSI, on December 23, 2003.

The third edition of the standard was approved by the IGAC on July 8, 2011 and by ANSI on February 25, 2011.

This the fourth edition of the standard was approved by the IGAC on October 14, 2013 and by ANSI on January 13, 2014.

The previous editions of the quick disconnect devices standard, and addenda thereto, approved by the Interprovincial Gas Advisory Council and American National Standards Institute, Inc. are as follows:

ANSI Z21.41-1998 • CSA 6.9-M98
ANSI Z21.41a-2001 • CSA 6.9a-2001
ANSI Z21.41b-2002 • CSA 6.9b-2002
ANSI Z21.41-2003 • CSA 6.9-2003
ANSI Z21.41a-2005 • CSA 6.9a-2005
ANSI Z21.41b-2010 • CSA 6.9b-2010

ANSI Z21.41-2011 • CSA 6.9-2011

The following identifies the designation and year of this Standard:

ANSI Z21.41-2014 • CSA 6.9-2014

ANSI Z21.41-2014 • CSA 6.9-2014
Quick disconnect devices for use with gas fuel appliances

1 Scope

Δ **1.1**

This Standard applies to newly-produced, hand-operated quick-disconnect devices, hereinafter also referred to as devices, constructed entirely of new, unused parts and materials which provide a means for connecting and disconnecting appliances or appliance connectors to gas supplies and which are for indoor and outdoor applications. These devices shall be equipped with automatic means to shut off the gas when the devices are disconnected. The mating parts shall be held together securely either by a positive locking means or by means requiring a straight pull to disconnect. These devices shall be capable of operation at ambient temperatures between 32°F to 200°F (0°C to 93.3°C) if intended for indoor use only, or temperatures between -20°F to 200°F (-28.8°C to 93.3°C) if intended for indoor/outdoor use. These devices shall also be capable of operation at temperatures of -40°F (-40°C) when so specified by the manufacturer.

Δ **1.2**

This Standard applies to quick disconnect devices for use with natural, manufactured and mixed gases, propane gas and LP gas-air mixtures, having maximum gas pressure ratings of up to and including 60 psi (414 kPa). A manufacturer must specify what pressure will be marked on the product and the applicable pressures in the performance tests shall be adjusted to meet the testing requirements.

1.3

All references to psi (kPa) throughout this standard are to be considered as gauge pressure unless otherwise specified.

1.4

Annex A contains provisions that are unique to Canada.

1.5

Clause 2, contains a list of standards specifically referenced in this standard, and sources from which these reference standards may be obtained.

1.6

This Standard contains SI (Metric) corresponding to the yard/pound quantities, the purpose being to allow the standard to be used in SI (Metric) units. (Standard for use of the International System of Units (SI): The Modern Metric System, IEEE/ASTM SI 10 or ISO 80000-1:2009 Quantities and units-Part 1: General are used as a guide in making metric conversion from yard/pound quantities.) If a value for a measurement and a corresponding value in other units are stated, the first stated value is to be regarded as the requirement. The given corresponding value may be approximate. If a value for measurement and a corresponding value in other units are both specified as a quoted marking requirement, the first stated unit, or both shall be provided.

2 Reference publications

This Standard refers to the following publications, and where such reference is made.

CSA Group

CSA C22.2 No. 0.15
Adhesive Labels

CAN/CSA B149.1
Natural Gas and Propane Installation Code

ANSI Z21.15 • CSA 9.1
Manually Operated Gas Valves for Appliances, Appliance Shut-Off Valves and Hose End Valves

ANSI Z21.54 • CSA 8.4
Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances

ANSI Z21.69 • CSA 6.16
Connectors for Moveable Gas Appliances

American Gas Association (AGA)

NFPA 54
National Fuel Gas Code

American National Standard Institute (ANSI)

Z535
Safety Alerting Standards

American Society of Mechanical Engineers (ASME)

ANSI/ASME B1.20.1
Pipe Threads, General Purpose (Inch)

ASTM International

IEEE/ASTM SI 10
Standard for Use of International System of Units (SI): The Modern Metric System

ASTM B858-10
Standard Test Method for Ammonia Vapor Test for Susceptibility of Stress Corrosion Cracking in Copper Alloys.

National Fire Protection Association (NFPA)

NFPA 54/ANSI Z223.1
National Fuel Gas Code

Underwriters Laboratory, Inc. UL)

UL 969
Marking and Labeling Systems

3 Definitions

The following definitions shall apply in this Standard:

Capable of rotation — the mating parts of the device are able to rotate relative to each other around the common axis by more than 5 degrees.

Quick disconnect device — a device which provides a means for manually connecting and disconnecting an appliance or appliance connector to a gas supply, without the use of tools. It is equipped with an automatic means to shut off the gas supply when the device is disconnected.

Gas appliance connector — a factory fabricated assembly of gas conduit and related fittings designed to convey gaseous fuel, used for making connections between a gas supply piping outlet and the gas inlet to an appliance.

Mating parts — the major parts of quick disconnect devices that are separable in the normal use of the device. These parts are normally referred to as the plug (male) and socket (female) of the quick disconnect device.

Propane — a liquefied petroleum gas that is classified as either “commercial propane” or “Special-Duty” propane in accordance with ASTM D1835 “Standard Specification for Liquefied Petroleum (LP) Gases.” Special-Duty propane is equivalent to Propane HD-5.

Simple tools — any tools or implement commonly available to the general public.

Rotating taper plug valve — a valve with an internal member with one end smaller than the other that controls the flow of gas by turning about an axis.

4 Construction

4.1 General

4.1.1

Twelve production samples of each device submitted for examination under this Standard shall be supplied by the manufacturer.

4.1.2

Detailed drawings of all basic models of devices submitted for examination under this standard shall be supplied in triplicate by the manufacturer.

4.1.3

When the device incorporates a valve of the tapered plug or rotating disc type, the valve shall comply with the applicable construction provisions of the *Standard for Manually Operated Gas Valves, ANSI Z21.15 • CSA 9.1*.

4.1.4

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

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

The general assembly of quick-disconnect devices shall be of a neat and workmanlike character with all parts well fitted.

4.1.5

Quick-disconnect devices for use with caster mounted equipment shall also comply with provisions outlined under Clauses 4.3.2, 4.3.3, 4.3.6, 4.3.7, 4.9.3, 4.9.4 and 5.4, Continued operation.

4.1.6

A quick-disconnect device intended for use outdoors shall also comply with provisions under Clauses 4.9.5, 5.1.2 and 5.6, Low temperature operation.

