# 25-16

# Earthquake-Actuated Automatic Gas Shutoff Devices

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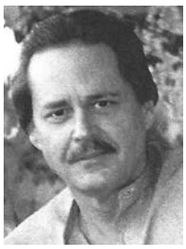

**Martin Rene Asbra**
**1945–2012**

The members of the Earthquake-Actuated Automatic Gas Shutoff Systems Standards Committee of the Structural Engineering Institute respectfully dedicate this edition of the standard in the memory of Martin R. “Marty” Asbra, who passed away in Tracy, California, in the spring of 2012. Marty was an ardent believer in the value of seismic valves and a founding member of this Committee.

Initiation of a standard for earthquake valves began in 1977 with a request from the American National Standards Committee Z21 to the Automatic Valve Working Committee of the Z21 Subcommittee on Standards for Gas Appliance Control Devices, which appointed an Earthquake Valve Working Group in 1978 to prepare a draft standard.

The ensuing draft standard was distributed for review and comment in mid-1979. A revised draft standard was adopted by the American National Standards Committee Z21 by letter ballot in December 1979. The first edition of a standard for earthquake valves—ANSI/AGA Z21.70, *Earthquake-Actuated Automatic Gas Shutoff Systems*—was approved as an American National Standard by the American National Standards Institute on April 16, 1981.

In 1981, the secretariat for the standard was transferred from the American Gas Association to the American Society of Mechanical Engineers (ASME). The ASME committee that was assigned responsibility for the standard did not initiate any changes. In 1991, a proposal was approved for the formation of a Pre-Standard Committee within the Gas and Liquid Fuel Lifelines Committee of the Technical Council on Lifeline Earthquake Engineering (TCLEE) of the American Society of Civil Engineers (ASCE) to revise ANSI Z21.70.

A full standard committee was formed in late 1992 and met for the first time in early 1993. The Committee was formed of manufacturing, engineering, local and state government, and insurance representatives.

The extensive data collected following the January 17, 1994, Northridge, California, Earthquake (hereafter referred to as the Northridge Earthquake) provided a unique opportunity to assess the risk posed to the public by natural gas–related postearthquake fires and ground motions for which automatic gas shutoff would be beneficial. The Committee met in the months following the Northridge Earthquake and finalized the scope of research needed to support development for a revised standard.

The Committee focused its research on two key areas: (1) dynamic testing of current devices, which was needed to quantify performance characteristics; and (2) in-depth examination of Northridge Earthquake data on ground motions, structural damage, fire initiation, and actuation of existing earthquake-actuated automatic gas shutoff devices.

A proposal to perform research in these two areas was prepared for ASCE by the Committee, and the project was jointly funded by FEMA, natural gas utilities, and shutoff-device manufacturers. The research project was initiated in March 1995 and completed in November 1995.

Performance characteristics of the devices tested were determined and evaluated for both discrete dynamic loads and complex motions (e.g., simulated ground motions). The results of the dynamic testing of devices that were then on the market bracketed the ranges that were used in defining the actuation requirements in response to seismic disturbances.

The second edition of the standard, ASCE 25-97, was published in 1999. The third edition of the standard, ASCE 25-06, was published in 2008. The present edition—ASCE 25-16, *Earthquake-Actuated Automatic Gas Shutoff Devices*—is the fourth edition of the standard.

The American Society of Civil Engineers (ASCE) acknowledges the work of the Earthquake-Actuated Automatic Gas Shutoff Systems Standards Committee of the Codes and Standards Activities Division of the Structural Engineering Institute. This Committee comprises individuals from a wide variety of backgrounds, including manufacturing, gas industry, consulting engineering, government, insurance industry, education, and private practice. This standard was prepared through the consensus-standards process, which includes balloting in compliance with procedures of ASCE's Codes and Standards Council. Individuals serving on the Committee are listed below.

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# CHAPTER 1
# GENERAL

Except as modified by this standard, devices qualified to this standard shall conform to the applicable specifications of ANSI/AGA Z21.21b/CSA 6.5b (ANSI/AGA/CSA 2004).

## 1.1 SCOPE

This standard provides minimum functionality requirements for earthquake-actuated automatic gas shutoff devices and systems (hereafter referred to as devices) meant to include mechanical devices consisting of a sensing means and a means to shut off the flow of gas. The components or parts of devices not covered by this standard or the applicable sections of ANSI/AGA Z21.21b/CSA 6.5b shall be in accordance with applicable American National Standards Institute and industry standards. The values stated throughout this document in in.-lb units are to be regarded as standard. The values stated within parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

## 1.2 APPLICABILITY

This standard applies to devices installed in lines carrying gaseous fuels, such as natural gas and propane. The purpose of these devices is to reduce the risk of gas leaks resulting from damage to gas systems caused by seismic shaking. The configurations considered in this standard are piping, equipment, or appliances typically found in single-family or multifamily structures of three stories or less. In lieu of engineering analysis and design, or other guidelines or standards, this standard may be applied for devices in industrial or commercial applications.

