ANSI Z21.87-2007
CSA 4.6-2007

American National Standard/
CSA Standard For

Automatic Gas Shutoff Devices For Hot Water Supply Systems

AMERICAN NATIONAL STANDARD
ANSI Z21.87-2007

CSA STANDARD
CSA 4.6-2007

Second Edition - 2007
This Standard is based on the Standard for
Automatic Gas Shutoff Devices
For Hot Water Supply Systems
ANSI Z21.87-1999 • CSA 4.6-M99
and ANSI Z21.87a-2004 • CSA 4.6a-2004,
ANSI Z21.87b-2005 • CSA 4.6b-2005

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ANSI provides that the interests of the public may have appropriate participation and representation in standardization activity, and cooperates with departments and agencies of U.S. Federal, state and local governments in achieving compatibility between government codes and standards and the voluntary standards of industry and commerce.

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10036

Preface

This publication represents a basic standard for safe operation, substantial and durable construction, and acceptable performance of automatic gas shutoff devices for hot water supply systems. It is the result of years of experience in the manufacture, testing, installation, maintenance, inspection and research on automatic gas shutoff devices for hot water supply systems. There are risks of injury to persons inherent in appliances that, if completely eliminated, would defeat the utility of the appliance. The provisions in this standard are intended to help reduce such risks while retaining the normal operation of the appliance.

Nothing in this standard is to be considered in any way as indicating a measure of quality beyond compliance with the provisions it contains. It is designed to allow compliance of automatic gas shutoff devices for hot water supply systems, the safety construction and performance of which may exceed the various provisions specified herein. In its preparation, recognition has been given to possibilities of improvement through ingenuity of design. As progress takes place, revisions may become necessary. When they are believed desirable, recommendations or suggestions should be forwarded to the Chairman of the Z21/83 Committee, 8501 East Pleasant Valley Road, Cleveland, Ohio 44131, or the Chairman of CSA Technical Committee on Gas Appliances and Related Accessories, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.

Safe and satisfactory operation of automatic gas shutoff devices for hot water supply systems depends to a great extent upon its proper installation, use and maintenance. It should be installed, as applicable, in accordance with the *National Fuel Gas Code, ANSI Z223.1*; the *Natural Gas and Propane Installation Code, CAN/CSA-B149.1*.

Users of this American National Standard/CSA Standard are advised that the devices, products and activities within its scope may be subject to regulation at the Federal, Territorial, Provincial, state or local level. Users are strongly urged to investigate this possibility through appropriate channels. In the event of a conflict with this standard, the Federal, Territorial, Provincial, state or local regulation should be followed.

THIS STANDARD IS INTENDED TO BE USED BY THE MANUFACTURING SECTOR AND BY THOSE APPLYING THE EQUIPMENT AND BY THOSE RESPONSIBLE FOR ITS PROPER INSTALLATION. IT IS THE RESPONSIBILITY OF THESE USERS TO DETERMINE THAT IN EACH CASE THIS STANDARD IS SUITABLE FOR AND APPLICABLE TO THE SPECIFIC USE THEY INTEND.

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EFFECTIVE DATE: An organization using this standard for product evaluation as a part of its certification program will normally establish the date by which all products certified by that organization should comply with this standard.

History Of The Development Of The Standard For Automatic Gas Shutoff Devices For Hot Water Supply Systems

(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 October 24, 1995 meeting, the Z21/CGA Joint Subcommittee on Standards for Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems appointed an ad hoc working group to prepare a draft bi-national standard for Automatic Gas Shutoff Devices. By letter ballot dated May 16, 1997, the joint subcommittee approved sending the draft standard for public review and comment.

The first draft harmonized standard was based on current coverage from the American National Standard for Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems, Z21.22-1986, and the Canadian Gas Association Standard for Automatic Gas Shutoff Valves and Devices for Hot Water Supply Systems, CAN1-4.6-78.

Following reconsideration and modification of the proposed draft standard, in light of comments received, the joint relief valve subcommittee at its September 30, 1997 meeting, recommended the proposed draft standard to Accredited Standards Committee Z21/83 and the (Interim CSA) Standards Steering Committee for approval.

The proposed draft of the harmonized standard for automatic gas shutoff devices, as modified by the joint subcommittee, was approved by the Z21/83 Committee at its April 30, 1998 meeting, and by the CGA Standards Steering Committee by letter ballot dated October 27, 1998.

The first edition of the American National Standard/CSA Standard for Automatic Gas Shutoff Devices for Hot Water Supply Systems was approved by the Canadian Interprovincial Gas Advisory Council on January 21, 1999, and by the American National Standards Institute, Inc., on October 16, 1998.

The second edition of the American National Standard/CSA Standard for Automatic Gas Shutoff Devices for Hot Water Supply Systems was approved by the Canadian Interprovincial Gas Advisory Council on September 14, 2007, and by the American National Standards Institute, Inc., on July 19, 2007.

The following identifies the designation and year of the harmonized standard:

ANSI Z21.87-1999 • CSA 4.6-M99
ANSI Z21.87a-2004 • CSA 4.6a-2004
ANSI Z21.87b-2005 • CSA 4.6b-2005

The following identifies the designation and year of the second edition of the standard:

ANSI Z21.87-2007 • CSA 4.6-2007

Note: This the second edition of Z21.87 • CSA 4.6 incorporates changes to the 1999 edition and addenda thereto. Changes, other than editorial, are denoted by a vertical line in the margin.

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Contents

Page

Part I Construction

Part II Performance

Tables

Figures

Contents (Continued)

NOTE

This standard contains SI (Metric) equivalents to the yard/pound quantities, the purpose being to allow the standard to be used in SI (Metric) units. (IEEE/ASTM SI-10 or CAN/CSA Z234.1 are used as a guide in making metric conversion from yard/pound quantities.) If a value for a measurement and an equivalent value in other units, the first stated is to be regarded as the requirement. The given equivalent value may be approximate. Except as noted if in Exhibit A, if a value for a measurement and an equivalent value in other units, are both specified as a quoted marking requirement, the first stated unit, or both shall be provided.

American National Standard/CSA Standard For Automatic Gas Shutoff Devices For Hot Water Supply Systems

Part I: Construction

1.1 Scope

1.1.1
This standard applies to newly produced automatic gas shutoff valves and devices constructed entirely of new, unused parts and materials.

When the term "device" is used in a provision of this standard, it refers to all types of automatic gas shutoff devices, unless otherwise specified.

1.1.2
An automatic gas shutoff device shall operate when the temperature sensing element is at 210°F (99°C) or less. A device with a higher operating temperature is not acceptable under this standard.

1.1.3
Exhibit A, Items Unique to the United States, contains provisions that are unique to the United States.

1.1.4
Exhibit B, Items Unique to Canada, contains provisions that are unique to Canada.

1.1.5
Exhibit C, List of Reference Standards, contains a list of reference standards.

1.2 General

1.2.1
An automatic gas shutoff valve shall be of the automatic reset type or the manual reset type.

A single-use type fusible cartridge or linkage shall not be employed in an automatic gas shutoff valve.

An automatic gas shutoff device designed to be part of an electrical system shall be of the automatic reset type, the manual reset type or the single-use type.

1.2.2
The construction of valves and shutoff devices shall be such that, in the course of normal handling and installation, they will not become damaged to an extent that would prevent their continued compliance with this standard.

1.2.3
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.

1.2.4

A gas shutoff device which is an integral assembly of a gas shutoff valve and an immersion type of temperature sensing element shall be constructed so that water will not pass into gas channels in the event of failure of parts immersed in water. Construction such that any surface exposed to water is without joints or seams, or has properly welded, brazed, silver-soldered or pressuretight threaded joints, shall be considered as complying with this provision.

1.2.5

The electrical contacts of switches shall be totally enclosed to prevent the entrance of dust or foreign matter.

1.2.6

The electrical contacts of switches shall open to effect gas shutoff.

1.2.7

Thermistor(s) used in automatic gas shutoff devices shall comply with the applicable provisions of the *Standard for Thermistor-Type Devices, UL 1434*.

1.2.8

Thermistors used as temperature sensors shall not carry a load current.

1.3 Data Furnished By Manufacturer

The manufacturer shall furnish the following as appropriate, for use by the testing agency in examining devices under this standard.

a. Drawings, blueprints, or photographs which describe each model, as specified by the testing agency.

b. Shutoff and reset temperature.

c. Each component of an automatic gas shutoff device shall be capable of operations throughout an ambient temperature range of 32°F (0°C) to 125°F (51.5°C). The manufacturer is allowed to specify temperatures below 32°F (0°C) and above 125°F (51.5°C).

d. The fuel gases for which intended.

e. Capacity with 1000 Btu/ft^3 (37.26 MJ/m^3), 0.64 specific gravity gas at a pressure drop of 1.0 in wc (249 Pa).

f. Minimum and maximum electrical resistance.

g. The rated current at rated voltage.

h. Documentation and risk assessment for safety-related software (See 2.6.2).

1.4 Materials

1.4.1

Polymeric insulating material(s) and enclosures shall comply with the *Standard for Polymeric Materials Use in Electrical Equipment Evaluations, UL 746C*. Dust covers are not considered to be enclosures and are exempt from this provision.

1.4.2

A polymeric part intended for the direct support of current-carrying parts, or as an electrical enclosure, shall be molded from material classified as 94-5VA, 95-5VB, 94V-0, or 94V-2 by the vertical burning test described in the *Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94* or the equivalent classification in the *Standard for Evaluation of Properties of Polymeric Materials CAN/CSA C22.2 No. 0.17.*

1.4.3

Devices employing a nonmetallic electrical enclosure shall withstand a 3.32 lb-ft (4.5 Nm) impact without exposure of live parts, impairment of operation, or creation of a risk of electrical shock.

Method of Test

The enclosure shall be mounted securely in a position of intended use on a surface representative of a typical installation. A 1.18 lb (535 g), 2 in (50.8 mm) diameter steel sphere is to be dropped from a height of 33.75 in (857 mm) or swung through a pendulum arc from a sufficient height to apply 3.32 lb-ft (4.5 Nm) of energy to the weakest section of the enclosure.

Following the impact, the device shall be examined and energized from a source of rated voltage and frequency and checked for normal operation. Cracking of the enclosure is acceptable if it does not impair operation of the device. Following the impact test the device shall comply with 2.2.1 (shutoff and reset temperatures).

1.5 Connections And Flow Areas

1.5.1

Tappings and threadings for connecting the device to tanks, gas pipes, water pipes or drains 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.*

Inlet and outlet connections shall be designed so that when a pipe which is threaded two threads beyond standard (for the size in question) is run into the threaded portion of a valve body, it will not materially reduce the capacity of the valve, distort any portion of the valve body, or adversely affect the operation of the valve.

1.5.2

All valve connections (inlet, outlet, etc.) shall be permanently marked to aid in correct installation of the device. Only markings which are stamped, etched, or cast on the valve shall be considered as complying with this provision.

1.6 Bolts, Nuts And Screws

Threads of bolts, nuts and screws used in the assembly of body parts or for installation of the device shall be in accordance with 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 68-1; or General Purpose Metric Screw Threads - General Plan, ISO 261*.

1.7 Adjustments

1.7.1

Devices covered by this standard shall have no means for field adjustment of temperature settings.

1.7.2

An automatic gas shutoff device having a temperature sensing element shall have no means for removal of the sensing element without disassembly of the device.

1.8 Strength

1.8.1

The strength of all parts and joints of the body of the device shall be such that no evidence of leakage or permanent deformation will develop as a result of the tests specified herein.

1.8.2

The device shall be capable of withstanding, without deformation, breakage or leakage, the turning effort exerted to connect the device to a tank or piping specified in Table I, Turning Effect.

Method of Test

Five samples of each style of device shall be subjected to the tests specified and none shall show evidence of design failure.

A pipe wrench or open-end wrench shall be utilized to apply the turning force. The turning force shall be applied to the wrench grip of the device or to the body of the device if a wrench grip is not provided. The measured torque specified in Table I shall be applied to the completely assembled device in fitting it into a tank or extra heavy piping of suitable size. Pipe thread lubricants and sealants shall not be used. After the force has been applied for 15 minutes, it shall be released, the device removed and examined for deformation or breakage, and then subjected to the leakage test(s) specified in 2.3, Leakage.

1.8.3

All parts of an automatic gas shutoff valve subjected to gas pressure, except a diaphragm, shall withstand a static pressure of 2.5 psi (17.2 kPa).

Method of Test

A separate automatic gas shutoff valve not used for the conduct of other tests shall be used for this test.

The inlet and outlet of the valve shall be connected to a suitable hydraulic system under room temperature conditions [77 ± 10°F (25 ± 5.5°C)].