4.2 Dimensions

4.2.1

If the device incorporates a rotating taper plug valve, the body of this valve shall be bored out at the small end of the taper to a diameter of at least 0.003 in (0.077 mm) larger than the small diameter of the plug taper for a distance equal to the take-up.

In such a gas valve, the largest diameter of the plug taper shall be at least 0.003 in (0.077 mm) smaller than the large end of the body taper. The diameter of the portion of valve plug extending beyond the body taper shall be at least $^{1}/_{64}$ in (0.40 mm) smaller than the large end of the plug taper.

4.2.2

The portions of a device threaded for connection to gas piping shall have tapered pipe threads as specified in the *Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1*.

4.3 Operation

4.3.1

Quick-disconnect devices shall not require the use of tools to either connect or disconnect the devices.

4.3.2

The net axial force necessary to connect a quick-disconnect device without positive locking means shall not exceed 30 lb (133 N), except for devices for use with caster mounted equipment on which the net axial force to connect shall not exceed 50 lb (222 N).

4.3.3

The net axial force necessary to disconnect a quick-disconnect device without positive locking means shall be a least 15 lb (67 N), except for devices for use with caster mounted equipment on which the net axial force to disconnect shall be not less than 30 lb (134 N) nor more than 50 lb (222 N).

4.3.4

On devices that incorporate a positive locking means, the axial force to lock or unlock the device plus any additional axial forces to connect or disconnect the device shall not exceed a total of 30 lb (133 N)

for devices with less than 1 in (25.4 mm) nominal diameter and 50 lb (222 N) for devices with 1 in (25.4 mm) or greater diameter.

4.3.5

On a positive locking device which incorporates a twist-type locking means, the torque to lock or unlock the locking means shall not exceed 8 in-lb (0.90 Nm) for a device having a diameter of 1 in (25.4 mm) or smaller and 15 in-lb (1.7 Nm) for a device having a diameter larger than 1 in (25.4 mm). Any axial forces to connect or disconnect shall not exceed those specified in Clause 4.3.4.

4.3.6

Quick-disconnect devices capable of rotation shall comply with the applicable provisions of Clause 5.4, Continued operation.

4.3.7

Quick-disconnect devices for use with caster mounted equipment shall be capable of rotation.

4.4 Safety

4.4.1

A quick-disconnect device shall be designed so that when disconnected it shall be impossible to cause gas leakage by manual manipulation or by the application of simple tools to external surfaces of the device.

When a simple tool is inserted into a recess of the device, the force to cause gas leakage from the supply side shall not be less than the following:

Table 1
Minimum force to unseat valve
(See Clause 4.4.1.)

Nominal pipe size, inches	Minimum force to unseat valve pounds (N)
1/8	5 (22)
1/4	5 (22)
3/8	5 (22)
1/2	8 (35)
3/4	8 (35)
1	8 (35)
1 1/4	12 (53)
1 1/2	12 (53)

The automatic gas shutoff means of the device shall reseat properly after being manually opened.

4.4.2

The design of the device shall be such that continuous leakage from the supply side will not occur during connection and disconnection of the mating parts or when the mating parts are only partially joined. Leakage shall be determined as specified in Clause 5.1, Leakage.

4.4.3

Quick-disconnect devices shall be designed so that the mating parts cannot be incorrectly joined.

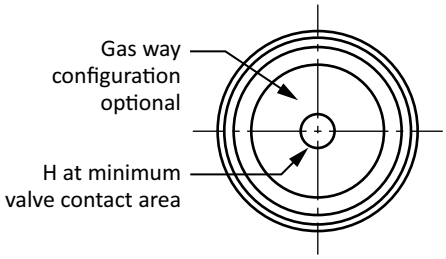
4.4.4

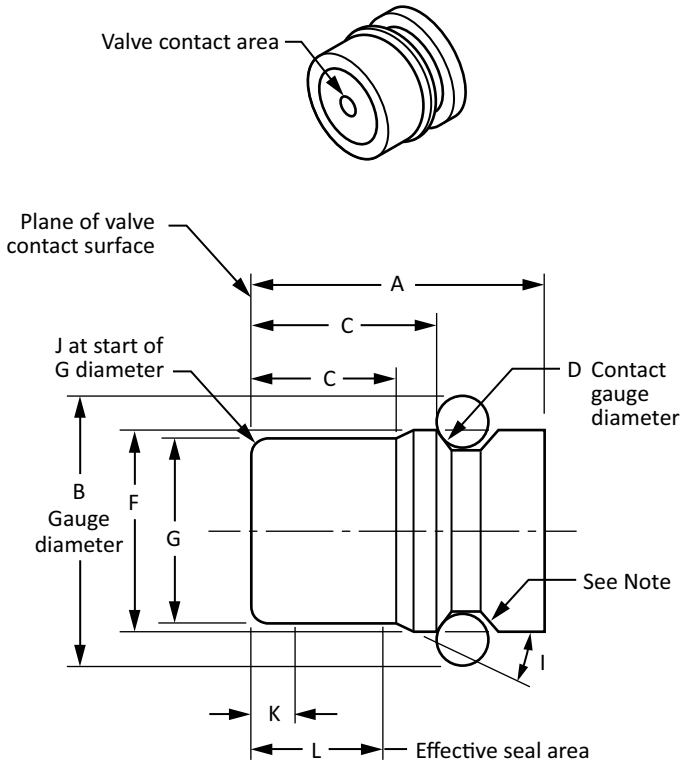
The male plug of a $^{3}/_{8}$ inch NPT quick disconnect intended for use with a gas convenience outlet, or with an outdoor appliance connector which complies with the *Standard For Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances, Z21.54 • CSA 8.4*, or a gas connector for movable appliances in residential applications that comply with the *Standard For Connectors for Movable Gas Appliances, Z21.69 • CSA 6.16*, shall comply with Figure 1.

This does not prohibit the use of other profiles intended for other applications.

Figure 1
Drawing of the plug profile
(See Clause 4.4.4.)

Legend:
A = .865 min.
B = .829
C = .520/.540
D = .156
E = .380 min.
F = Ø .605/.616
G = Ø .555/.556 (Seal ssurface)
H = Ø .095 min.
I = 30° max.
J = .03 R or .03 × 45° min.
K = .145 max. chamfer or start position of G diameter
L = .375 min.





4.5 Strength

4.5.1

Quick-disconnect devices shall be capable of supporting the following weights suspended from the extreme outlet end without deformation, breakage, or leakage:

Table 2
Suspended weight
(See Clause 4.5.1.)