Devices that comply with this standard may not activate during design-level seismic shaking in a particular region.

**1.2.1 Pressure Rating.** This standard applies to devices having maximum operating gas-pressure ratings of 0.5 psi (3.4 kPa) up to and including 60 psi (414 kPa).

**1.2.2 Mounting.** This standard applies to devices that are to be mounted in strict accordance with their manufacturer's installation instructions and in a manner that is sensitive to earthquake ground motions and not motions that might result from the dynamic response of structures, equipment, or other appurtenances.

## 1.3 OPERATION

**1.3.1 Mode of Operation.** The device shall be designed to operate automatically. Actuation of the gas shutoff means may be accomplished either directly or indirectly by mechanical or other means. The use of one or more permanent magnets as valve components is not permitted if their placement might cause iron oxides, iron sulfides, or similar ferrous materials to collect on valve seating surfaces.

**1.3.2 Operating Conditions.** Devices covered by this standard shall be capable of operating at ambient temperatures of −10°F to +150°F (−23°C to +66°C), unless their manufacturer specifies lower minimum or higher maximum operating temperature limits.

**1.3.3 Pressure Specification.** All references to internal pressure throughout this standard are gauge pressures, unless otherwise noted.

## 1.4 MARKING

**1.4.1 Permanent Label.** In addition to the requirements of ANSI/AGA Z21.21b/CSA 6.5b, each device shall have permanent labeling to identify this standard, as follows:

*ASCE 25-16.*

**1.4.2 Installation Warning.** All devices shall have the following warning affixed to the device with a tag and also to the device's packaging carton:

*WARNING! This device must be installed by a qualified installer in accordance with the manufacturer's installation instructions; if improperly installed, failure to function as intended or unwarranted interruption of gas service could result.*

**1.4.3 Resetting Warning.** All devices shall bear the following warning:

*WARNING! Following actuation of this device, reset the device and restore service only after a qualified person has verified no gas leak exists.*

## 1.5 WARRANTY

Manufacturers shall warrant the performance of devices for a specified time to meet this standard.

# CHAPTER 2
# CONSTRUCTION

## 2.1 GENERAL

The construction of parts not covered by this standard shall employ reasonable concepts of safety and durability. General assembly shall be of a neat and workmanlike character, with all parts and components well fitted.

**2.1.1 Indication of Actuation.** The device shall have an external means of indicating whether or not actuation has occurred, without the use of tools or equipment.

**2.1.2 Resetting.** The device shall require manual resetting after having been actuated.

## 2.2 EQUIPMENT AND DATA TO BE FURNISHED BY THE MANUFACTURER

The manufacturer shall furnish the following equipment and data for the use of the testing agency in listing devices under this standard:

A) Representative devices, as specified by the testing agency;
B) Drawings, blueprints, or photographs that describe each model of the device as specified by the testing agency;
C) Minimum and maximum operating pressure;
D) Operating ambient temperature range;
E) Drawings, blueprints, or photographs that describe the mounting configurations and leveling tolerances;
F) Operating instructions for the device that prescribe the steps necessary to reset the device;
G) A plot of pressure drop versus flow rate; and
H) Flow capacity with 1,000 Btu/ft$^3$ (37.25 MJ/m$^3$), 0.64 specific-gravity gas at 60°F (15.6°C), and the following conditions:
   1) A pressure drop of 1.0 in. of water column (249.1 Pa) for a device with a maximum operating pressure of 0.5 psi (3.4 kPa); and
   2) A pressure drop of 10% of the maximum operating pressure for a device with a maximum operating pressure of more than 0.5 psi (3.4 kPa).

## 2.3 CORROSION AND CHEMICAL RESISTANCE OF EXTERNAL PARTS

Valve bodies, casings, and external parts shall be made of or protected by materials that are resistant to attack over the expected life of the device by the atmosphere, weather (sunlight, humidity, and temperature changes), and common cleaning and other agents to which it may be exposed. The device case and exterior parts shall be capable of meeting or exceeding the requirements of ANSI/AGA B109 (ANSI/AGA 2001) for gas meters.