The pressure shall be raised slowly to 2.5 psi (17.2 kPa) and held at that pressure for 1 minute.

For a diaphragm type valve, the diaphragm shall be substantially removed to permit the test medium to flow freely to both sides of the diaphragm chamber.

There shall be no sign of rupture or mechanical dislocation of parts of the enclosure communicating with the atmosphere.

1.8.4

A surface contact type gas shutoff device shall be constructed so as to provide means for holding the device securely against a tank without distorting the body or changing the electrical or operating characteristics.

1.9 Corrosion

1.9.1

Parts of a valve which are constantly in contact with water shall possess a resistance to corrosion equivalent to that of brass containing at least 60 percent copper.

1.9.2

Materials, or coatings of materials provided with protective coatings, for automatic mechanisms and current-carrying components exposed to fuel gases shall be resistant to moisture, sulfur compounds, corrosion and the effects of such gases. Parts containing in excess of 65 percent copper exposed to fuel gas, other than cast or forged bodies, shall be protected from the effects of sulfur-bearing compounds.

1.9.3

Surface of millivoltage switching contacts shall be of gold or equivalent.

1.9.4

Surfaces of electrical terminal connections shall be coated with tin or equivalently treated.

1.10 Thermal Sensing Element TubeS

For a device containing part(s) intended for contact with potable water, the manufacturer shall supply evidence satisfactory to the testing agency that material used as a protective coating for thermal sensing element tubes is suitable for the service, particularly with respect to toxicity, solubility, brittleness and temperature limits. Evidence of current certification under *National Sanitation Foundation Standard ANSI/NSF 14, Plastic Piping System Components and Related Materials* with appropriate end use shall be deemed acceptable.

1.11 Assembly

The construction of an automatic gas shutoff valve shall be such that operating parts are not capable of field disassembly. Use of tamper-resistant fastenings is acceptable.

1.12 Instructions

1.12.1

A device supplied for field installation shall be accompanied by complete and proper installation instructions. These instructions shall be reviewed by the testing agency for accuracy and compatibility with results of test from a technical standpoint.

1.12.2

Instructions for immersion type gas shutoff devices that do not have extension elements shall specify that the valve be mounted directly in a tank tapping located within the top 6 in (152 mm) of the tank and shall be adequately insulated and located so as to be isolated from flue gas heat or other ambient conditions that are not indicative of stored water temperature.

Instructions for a surface contact type gas shutoff device shall specify that the temperature sensing element be securely located against the exterior surface of the tank within 6 in (152 mm) of the top and shall be adequately insulated and located so as to be isolated from flue gas heat or other ambient conditions that are not indicative of stored water temperature.

Sketches or diagrams showing recommended methods of installation shall be provided.

1.13 Marking

1.13.1

Each automatic gas shutoff device and automatic gas shutoff valve shall bear a marking on which appears the following:

a. Manufacturer's or dealer's name, trademark or symbol.

b. Name or model number of the device.

c. Symbol of the organization making the tests for compliance with this standard.

1.13.2

Each automatic gas shutoff device shall bear a separate marking indicating the date of manufacture. This marking shall be as specified in "a," "b" or "c" below:

a. The date in the form of:

    1. The month, day and year; or

    2. The day, month and year.

The abbreviation of the month shall be at least the first three letters of the month. The day may be the Monday of the week and the year must be at least the last two digits of the year.

b. A four digit code consisting of:

    1. The first and second digits indicating the calendar year in which the device was manufactured (e.g., 07 for 2007).

    2. The third and fourth digits indicating 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.

A four digit 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.

c. A five-digit code consisting of:

1. The first and second digits indicating the calendar year in which the automatic gas shutoff device was manufactured (e.g., 07 for 2007); and

2. The third, fourth and fifth digits indicating the day of the year in which the automatic gas shutoff device was manufactured (e.g., 183 for the one hundred and eighty-third day in the year 2007, which is July 2, 2007).

Additional numbers, letters or symbols may follow the five digit code. If additional numbers are used, they shall be separated from the five-digit code.

1.13.3

Automatic gas shutoff valves of the immersion type having extended elements shall be marked with the length in inches, to the nearest full inch, of the extension element beyond the inlet of the valve. This marking may be included as a suffix to the manufacturer's model or type number.

1.13.4

a. The markings specified in 1.13.1 through 1.13.3 and "-b" in this provision shall be securely affixed to the device and shall meet the following specifications. All metal marking materials shall be rustproof. All markings shall be suitable for application to the surfaces upon which applied and shall demonstrate suitable legibility as specified under 2.11, Marking Material Adhesion and Legibility.

b. A gas shutoff device shall be marked with the shutoff temperature or temperature code and corresponding identification number.

c. Also see 1.5.2.

1.13.5

Electrical devices supplied with current from an external source, except thermoelectric devices shall be marked with voltage and current rating and, if applicable, frequency rating.

Part II: Performance

2.1 General

The performance of a shutoff device observed during conduct of the tests prescribed herein shall show no indication that the device will not continue to comply with this standard in the course of normal usage.

2.2 Shutoff And Reset Temperatures

2.2.1

A gas shutoff device shall operate to shut off the gas supply within ± 10°F (5.5°C) of the manufacturer's specified shutoff temperature, but in no case at a temperature greater than 210°F (99°C).

A gas shutoff device of other than the single-use type shall automatically reset or shall function to be manually resettable at a temperature not lower than 120°F (49°C).

Method of Test

Four devices shall be simultaneously tested installed on a suitable water bath. The four samples are to be provided with individual thermocouples complying with the next paragraph. The temperature sensing element of an immersion type of device shall be immersed in the water as in normal installation. A surface contact type of device shall be attached to the exterior of a side of the bath formed on a radius of 6 in (152 mm) with the temperature sensing element in contact with that surface. A 2 in (50.8 mm) thick pad of glass wool insulation extending at least 2 in (50.8 mm) beyond the device shall be placed directly over the device.

Operating temperatures shall be determined with a single No. 24 AWG (0.20 mm^2) thermocouple for each device. With immersion temperature sensing elements, the thermocouple shall be placed as close to the element as possible opposite the midpoint of its length. With surface contact temperature sensing elements, the thermocouple shall be silver-soldered to the interior surface of the bath immediately opposite the location of the geometrical center of the element.

The opening of an electrical circuit within a device is to be determined by any suitable means connected in a circuit typical of that in which the device is to be used.

The bath shall be filled with water and heated until the four test thermocouples indicate an average temperature 20°F (11°C) less than the manufacturer's specified shutoff temperature. The rate of heating then shall be controlled to cause a temperature rise of not less than 1°F (0.5°C) not more than 2°F (1°C) per minute. The temperature indicated by a test thermocouple at the instant the corresponding device functions shall be recorded.

With devices of other than the single-use type, the means for heating the bath shall then be shut off and cold water admitted in such a manner that it does not flow directly against the side of the bath in which the devices are installed. As the average temperature indicated by the test thermocouple approaches the reset temperature, the flow of water shall be controlled to cause a temperature decrease of not more than 1°F (0.5°C) per minute. At the instant the indicated temperature for each device reaches 120°F (49°C), the device shall have reset or shall have functioned to be resettable.

One determination of shutoff temperature and, if applicable, one verification of reset operation for each device shall be made. All shall comply.

2.2.2

A gas shutoff device for field installation, when installed on a hot water storage vessel in accordance with the manufacturer's installation instructions (see 1.12.2), shall operate to shut off the gas supply when the temperature of the stored water within the upper 6 in (152 mm) of the storage vessel is at or below 210°F (99°C).

Method of Test

The gas shutoff device shall be installed on a suitable automatic storage type water heater in accordance with the manufacturer's installation instructions (see 1.12.2).

The automatic storage type water heater shall be equipped with a control which will permit adjustment for a water temperature of 220 ± 5°F (104.5 ± 3°C). A thermocouple or thermometer shall be installed 3 in (76.2 mm) below the top of the storage vessel for measuring the temperature of the stored water. The input rating of the water heater shall be adjusted so that the water temperature rise within the storage vessel is not less than 4°F (2°C) nor more than 5°F (3°C) per minute.

The automatic storage water heater shall then be filled with water at a temperature of less than 140°F (60°C). Some water shall then be drawn from the hot water outlet, after which the hot water outlet shall be closed.

The burner of the water heater shall be operated until the temperature of the stored water 3 in (76.2 mm) below the top of the storage vessel reaches 140 ± 5°F (60 ± 3°C). The burner shall then be shut off for a period of 15 minutes. The water heater control shall then be set at 220°F (104.5°C) and the burner operated. The device shall function to shut off the gas supply when the temperature of the stored water within the upper 6 in (152 mm) of the storage vessel is at or below 210°F (99°C).

2.2.3

Aging at a constant elevated temperature shall not affect the shutoff and reset temperatures of an automatic gas shutoff device.

Method of Test

The same four reset type devices tested under 2.2.1 or four new single-use type devices from the same production run as the samples tested under 2.2.1 shall be used for this test. The four devices shall be tested installed in the same manner as specified in 2.2.1. The bath shall be heated until the test thermocouples indicate an average temperature 10°F (5.5°C) less than the average of the four shutoff temperatures obtained during conduct of 2.2.1. This temperature shall be maintained within ± 1°F (± 0.5°C) for seven days and no operation of the devices shall occur.

Within an intervening initial cooling period, a determination of shutoff temperature and, if applicable, a verification of reset operation shall then be made for each device as specified in 2.2.1. All shutoff temperatures shall be within ± 10°F (5.5°C) of the average shutoff temperature originally obtained during conduct of 2.2.1, but in no case more than 210°F (99°C).

2.2.4

Aging at usage temperatures shall not affect the shutoff and reset temperatures of an automatic gas shutoff device.

Method of Test

The same four reset type devices tested under 2.2.1 or four new single-use type devices from the same production run as the samples tested under 2.2.1 shall be used for this test. The four devices shall be tested installed in the same manner as specified in 2.2.1. The bath shall be heated until the test thermocouples indicate an average temperature equal to the maximum thermostat setting for automatic gas shutoff devices incorporated as part of a control which includes a water heater thermostat or 180°F (82°C) for other automatic gas shutoff devices. As soon as this temperature is attained, the means for heating the bath shall be shut off and cold water shall be admitted until the test thermocouples indicate an average temperature of 120°F (49°C) or less. This heating-cooling cycle of the bath shall be repeated 100,000 times and no operation of the devices shall occur. A determination of shutoff temperature and, if applicable, a verification of reset operation shall then be made for each device as specified in 2.2.1. All shutoff temperatures shall be within ± 10°F (5.5°C) of the average shutoff temperature originally obtained during conduct of 2.2.1, but in no case more than 210°F (99°C).

2.3 Leakage

2.3.1

The assembly of an immersion type of gas shutoff device shall be of such tightness as to show no leakage when subjected to a hydrostatic pressure of 300 psi (2.1 MPa) on all surfaces normally exposed to tank water.

Method of Test

The device shall be connected to the outlet of a suitable pump in a manner that will permit the application of hydrostatic pressure to surfaces normally in contact with tank water. A Bourdon pressure gage, graduated in increments of not more than 5 psi (34.5 kPa), shall be connected in the system near the test device. By means of the pump, hydrostatic pressure shall be applied and gradually increased to 300 psi (2.1 MPa). Under these conditions, no leakage shall be evidenced within a period of 5 minutes.

2.3.2

A gas shutoff valve shall not leak gas externally at a rate in excess of 200 cm^3/hr, when tested with clean air at 2.0 and 21.0 in wc pressure (498 Pa and 5.23 kPa), when the valve is in the open position with the outlet capped.

Method of Test

An airtight connection shall be made between the inlet of the valve and a suitable pneumatic system incorporating a flowmeter capable of indicating accurately a flow rate of 200 cm^3/hr. The outlet of the valve shall be sealed.

The valve shall be opened normally and air shall be admitted slowly and maintained at 2.0 in wc pressure (498 Pa). Leakage corrected to standard conditions of 30 inches mercury column pressure (101.3 kPa) and 60°F (15.5°C) shall be determined. This test shall be repeated at 21.0 in wc pressure (5.23 kPa). Any leakage noted shall not be in excess of 200 cm^3/hr.

2.3.3

Leakage through a gas shutoff valve in the closed position assumed as the result of normal operation shall not exceed a rate of 235 cm^3/hr for a valve having a seal-off diameter of 1 in (25.4 mm) or less, or 235 cm^3/hr/in (25.4 mm) of seal-off diameter for a valve having a seal-off diameter greater than 1 in (25.4 mm). See Figure 1, Seal-off Diameter Size - Inches (mm).