Nominal pipe size, inches	Weight pounds (N)
1/8	50 (222)
1/4	65 (289)
3/8	80 (356)
1/2	100 (445)
3/4	125 (556)
1	150 (667)
1 1/4	175 (778)
1 1/2	200 (890)

Method of test

Five samples of each style and size of device shall be subjected to the tests specified.

The inlet ends of completely assembled devices shall be attached to a rigidly supported extra heavy pipe manifold so that they will be horizontal. The weight specified above shall then be suspended from the extreme outlet end of the assembled device without shock. At the end of 15 minutes the device shall be subjected to the leakage tests specified in Clause 5.1, Leakage. The weight shall be removed, the device examined for deformation and breakage and again subjected to the leakage test specified in Clause 5.1.

4.5.2

A quick-disconnect device shall be capable of withstanding, without deformation, breakage, or leakage, the following turning effort exerted to screw the inlet of the device into a conventional manifold or onto a pipe.

Table 3
Turing effort
(See Clause 4.5.2.)

Nominal pipe size, inches	Turning effort lb-in (Nm)
1/8	170 (19.2)
1/4	220 (25)
3/8	280 (32)
1/2	375(42)
3/4	560 (63)
1	750 (85)

(Continued)

Table 3 (Concluded)

Nominal pipe size, inches	Turning effort lb-in (Nm)
1 1/4	875 (99)
1 1/2	940 (106)

Method of test

Five samples of each style and size of device shall be subjected to the tests specified below, all of which shall comply.

A tool, which fits snugly about the body of the device, or to a section of the device shaped for a wrench if such a section is provided, shall be utilized to apply the turning force. The measured torque specified above shall be applied to the device in fitting it into an extra heavy pipe manifold of suitable size or onto a pipe. The force shall be applied for 15 minutes and then released. The device shall be removed and examined for deformation and breakage and shall be subjected to the leakage test specified in Clause 5.1, Leakage.

4.5.3

A quick-disconnect device shall be capable of withstanding the following impacts without cracking or breaking:

Table 4
Impact
(See Clause 4.5.3.)

Nominal pipe size, inches	Impact, foot-pounds (Nm)
1/8	1 (5.4)
1/4	10 (13.5)
3/8	15 (20)
1/2 and larger	20 (27)

Method of test

The inlet end of the completely assembled device under test shall be supported by securing it to a close pipe nipple of Schedule 80 pipe or a standard weight pipe coupling mounted on a rigid surface so that the full length of the nipple or coupling is not greater than 1 in (25.4 mm).

A suitable fitting (nipple or coupling) shall be assembled to the outlet end of the device. The test equipment shall be arranged so that the center of impact between the striking weight and the body of the device will be 1/4 in (6.4 mm) from the extreme outlet end of the device.

The device shall then be struck four (4) successive impacts at right angles to the longitudinal center line of the outlet gasway, the device being turned 90 degrees (1.57 rad) between each impact. After each impact, the device shall be examined visually for cracks or breakage. After the fourth impact, the device shall be subjected to the leakage test specified in Clause 5.1, Leakage.

The test shall then be repeated on four (4) additional devices. (Total of five (5) devices.) This provision shall be deemed met if all devices satisfactorily comply with the test provisions.

4.5.4

Quick-disconnect devices shall be capable of withstanding the following static loads, without leakage, under bending moments similar to those applied to the device as part of a piping system:

Table 5
Static loads
(See Clause 4.5.4.)

Nominal pipe size, inches	Static load pounds (N)
1/8	35 (156)
1/4	35 (156)
3/8	37 ½ (167)
1/2	40 (178)
3/4	42 1/2 (189)
1	45 (200)
1 1/4	47 1/2 (211)
1 1/2	50 (222)

Method of test

The device under test and two 2 ft (610 mm) lengths of standard weight pipe shall be made up into a pressure-tight assembly, with the outlet pipe capped and the inlet pipe connected to an air pressure system including a mercury manometer. This assembly shall be placed across two horizontal supports spaced so that the assembly is supported at points 12 in (305 mm) on each side of the center line of the device. The appropriate static load shall then be applied to the device symmetrically with respect to the mating parts and in a vertically downward position. While being subjected to this load, the device shall be checked for evidence of leakage with a soap solution with the test assembly under air pressure of 6 in Hg (20.3 kPa).

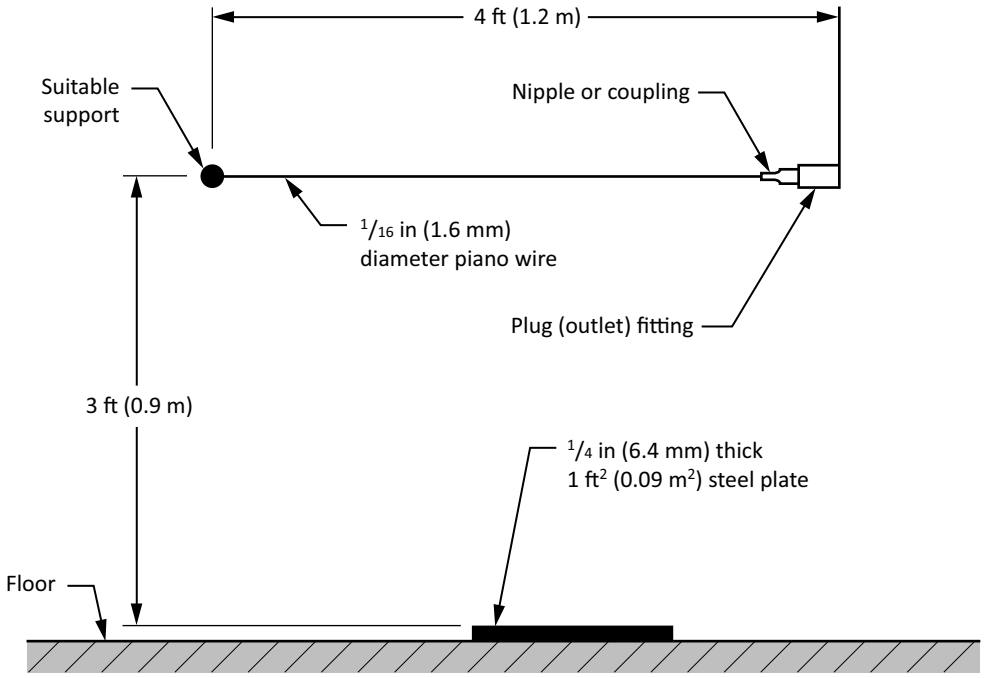
4.5.5

Quick-disconnect devices shall be capable of normal operation and shall not show any evidence of leakage after the plug (outlet) end has been dropped 25 times.