## 2.4 INSTRUCTIONS

Complete instructions covering installation and proper operation shall be furnished by the manufacturer. These instructions shall be reviewed by the testing agency for accuracy and compatibility with results of tests. Included in these instructions shall be the following:

A) A statement that the system must be installed by a qualified installer as defined by this standard or the authority having jurisdiction;
B) A statement that it is necessary to comply with local codes; or, in the absence of local codes, with the National Fuel Gas Code (ANSI/NFPA 2012) and, if applicable, the National Electrical Code (ANSI/NFPA 2011);
C) Step-by-step installation-and-inspection procedures;
D) Step-by-step procedures for resetting the device, including notice that a qualified person, as defined by this standard, must verify that no gas leak exists;
E) Instructions on how the device is to be located with respect to the related gas service and structures;
F) Instructions on how the devices should be mounted to meet the requirements of Section 1.2.2;
G) Clearances not less than those needed for testing and resetting and provisions for access;
H) A description of how the system operates;
I) Instructions for examining the system for continued safe operation indicating the necessity and minimum frequency for these examinations;
J) A plot of pressure drop versus flow rate; and
K) The equivalent length of pipe, of the same nominal size as the piping connection to the device, that would produce the same pressure drop indicated in the plot of pressure drop versus flow rate. Calculations used to determine the equivalent length of pipe must be specified.

## 2.5 CONTINUED OPERATION

The continued operation requirements of ANSI/AGA Z21.21b/CSA 6.5b shall not apply to devices qualified under this standard.

# CHAPTER 3
# PERFORMANCE

## 3.1 RIGIDITY OF MOUNTING

Rigidity of mounting specified by a manufacturer shall be considered to meet the minimum requirements of Section 1.2.2 if the mounting assembly for the sensing means has no resonant period greater than 0.06 s.

## 3.2 DEFLECTION LIMITS

One sample of the device shall be tested to confirm that after having closed, it will remain in the closed position with the device in any position up to a maximum deflection of 45° from vertical at any azimuth.

## 3.3 TEST SPECIMENS

Tests other than those specified in Sections 3.4 and 3.5 shall be conducted on one sample of the device.

## 3.4 RUGGEDNESS OF DEVICE

Three samples of the device shall be tested at room temperature to confirm that after having closed, it will not return to the open position after being subjected to horizontal sinusoidal oscillations. These tests shall be performed with the device in a closed position and oriented in a 20° deflected position from vertical as described in Section 3.4.2, prior to performing the tests described in Section 3.4.1. Two samples shall be tested at no more than 0.5 psi (3.4 kPa), and one sample shall be tested at the maximum specified operating pressure of the device.

**3.4.1 Ruggedness Test Requirements.** The device, when in a closed position and a deflected position of 20° from vertical, shall not be placed in an open position after being subjected to 20 s of horizontal sinusoidal oscillation having

A) A peak acceleration of 0.85$g$ (8.33 m/s$^2$) and a period of 0.13 s,
B) A peak acceleration of 1.00$g$ (9.81 m/s$^2$) and a period of 0.20 s,
C) A peak acceleration of 0.85$g$ (8.33 m/s$^2$) and a period of 0.40 s, and
D) A peak acceleration of 0.30$g$ (2.94 m/s$^2$) and a period of 0.90 s.

These conditions shall be met for horizontal axes of the sensing means.

**3.4.2 Method of Test.** Each test shall be conducted on three samples of the device. With the agreement of the manufacturer, all three samples may be tested simultaneously.

The device shall be rigidly attached to a table or platform capable of being adjusted to provide the horizontal or vertical, sinusoidal, unidirectional acceleration forces necessary to conduct the tests described herein.

Test motions shall be monitored by measuring the acceleration of the sensing means.

Pipe-mounted devices shall be pipe mounted and shall be mounted within 6 in. (15 cm) of either the surface of the table or a rigid object rigidly fastened to the table. Rigidity of mounting may be demonstrated by resonance search testing as described in ANSI/IEEE 344 (ANSI/IEEE 2004).

The device shall be connected to a pneumatic system using inlet and outlet connectors that will not interfere with the motion of the platform. This pneumatic system shall be capable of being monitored to determine whether the device under test has remained in a closed position. At the discretion of the testing agency, alternate means of determining the status of the device may be used provided such means are objective and measurable.

The device under test shall be positioned at 20° from vertical relative to the specified position in the manufacturer's installation instructions with the sensing means in the manufacturer's specified operating position. The device shall be rotated about its vertical axis to correspond to the least favorable orientation of the device with respect to the direction of acceleration of the table. At the discretion of the testing agency, additional tests may be conducted at other orientations about the vertical axis.

The table shall be adjusted to provide a horizontal oscillation at a period specified in Section 3.4.1. The acceleration levels shall be increased to the maximum acceleration level for a selected oscillating period specified in Section 3.4.1. The oscillations shall be maintained at this level for 20 s.

If the shutoff means is open following this test, the device shall be considered as not meeting the requirements of this standard.

## 3.5 PERFORMANCE REQUIREMENTS

The range of motions defining the appropriate response for devices is illustrated in Figure 3-1. Tests are required to confirm that devices meet the response requirements shown in Figure 3-1.

