

White Paper: Earthquake Actuated Shutoff Systems for Industrial and Commercial Applications

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1 Introduction

Although there is a national standard for natural gas shutoff devices for residential wood-frame structures, ANSI / ASCE / SEI 25-16, no such standard exists for industrial and commercial applications. ASCE 25 specifies the MINIMUM acceptable performance and features for devices intended for RESIDENTIAL applications. In the absence of a risk-informed, performance-based analysis, ASCE 25 serves as a reasonable starting point for the selection and application of earthquake devices for the automatic shutoff of natural gas for commercial and industrial facilities. Further, **ASCE 25 saves the plant owner/engineer the heartache (read: cost) of performing a seismic risk analysis** and determining site specific shutoff response criteria for the seismic sensing means. However, the low-cost mechanical ASCE 25 devices designed for residential use often lack features required for industrial and commercial service such as: mitigating false positives by 2/2 or 2/3 voting, controlling secondary processes (i.e. shutoff pumps), signaling life safety systems or facility management systems, providing back-up power for motors and solenoids (for controlled shutdown in the absence of primary 110 Vac or 220 Vac power), providing automatic shutoff of other non-NG fluids and gases (fuel oils, toxic gases, corrosive gases, cooking oils, etc.), expandability for future processes, back-up power fault monitoring, venting residual pressurized gas in long pipelines, and more.

2 Objective

The objective of this white paper is to educate decision makers on the applicability of the ANSI / ASCE / SEI 25 standard to industrial and commercial sites and to provide guidance on selecting strong motion instrumentation (seismic switches and/or seismic controllers) for non-residential earthquake actuated automatic shutoff applications.

3 Background

ASCE Standard 25-97 was a voluntary consensus standard that was developed over five years by a balanced committee and subjected to a public ballot. It supersedes the previous national standard for these types of devices, ANSI Standard Z21.70 (1981), which was adopted in 1981 by California's Office of the State Architect as California State Standard 12-23-1. ASCE Standard 25-97 was adopted in November 2000 by California's Division of the State Architect, and approved in January 2001 by California's Building Standards Commission, as California State Standard 12-16-1. Standard 12-16-1 supersedes Standard 12-23-1. Since July 1, 2001, the California Division of the State Architect requires that all seismic gas shutoff valves sold in California be certified by California's Division of the State Architect to Standard 12-16-1. ASCE 25 was revisited in 2005 & 2013 respectively leading to the ASCE 25-06 and ASCE 25-16 versions.

The -06 and -16 revisions to the standard still provide the minimum performance criteria for residential applications. The foundational work for the ASCE 25 Standard, performed in the mid-90's by the Earthquake Actuated Automatic Gas Shutoff (EAAGS) Devices Standards Committee of the Lifelines Standards Council, is un-touched. Therefore, the actuation criteria for the sensing means is same in the -06 and -16 revisions. No additional analyses addressing industrial or commercial sites have been performed by subsequent ASCE 25 committees.

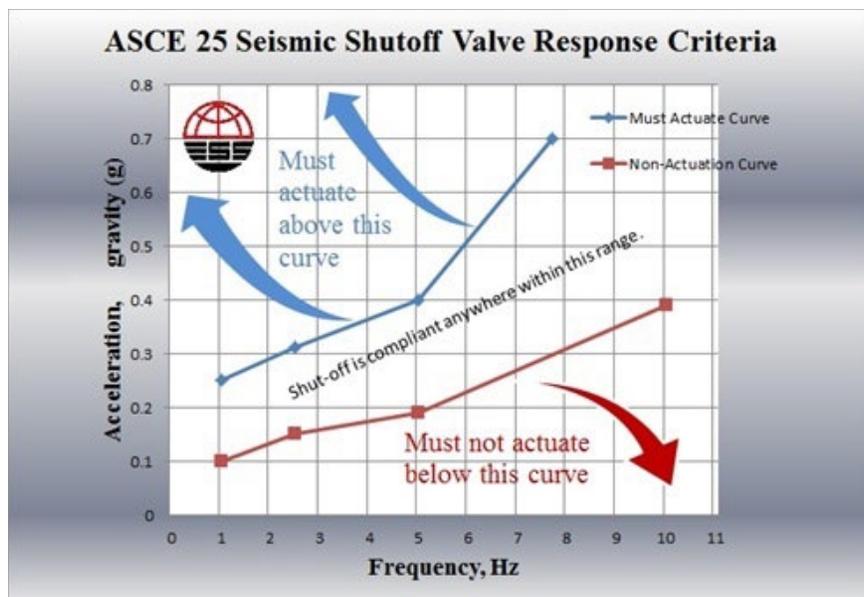


Figure 1: ASCE 25-97 Earthquake Actuated Gas Shutoff Criteria

As shown in Figure 1, the ASCE 25 requirement for actuation is not very accurate. At 7 Hz, devices shutting off at 0.6 g_{pk} are as compliant as devices shutting off at 0.275 g_{pk}. Based on published formulae applicable to California's geology, that roughly corresponds to a difference of actuating on a proximal M5.5 earthquake vs. a M7.0+ earthquake. For more information on estimating the expected peak ground acceleration based on earthquake magnitude and distance, the reader is invited to visit: <https://eqsafetysys.com/wp-content/uploads/2022/03/shakemap22a.pdf>

The testing of devices for compliance with ASCE 25 presumed that the shutoff device is mounted close to the ground (i.e. within 6"). That is, that the shutoff device must sense ground motion and "...not motions that might result from the dynamic response of structures, equipment or other appurtenances." (ASCE 25-16, Paragraph 1.2.2 Mounting)

ASCE 25 devices are generally shutoff valves with a seismic sensing element integral to the shutoff valve. Where the valve is installed is where the earthquake is 'sensed'. In smaller sizes (i.e. 1/2", 3/4") these devices are available 'off-the-shelf' and can be installed by a trained licensed plumber on the customer side of the gas meter at apartments, homes and buildings.