Method of test

The plug (outlet) fitting shall be mounted in a test arrangement as shown in Figure 2. The steel plate shall be located where the fitting will strike it when released. The fitting shall be released from the position shown and allowed to strike the steel plate a total of 25 times. The assembled coupling shall then be subjected to 100 connecting and disconnecting cycles as specified in Clause 5.4, Continued operation, and then shall be subjected to the leakage test specified in Clause 5.1, Leakage. Any condition which prevents normal operation when tested as specified in Clause 5.4, or any leakage when tested as specified in Clause 5.1, shall be considered as failure to comply with this provision.

Figure 2
Test arrangement
(See Clause 4.5.5.)



4.5.6

A quick-disconnect device shall not leak while subjected to a side force during connection or disconnection.

Method of test

For this test the male and female halves of the device shall be oriented in the relative position(s) deemed most critical by the testing agency.

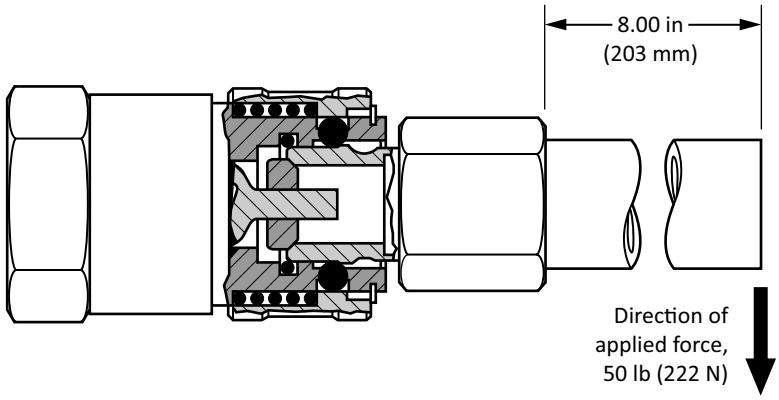
The female half of the device shall be clamped to a fixture so that the centerline is parallel to the floor (see Figure 3). The female half of the device shall be attached to a pressure source and leakage measurement system as specified in Clause 5.1, Leakage.

The male and female portions shall be connected until they are just engaged without compressing the internal valve spring. A 50 lb (222 N) force shall be applied to a section of pipe attached to the threaded end of the male half of the device at a distance 8 in (203 mm) from the face of the female half. With this force applied, the connection shall be completed.

If the applied weight precludes connection, it may be reduced to the maximum value which will permit connection to be completed. Leakage shall then be measured as specified in Clause 5.1.

The male half of the device shall be disconnected and leakage again measured as specified in Clause 5.1.

Figure 3
Side force test for quick-disconnect device
(See Clause 4.5.6.)



4.6 Materials

4.6.1

The manufacturer shall supply evidence acceptable to the testing agency that all materials have been evaluated and found to be suitable for their intended usage. Test data based on ASTM or other appropriate test procedures, certifications or historical data may be submitted for this purpose. The evidence shall show that the materials have been evaluated, as appropriate for resistance to moisture, corrosion and the effects of fuel gases, including the sulphur compounds therein, and that nonmetallic diaphragm and seal materials are suitably resistant to the effects of ozone.

4.6.2

Those parts which are provided for automatic compensation for wear shall be made of corrosion-resistant material or shall have a corrosion resistant finish.

4.6.3

Iron and steel parts shall be protected with a corrosion-resistant metallic finish, such as cadmium plating or zinc plating, which is at least 0.0003 in (0.008 mm) thick.

4.6.4

Materials which come in contact with the gas stream shall be resistant to the action of liquefied petroleum gases.

4.7 Assembly

The construction of quick-disconnect devices shall be such that the mating parts cannot be assembled incorrectly, unless such incorrect assembly would not permit gas to flow.

4.8 Instructions

Instructions covering proper usage and installation shall be attached to each assembled quick-disconnect device.

These instructions shall be reviewed by the testing agency for accuracy and compatibility with the results of test from a technical standpoint, and with the *National Fuel Gas Code, ANSI Z223.1/NFPA54*,

or the *Natural Gas and Propane, CSA B149.1*, Installation Codes, respectively for the United States and Canada.

Δ 4.9 Marking

When text is shown in quotation marks it shall appear on markings exactly as shown.

Δ 4.9.1

Marking material shall be identified by class number and shall meet the following specifications:

a) All marking material shall be rustproof.
b) All markings shall be suitable for application to surfaces upon which applied.
c) All markings shall demonstrate suitable adhesion and legibility as specified in Clause 5.7, Marking material adhesion and legibility.
d) The designation of any class of marking shall not preclude the use of a marking of a lower class number.
e) All markings shall be designed and typeset so as to be easily readable and comprehensible. See the ANSI Z535 Series of Standards for Product Safety Markings.
f) Units of measure shall be expressed in with the first units of measure prescribed herein, or both.

Δ 4.9.2

The following classes of markings shall be used as directed in this specification:

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 (0.31 mm). Shall be securely attached by mechanical means and shall comply with Clause 5.7, Marking material adhesion and legibility.

Class IIA-2. Permanent plate

Shall be made of metal having a thickness of 0.006 to 0.012 in (0.15 to 0.31 mm). Shall have a 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, Marking material adhesion and legibility.

Class IIA-3. Permanent plate

Shall be made of metal having a thickness not less than 0.006 in (0.15 mm). Such plates shall be attached by means of non-water-soluble adhesive which shall comply with Clause 5.7, Marking material adhesion and legibility. These materials shall not be located on surfaces having temperatures exceeding 300°F (149°C).

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, Marking material adhesion and legibility. These materials shall not be located on surfaces having temperatures exceeding 300°F (149°C).

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, Marking material adhesion and legibility. These materials shall not be located on surfaces having temperatures exceeding 300°F (149°C).

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, Marking material adhesion and legibility. These materials shall not be located on surfaces having temperatures exceeding 175°F (79.5°C).

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, Marking material adhesion and legibility. This marking shall not be used on surfaces having temperatures exceeding 175°F (79.5°C).

Class IIIC. Waterproof label

Shall be made of material not soluble in water. May use water-soluble adhesive for attachment.

Class IV. Non-waterproof label

Shall be made of material which may be soluble in water. May use water-soluble adhesive for attachment.

Class V. Printed marking

Marking shall be clear and prominent and may be printed by any method and applied directly to the device.