Three samples shall be tested for conformance to the performance requirements. All three samples must pass the response requirements of this section.

Two samples shall be tested at no more than 0.5 psi (3.4 kPa). One sample shall be tested at the maximum specified operating pressure of the device.

The three samples shall be tested at the minimum and maximum operating temperature defined in Section 1.3.2.

**3.5.1 Actuation Requirements.** The sensing means of the device shall actuate the shutoff means within 5 s when subjected to horizontal sinusoidal oscillation having

A) A peak acceleration of 0.70$g$ (6.87 m/s$^2$) and a period of 0.13 s,

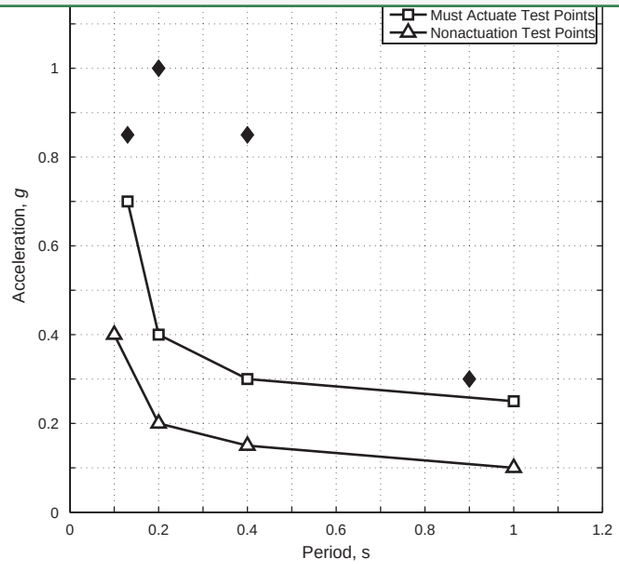


**FIGURE 3-1. Actuation-Tolerance Band for Earthquake-Actuated Automatic Gas Shutoff Devices**

B) A peak acceleration of 0.40$g$ (3.92 m/s$^2$) and a period of 0.20 s,
C) A peak acceleration of 0.30$g$ (2.94 m/s$^2$) and a period of 0.40 s, and
D) A peak acceleration of 0.25$g$ (2.45 m/s$^2$) and a period of 1.00 s.

These conditions shall be met for horizontal axes of the sensing means.

**3.5.2 Nonactuation Requirements.** The sensing means of a device shall not actuate the shutoff means when subjected for 5 s to sinusoidal oscillations having

A) A peak acceleration of 0.40$g$ (3.92 m/s$^2$) with a period of 0.10 s,
B) A peak acceleration of 0.20$g$ (1.96 m/s$^2$) and a period of 0.20 s,
C) A peak acceleration of 0.15$g$ (1.47 m/s$^2$) with a period of 0.40 s, and
D) A peak acceleration of 0.10$g$ (0.981 m/s$^2$) with a period of 1.00 s.

These conditions shall be met for both horizontal and vertical axes of the sensing means.

**3.5.3 Method of Test.** Each test shall be conducted on three samples of the device. With the agreement of the manufacturer, all three samples may be tested simultaneously.

The device(s) shall be rigidly attached to a table or platform capable of being adjusted to provide the horizontal or vertical, sinusoidal, unidirectional acceleration forces necessary to conduct the tests described herein. Test motions shall be monitored by measuring the acceleration of the device(s).

Pipe-mounted devices shall be pipe mounted and shall be mounted within 6 in. (15 cm) of either the surface of the table or a rigid object rigidly fastened to the table. Rigidity of mounting may be demonstrated by resonance search testing as described in ANSI/IEEE 344.

inlet and outlet connectors that will not interfere with the motion of the platform. This pneumatic system shall be capable of being monitored to determine whether the device under test has been actuated to close the shutoff means. At the discretion of the testing agency, alternate means of determining triggering of the sensing means can be used, provided such means are objective and measurable.

The device under test shall be positioned as specified in the manufacturer's installation instructions so that the sensing means is in the manufacturer's specified operating position.

The shake table shall be adjusted to provide an oscillation at a period specified in Sections 3.5.1 or 3.5.2. This acceleration shall be increased slowly until the acceleration corresponds to the nonactuation level in Section 3.5.2. The oscillations shall be maintained at this level for 5 s. If the shutoff means closes during this time, the device will be considered as not meeting the requirements of this standard.

For tests in the horizontal direction, the acceleration shall again be increased after dwelling at the nonactuation level specified in Section 3.5.2 for 5 s. The rate of increase in acceleration shall not exceed 0.01$g$ per s. The levels shall be increased to the maximum acceleration level for a selected oscillating period specified in Section 3.5.1, or until the shutoff means closes. The acceleration and time at which the shutoff means closes shall be recorded. If the level specified in Section 3.5.1 is reached, it shall be maintained for 5 s to complete the testing. If no actuation occurs at the levels specified in Section 3.5.1, the device shall be considered as not meeting this specification.