Method of Test

An airtight connection shall be made between the inlet of the gas shutoff valve and a suitable pneumatic system capable of supplying clean dry air at the specified range of leakage test procedures. An airtight connection shall be made to the valve outlet, terminating in a flow measuring device capable of accurately indicating flow rates equal to the maximum permissible leakage, corrected to standard conditions of 30 inches mercury column pressure (101.3 kPa) and 60°F (15.5°C).

With the gas shutoff valve in the closed position assumed as the result of normal operation and after several cycles of operation, two tests shall be conducted. In the first, a test pressure of 21.0 in wc (5.23 kPa) shall be applied to the valve inlet for a period of not less than 2 minutes. During this time, the flow measuring device shall not indicate a total leakage, through the valve seat, in excess of the maximum permitted. In the second test, the test pressure shall be reduced to 2.0 in wc (498 Pa) with the other conditions remaining the same.

2.4 Capacity

The gas carrying capacity of a gas shutoff valve shall not be less than that specified by the manufacturer. This shall be determined by the quantity in Btu per hour of a gas having a specific gravity of 0.64 and a heating value of 1000 Btu/ft^3 (37.3 MJ/m^3) which can be passed through the valve with a pressure drop equal to 1.0 in wc (249 Pa).

Method of Test

The temperature sensing element of the gas shutoff device shall be maintained at room temperature during this 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 valve. When a valve is provided with semi-rigid tubing connections, fittings and semi-rigid tubing of the proper size, reamed to remove burrs caused by cutting, shall be used instead of standard weight pipe.

The length of straight run of pipe before the inlet pressure tap shall not be less than 50 pipe diameter (I.D.), or in accordance with the principles established for pipe tap connections as presented in Orifice Metering of Natural Gas *(Gas Measurement Committee Report No. 3, 1969)* of the American Gas Association. The length of straight run of pipe between the valve and any downstream controlling means shall be 10 pipe diameter (I.D.).

Two short lengths of pipe or metal tubing having a small diameter shall be securely attached to the pipe or semi-rigid tubing, one before the inlet and the other after the outlet connection. The pressure tap before the inlet shall be located 5 pipe diameters from the discharge end of the inlet pipe or tubing and the pressure tap after the outlet connection located 5 pipe diameters from the inlet end of the discharge pipe or tubing. A $^1/_8$ in (3.2 mm) diameter drill shall be inserted in each short length of pipe or metal tubing and a hole drilled through the wall of the larger pipe or semi-rigid tubing, care being taken to remove any burrs caused thereby.

The pressure taps shall be connected to independent pressure measuring devices having an accuracy of 1 percent as well as to a differential gage (one tap being connected to each side) which has an accuracy of 1 percent. An adjustment control valve system of the same size as the valve or combination control under test, permitting precise control, shall be installed not less than the above specified number of pipe or tubing diameters from the valve or combination control under test. The function of interrupting the gas flow through the combination controls, including an automatic gas shutoff valve function, without changing the adjustment control valves, shall be performed by the automatic valve function of the combination control.

A typical arrangement of the test apparatus is shown in Figure 2, Typical Arrangement of Gas Shutoff Valve Capacity Test Apparatus.

The capacity of the device shall be determined with the valve in the widest open position it naturally assumes under normal operating conditions. No manual adjustments of the opening shall be made. Bypasses, if any, shall be shut off or sealed.

The flow rate through the valve shall be adjusted to give an indication on the gages approximately equal to a pressure drop of 1.0 in wc (249 Pa) and with the inlet pressure maintained at 3.0 in wc (747 Pa), and the necessary observations made and recorded. Observations shall also be made at a number of different pressure drops.

The capacity shall be measured by means of a direct reading flow measuring device suitable for air and selected so as to provide a reading of volumetric accuracy within ± 1 percent of the rated flow. Corrections shall be made to standard conditions of 30 inches mercury column pressure (101.3 kPa) and 60°F (15.5°C).

When the inlet and outlet connections of a valve differ in size, the observed pressure drop shall be corrected for the change in velocity pressure.

The data obtained shall then be resolved and a graph plotted of pressure drop versus flow rate. The flow rate at a pressure drop of 1.0 in wc (249 Pa) shall then be recorded, in terms of the reference gas having a specific gravity of 0.64 and heating value of 1000 Btu/ft^3 (37.3 MJ/m^3), as the capacity.

For other gases, the capacity may be computed by the use of the following conversion factors:

Heating Valve, Btu/ft^3 (MJ/m^3)	Specific Gravity	Multiplication Factor
500 (18.6)	0.6	0.516
800 (29.8)	0.7	0.765
2500 (93.2)	1.53	1.62

2.5 Continued Operation

2.5.1

After 100 cycles of operation, a device of other than the single-use type or the type incorporating electronic components shall actuate and reset within the temperature limits specified in 2.2.1.

Method of Test

Four devices shall be installed on a suitable water bath, as specified in 2.2.1. A switch type gas shutoff device shall be connected in a circuit typical of that in which it is to be used.

The water bath temperature shall be raised until all the devices function and then lowered until all the devices automatically reset or can be manually reset. This cycle shall be repeated until 100 cycles have been completed for each device, after which the devices shall be retested for compliance with 2.2.1.

2.5.2

Automatic gas shutoff devices incorporating electronic components shall actuate and reset within the temperature limits specified in 2.2.1 after being tested as specified in the following Method of Test.

Method of Test

a. One device shall be energized for a total of 720 hours in a test chamber maintained at a temperature equal to the maximum ambient temperature [within plus 5°F (3°C)] as specified by the manufacturer (See 1.3-c).

b. The sensing element of the device tested in 2.5.2-a shall be installed on a suitable water bath, as specified in 2.2.1. The remaining parts of the device shall be placed in a test chamber(s) and maintained at a temperature equal to the maximum ambient temperature [within plus 5°F (3°C)] specified for the component parts (See 1.3-c). The temperature of the sensing element shall be raised until the device automatically functions then the temperature of the sensing element shall be lowered until the device automatically resets or can be manually reset. This procedure shall be repeated for 50 cycles.

This test shall be repeated at the manufacturer's minimum ambient operating temperature [within minus 5°F (3°C)] (See 1.3-c) for an additional 50 cycles.

After completion of these tests the system shall be retested for compliance with 2.2.1.

2.6 Safety Circuit Analysis

2.6.1

The design of a safety circuit that is part of an automatic gas shutoff device incorporating electronic components shall be such that electrical failure of an individual functional part will cause either "-a" or "-b" to occur:

a. Act to interrupt flow of gas under its control.

b. Continue to operate without exceeding the manufacturer's specified maximum cut out temperature. In this event, failure of any one additional functioning part shall cause the device to continue to operate properly without exceeding the manufacturer's specified maximum cutout temperature or shall cause "-a" to occur.

Method of Test

A complete prewired safety circuit including valves, relays, sensors, accessories, etc., shall be evaluated. Additional components and parts deemed necessary by the testing agency to conduct these tests shall also be submitted. This evaluation shall be conducted at room temperature and normal voltage as the failure modes and drift values* anticipate temperature and voltage variations. A "Failure Mode and Effects Analysis" shall be submitted. A typical analysis is shown in Appendix B, Failure Modes and Effects Analysis.

The safety circuit shall be tested with each individual functional part in its established failure mode(s) (open circuit and/or short circuit) as verified by the manufacturer and at any value within the tolerance and drift value extremes as verified by the manufacturer.

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* Drift values of components, such as resistors, capacitors, semi-conductors, connections and wiring , shall be established so as to include maximum specified drift values of resistance, voltage drop, capacitance, turn-on and other electrical parameters due to time, environmental, electrical stress, and corrosion.

The failure mode(s), tolerance and drift value extremes on any individual component may be checked in any part of the operation cycle (operating, shutoff, standby, etc.). No more than a single failure shall be introduced on any cycle of operation.

Any individual functional part which causes "-b" above to occur shall be left in that mode of failure, tolerance or drift extreme and, during subsequent operational cycles, one additional functional part at a time shall be tested as outlined above to determine that "-a" or "-b" shall occur.

Relays, switches, transformers and the like which have been separately tested and recognized or certified for their intended or equivalent usage by a nationally recognized testing agency, shall not be subjected to these tests when applied within their certified parameters.

2.6.2

Controls employing safety-related software shall be evaluated using the Standard for Software in Programmable Components, UL 1998, with the exception of sections 1.6, 4.1, 4.3, 7.1.2, 10, 11.2.1-c and 13. In conducting this evaluation, each failure or fault shall be considered separately. Also, with regard to the requirements of 7.1.1 and Table 7.1 in UL 1998, other means may be employed to address fault/errors if it can be shown that they provide the required fault/error coverage specified in Table 7.1.

The investigation of the software shall include an integral investigation of the controlling hardware to perform its specified safety-related function in accordance with this standard.

Documentation as required by UL 1998 shall be provided, and a risk assessment, as described in UL 1998, shall be performed by the manufacturer and submitted to the certifying agency. In conducting the risk assessment, the hardware and safety-related software shall be considered as an integrated system. The requirements for software Class 2, shall be applied. Detection of an error in the software shall result in "-a" or "-b" as specified in 2.6.1.

2.7 Effects Of Voltage Variation

2.7.1

Under the conditions of voltage and temperature variation specified in the following Method of Test, an automatic gas shutoff device incorporating electronic components shall operate to shut off the gas supply within ±10°F (±5.5°C) of the manufacturer's specified shutoff temperature (See 2.2.1).

Method of Test

This test shall be conducted at both the manufacturer's specified maximum and minimum ambient temperatures (See 1.3-c).

The following voltages shall be used during conduct of this test:

a. Undervoltage

   The voltage to the device shall be adjusted to 85 percent of the rated voltage.

b. Overvoltage

   The voltage to the device shall be adjusted to 110 percent of the rated voltage.

Under the conditions of both undervoltage and overvoltage as specified in "-a" and "-b" above, the automatic gas shutoff device shall operate to shut off the gas supply within ±10°F (±5.5°C) of the manufacturer's specified shutoff temperature.

2.7.2

An automatic gas shutoff device incorporating electronic components shall be subjected to the following overvoltage tests without evidence of unsafe failure.

Method of Test

One of the devices tested under 2.2.1 shall be operated at the manufacturer's maximum specified ambient temperature until burnout occurs or for a period of 8 hours, whichever occurs first, at either 120 volts a.c. for low voltage device, or twice line voltage for line voltage device.

If operable after completion of this test, the device shall be retested in accordance with the applicable provisions of 2.2.1.

2.8 Current Input

The current input to an automatic gas shutoff device which consumes electrical power shall not exceed the rating specified by the manufacturer (See 1.3-g) by more than 10 percent when the device is operated under conditions of rated voltage and frequency.

Method of Test

This test shall be conducted in a heated test chamber maintaining the temperature of the automatic gas shutoff device at the manufacturer's maximum specified ambient temperature. With the device energized, the current shall be measured at the time equilibrium temperature has been established.

2.9 Transient Voltage

An automatic gas shutoff device incorporating electronic components shall be subjected to the electrical transient (see Part IV, Definitions) voltage tests specified in the following Method of Test without evidence of unsafe failure.

Method of Test

The tests outlined below shall be conducted at rated voltage with the device operating in each of the modes for which it is designed (i.e., operating, shutoff, standby, etc.). These tests shall be conducted on two representative samples of the device. A different set of samples may be used for evaluation of each mode.

If a component or network is incorporated whose sole function is that of suppressing external transient voltages, these tests shall be conducted with the components or network both functional and bypassed.

Evidence of an unsafe failure during or upon completion of any of the tests specified below shall constitute noncompliance.

a. Line Transients

   This test shall be applied only to devices intended for connection to an alternating current electrical supply.

   A transient voltage generator having an output impedance of 50 ± 2.5 ohms shall be used for conduct of this test. The generator shall be connected to a noninductive load of 50 ± 2.5 ohms, and adjusted so that the peak voltage of the transient voltage pulse is 1200 ± 50 volts, and the pulse shape is 2.5 microseconds maximum rise time from 30 to 90 percent peak voltage and between 15 and 30 microseconds decay time to half peak voltage. After adjustment of the generator, the load shall be removed.

The device under test shall then be connected to a power supply of rated voltage. The transient voltage pulse output of the generator shall be applied to the primary power supply with the device operating in the mode(s) under test. The pulses shall be imposed without synchronization to the power sine wave at a repetition rate of 26 ± 3 pulses per second. A total of 1000 pulses, or the number of pulses which can be applied during the time period of the mode if this period is insufficient for the application of 1000 pulses, shall be applied with a positive polarity. This test shall then be repeated with the application of pulses having a negative polarity.

b. Lightning Transients

This test shall be applied only to devices intended for connection to an alternating current power supply.

The transient shall have an energy level equivalent to 6 kilovolts discharge from a 0.1 microfarad capacitor through a 100 ohm resistor.