Class VI. Attached tags

Δ **4.9.3**

A quick-disconnect device shall bear a clear and permanent marking of the following:

a) The manufacturer's identifying marking on each mating part.
b) The capacity, when the capacity of a quick-disconnect device of $^3/_8$ or $^1/_4$ inch inlet size is less than that specified in Table 6 (see Clause 5.2).
c) The direction of gas flow.
d) The maximum operating pressure.
e) The symbol of the organization making the tests for compliance with this standard.

Table 6
Minimum capacities for quick-disconnect devices
(See Clauses 4.9.3 and 5.2.1.)

Inlet size, inches	Minimum capacity Btu/hr, 0.64 Sp Gr 1000 Btu/ft³ gas at 0.3 in wc pressure drop
$^1/_8$	15 000
$^1/_4$	30 000
$^3/_8$	50 000

(Continued)

Table 6 (Concluded)

Inlet size, inches	Minimum capacity Btu/hr, 0.64 Sp Gr 1000 Btu/ft³ gas at 0.3 in wc pressure drop
1/2	75 000
3/4	115 000
1	175 000
1 1/4	290 000
1 1/2	385 000

4.9.4

Each mating part of a quick-disconnect device shall bear a date code marking, or the manufacturer shall submit a plan acceptable to the certifying agency which will outline means of establishing the date of manufacture so it is traceable to the purchaser.

When a date code marking is used, this marking shall consist of at least four consecutive digits determined as follows:

a) The first and second digits shall indicate the calendar year in which the device is manufactured (e. g., 13 for 2013).
b) The third and fourth digits shall indicate the week in which the device was manufactured (e.g. 03 for the third week of the year). For purposes of this marking a week shall begin at 0001 hours on Sunday and end at 2400 hours on Saturday.

The same date code may be used for more than one week. However, it shall not be used for more than four consecutive weeks, nor for more than two weeks into the next calendar year.

Additional numbers, letters or symbols may follow the four digit number specified in “-a” and “-b.” If additional numbers are used, they must be separated from the date code.

Δ **4.9.5**

A quick-disconnect device for use with a caster mounted (CM) appliance shall bear a clearly legible Class I permanent marking “CM.”

Δ **4.9.6**

A quick-disconnect device for use with a caster mounted appliance shall bear a Class IV marking tag stating that the quick-disconnect device is suitable for use with a caster mounted appliance and shall include the manufacturer's instructions for its proper application, installation and operation.

4.9.7

For commercial cooking applications the quick-disconnect device shall bear the following warning in 10-point type on a Class IIIA marking material:

“DO NOT REUSE FOR COMMERCIAL COOKING APPLICATIONS.”

Δ **4.9.8**

A quick-disconnect device shall bear a clearly legible marking:

a) “Indoor Use Only.” or

b) “Indoor/Outdoor Use” and“ -20°F (-29°C).” or
c) “Indoor/Outdoor Use” and“ -40°F (-40°C).”

Δ **4.9.9**

The manufacturer and certifying agency shall mutually agree to one of the following marking methods specified in Clause 4.9.8. This marking shall be:

a) A permanent marking; or
b) On a marking material that meets the performance test of Clause 5.7, Marking material adhesion and legibility; or
c) On a Marking material recognized as complying with the *Standard for Adhesive Labels, CSA C22.2 No. 0.15*, or the *Standard For Marking and Labeling Systems, UL 969,* and determined to be suitable for the conditions of intended use by the testing agency; or
d) Included on the attached instructions identified in Clause 4.8, Instructions or Clause 4.9.6.

5 Performance

5.1 Leakage

Δ **5.1.1**

A quick-disconnect device for use between 32°F and 200°F (0°C and 93.3°C) shall not leak in excess of 1.22 in^3 (20 cm^3) of air per hour when subjected to air pressures of 2.0 in wc (498 Pa) and 150 percent of the maximum rated working pressure.

Method of test

The inlet of the quick-disconnect device shall be connected to a pneumatic system capable of supplying clean air at the specified test pressures, and to a flow-measuring device capable of accurately indicating the allowable leak rate. The flow-measuring device shall be located between the air supply and the inlet of the device.

a) With the mating plug disconnected, the quick disconnect device shall be placed in a chamber and cooled to 32°F (0°C), as indicated by a thermocouple attached to the quick disconnect device. The quick disconnect device shall be maintained at 32°F (0°C) for at least 1 hour and throughout the remainder of the test. Air shall be admitted and maintained at a pressure of 2.0 in wc (498 Pa) for 1 minute, after which leakage shall be measured. The pressure shall then be increased slowly to 150 percent of maximum rated pressure and maintained at that pressure for 1 minute, after which leakage shall again be measured.
b) With the mating plug connected, the quick disconnect device shall be placed in a chamber and cooled to 32°F (0°C), as indicated by a thermocouple attached to the quick disconnect device. The quick disconnect device shall be maintained at 32°F (0°C) for at least 1 hour and throughout the remainder of the test. Air shall be admitted and maintained at a pressure of 2.0 in wc (498 Pa) for 1 minute, after which leakage shall be measured. The pressure shall then be increased slowly to 150 percent of maximum rated pressure and maintained at that pressure for 1 minute, after which leakage shall again be measured.

   The above tests shall be repeated with the quick disconnect device placed in a test oven and heated to 200°F (93.3°C) as indicated by a thermocouple attached to the quick disconnect device. The quick disconnect device shall be maintained at 200°F (93.3°C) for at least 1 hour and throughout the remainder of the tests

   Observed leak rates shall be corrected to standard conditions of 30 in Hg (101.3 kPa) pressure at 60°F (15.5°C).

c) There shall be no evidence of continuous leakage while the mating parts are being connected or disconnected at room temperature. It is acceptable to use a bubble bottle instead of a flow measuring device for this test only.

5.1.2

Leakage of quick-disconnect at –20°F (-29°C).

A quick-disconnect device intended for outdoor use shall not leak in excess of 3 in^3 (50cm^3) of air per hour at -20°F (-29°C) when subjected to air pressures of 2.0 in wc (498 Pa) and 150 percent of maximum rated working pressure.

Method of test

The leakage test as specified in Clause 5.1.1 shall be repeated on a quick-disconnect device that has been cooled to -20°F (-29°C) and maintained at this temperature for 1 hour, and throughout the remainder of the test.

If the manufacturer has a specified operating temperature of -40°F (-40°C), then the above test is to be conducted at -40°F (-40°C) instead of -20°F (-29°C).

5.2 Capacity

Δ

5.2.1

Test For Capacity For Quick-Disconnect Devices Rated in Btuh (kW).

The capacity of a quick-disconnect device shall not be less than that specified in Table 6 except for devices $^3/_8$ in or smaller.