The horizontal oscillation test shall be repeated three times, with the device successively rotated in a horizontal plane on the table or platform to be at 45°, 90°, and 135° (0.79, 1.57, and 2.36 radians) from the original position with respect to the direction of acceleration of the table. At the discretion of the testing agency, additional tests may be conducted at other horizontal orientations. The device shall be reset after each test.

*Note: If the testing agency determines that the response to testing would be identical at any rotated position with respect to a horizontal plane because of symmetrical construction of the device, then testing to the requirements of Sections 3.5.1 and 3.5.2 can be limited to the original position.*

## 3.6 MARKING MATERIAL DURABILITY AND ADHESION

**3.6.1 Marking Material Durability.** All marking materials shall not be adversely affected when exposed to conditions expected over the life of the device due to the atmosphere, weather (sunlight, humidity, and temperature changes), and common cleaning and other agents to which they may be exposed. The marking materials shall be capable of meeting or exceeding the requirements of ANSI/AGA B109 for gas meters.

**3.6.2 Adhesion Evaluation.** All markings shall be evaluated for adhesion following leakage tests and shall not be adversely affected when exposed to conditions expected over the life of the device due to the atmosphere, weather (sunlight, humidity, and temperature changes), and common cleaning and other agents to which they may be exposed. The adhesion shall be capable of meeting or exceeding the requirements of ANSI/AGA B109 for gas meters.

# CHAPTER 4
# DEFINITIONS

The following definitions shall apply to this standard:

**Actuating means:** The component of an earthquake-actuated automatic gas shutoff device that is designed to react to a signal from the device's seismic sensing means and to act to close the device's gas shutoff means.

**Earthquake-actuated automatic gas shutoff device:** A device or assembly of devices consisting of a seismic sensing means, an actuating means, and a gas shutoff means that are designed to automatically shut off the gas at the location of the gas shutoff means in the event of a seismic disturbance that reaches or exceeds any of the actuation conditions specified in Section 3.5.1. The device may consist of separable components or may incorporate all functions in a single body.

**Gas shutoff means:** The component of an earthquake-actuated automatic gas shutoff device that is designed for installation in a gas-piping system and intended to shut off the gas.

**Qualified installer:** Any individual, firm, corporation, or company that is responsible for the installation and operation of the devices and that is experienced in such work, is familiar with all precautions required, and has complied with all requirements of local codes and the authority having jurisdiction.

**Qualified person:** Any individual, firm, corporation, or company that is experienced in such work and is familiar with all precautions required because of the manufacturer's installation instructions, local codes, and the authority having jurisdiction.

**Seismic sensing means:** The component of an earthquake-actuated automatic gas shutoff device that is designed to sense and respond to seismic disturbances.

# CHAPTER 5
# REFERENCES

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# COMMENTARY

This Commentary is not a part of the ASCE Standard. It is included for informational purposes only. This information is provided as explanatory and supplementary material designed to assist in applying the recommended requirements.

The sections of this Commentary are numbered to correspond to the sections of the Standard to which they refer. Since it is not necessary to have supplementary material for every section in the Standard, there are gaps in the numbering sequence of the Commentary.

# CHAPTER C1
# GENERAL

The intent of this standard is to require earthquake-actuated automatic gas shutoff devices (hereafter referred to in this Commentary as devices) to meet most of the current requirements for other gas-appliance control devices. In this standard, this is done by reference to ANSI/AGA Z21.21b/CSA 6.5b, *Automatic Valves for Gas Appliances* (ANSI/AGA/CSA 2004).

The following points are provided to clarify the use of ANSI/AGA Z21.21b/CSA 6.5b within this standard:

A) Devices tested to this standard do not need to be rated in 5-psi (34-kPa) increments, as required by ANSI/AGA Z21.21b/CSA 6.5b.
B) Determination of pressure drop versus flow rate and capacity at specified conditions should be confirmed by the testing agency using the procedures in ANSI/AGA Z21.21b/CSA 6.5b.
C) The integrity of operation requirements and resistance to permanent damage at excessive supply pressures required by ANSI/AGA Z21.21b/CSA 6.5b can be waived for devices tested to this standard.
D) The gas-cracking and internal explosion requirements of ANSI/AGA Z21.21b/CSA 6.5b apply to devices tested to this standard only when electrical components are located within the gas stream.