The lightning transient shall be applied to the primary power supply 10 times with a positive polarity and 10 times with a negative polarity for each mode.

c. Static Discharge

This test shall be applied to all devices regardless of the type of power supply.

The test shall be conducted with the power supply connected as indicated in application with the device (1) electrically grounded and (2) isolated from ground. The test shall then be repeated with the power supply disconnected and with the device (1) electrically grounded and (2) isolated from ground.

The static discharge transient shall consist of 20 kilovolts discharged from a 100 picofarad capacitance through a 100 ohm resistance.

The static discharge transient shall be applied between any surface and terminal which could be contacted during normal servicing.

If operable after completion of the transient voltage test, the device shall be tested to the applicable provisions of 2.2.1 and shall operate to shutoff the gas supply within ±10°F (±5.5°C) of the manufacturer's specified shutoff temperature.

2.10 Effects Of Humidity Variation

2.10.1

An automatic gas shutoff device incorporating electronic components shall be subjected to the following humidity conditions without evidence of unsafe failure.

Method of Test

One of the devices tested under 2.2.1 shall be conditioned for 4 hours at a temperature of 60 ± 5°F (15.5 ± 3°C) and immediately placed in a humidity chamber at 95 ± 4 percent relative humidity condensing, at a temperature of 104 ± 4°F (40 ± 2°C) for 48 hours without the device being operated. During the test, the device shall be protected from any dripping condensate. The device while in the chamber shall then be operated at rated voltage and cause either "-a" or "-b" to occur as specified in section 2.6.1. If "-b" occurs, the test in 2.10.2 shall be conducted.

2.10.2

When required by 2.10.1, an automatic gas shutoff device incorporating electronic components shall be capable of normal operation when subjected to the following humidity conditions.

Method of Test

The device tested under 2.10.1 shall be conditioned for 24 hours at a temperature of 104 ± 4°F (40 ± 2°C) at a relative humidity of 50 ± 4 percent. The device is then to be conditioned for 48 hours at 88 ± 4 percent relative humidity noncondensing and 104 ± 4°F (40 ± 2°C) without the device being operated. While maintained at these conditions, the device shall then be operated at rated voltage and shall operate as specified by the manufacturer in 2.2.1.

2.11 Marking Material Adhesion And Legibility

The adhesive quality and legibility of marking materials for automatic gas shutoff devices shall not be adversely affected when the marking materials are exposed to heat and moisture as specified in the following Method of Test.

Method of Test

a. The following tests shall be conducted on two sample devices. The manufacturer shall have applied the marking materials to the devices as they would be applied in production.

   Each sample of marking materials shall exhibit:

   1. Good adhesion and no curling at edges;

   2. No illegible or defaced printing when rubbed with thumb or finger pressure; and

   3. Good adhesion when a dull metal blade (as the back of a pocketknife blade) is held at 90 degrees (1.57 rad) to the applied marking and scraped across the edges of the marking.

b. Nonadhesive 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. The two samples of the marking materials shall then be placed in an oven for a period of 2 weeks with the oven temperature maintained at the manufacturer's maximum rated ambient temperature of the device.

   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.

Tables Referenced In Part I And Part II

Table I

Turning Effort

Nominal Pipe Size (Inches)	Turning Effort, Inch-Pound (N•m)
1/2	375 (42.38)
3/4	560 (63.28)
1	750 (84.74)
1 1/4	875 (98.86)
1 1/2	940 (106.20)
2	1190 (134.45)
2 1/2	1310 (148.01)
3	1310 (169.48)

Table A-I

Minimum Spacings For Parts Connected To Highvoltage Circuits

Between Any Uninsulated Live Part And:	General Voltage Range			Maximum Rating 2000 VA: Voltage Range
	0-150 volts	151-300 volts	301-600 volts	0-300 volts
	in (mm)	in (mm)	in (mm)	in (mm)
1. An uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosures, or exposed metal part.				
Through Air	1/8[b] (3.2)	1/4 (6.4)	3/8 (9.5)	1/8[b] (3.2)
Over Surface	1/4 (6.4)	3/8 (9.5)	1/2[a] (12.7)	1/4 (6.4)
2. An uninsulated live part of the same polarity, except at contacts[b]				
Through Air	1/32 (0.8)	1/32 (0.8)	1/32 (0.8)	1/32 (0.8)
Over Surface	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)
3. Walls of a metal enclosure, including fittings for conduit or metal-clad cablec.				
Shortest Distance	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/4 (6.4)

[a] In a self-actuated, alternating-current, pilot duty contact control (that may have an external adjusting knob or handle, but not an operating one) rated at not more than 125 volt-amperes, 301-600 volts, and responding to changes in temperature, pressure, humidity, liquid level and the like, the spacings may be those indicated for a voltage range of 151-300.

[b] The spacing between wiring terminals by which connections are to be made to the control, regardless of polarity, and the spacing between a wiring terminal and a dead-metal part, (including the enclosure) that may be grounded when the control is installed, shall not be less than 1/4 in (6.4 mm).

[c] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is liable to reduce spacings between the metal piece and uninsulated live metal parts.

Table A-II

Minimum Spacings Line Voltage Safety Circuits

Between Any Uninsulated Live Part And:	General: Voltage Range			Maximum Rating, 2000 VA: Voltage Range
	0-150 volts	151-300 volts	301-600 volts	0-300 volts
	in (mm)	in (mm)	in (mm)	in (mm)
1. An uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosures, or exposed metal part				
Through Air	$^{1}/_{8}$[b] (3.2)	$^{1}/_{4}$ (6.4)	$^{3}/_{8}$ (9.5)	$^{1}/_{16}$[b] (1.6)
Over Surface	$^{1}/_{4}$ (6.4)	$^{3}/_{8}$ (9.5)	$^{1}/_{2}$ (12.7)	$^{1}/_{16}$[b] (1.6)
2. Walls of a metal enclosure, including fittings for conduit or metal-clad cable[a]				
Shortest Distance	$^{1}/_{2}$ (12.7)	$^{1}/_{2}$ (12.7)	$^{1}/_{2}$ (12.7)	$^{1}/_{4}$ (6.4)

a For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is liable to reduce spacings between the metal piece and uninsulated live parts.

b The spacing between wiring terminals by which connections are to be made to the control, regardless of polarity, and the spacing between a wiring terminal and a dead-metal part, (including the enclosure) that may be grounded when the control is installed, shall not be less than $^{1}/_{4}$ in (6.4 mm).

Table A-III

Minimum Spacings-Millivoltage Circuits Intended for Access after the Control is Manufactured and for Class 2 Low Voltage Safety Circuits (0-30 Volts)

The following spacings apply to millivolt circuits intended for access after the control is manufactured and to Class 2 low voltage circuits, if short circuiting between the parts for which spacings are specified may result in unsafe operation.

Spacings Between Uninsulated Live Parts and	Minimum Spacing, In (mm)
a. Another Uninsulated Live-Metal Part Regardless of Polarity	
Through Air	$^1/_{32}$[b] (0.8)
Over Surface	$^1/_{32}$[b] (0.8)
b. Grounded Metal Part Other than the Enclosure	
Through Air	$^1/_{32}$ (0.8)
Over Surface	$^1/_{32}$ (0.8)
c. Walls for Metal Enclosure[a]	
Through Air	$^1/_8$ (3.2)
Over Surface	$^1/_8$ (3.2)
d. Between Terminals	
Through Air	$^1/_4$ (6.4)
Over Surface	$^1/_4$ (6.4)

a For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is liable to reduce spacings between the metal piece and uninsulated live-metal parts.

b The spacing between wiring terminals by which connections are to be made to the control, regardless of polarity, and the spacing between a wiring terminal and a dead-metal part, (including the enclosure) that may be grounded when the control is installed, shall not be less than $^1/_4$ in (6.4 mm).

Figures Referenced In Part I And Part II

Referenced Figures

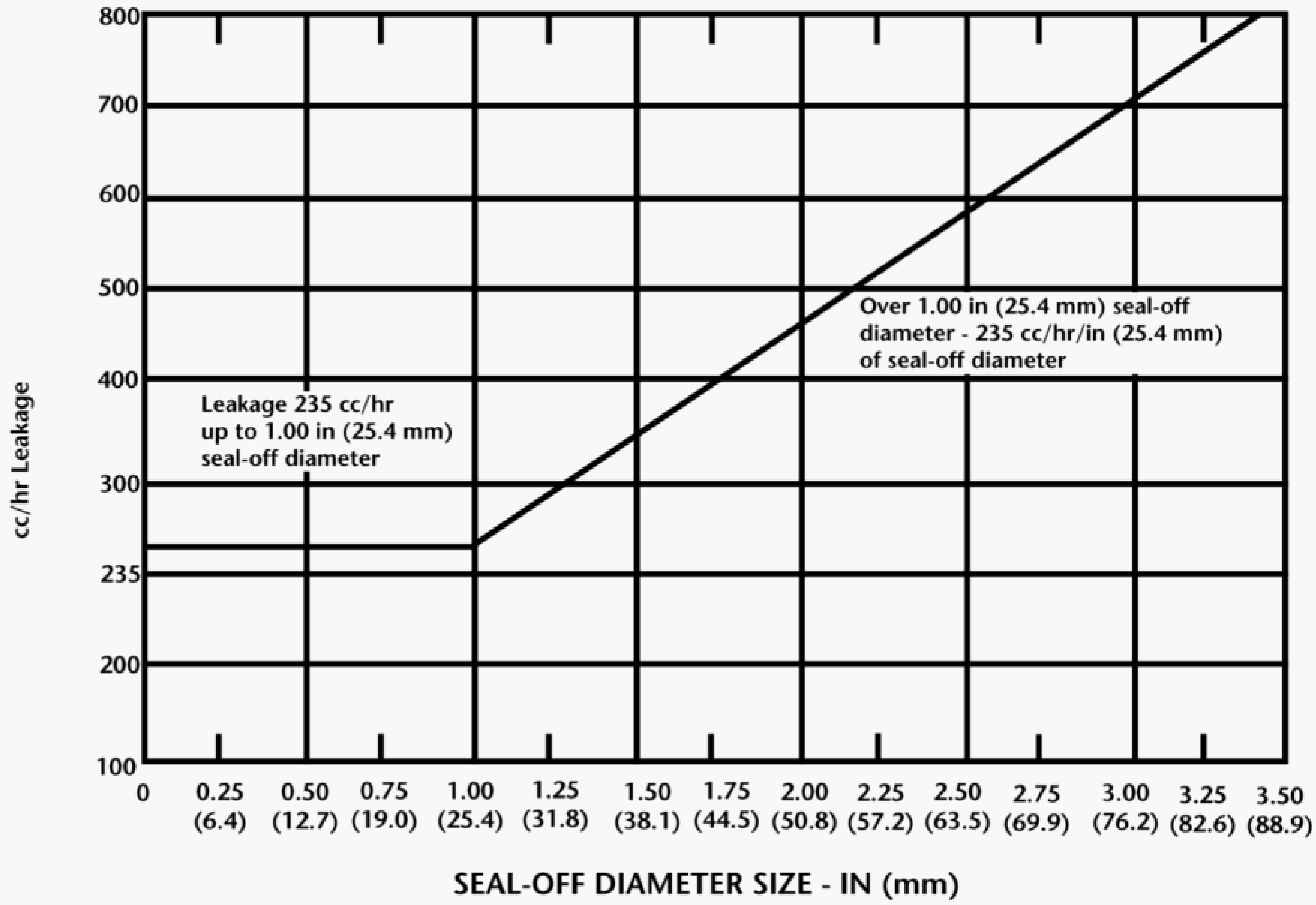


Figure 1.