When the capacity of a quick-disconnect device of $^3/_8$ or $^1/_4$ or $^1/_8$ in inlet size is less than that specified in Table 6, the device shall be permanently marked to indicate the capacity in Btu per hour at 0.3 in wc (0.075 kPa) pressure drop and the type of gas(es) for which the capacity has been specified.

Capacity shall be determined by the quantity in Btu per hour of a gas of 0.64 specific gravity having a total heating value of 1000 Btu/ft^3 (37.2 MJ/m^3) which can be passed with a pressure drop equal to 0.3 in wc (0.075 kPa).

Method of test

Standard weight pipe of proper size reamed to remove burrs caused by cutting shall be fitted to the inlet and outlet connections of the device. The straight runs of pipe before and after the device shall be of a length not less than 10 pipe diameters (I.D.). Two short lengths of metal tubing shall be soldered to the lengths of pipe before the inlet and after the outlet connections. These pressure tappings shall be located 5 pipe diameters (I.D.) from the inlet and outlet connection. A drill shall be inserted in the short length of tubing and a hole drilled through the walls of the large pipes, care being taken to remove any burrs caused thereby. The two pressure tappings shall be connected to a differential pressure gauge which may be read directly to at least 0.01 in wc (0.002 kPa). (See Table 6)

Either gas or air may be used for the test. If gas is used it shall be vented or burned as far away from the device, test meter and other instruments as will preclude the heating of such equipment. The gas rate shall be adjusted to give an indication on the gauge approximately equal to the pressure drop specified above, and the necessary observations made and recorded. Observations may be made at a number of different pressure drops.

The capacity of the device shall be resolved from these data according to the following formula:

$$q_{SC} = KQ_1\sqrt{\frac{P_t \times sp\ gr_t}{pd_t \times \Theta_t}}$$

where:

K = 2862 for U.S. customary units (189.54 for metric units)

q_{sc} = capacity with gas of 1000 Btu/ft³ (37.2 MJ/m³) and 0.64 sp gr [saturated with water at 60°F (15.5°C) and 30 in. Hg column (101.3 kPa)], at which a pressure drop of 0.3 inch equivalent water column (74.7 Pa) occurs, Btu/hr (kW);

Q_1 = quantity of test gas (or air) as metered, ft³/hr (m³/hr);

sp gr_t = corrected or actual specific gravity of test gas (or air) as metered;

P_t = absolute pressure of test gas (or air) as metered, in Hg column (kPa);

pd_t = observed pressure drop (corrected for difference in velocity head, if any, due to change of area at points tappings are taken), in wc (Pa); and

Θ_t = temperature of test gas (or air) as metered °F absolute (K).

In the event the areas at the inlet and outlet tappings are different, the formula outlined below for this condition shall be employed:

$$pd_t = pd_0 + hv_1 - hv_2$$

where

The velocity head, in. water column, at the inlet tapping (hv_1) or outlet tapping (hv_2) is found by the following formula:

$$h_V = \frac{C \times Q_1^2 \times P \times sp\ gr_t}{D^4\ \Theta_t}$$

and

C = 1.0335 x 10-5 for U.S. customary units (2.1923 x 10-10 for metric units);

Q_1 = quantity of test gas (or air) as metered, ft³/hr (m³/hr);

Sp gr_t = corrected or actual specific gravity of test gas (or air) as metered;

pd_o = pressure drop (may be negative) between inlet and outlet pressure tappings on manifold as observed, in wc (Pa);

D = inside diameter of pipe at inlet or outlet pressure tapping, in (mm);

P = absolute pressure of test gas (or air) at inlet or outlet pressure tapping, in Hg column (kPa); and,

Θ_t = temperature of test gas (or air) as metered, °F absolute (K).

5.2.2

Test for capacity for quick-disconnect devices rated in kilowatts.

The capacity of a quick-disconnection device shall not be less than that specified in Table 7, except for devices nominal $^3/_8$ in or smaller.

When the capacity of a quick-disconnect device of nominal $^3/_8$ or $^1/_4$ in inlet size is less than that specified in Table 7, the device shall be permanently marked to indicate the capacity in kilowatts at 75 Pa pressure drop and the type of gas(es) for which the capacity has been specified.

Capacity shall be determined by the quantity in kW of a gas of 0.64 Sp Gr having a total heating value of 37.9 MJ/m³ which can be passed with a pressure drop equal to 75 Pa.

Method of test

Standard weight pipe of proper size reamed to remove burrs caused by cutting shall be fitted to the inlet and outlet connections of the device. The straight runs of pipe before and after the device shall be of a length not less than 10 pipe diameters (I.D.). Two short lengths of metal tubing shall be soldered to the lengths of pipe before the inlet and after the outlet connections. These pressure tappings shall be located 5 pipe diameters (I.D.) from the inlet and outlet connection. A drill shall be inserted in the short length of tubing and a hole drilled through the walls of the large pipes, care being taken to remove any burrs caused thereby. The two pressure tappings shall be connected to a differential pressure gauge which may be read directly to at least 2.5 Pa.

Either gas or air may be used for the test. If gas is used it shall be vented or burned as far away from the device, test meter and other instruments as will preclude the heating of such equipment. The gas rate shall be adjusted to give an indication on the gauge approximately equal to the pressure drop specified above, and the necessary observations made and recorded. Observations may be made at a number of different pressure drops. (See Table 7)

The capacity of the device shall be resolved from these data according to the following formula:

$$q_{sc} = 97.675 K Q_1 \sqrt{\frac{P_t \times rd_t}{pd_t \times \Theta_t}}$$

where:

q_{sc} = capacity with gas of 37.9 MJ/m³ and 0.64 relative density (saturated with water at 15.6°C and 101.3 kPa, kW;

K = 1.94 for natural gas (other values should be used for other gases);

Q_1 = quantity of test gas (or air) as metered, m³/h;

rd_t = corrected or actual relative density of test gas (or air) as metered;

P_t = absolute pressure of test gas (or air as metered), kPa;

pd_t = observed pressure drop (corrected for difference in velocity head, if any, due to change of area at points tappings are taken), Pa; and

Θ = temperature of test gas (or air) as metered, degree K.

In the event the areas at the inlet and outlet tappings are different:

$$pd_t = pd_o + hv1 - hv2$$

where:

The velocity head, Pa, at the inlet tapping (hv1) or outlet tapping (hv2) is found by the following formula:

$$h_v = \frac{2.1963 \times 10^{-5} \times Q_1^2 \times P \times rd_t}{D^4 \Theta_t}$$

and:

pd_o = pressure drop (may be negative) between inlet and outlet pressure tappings on manifold as observed, Pa;

D = inside diameter of pipe at inlet or outlet pressure tapping, mm; and

P = absolute pressure of test gas (or air) at inlet or outlet pressure tapping, kPa.