## C1.1 SCOPE

This publication is a basic standard for the construction, installation, inspection, and performance of earthquake-actuated automatic gas shutoff devices. A device tested to this standard directly senses the ground shaking through its sensing means and then, at certain clearly defined levels of the ground motion, actuates its gas shutoff means. This standard provides minimum requirements and is designed to allow compliance of devices that exceed the various provisions specified herein. The provisions of this standard do not consider site-specific earthquake hazards. Consideration of expected site-specific ground motions with the actuation requirements of this standard may influence the choice by the person(s) responsible for selecting the device(s) for a particular facility from the various devices that conform to this standard, as part of their overall actions to reduce the risk of the facility's building(s) from potential earthquake-related damage to the gas-piping system(s) in that (those) building(s). As technological improvements take hold in the marketplace, modifications to this standard may become desirable. This standard may be revised or withdrawn at any time.

## C1.2 APPLICABILITY

The suitability and conditions of devices tested to this standard should be reviewed and approved by the local jurisdiction having authority. Devices that comply with this standard have approximately a 50% probability of actuating when the peak horizontal ground acceleration (PGA) is between 0.16$g$ and 0.26$g$. Hence, a device may not actuate when needed and may actuate when not needed. In the United States, jurisdictions and device users can calculate the probabilities of actuation and nonactuation by using the current set of probabilistic ground motions generated by the USGS. Users in other nations should seek guidance from appropriate regional maps or reports. This information can be used in determining the appropriateness of installing these devices within various regions or jurisdictions. When possible, site-specific soil-adjusted ground motions should be used in making this determination.

The roles of these devices in improving natural gas safety and the effectiveness of other types of products and measures are discussed in the report titled *Improving Natural Gas Safety in Earthquakes* (California Seismic Safety Commission, 2002). Issues specifically related to gas shutoff products can be found in Section 6.0 ("Consequences of Earthquake Damage to the Natural Gas System") and Section 7.0 ("Options to Reduce Incidences of Fire and Service Disruptions Following Earthquakes") of the aforementioned report. It should be noted, however, that this Committee in no way endorses or recommends the use of excess flow valves referred to in that report. Excess flow valves are not earthquake-actuated devices and will not respond to leakage that mimics normal use.

The user of a device that meets this standard should be appropriately informed of the following considerations:

A) This standard's testing requirements were established for protection of wood-frame, single- or multifamily structures of three stories or less. Lacking other applicable guidelines or standards, the use of this standard for devices in industrial or commercial applications is not precluded. The condition of these structures is assumed to be such that structures will not become totally damaged, severely deformed, displaced, or collapsed from ground shaking below the standard's must-actuate test levels.
B) Facilities with atypical structures, including multistory buildings or special gas installation configurations, may require an engineering evaluation and/or a suitable system consistent with the structure's characteristics and the risk tolerance of the person(s) responsible for selecting the device(s) for each such situation.
C) Devices of different mechanical design characteristics or made by different manufacturers may shut off the gas flow at varying levels of ground shaking, even though all conform to this standard's actuation requirements.
D) This standard requires each device to be installed and maintained by properly qualified and trained personnel. Following a significant earthquake, such a person may not

device, and restore the gas service. It is expected that aftershocks may cause additional actuations of the device, which would also require restoration of gas service.

E) Other mitigation measures are still necessary to provide protection from potentially hazardous conditions resulting from a seismic event. These measures may include properly bracing water heaters and other gas appliances, structurally reinforcing foundations or structural elements, limiting the source of fire ignitions (for example, by providing earthquake-actuated automatic electrical service isolation), and installing fire-suppression devices such as automatic sprinklers.

**C1.2.2 Mounting.** When installing a device tested to this standard near a gas meter that is owned and operated by the serving gas supplier (i.e., local gas utility), the device should be installed in the consumer's piping system at a point somewhere downstream of the utility's gas meter, associated piping, and equipment, unless otherwise permitted by the gas utility. The serving gas supplier's meter-bypass fittings or outlets should never be used, altered, or obstructed to prevent the utility's access.

Installing a manual shutoff valve immediately upstream of the earthquake-actuated automatic gas shutoff device is advisable to assist and ensure that the serving gas supplier and qualified installer comply with all jurisdictional requirements. Only utility-qualified persons may operate, maintain, or service the utility's gas meter, service-line valves, or other equipment. The customer-owned manual shutoff valve that is recommended must have sufficient flow characteristics based on the nominal pipe size of the customer's piping at the "point of delivery" to provide sufficient gas volume and delivery pressure.

Compliance with this advice would provide the following benefits:

A) Serving gas suppliers, building owners, and plumbing contractors could more easily comply with jurisdictional requirements that allow only utility-qualified persons to operate the gas utility's service valve. Operation of the serving gas supplier's service valve would not be required to replace, maintain, or repair the building owner's device or gas-piping system.

B) Building owners would be responsible for maintenance and care of the manual shutoff valve and the earthquake-actuated automatic gas shutoff device because both would be installed in the building owner's gas-piping system.