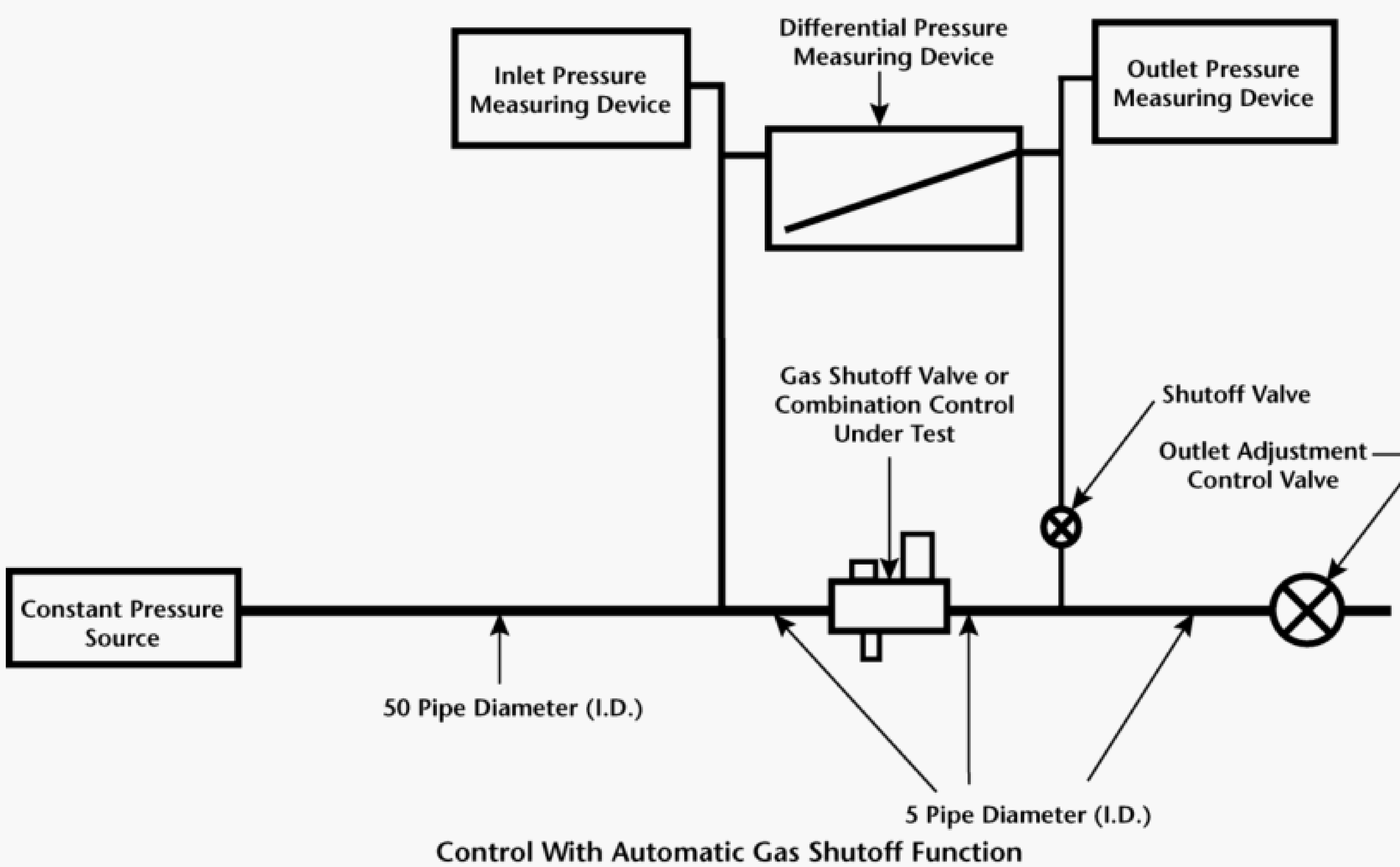
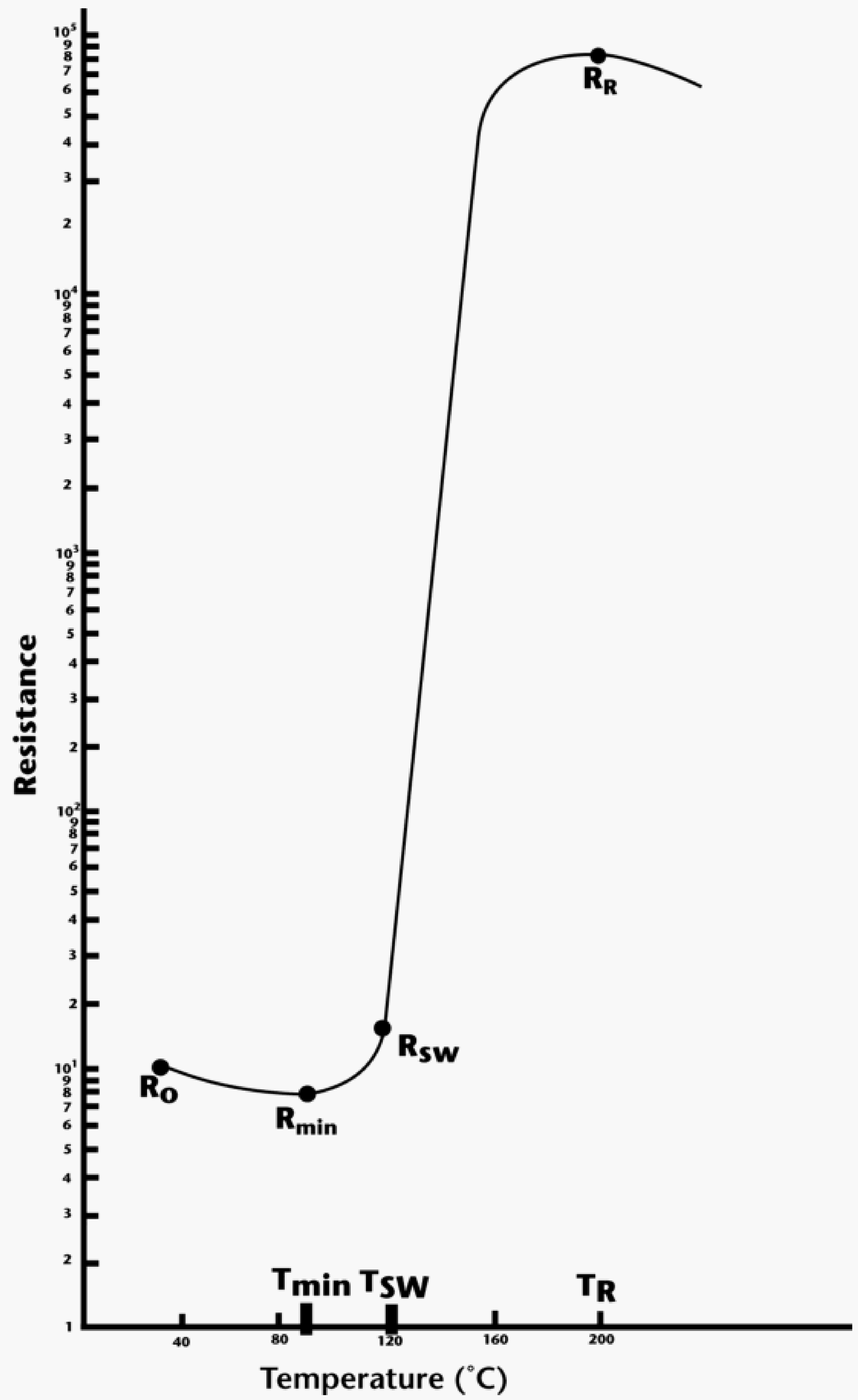


Figure 2. Typical Arrangement of Gas Shutoff Valve Capacity Test Apparatus



NOTES

R_{min}	The point of minimum resistance.
R_0 (R_{25})	Resistance at 25 ± 2°C (77 ± 3.6°F) or at a temperature specified by the manufacturer.
T_{SW}	Switching temperature at which the resistance (R_{SW}) begins to increase sharply with temperature increases.
T_R	Thermal runaway temperature where resistance RR starts to decrease.

Figure 3. Typical R/T curve for a ceramic PTC thermistor

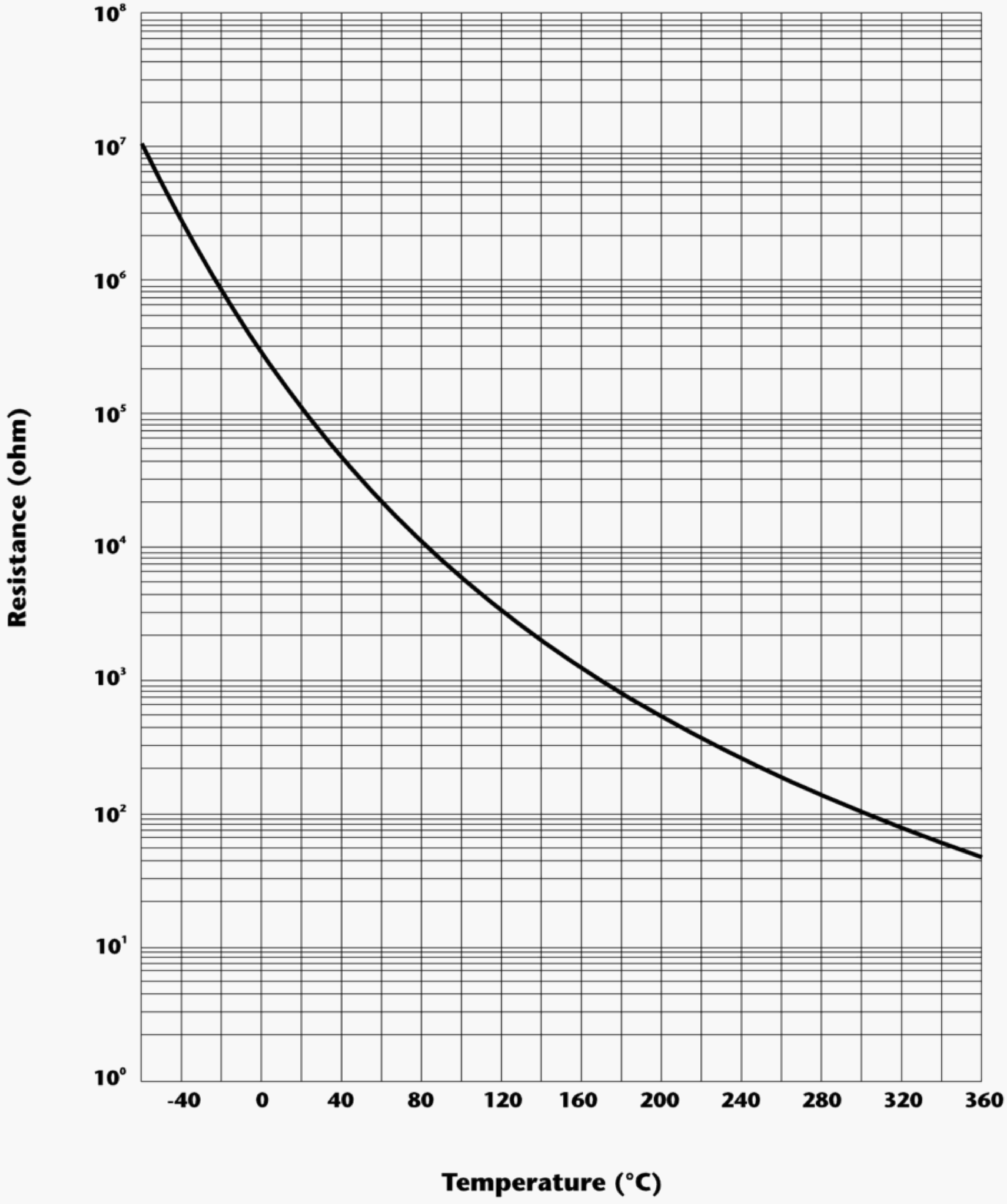


Figure 4. Typical R/T curve for a NTC thermistor

Exhibit A
Items Unique To The United States

A.1 Electrical

An electrically operated automatic gas shutoff device shall have provisions to permit installation in conformance with the National Electrical Code, ANSI/NFPA 70.

Electrical components shall be of approved types or shall be investigated for construction and performance equivalent to approved types.

Electrical components which are listed or certified by a nationally recognized testing agency qualified to certify or list electrical equipment or wiring shall be deemed to be of approved types and to comply with the electrical construction provisions.

Millivolt circuits need not comply with spacing, insulation, enclosure and grounding provisions. If shorting of such a circuit can result in unsafe operation, the construction of the device shall be such that the spacings provided will be maintained permanently.

A.1.1 Insulating Material

a. A joint shall be provided with insulation equivalent to that of the wires involved if permanence of spacing between the joint and uninsulated live-metal parts of opposite polarity or grounded dead-metal parts is not assured.

b. Material used shall be judged with respect to its suitability for the particular application. In determining the suitability of an electrical insulating material, consideration shall be given to its mechanical strength, dielectric strength, heat- and moisture-resistant properties, the degree to which it is enclosed or protected, and any other features having a bearing on its application in the device.