Table 7
Minimum capacities for quick-disconnect devices
(See Clause 5.2.2.)

Inlet size, inches	Minimum capacity KW 0.64 Sp Gr 37.9 MJ/m³ at 75 Pa. pressure drop
1/4	8.8
3/8	15
1/2	22
3/4	34
1	52
1 1/4	85
1 1/2	113

5.3 Durability at high temperatures

5.3.1

Quick-disconnect devices shall be capable of withstanding a temperature of 800°F (427°C) without leakage in excess of 1.0 ft³ (0.03 m³) in 10 minutes at 14.0 in wc (3.5 kPa) test pressure.

Method of test

Thermocouples shall be soldered, brazed or otherwise attached to three assembled devices to determine their temperature. The devices shall then be placed in a preheated oven. When the temperature of the devices reaches 790°F (422°C), oven temperature shall be adjusted so that the temperature of the devices does not exceed 810°F (432°C) nor drop below 790°F (422°C) in the succeeding 15 minutes. At the end of this period, the devices shall be removed from the oven and cooled to room temperature.

The outlets of the assembled devices shall then be plugged or capped and the devices individually attached to a suitable pneumatic system capable of supplying clean air or nitrogen at pressures up to 14.0 in wc (3.5 kPa) and incorporating a flow meter capable of indicating accurately a flow rate of 1.0 ft³ (0.03 m³) in 10 minutes. Leakage readings shall be taken at internal gas pressures up to and including 14.0 in wc (3.5 kPa).

Any leakage noted shall not be in excess of 1.0 ft³ (0.03 m³) in 10 minutes.

The above tests shall also be performed on three additional devices with the mating parts separated. The inlet ends only shall then be tested for leakage as outlined above.

5.3.2

Quick-disconnect devices shall be capable of withstanding a temperature of 350°F (177°C) without leakage when subjected to a test pressure of 14.0 in wc (3.5 kPa).

Method of test

Thermocouples shall be soldered, brazed or otherwise attached to three assembled devices to determine their temperature. The devices shall then be placed in a preheated oven. When the devices have attained a temperature of 340°F (171°C), oven temperature shall be adjusted so that the temperature of the device is maintained within plus 10°F (5.5°C) of 350°F (177°C) for the succeeding 15 minutes. At the end of this period, the devices shall be removed from the oven, cooled at room temperature and tested for leakage as specified in Clause 5.1, with the exception that a test pressure of 14.0 in wc (3.5 kPa) shall be applied.

The above tests shall also be conducted on three additional devices with the mating parts separated.

Δ 5.4 Continued operation

A quick-disconnect device shall show no evidence of leakage or undue wear after the conduct of Clauses 5.4.1 and 5.4.2.

The device shall not be lubricated or serviced in any manner during these tests.

Following conduct of the tests under Clauses 5.4.1 and 5.4.2, the device shall be tested for leakage at room temperature as specified in Clause 5.1, Leakage and shall comply.

5.4.1

The device shall be subjected to 4000 connecting and disconnecting cycles.

5.4.2

If the device is capable of rotation, 4000 cycles through the available degree of rotation, up to 360 degrees (6.29 rad), shall be applied in alternate directions. The first 2000 cycles shall be applied with the device previously tested under Clause 5.4.1 installed in the horizontal position and the remaining 2000 cycles in the vertical position with the part containing the automatic means to shut off the gas positioned on the bottom. The cycles shall be applied at a rate which will not cause an appreciable increase in the temperature of the device and in a manner that will not result in side thrust being applied to the device.

This test may be conducted concurrently with Clause 5.4.1.

5.5 Season cracking

Specimens of brass devices shall not show cracks or flaws when tested in accordance with the *Standard for Test Method for Ammonia Vapor Test for Determination Susceptibility to Stress Corrosion Cracking in Copper Alloys, ASTM B858*, using a pH value of 9.8 - 10.0. This test shall be conducted on unplated samples.

5.6 Low temperature operation

A quick-disconnect device intended for outdoor use shall be capable of operation at low temperature as specified below. This test may be performed concurrently with the leakage test specified in Clause 5.1, Leakage .

The force necessary to connect and disconnect a quick-disconnect device at low temperatures shall not exceed 60 lb (267 N) as specified in the following Method of test.

Method of test

A quick-disconnect shall be placed in a chamber and cooled to -20°F (-29°C) as indicated by a thermocouple attached to the device. The quick-disconnect shall then be maintained at this temperature for at least 1 hour. The quick-disconnect mating plug shall then be connected and disconnected 10 times. During each cycle the force to connect or disconnect the device shall not exceed that specified above.

If operation at -40°F (-40°C) is specified by the manufacturer, then the above test shall be performed at -40°F (-40°C) instead of -20°F (-29°C).

5.7 Marking material adhesion and legibility

This test applies only to markings specified in Clause 4.9, Markings.

The adhesive quality of marking materials and the legibility of all marking materials shall not be adversely affected when the materials, are exposed to heat, cold and water as specified in the following Method of test.

Method of test

One sample of the quick disconnect, shall be placed in a test oven and heated to 125°F (51.5°C).and one sample shall be placed in a chamber cooled to the minimum operating temperature of the quick disconnect (-20°F (-29°C) or -40°F (-40°C)). These samples shall remain at the specified temperatures for seven days. Following this test each marking shall exhibit:

a) Good adhesion and no curling at edges;
b) No illegible or defaced printing by rubbing with thumb or finger pressure; and
c) Good adhesion when a dull metal blade (as the back of a pocketknife blade) is held at right angles to the applied marking and scraped across the edges of the marking.

These samples shall then be immersed in water for a period of 24 hours after which adhesion and legibility shall be rechecked as specified above.

6 Manufacturing and production tests

The manufacturer shall submit to the certifying agency a plan which is mutually acceptable to the manufacturer and the certifying agency and which describes the programs and test procedures specified in Clauses 6.1, 6.2 and 6.3, and the records to be kept by the manufacturer.

6.1

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

6.2

The manufacturer shall test each device covered by this standard for leakage to atmosphere.

6.3

The manufacturer shall use a program which includes a mutually acceptable schedule(s) to:

a) Conduct continued operation tests;

b) Conduct safety tests;
c) Check high temperature operation; and
d) Conduct strength tests on complete valves.

6.4

The manufacturer's test method(s) shall be capable of relating back to the test(s) specified in the standard.