C) Future maintenance on the building's gas-piping system could be performed without the gas utility's assistance because the manual shutoff valve could be utilized to shut off the gas supply and would not interrupt the serving gas supplier's metered gas supply.

D) Installation of the manual shutoff valve and earthquake-actuated automatic gas shutoff device downstream of the maintain its facility without interference from closure of the manual valve or the device.

**C1.3.1 Mode of Operation.** Iron oxides or iron sulfides may form within steel natural gas pipelines owing to the chemical reaction of constituents within the gas stream or microbiologically influenced (e.g., bacteria) corrosion. Where gas velocities are high, this powder material may be carried a significant distance from where it was formed. Magnets used to position or reset the sealing component of a device may attract these iron compounds to seating surfaces, causing incomplete seating and resultant gas leakage around the seat. This provision is not intended to exclude devices that incorporate magnets but do not contribute to this problem.

**C1.4.2 Installation Warning.** Installation of devices should be performed by a "qualified installer" for the following reasons:

A) The orientation and support requirements can vary depending on the brand and model of the selected device and the piping configuration where the device is installed. It is recommended that contractors or others installing a device be trained and qualified by the device's manufacturer or one of its authorized representatives.

B) Devices cause a drop in pressure, which reduces the gas-flow capacity of the gas piping entering a structure. The magnitude of this pressure drop is required by this standard to be reported for each device. Most persons are unfamiliar with the sizing of gas systems and are often not aware of this feature of their gas system. As a result, potential exists to install a device that could adversely affect the function of appliances or produce a hazardous condition. Therefore, care should be taken in ensuring that the additional pressure drop does not cause the total pressure drop for the system to exceed the maximum allowed by the authority having jurisdiction.

**C1.4.3 Resetting Warning.** It is recommended that the resetting warning also be displayed on the device's packaging.

## C1.5 WARRANTY

The issue of specifying a minimum warranty is considered necessary to alert regulators and potential consumers as to the expected reliability of performance. Without periodic examination, a warranty period of more than 10 years is not recommended. Periodic examination and servicing or a replacement date may be specified by the manufacturer or required by regulators. A random sampling examination program may be considered for extending the performance warranty period.

# CHAPTER C2
# CONSTRUCTION

**C2.1.1 Indication of Actuation.** The intent of this requirement is to allow rapid determination of whether the device is in an open or closed position. This requirement assumes that access to common tools (e.g., screwdriver or pliers) may be limited following an earthquake. The use of protective covers that are removable by hand is an acceptable option.

## C2.2 EQUIPMENT AND DATA TO BE FURNISHED BY THE MANUFACTURER

The data required on flow capacity is to be in a specified format that is readily usable by qualified persons and qualified installers responsible for sizing interior gas-piping systems.

Capacity requirements have not been specified in this standard to prevent restrictions on the design, operational characteristics, and applications of particular devices. Guidance for minimum capacities can be found in other standards for residential and industrial gas-control devices (ANSI/ASME 2002; ANSI/AGA/CSA 1997).

# CHAPTER C3
# PERFORMANCE

The following guidelines are provided for the tests described in this section:

A) Qualification of test procedures: Test procedures should be qualified by a testing laboratory in compliance with a nationally or internationally recognized standard, such as ISO/IEC DIS 17025 (ISO/IEC 1998) for laboratories, or by certification by an authority having jurisdiction (e.g., a municipality that requires such tests). Tests performed outside a recognized laboratory may be qualified by persons representing an approved laboratory that is in compliance or by the authority having jurisdiction that is overseeing the tests.
B) Excitation of the device: The device should be excited with harmonic motion on a single axis having an amplitude variance of less than ±0.03$g$ of the average peak value of the waveform.
C) Transducers: Motions are to be measured by accelerometers. Servo-type accelerometers capable of measuring accelerations to DC may be calibrated in the field of gravity. Piezo-electric or charge-output type accelerometers should be calibrated by methods traceable to NIST at frequencies of 1 Hz and 10 Hz. The frequency response of the accelerometer should be greater than 25 Hz.
D) Data acquisition and signal conditioning: Digital sampling of data should not be less than 100 Hz. A/D converters should be no less than 12 bits. Any difference between the data measured and the test point of acceptance should be greater than or equal to the accuracy of the system of measurement.
E) Processing of data: Postprocessing of data should be limited to mean-value offset correction of accelerations and truncation of extraneous data. No high- or low-pass digital filtering or running averages of raw data should be done. Preprocessing of data may consist of low-pass antialias filters with a corner frequency not lower than 20 Hz. Displacement or velocity histories should not be used to calculate acceleration histories.
F) Presentation of test reports: Test reports should include representative plots of signal histories and trip indications demonstrating the quality of the data. Reports should include a list of equipment and specifications supporting the acceptance of data in accordance with the allowed tolerance, including the calibration data records, and be dated and signed by the responsible person.