A.1.2 Conductors and Connectors

a. A device shall be provided with suitable wiring terminals or leads for connection of conductors of at least the size required by the *National Electrical Code, ANSI/NFPA 70*, corresponding to the rating of the device, but in no case less than No. 18 AWG (0.82 mm2). The insulation shall not be less than $^{1}/_{32}$ inch (0.8 mm) thick.

b. The internal wiring of a device shall be suitably insulated and shall have current- carrying capacity adequate for the intended service.

c. Strain relief shall be provided for all conductors leaving an electrical enclosure. The strain relief device shall be capable of withstanding a direct pull of 20 lb (89 N) applied to each conductor for one minute without damage to the conductor and without displacing the strain relief device.

d. Terminal parts to which connections are made shall provide good connections. Wire-binding screws shall not be smaller than No. 8, except that No. 6 screws may be used for the connection of a No. 18, 16 or 14 AWG (0.82, 1.3 or 2.1 mm^2) conductor. Terminal plates for wire binding screws shall be of metal not less than 0.030 in (0.762 mm) thick, tapped with not less than 2 full threads.

e. A terminal or lead for the connection of a neutral supply conductor shall be identified by means of a substantially white metallic plating or by having a white or natural gray insulation, and shall be readily distinguishable from other terminals or leads or properly identified to indicate the terminal for connection to a neutral supply connector.

f. The leads or terminals of an individual component, that are provided for making electrical connections and which are intended to be disconnected in order to replace or service the control, shall be identified by a number(s), symbol(s) or combination thereof, in a color which contrasts with the background. This provision does not apply when:

   1. The individual component incorporates means which will physically prevent miswiring; or

   2. The individual component incorporates only two terminals or leads, the interchange of which does not change the operation of the component.

g. Conductors joined by splicing shall be mechanically secure without solder and unless made with an approved splicing device, shall be soldered with a fusible metal or alloy, brazed or welded. Provision shall be made to prevent mechanical strain on splicing devices. The means to prevent mechanical strain shall be capable of withstanding a direct pull of 20 lb (89 N) applied to the conductor for 1 minute without damage to the splice.

A.1.3 Current-Carrying Parts

The internal wiring of a gas shutoff valve shall be suitably insulated and shall have current carrying capacity adequate for the intended service.

a. Uninsulated live-metal parts, including terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position, if such motion may result in reduction of spacings to less than those specified elsewhere in this standard. Contact assemblies shall be secured such that the alignment of contacts will be maintained.

b. Where corrosion could interfere with the electrical characteristics of the device, parts shall be constructed of corrosion resistant material or have a corrosion-resistant finish.

c. A safety circuit shall permit operation of the controlled equipment only when the circuit is closed, or the design shall be such that failure to close the circuit or an accidentally opened circuit will cause the gas to shut off.

A.1.4 Grounding

a. A lead intended for the connection of an equipment-grounding conductor shall have a free length of 6 in (152 mm) or more. The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead visible to the installer in the field shall be so identified.

b. A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal shaped, slotted, or both. The wire binding screw shall be so located that it is unlikely to be removed during normal servicing.

c. A pressure wire connector intended for connection of an equipment-grounding conductor shall be plainly identified, such as by being marked "GND," "Ground," "Grounding" or by a suitable marking on a wiring diagram provided on the control. The pressure wire connector shall be so located that it is unlikely to be removed during normal servicing.

A.1.5 Bond

A line voltage device shall be constructed so that all dead-metal parts, which are exposed or which are likely to be touched by a person during normal usage of the device and which are liable to become energized, shall have electrical continuity to the device body.

All such dead-metal parts shall show continuity to the device body as indicated by a resistance not in excess of 0.1 ohm measured between the device body and any dead-metal parts (insulating finishes may be scraped from the test points).

A.1.6 Switches

Single-pole switches in safety circuits shall not be wired in a neutral or grounded line. Switches shall have current and voltage ratings not less than that of the circuits they control.

A.1.7 Transformers

Low-voltage circuits (30 volts or less) shall be supplied by a Class 2 transformer (see Article 725, Section 725-31, *National Electrical Code, ANSI/NFPA 70*), unless wiring suitable for line-voltage service is used and all spacings through-air and over insulating surfaces for live-metal parts to ground are not less than $^{1}/_{16}$ in (1.6 mm).

A supply transformer, if provided as an integral part of a device operating at less than line voltage, shall be of the isolating type (separate primary and secondary windings).

A.1.8 Spacings

Electrical spacings shall comply with the following specifications except for spacings that comply with A.1.9, Corrosion.

a. The electrical clearance resulting from the assembly of line-voltage parts into the complete compartment, except for millivolt circuits, shall comply with the spacings specified in Tables A-I, Minimum Spacings Line Voltage Safety Circuits, or A-II, Minimum Spacings Line Voltage Circuits for Other Than Safety Circuits, as applicable.

b. For parts connected to Class 2 low-voltage circuits and millivoltage circuits intended for access after the control is manufactured (e.g., filed or factory-wiring terminals), the spacings shall not be less than those indicated in Table A-III, if a short circuit or ground between those parts could result in unsafe operation.

For millivoltage circuits not intended for access after the control is manufactured, if shorting of the circuit can result in unsafe operation, the construction of the control shall be such that the spacings are permanently maintained.

A.1.9 Alternative to Spacings

An electric automatic gas shutoff device shall (1) have provision for either connection of conduit or metal-clad cable, (2) be provided with terminals, or (3) be provided with leads entering the enclosure through a bushing or opening.

As an alternative to the spacing specifications in A.1.8, Strength, spacings must be evaluated in accordance with the requirements specified in the *Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, ANSI/UL 840*. This alternative does not apply to spacings for field wiring terminals or spacings between uninsulated live parts and a metal enclosure, including fittings for conduit or armored cable.

In conducting this evaluation, the following guidelines shall be used.

a. Evaluation of clearances shall be conducted in accordance with the following sections of *ANSI/UL 840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment,* as applicable, Section 4, Clearance A (Equivalency); Section 5, Clearance B (Controlled Overvoltage); and Section 6, Creepage Distances.

   Pollution Degree 1 is considered to exist on printed wiring boards that have the requirements for conformal coatings in the *Standard for Safety Polymeric Materials-Use in Electrical Equipment Evaluations, ANSI/UL 746C.*

   Pollution Degree 1 may also be achieved at a specific printed wiring board location by application of at least a $^{1}/_{32}$ in (0.8 mm) layer of silicone rubber which has been separately tested and recognized or certified for the intended usage by a nationally recognized testing agency or for a group printed wiring boards through potting, without air bubbles, in epoxy or a potting material which has been separately tested and recognized or certified for the intended usage by a nationally recognized testing agency.

b. Pollution Degree 3 applies, except that Pollution Degree 2 is considered to exist on a printed wiring board between adjacent conductive material which is covered by an uninterrupted nonconductive coating.

c. For Clearance B (Controlled Overvoltage) requirements, the applicable overvoltage category for line voltage circuits is Category III. If the control is used at the load level of an appliance that is connected to the electrical supply then Category II applies. Category I is applicable to low-voltage circuits if short circuits between the parts involved may result in operation of the controlled equipment that increases the risk of fire or electric shock. A suitable overvoltage protection device may be provided as part of the control. The failure of a component of the system or device employed for overvoltage protection shall cause shutdown of the control.

d. Any printed wiring board which complies with the requirements in the Standard for Printed-Wiring Boards, ANSI/UL 796, shall be considered to provide a Comparative Tracking Index (CTI) of 100, and if it further complies with the Direct Support Requirements of ANSI/UL 796, then it shall be considered to provide a CTI of 175.

e. The Phase-to-Ground Rated System Voltage used in the determination of Clearances shall be equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product if no isolating transformer is provided. The System Voltage used in the evaluation of secondary circuitry may be interpolated with interpolation continued across the table for the Rated Impulse Withstand Voltage Peak and Clearance.

f. Determination of the dimension of clearance and creepage distances shall be conducted in accordance with the requirements in Section 8, *Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, ANSI/UL 840.*

A.1.10 Barriers

a. With the following exceptions, an insulating barrier or liner which is used to provide spacings shall be of material suitable for the particular application and not less than a minimum 0.028 in (0.71 mm) thick. A barrier or liner which is used in conjunction with not less than one half the specified spacing through-air, may be less than 0.028 in (0.71 mm) but not less than 0.013 in (0.33 mm) thick, provided the barrier or liner is of suitable insulating material resistant to moisture, of adequate mechanical strength if exposed or otherwise likely to be subjected to mechanical damage, reliably held in place, and located so it will not be adversely affected by operation of the equipment in service-particularly arcing.

   Insulating material having a thickness less than that specified in the preceding paragraph may be used if found acceptable for the purpose if listed or certified for the purpose by a nationally recognized testing agency.

   Mica may be less than 0.028 in (0.71 mm) thick but not less than 0.013 in (0.33 mm) thick when the mica is used in lieu of through-air spacing specified in Table A-I, Turning Effort, provided the mica is tightly held in a fixed position by the parts between which the spacing is involved.

b. A barrier used to provide separation between the wiring of different circuits shall have adequate mechanical strength and shall be reliably held in place.

   A barrier between uninsulated live-metal parts connected to different circuits, and a barrier between uninsulated live-metal parts of one circuit and the wiring of another circuit shall also comply with A.1.10-a.

A.1.11 Enclosures

a. Electrical parts of a device, other than low-voltage terminals, shall be located or enclosed so that suitable protection against accidental contact with uninsulated live parts will be provided, except an enclosure is not required for a device designed for assembly as part of another device which is enclosed.

b. A space within the enclosure of a device shall be sufficient to provide adequate room for distribution of wires and cable required for the proper field wiring of the device (see Article 370, Section 370-6, *National Electrical Code, ANSI/NFPA 70*). The cover of the enclosure shall be provided with a means for securing it in place.

   When threads for the connection of conduit are provided, there shall not be less than $3^1/_2$ nor more than 5 threads. When not tapped all the way through the opening, there shall be a smooth, well-rounded inlet opening for the conductors with an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

   A device shall be equipped with an interlock to shut off the gas supply, if opening or removal of the cover could result in unsafe operation of the device or system.

A.1.12 Fuses

Fuses which are a part of the safety circuit are not intended to be replaced and shall not be accessible.

A.1.13

A valve or device which utilizes electrical energy shall be capable of withstanding, for 1 minute without breakdown, the application of a 60 hertz alternating potential of 1000 volts, plus twice the maximum rated voltage:

a. Between uninsulated live-metal parts; and

   1. Live-metal parts of opposite polarity;

   2. An enclosure;

   3. A grounded dead-metal part; and

   4. An exposed dead-metal part insulated with a barrier or liner.

b. Between uninsulated live-metal parts or high- and low-voltage circuits and different high-voltage circuits.

A device employing a low-voltage circuit shall be capable of withstanding, for 1 minute without breakdown, the application of 60 hertz alternating potential of 500 volts applied between uninsulated low-voltage live-metal parts of opposite polarity, between uninsulated and low-voltage live-metal parts and the enclosure and grounded dead-metal parts.

The above provision does not apply to valves or devices designed for use in millivolt circuits.

Method of Test

Dielectric strength test shall be made with a testing transformer, the output voltage of which can be regulated. Starting at zero, the applied potential shall be raised gradually until the specified test value is reached and shall be held at that value for 1 minute.

There shall be no evidence of electrical breakdown during any of these tests.

Exhibit B
Items Unique To Canada

B.1
Units of measurement required on printed instructions and marking shall include the SI (metric) values as a minimum.

B.2
ELECTRICAL REQUIREMENTS. Electrical equipment and wiring supplied on the system shall be in compliance with the applicable sections of the current Standard *CSA C22.2 No. 139, Electrically Operated Valves.*

B.3
All installation and marking provisions specified in this standard are required to be in a form easily understood in both English and French.

Exhibit C
List Of Reference Standards

AMERICAN GAS ASSOCIATION
1515 Wilson Boulevard, Arlington, Virginia, U.S.A 22209.

ANSI Z223.1-2006, National Fuel Gas Code

Gas Measurement Committee Report No. 3, 1969

AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
United Engineering Center, 345 East 47th Street, New York, New York, U.S.A. 10017

ANSI/ASME B1.1-2003, Unified Inch Screw Threads (UN and UNR Thread Form)

ANSI/ASME B1.20.1-1983 (R2001), Pipe Threads, General Purpose (Inch)

AMERICAN SOCIETY FOR TESTING & MATERIALS,
100 Barr Harbor Dr., West Conshohocken PA, U.S.A. 19428-2959

IEEE/ASTM SI-10-2002, Standard for Use of the International System of Units (SI) (The Modern Metric System)

CANADIAN STANDARDS ASSOCIATION,
178 Rexdale Boulevard, Etobicoke, Ontario, Canada M9W 1R3

CSA C22.2 No. 139-1982 (R2000), Electrically Operated Valves

CAN/CSA Z234.1-2000, Metric Practice Guide

CAN/CSA B149.1-2005, Natural Gas and Propane Installation Code

CAN/CSA C22.2 No. 0.17 (R2004), Evaluation of properties of Polymeric Materials

INTERNATIONAL STANDARDIZATION ORGANIZATION,
1, Rue de Varembé, Case postale 56, CH-1211 Genéve 20, Switzerland.