Annex A (Normative)
Items unique to Canada

A.1 Units of measurement

SI units are the units of record in Canada. Units of measurement required on printed instructions and markings shall include the SI (metric) values as a minimum.

A.2 French installation and marking provisions

All installation and marking provisions specified in this standard are required to be in a form easily understood in both English and French.

French translations for quoted instructions and markings.

	English	French
4.9.5	Quick-disconnect devices for use with caster mounted equipment shall bear a clearly legible permanent marking “CM.”	*«CM»*
4.9.7	For commercial cooking applications the quick-disconnect device shall bear the following warning in 10-point type on a Class IIIA marking material: “DO NOT REUSE FOR COMMERCIAL COOKING APPLICATIONS.”	«NE PAS RÉUTILISER DANS UN CONTEXTE COMMERCIAL»
4.9.8	A quick-disconnect device shall bear a clearly legible marking: “For Indoor Use Only.” or “For Indoor/Outdoor Use” and“ -20°F (-29°C).” or “For Indoor/Outdoor Use” and“ -40°F (-40°C).”	a) «Pour utilisation à l'intérieur seulement.» b) «Pour utilisation à l'intérieur/à l'extérieur.»

Annex B
Table of conversion factors

Note: *This annex is informative and is not part of the standard.*

B.1

Table B.1
Table of conversion factors

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	2.540×10	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	2.832×10	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
	mile/hour	m/hr	1.609	6.214×10^{-1}	k/hr	kilometer/hour
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	2.835×10	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	1.602×10	6.243×10^{-2}	kg/m^3	kilogram/meter^3
SPECIFIC VOLUME	foot^3/pound	ft^3/lb	6.243×10^{-2}	1.602×10	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^2hr	1.356×10^{-3}	7.374×10^{2}	kg/m^2s	kilogram/ meter^{2}second
	pound/inch^{2}hour	lb/in^2hr	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	2.832×10	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}	2.119×10	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}	1.585×10	l/s	liter/second
	gallon/hour	gal/hr	1.052×10^{-6}	9.505×10^{5}	m^3/s	meter^3/second

(Continued)

Table B.1 (Concluded)

Quantity	U. S. unit		Multiplying factor		SI units*	
	Name	Symbol	U.S. to SI	SI to U.S.	Symbol	Name
	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	4.788×10	2.088×10^{-2}	Pa	pascal
	atmosphere	inch H_2O (4°C)	2.491×10^{2}	4.014×10^{-3}	Pa	pascal
	pounds/square	inch Hg (0°C)	3.386×10^{3}	2.953×10^{-4}	Pa	pascal
	inch‡	atm (std)	1.013×10^{5}	9.871×10^{-6}	Pa	pascal
	pounds/square	psi	2.768×10	3.613×10^{-2}	iwc	inch water column
	inch	psi	6.895×10	1.450×10^{-2}	mb	millibar
	inch water column	iwc	2.491	4.015×10^{-1}	mb	millibar
ENERGY, WORK, QUANTITY OF HEAT		Btu	1.055×10^{3}	9.478×10^{-4}	J	joule
	horsepower hour	Btu	1.055	9.478×10^{-1}	kJ	kilojoule
	horsepower hour	hphr	2.685×10^{6}	3.724×10^{-7}	J	joule
	kilowatt hour	hphr	2.685	3.724×10^{-1}	MJ	megajoule
	kilowatt hour	kwhr	3.6×10^{6}	2.777×10^{-7}	J	joule
		kwhr	3.6	2.777×10^{-1}	MJ	megajoule
POWER, HEAT FLOW RATE	Btu/hr		2.931×10^{-1}	3.412	W	watt
	Btu/hr		2.931×10^{-4}	3.412×10^{3}	kW	kilowatt
	hp		7.457×10^{2}	1.341×10^{-3}	W	watt
	hp		7.457×10^{-1}	1.341	kW	kilowatt
	ton refrigeration (12,000 Btu/hr)		3.516×10^{3}	2.844×10^{-4}	W	watt
	ton refrigeration (12,000 Btu/hr)		3.516	2.844×10^{-1}	kW	kilowatt
	Btu/hour Btu/hr		2.929×10^{-4}	3.414×10^{3}	kW	kilowatt
	Btu/hourfoot^2 Btu/hrft^2		3.155	3.1695×10^{-1}	W/m^2	watt/meter^2
HEAT CAPACITY SPECIFIC HEAT CAPACITY	Btu/degree F		1.899×10^{3}	5.265×10^{-4}	J/°C	joule/degree Celsius
	Btu/	Btu/°F	4.187×10^{3}	2.388×10^{-2}	J/kg•°C	joule/kg•degree Celsius
	pounddegree F	Btu/lb°F	4.187	2.388×10^{-5}	kJ/kg•°C	kilojoule/ kg•degree Celsius
	Btu/ pounddegree F	Btu/lb°F				
LATENT HEAT	Btu/pound	Btu/lb	2.326×10^{3}	4.299×10^{-4}	J/kg	joule/kilogram
	Btu/pound	Btu/lb	2.326	4.299×10^{-1}	kJ/kg	kilojoule/kilogram
VOLUME AT STD. CONDITIONS†	ft^3 (60°F, 30 inches Hg, sat)		.9826	1.0177	ft^3 (60°F, 30 inches Hg, dry)	
	" " "		.02784	35.92	m^3 (15°C, 760 mm Hg, dry)	
	" " "		.02832	35.31	m^3 (15°C, 760 mm Hg, sat)	
	" " "		.02639	37.89	m^3 (0°C, 760 mm Hg, dry)	
	" " "		.02655	37.66	m^3 (0°C, 760 mm Hg, sat)	
HEATING VALUE	Btu/cubic foot	Btu/ft^3	3.752×10^{-2}	2.684×10	MJ/m^3	megajoule/meter^3

** 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 (ms3) measured @ 15°C and 760 mm Hg, dry. (SI Conditions)
Normal cubic meter (mn3) measured @ 0°C and 760 mm Hg, dry.
‡ U.S. unit to U.S. unit.

B.2

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	–40.0	25	77.0	70	158.0
–20	–4.0	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	M
1 000	=	10^{3}	kilo	k
100	=	10^{2}	hecto	h
10	=	10^{1}	deka	da
0.1	=	10^{-1}	deci	d
0.01	=	10^{-2}	centi	c
0.001	=	10^{-3}	milli	m
0.000 001	=	10^{-6}	micro	µ
0.000 000 001	=	10^{-9}	nano	n
0.000 000 000 001	=	10^{-12}	pico	p

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