## C3.2 DEFLECTION LIMITS

The limits on deflection that can be accommodated in a closed position are to minimize the likelihood that a device will have internal leakage following earthquake-related displacement of the building structure.

## C3.4 RUGGEDNESS OF DEVICE

The ruggedness-response requirements are intended to provide some level of confidence that (a) an aftershock will not cause a device that has actuated to be placed in a nonactuated position, and (b) the device is capable of performance during severe seismic motions.

The prescribed angular deflection of 20° was selected as an upper-bound estimate of the level of rotation that might be experienced by a gas-service installation prior to the structure undergoing a level of damage inconsistent with the definition in Section 3.2.

## C3.5 PERFORMANCE REQUIREMENTS

Although the historical use of earthquake-actuated automatic gas shutoff devices dates back over 60 years, there have been few attempts to obtain information on (a) the performance of a known population of devices during past earthquakes or (b) the effectiveness of these devices in reducing property damage or risk to life. Most government agencies do not maintain a record of device installations, and manufacturer and distributor records are incomplete, nonexistent, or proprietary. Estimating the number of devices in a particular region is therefore difficult. Determining the number of devices that actuated or the improved level of safety associated with their use for any particular earthquake is equally difficult.

The task of collecting the data necessary to better evaluate the requirements of this standard in the future would be greatly improved if government agencies that permit or require the installation of these devices were to provide a means to easily track the model, size, location, and installation date of all devices within their jurisdiction (ownership changes notwithstanding). Postearthquake investigations (e.g., root-cause analyses) of life-safety impacts, building damage, gas piping and appliance damage, and fire occurrences that may be related to gaseous fuels would be invaluable for improving the understanding of seismic risks associated with fuel-gas piping systems.

Actuation requirements in this standard are based on detailed examination of the available information from the Northridge Earthquake (Diehl, 1995; Honegger, 1995; EQE/OES, 1995; Strand, 1995). The fire experience for that earthquake was generally consistent with the experience from previous earthquakes in the United States.

The upper limit of the actuation-tolerance band defined by the must-actuate test levels of this standard corresponds to the acceleration levels at which the onset of actuation was

ridge Earthquake gas-related fire data. On the basis of Northridge Earthquake data, this standard's requirements are judged to underestimate the horizontal ground motions associated with a significant risk of gas-related postearthquake fires by 30% to 50% in the critical frequency range of 2.5 Hz to 5 Hz.

The Committee made several assumptions while establishing appropriate limits for actuation. The more important assumptions are as follows:

A) The identified limits are based on encompassing more than 95% of all gas-related fires.
B) The typical structural configuration is considered to be a wood-frame, single- or multifamily structure of three stories or less.
C) An atypical structural or gas-piping configuration may require an engineered system that is suitable for the type of facility and the risk tolerance of the person(s) responsible for selecting the device for each such situation.
D) The dynamic loads on gas appliances caused by the earthquake can be related to free-field ground motions. Global response of gas-fired equipment located at ground level (i.e., sliding and overturning) was considered in establishing actuation limits.
E) The structure and the gas-appliance configurations are consistent with an assumed damping ratio of 5% or greater.
F) Within the actuation limits, it is assumed that leaks in gas-fired equipment or houselines do not occur. Houseline damage is generally associated with significant structural damage, which is not expected within the actuation ranges.

The Committee's research of Northridge Earthquake data did not investigate the complex relationships among observed soil and geologic conditions, and ages of the structures.

The actuation requirements were selected by considering that for a constant level of acceleration, greater energy and more structural damage potential are associated with lower frequency responses than with higher.

The lower limit of the actuation-tolerance band defined by the nonactuation test levels of this standard, which are 0.15*g* or 0.20*g* below the corresponding must-actuate level, were selected by the Committee after weighing several competing considerations.

An actuation-tolerance band that is too wide would allow significant variability of the device's response to an earthquake. Devices of different mechanical design or from different manufacturers may be set to shut off the gas flow at any level within this band. When devices are set to actuate at low actuation levels, actuation may occur more frequently owing to the greater number of ground motions that occur with increasingly lower acceleration levels. The result may be more unnecessary service interruptions with their attendant risks and costs, which cause unnecessary inconvenience or hardship.

A narrow actuation-tolerance band is desirable but has not been adopted in this standard for technical and cost considerations. Many of the devices currently available on the market were tested in 1995 and found to respond within this standard's actuation-tolerance band, without requiring modifications or substantial redesign. This standard is not intended to inhibit development of new equipment or practices or to influence how such innovations are accepted in the marketplace. After improved designs or newer technologies become affordable, there will be opportunities to update the performance requirements in future editions of this standard.

# CHAPTER C5
# REFERENCES

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