ISO 68-1-1998, General Purpose Screw Threads - Basic Profile

ISO 261-1998, General Purpose Metric Screw Threads - General Plan

NATIONAL FIRE PROTECTION ASSOCIATION,
One Batterymarch Park, P.O. Box 9101, Quincy, Massachusetts, U.S.A. 02269-9101.

NFPA 54-2006, National Fuel Gas Code

ANSI/NFPA 70-2005, National Electrical Code

NSF INTERNATIONAL
P.O. Box 130140, Ann Arbor, Michigan, U.S.A. 481130-0140.

ANSI/NSF 14-2004, Plastics Piping System Components and Related Materials

UNDERWRITERS LABORATORIES INC.
333 Pfingsten Road, Northbrook, Illinois U.S.A. 60062

ANSI/UL 746C-2006, Polymeric Material - Use in Electrical Equipment Evaluations

ANSI/UL 94-2006, Tests for Flammablility of Plastic Materials for Parts in Devices and Appliances

ANSI/UL 840-2007, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment

ANSI/UL 796-2006, Printed Wiring Boards

ANSI/UL 1998-2004, Standard for Software in Programmable Components

UL 1434-1998, Thermistor-Type Devices

Part III: 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 3.1, 3.2 and 3.3 and the records to be kept by the manufacturer.

3.1

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

3.2

The manufacturer shall test each device covered by this standard for:

a. Gas and water leakage, as applicable;

b. Calibration; and

c. Dielectric withstand, if applicable.

3.3

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

a. Conduct capacity tests;

b. Conduct tests on shutoff and reset temperatures;

c. Conduct continued operation tests;

d. Conduct strength tests; and

e. Check circuit resistance of devices for use in automatic circuits.

3.4

The manufacturer's test method(s) used for determining 3.2 and 3.3-a through -e shall be capable of relating back to the test(s) specified in the standard.

Part IV: Definitions

AUTOMATIC GAS SHUTOFF DEVICE. A safety control designed to cause a shutoff of the gas supply to the equipment serving a hot water supply system when the water temperature exceeds a predetermined limit.

AUTOMATIC GAS SHUTOFF VALVE. A valve used in conjunction with an automatic gas shutoff device to shut off the gas supply to a gasfired water heating system. It may be constructed integrally with the gas shutoff device or be a separate assembly.

BODY. The principal structure of the device which contains and supports the actuating mechanism.

BTU. Abbreviation for British Thermal Unit which is the quantity of heat required to raise the temperature of one pound of water 1 degree Fahrenheit.

CIRCUIT.

1. Line-Voltage. A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

2. Low-voltage. A circuit involving a potential of not more than 30 volts supplied by a primary battery, by a standard Class 2 transformer (see Article No. 725, Section 725-31, *National Electrical Code, ANSI/NFPA 70*), or by a suitable combination of transformer and a fixed impedance which, as a unit, complies with all the performance provisions for a NEC Class 2 transformer.

3. Millivolt. A circuit which receives its electrical energy by means of a thermocouple(s) or photovoltaic device(s).

COMBINATION CONTROL. An assembly of two or more different functions, at least one of which conveys gas in a single unit without the use of pipe nipples or tubing, including:

1. Manually Operated Gas Valves;

2. Gas Appliance Pressure Regulator;

3. Automatic Gas Valve;

4. Thermostat Other than Electric Type;

5. Ignition System Components; and

6. Automatic Gas Shutoff Device.

CUBIC FOOT OF GAS. The amount of gas which would occupy one cubic foot when at a temperature of 60°F if saturated with water vapor and under a pressure equivalent to that of 30 inches mercury column.

ELECTRICAL DIAGRAM, SCHEMATIC. A diagram which shows by means of graphic symbols, the electric connections and functions of a specific circuit arrangement. This diagram facilitates tracing the circuit and its functions without regard to the actual physical size, shape or location of the component device or parts.

Ladder Form of Schematic. A diagram drawn in the form of a vertical ladder. The outer vertical lines represent the electrical supply conductors. The horizontal steps represent each individual circuit with all component devices.

ELECTRICAL TRANSIENT. Any voltage or current which deviates from the normal steady state condition.

1. Lightning Transient. Any voltage or current which deviates from the normal steady state condition due to electrical disturbances in the atmosphere.

2. Line Transient. Any voltage or current which deviates from the normal steady state condition due to collapsing magnetic fields, solid state switching, motor or inductive inrush or momentary power losses.

3. Static Voltage. The voltage created by the buildup of static charges on people or objects.

FAILURE MODES AND EFFECTS ANALYSIS. For the purpose of this standard, an analysis of a design for describing the most probable ways automatic gas shutoff devices can fail and the consequences of such failures.

***RESISTANCE/TEMPERATURE (R/T) CURVE.** The graphical representation of the characteristics of resistance versus temperature. See Figures 3, Typical R/T Curves for a PTC Thremister, and Figure 4, Typical R/T Curve for NTC Thermister, for typical curves. The significant portion of the curve for a PTC thermistor, as illustrated in Figure 3, is usually that portion of the curve representing the range of temperature over which the product is used. The R/T curve of some PTC thermistors has a negative slope from R_o to R_{min} before the resistance begins to increase.

SAFETY CIRCUIT. A circuit or portion thereof involving one or more safety controls.

SAFETY-RELATED SOFTWARE. Software whose failure could result in unsafe operation of the controlled equipment.

SETTING. That particular temperature at which the device is adjusted or designed to function.

SPECIFIC GRAVITY. As applied to gas, the ratio of the weight of a given volume to that of the same volume of air, both measured at the same temperature and pressure.

***THERMISTOR.** A thermally sensitive semiconductor resistor that has, over at least part of its R/T curve, a significant nonlinear change in its electrical resistance with a change in temperature. Typically, a change in temperature occurs due to the flow of current through the thermistor, as a result of a change in ambient temperature, or a combination of both.

***THERMISTOR, NTC.** A thermistor that exhibits a negative temperature coefficient (NTC) as indicated by a decrease in resistance with increasing temperature over the significant portion of the R/T curve. See Figure 4.

***THERMISTOR, PTC.** A thermistor that exhibits a positive temperature coefficient (PTC) as indicated by an increase in resistance with increasing temperature over the significant portion of the R/T curve. See Figure 3.

VALVE. As used in this standard, that portion of the gas shutoff device which shuts off the main gas supply.

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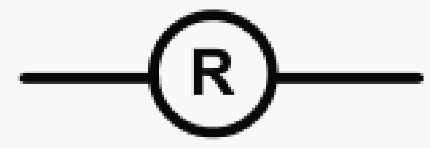
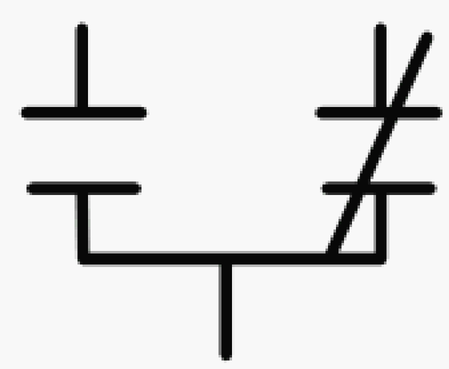
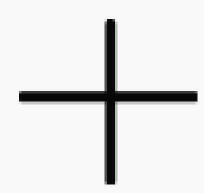
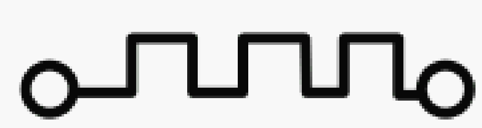
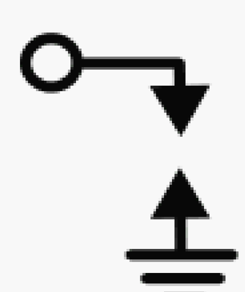
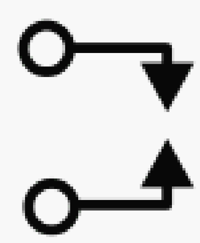
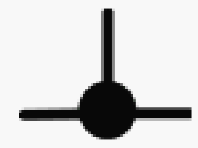
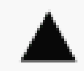
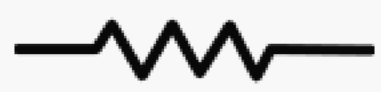
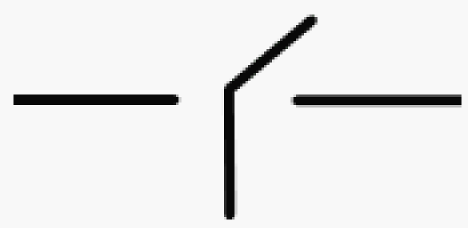
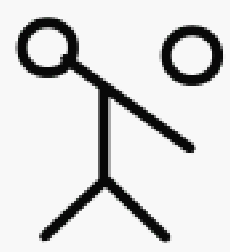
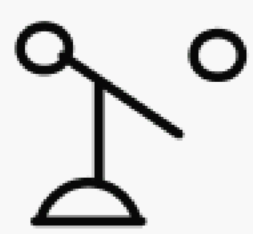
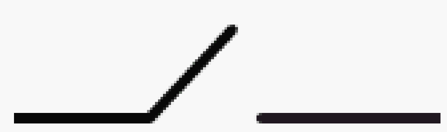
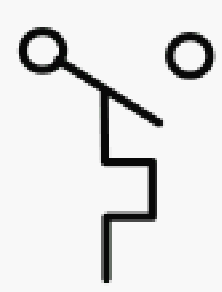
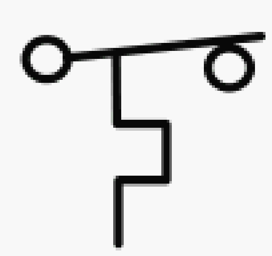
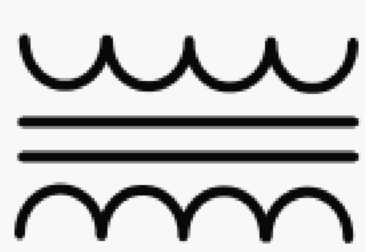
Appendix A
Preferred graphic symbols of commonly used Items, extracted from Standard ANSI/IEEE 315, Graphic symbols for electrical and electronics diagrams, and abbreviations for these items

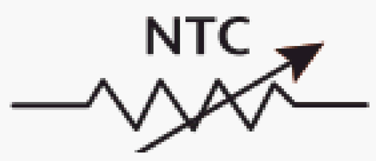
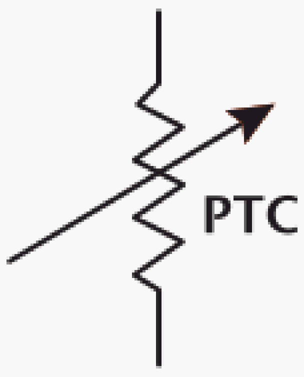
(This appendix is informative and is not part of the standard.)

Item description	Abbreviation	Symbol	IEEE Standard 315 Section reference
Capacitor (*Closest To Grnd)	CAP		2.2.1
Coil, Relay	R		4.5
Contact, Normally Closed	N.C.		4.3.1
Contact, Normally Open	N.O.		4.3.2
Contact, Transfer Single Pole Double Throw	S.P.D.T.		4.3.3
Crossing of Paths (Conductors not Connected)	—		3.1.5
Fuse, General	FUSE		9.1.1
Ground (Direct Circuit Return to Earth)	GND		3.9.1
Igniter; Glow Bar, Glow Coil, Hot Wire	IGN		—
Igniter, Spark, Grounded	IGN		—
Igniter, Spark, Ungrounded	IGN		—

(Continued)

Item description	Abbreviation	Symbol	IEEE Standard 315 Section reference
Junction of Paths (Conductor or Cable)	—		3.1.6.3
Link, Fusible	FL		2.12.3
Motor, General	MOT	MOT	13.1.3
Resistor, Adjustable	RES		2.1.3
Resistor, Heating	RES		2.1.8
Resistor, Variable	RES		2.1.4
Switch, Double Throw General	S.P.D.T.		4.6.2
Switch, Normal Closed Time Delay Opening	N.C.SW		4.16.2
Switch, Normally Open Time Delay Closing	N.O.SW		4.16.1
Switch, Pressure or Vacuum Actuated (Closes on Rising Pressure)	N.O.SW		4.19.1
Switch, Single Throw General	N.O.SW		4.6.1
Switch, Temperature Actuated (Closes on Rising Temperature)	N.O.SW		4.20.1
Switch, Temperature Actuated (Opens on Rising Temperature)	N.C.SW		4.20.2
Transformer, Magnetic Core Nonsaturating	TRAN.		6.4.2.1

(Continued)

Item description	Abbreviation	Symbol	IEEE Standard 315 Section reference
Thermistor	NTC		
Thermistor	PTC		

Appendix B
Failure Modes and Effects Analysis*

Equipment:		References:			
Submitted By:	Date:				
(1) Functional Part(s)	(2) Failure Modes The potential failure mode(s) and drift values for each functional part shall be determined within the parameters of time, electrical stress and envirnment specified by the manufacturer.	(3) Effect	(4) Consequences		(5) Remarks
			2.6.1-a	2.6.1-b	

Appendix C
Table of Conversion Factors

(This appendix is informative and is not part of the standard.)

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^2•hr	1.356×10^{-3}	7.374×10^{2}	kg/m^{2}s	kilogram/meter^2•second
	pound/inch^2•hour	lb/in^2•hr	1.953×10^{-1}	5.120	kg/m^{2}s	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
	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
		inch H_2O (4°C)	2.491×10^{2}	4.014×10^{-3}	Pa	pascal
	atmosphere	inch Hg (0°C)	3.386×10^{3}	2.953×10^{-4}	Pa	pascal
		atm (std)	1.013×10^{5}	9.871×10^{-6}	Pa	pascal
	pounds/square inch***	psi	2.768×10	3.613×10^{-2}	iwc	inch water column
	pounds/square 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
		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	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/hour•foot^2	Btu/hr•ft^2	3.155	3.1695×10^{-1}	W/m^2	watt/meter^2
HEAT CAPACITY	Btu/degree F	Btu/°F	1.899×10^{3}	5.265×10^{-4}	J/°C	joule/degree Celsius
SPECIFIC	Btu/pound•degree F	Btu/lb•°F	4.187×10^{3}	2.388×10^{-2}	J/kg•°C	joule/kg•degree Celsius
HEAT CAPACITY	Btu/pound•degree F	Btu/lb•°F	4.187	2.388×10^{-5}	kJ/kg•°C	kilojoule/kg•degree Celsius
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 (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.

****U.S. unit to U.S. unit.*

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

List of Harmonized Z21/Z83 • CSA/CGA Series of American National Standards • CSA/Canadian Gas Association Standards for Gas Appliances and Gas Appliance Accessories

(The information in this list is informative and is not to be considered part of the standard.)

Appliances

Gas Clothes Dryers,
    Volume I (Z21.5.1 • CSA 7.1) Type 1 Clothes Dryers
    Volume II (Z21.5.2 • CSA 7.2) Type 2 Clothes Dryers

Gas Water Heaters,
    Volume I (Z21.10.1 • CSA 4.1) Storage Water Heaters With Input Ratings of 75,000 Btu Per Hour or Less
    Volume III (Z21.10.3 • CSA 4.2) Storage, With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous Water Heaters

Gas-Fired Low Pressure Steam and Hot Water Boilers, Z21.13 • CSA 4.9

Refrigerators Using Gas Fuel, Z21.19 • CSA 1.4

Gas-Fired, Heat Activated Air Conditioning and Heat Pump Appliances, Z21.40.1 • CGA 2.91

Gas-Fired, Work Activated Air-Conditioning and Heat Pump Appliances (Internal Combustion), Z21.40.2 • CGA 2.92

Performance Testing and Rating of Gas-Fired Air-Conditioning and Heat Pumping Appliances, Z21.40.4•CGA 2.94

Gas-Fired Central Furnaces (Except Direct Vent Central Furnaces), Z21.47•CSA 2.3

Vented Decorative Gas Appliances, Z21.50 • CSA 2.22

Gas-Fired Pool Heaters, Z21.56 • CSA 4.7

Outdoor Cooking Gas Appliances, Z21.58 • CsA 1.6

Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces, Z21.60 • CGA 2.26

Portable Type Camp Heaters, Z21.63 • CSA 11.3

Portable Type Camp Cook Stoves, Z21.72 • CSA 11.2

Portable Type Camp Lights, Z21.73 • CSA 11.1

Vented Gas-Fired Space Heating Appliances, Z21.86 • CSA 2.32

Vented Gas Fireplace Heaters, Z21.88 • CSA 2.33

Outdoor Cooking Specialty Gas Appliances, Z21.89 • CSA 1.18

Accessories

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

Domestic Gas Conversion Burners, Z21.17 • CSA 2.7

Gas Appliance Pressure Regulators, Z21.18 • CSA 6.3

Automatic Valves for Gas Appliances, Z21.21 • CSA 6.5

Relief Valves for Hot Water Supply Systems, Z21.22 • CSA 4.4

Connectors for Gas Appliances, Z21.24 • CSA 6.10

Pilot Gas Filters, Z21.35 • CGA 6.8

Quick-Disconnect Devices for Use With Gas Fuel, Z21.41 • CSA 6.9

Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances, Z21.54 • CGA 8.4

Automatic Vent Damper Devices for Use With Gas-Fired Appliances, Z21.66 • CGA 6.14

Connectors for Movable Gas Appliances, Z21.69 • CSA 6.16

Connectors for Outdoor Gas Appliances and Manufactured Homes, Z21.75 • CSA 6.27

Manually-Operated Piezo-Electric Spark Gas Ignition Systems and Components, Z21.77 • CGA 6.23

Combination Gas Controls for Gas Appliances, Z21.78 • CSA 6.20

Gas Appliance Sediment Traps, Z21.79 • CGA 6.21

Line Pressure Regulators, ANSI Z21.80 • CSA 6.22

Cylinder Connection Devices, ANSI Z21.81 • CSA 6.25

Automatic Gas Shutoff Devices for Hot Water Supply Systems, ANSI Z21.87 • CSA 4.6

Gas Convenience Outlets and Optional Enclosures, ANSI Z21.90 • CSA 6.24

Manually Operated Electric Gas Ignition Systems and Components, ANSI Z21.92 • CSA 6.29

List of Harmonized Z83/CGA Series of American National Standard/Canadian Gas Association Standards

Direct Gas-Fired Make-Up Air Heaters, Z83.4 • CSA 3.7

Gas-Fired Construction Heaters, Z83.7 • CSA 2.14

Gas Unit Heaters and Gas-Fired Duct Furnaces, Z83.8 • CGA 2.6

Gas Food Service Equipment, Z83.11 • CGA 1.8

Gas-Fired High Intensity Heaters, Z83.19 • CSA 2.35

Gas-Fired Tubular and Low Intensity Infrared Heaters, Z83.20 • CSA 2.34

List of LC Series of Harmonized Standards for Gas Equipment

Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST), LC1 • CSA 6.26

List of Z21 Series of American National Standards for Gas Appliances and Gas Appliance Accessories

Appliances

Household Cooking Gas Appliances, Z21.1

Gas-Fired Room Heaters, Volume II Unvented Room Heaters, Z21.11.2

Domestic Gas Conversion Burners, ANSI Z21.17

Gas-Fired Illuminating Appliances, Z21.42

Recreational Vehicle Cooking Gas Appliances, Z21.57

Gas-Fired Toilets, Z21.61

Portable Refrigerators for Use With HD-5 Propane Gas, Z21.74

Gas-Fired Unvented Catalytic Room Heaters for Use With Liquified Petroleum (LP) Gases, Z21.76

Stationary Fuel Cell Power Systens, FC 1

Manually Lighted, Natural Gas Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces, Z21.84

Ventless Firebox Enclosures for Gas-Fired Unvented Decorative Room Heaters, Z21.91

Accessories

Draft Hoods, Z21.12

Automatic Gas Ignition Systems and Components, Z21.20

Gas Appliance Thermostats, Z21.23

Automatic Intermittent Pilot Ignition Systems for Field Installation, Z21.71

Installation

Domestic Gas Conversion Burners, Z21.8

List of Z83 Series of American National Standards

Direct Gas-Fired Industrial Air Heaters, Z83.18

List of LC Series of American National Standards for Gas Equipment

Direct Gas-Fired Circulating Heaters for Agricultural Animal Confinement Buildings, LC 2

Appliance Stands and Drain Pans, LC 3

Press-Connect Copper And Copper Alloy Fittings For Use In Fuel Gas Distibution System, LC 4

List of CSA/CGA Series of Canadian Gas Association Standards/National Standards of Canada for Gas Appliances and Gas Appliance Accessories

Appliances

Domestic Gas Ranges, CAN1-1.1-M81

Domestic Hot Plates and Laundry Stoves, CGA 1.3

Propane-Fired Cooking Appliances for Recreational Vehicles, CAN1-1.16

Gas-Fired Unvented Construction Heaters (Unattended Type), CGA 2.14

Gas-Fired Domestic Lighting Appliances, CAN1-2.15

Gas-Fired Appliances for Use at High Altitudes, CGA 2.17

Gas-Fired Appliances for Outdoor Installation, CAN1-2.21

Gas-Fired Waterless Toilet, CGA 5.2

Portable Type Gas Camp Refrigerators, CAN1-11.4

Accessories

Lever Operated Pressure Lubricated Plug Type Gas Shut-Off Valves, CGA 3.11

Lever Operated Non-Lubricated Gas Shut-Off Valves, CGA 3.16

Draft Hoods, CAN1-6.2

Automatic Gas Ignition Systems and Components, CAN1-6.4

Gas Appliance Thermostats, CAN1-6.6

Internal Relieved Service Regulators for Natural Gas, CGA 6.18

Residential Carbon Monoxide Detectors, CAN/CGA-6.19

Elastomeric Composite Hose and Hose Couplings for Conducting Propane and Natural Gas, CAN/CGA-8.1

Thermoplastic Hose and Hose Couplings for Conducting Propane and Natural Gas, CAN1-8.3

Manually Operated Shut-Off Valves for Gas Piping Systems, CGA 9.2

Installation

Definitions and General Field Recommendations, CGA 3.0

Natural Gas and Propane Installation Code, CGA B149.1

Code for Digester Gas and Landfill Installations, CAN/CGA-B105

Code for the Field Approval of Fuel-Related Components on Appliances and Equipment, CAN/CGA-B149.3

Performance

Testing Method for Measuring Annual Fuel Utilization Efficiencies of Residential Furnaces and Boilers, CGA P.2

Testing Method for Measuring Energy Consumption and Determining Efficiencies of Gas-Fired Water Heaters, CAN/CSA-P.3

Testing Method for Measuring Per-Cycle Energy Consumption and Energy Factor of Domestic Gas Clothes Dryers, CGA P.5

Testing Method for Measuring Thermal and Operating Efficiencies of Gas-Fired Pool Heaters, CGA P.6

Testing Method for Measuring Energy Loss of Gas-Fired Instantaneous Water Heaters, CAN/CSA-P.7

Thermal Efficiencies of Industrial and Commercial Gas-Fired Package Furnaces, CGA P.8

List of Canadian Gas Association Commercial/Industrial Standards

Gas-Fired Infra-Red Heaters, CAN1-2.16

Gas-Fired Appliances for Use at High Altitudes, CGA 2.17

Gas-Fired Brooders, CAN1-2.20

Gas-Fired Portable Infra-Red Heaters, CAN1-2.23

Decorative Gas Appliances for Installation in Solid Fuel Burning Fireplaces, CGA-2.26

Industrial and Commercial Gas-Fired Package Boilers, CAN1-3.1

Industrial and Commercial Gas-Fired Package Furnaces, CGA 3.2

Industrial and Commercial Gas-Designed Atmospherical-Fired Vertical Flue Boilers and Hot Water Supply Heaters, CGA 3.3

Industrial and Commercial Gas-Fired Conversion Burners, CGA 3.4

Gas-Fired Equipment for Drying Farm Crops, CAN/CGA-3.8

Direct Gas-Fired Door Air Heaters, CAN1-3.12

Internal Relieved Service Regulators for Natural Gas, CGA 6.18

STANDARDS PROPOSAL FORM

FAX OR MAIL TO:

CSA AMERICA, INC.
8501 East Pleasant Valley Road,
Cleveland, Ohio, U.S. 44131
Fax: (216) 520-8979

or

CANADIAN STANDARDS ASSOCIATION
5060 Spectrum Way, Suite 100,
Mississauga, Ontario, Canada L4W 5N6
Fax: (416) 747-2473

DATE: ________ NAME: ____________________

ADDRESS: ____________________

TELEPHONE NUMBER: (   ) ____________________

REPRESENTING (Please indicate organization, company or self):

1. a) Title of Standard: ____________________

   b) Section/Paragraph Number and Title: ____________________

2. Proposal Recommends: (check one) ☐ New Text ☐ Revised Text ☐ Deleted Text

3. Proposal (Include proposed wording change(s)* or identification of wording to be deleted. If proposed wording change(s) is not original, provide source.):

4. Statement of Rationale for Proposal:

5. ☐ This proposal is original material.

   ☐ This proposal is not original material, its source (if known) is as follows:

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