In practice, however, many industrial or commercial installations employing ASCE 25 devices are non-compliant with the ASCE 25 standard because most piping runs in industrial facilities are well above grade-- subjecting the ASCE 25 device to the dynamic response of the piping system itself. Mechanical contractors try to ‘solve’ the issue by installing bracing to rigidly affix the valve and/or piping to another structure (steel post, building, etc). This subjects the ASCE 25 shutoff device to the complex dynamic motion of both the piping system and the supporting structure- which the ASCE 25 standard explicitly says not to do. **What is rigid under static conditions will flex, bounce & bend under tectonic forces.** As shown in Figure 2, it appears that the mechanical contractor & owner (with the blessing of building officials and/or the insurance carrier) have installed hap-hazard seismic protection- deluding themselves that it complies with the ASCE 25 standard.

If the piping system and/or support structure has a resonance within the ASCE 25 frequency response range, then pre-mature actuation is likely. Non-actuation is also a possibility.



Figure 2: Non-compliant installations based on ASCE 25-16, Paragraph 1.2.2, Mounting.

4 What Is Needed?

If the application is simply the heating of a building (i.e. no cafeteria, no production) and the risks associated with non-actuation are minimal, then there is an argument for using a simple ASCE 25 residential shutoff valve for natural gas or propane gas shut off. The presumption is that there is no appreciable cost to the owner from false positive shut offs, there is no need for controlling secondary equipment or annunciating other alarms, the gas operating pressure is less than 60 PSI and minimal pressurized gas is trapped downstream at shut off. If for some reason the seismic valve doesn't work, the gas can be shut off by one person using a small wrench on a manual gas shutoff valve after the strong motion has ceased.

There are many instances where a commercial or industrial facility cannot find an ASCE 25 device for their application, including:

- gas lines > 6” diameter
- operating pressures higher than 60 PSI (ASCE 25 maximum)
- early warning for ‘duck, cover, hold’ messaging
- requires shutoff at temperatures below 10° F (ASCE 25 minimum)
- controlled media is other than natural gas (ASCE 25 applies to NG and propane)
- voting is required to mitigate false positive shut offs
- an atypical structure is involved
- the venting of residual, pressurized gas is required
- signaling is required to initiate secondary processes (i.e. pump shut off)
- the ASCE 25 device cannot be mounted proximal to the ground.

What is needed is a remote sensing earthquake actuated shutoff system that is compliant with ASCE 25.

5 The Solution

If there are factors that preclude the use of an ‘off the shelf’ ASCE 25 device, then the owner has a number of options depending upon the facility’s current infrastructure. The foundation for each of these solutions is to employ a sensing means that is not integral to the shut off valve. Rather, the sensing means (seismic switch) is coupled to the ground and only the actuated shut off valve(s) is installed in the piping run. This approach insures a direct, unequivocal correlation to the ASCE 25 Standard’s sensing means criteria and allows the option to use multiple seismic switches for voting and a wide variety of actuated shutoff valves. The owner has the ability to place the sensing means in a low-traffic, controlled location. There are various configurations of ‘remote sensing’ ASCE 25 compliant systems in service.

5.1 Add a Seismic Switch(es) to an Existing Life Safety System

Some facilities already have a fire safety system, building management system or life safety system (LSS) that automatically shuts off the gas or shuts down processes based on other alarm conditions (fire, gas detection, etc.). For the purposes of this paper the LSS will be referenced but, the other types of systems equally apply. Where there is an existing LSS and actuated shutoff valves are already under LSS control, then, consider installing ASCE25 sensing means and ‘feed’ the seismic alarm signals into the LSS. **To properly transduce strong ground motion, the sensing means must be rigidly attached to a large inertial seismic mass such as the building foundation, tank ring wall, etc.** Proper mounting of the sensing means is the most basic step toward mitigating pre-mature shutdown or false positive alarms. Sample seismic switch installations are shown in Figure 3.



Figure 3: ASCE 25 Saturn S-001 sensing means installed remotely from the shutoff device

Semi-conductor plants/foundries are a good example of an application that already has the infrastructure in place to automatically (and rapidly) shutoff the flow of toxic gases. Emergency Power Off (EPO) buttons and gas ‘sniffers’ are already employed by the Life Safety System to trip ‘off’ the toxic gas cabinets. This type of user only needs a seismic signal at the ONSET of strong motion for their Life Safety System to similarly initiate the shutoff of the gas cabinets. Additionally (and very importantly), these systems require a manual reset in order to be returned to operation. So, if the owner’s non-seismically qualified LSS trips the gas cabinets OFF at the onset of the earthquake and then subsequently fails, sends erroneous signals or power is cycled to the LSS, toxic gas will not flow until each cabinet is manually reset.

To mitigate losses from false positive seismic shutdown alarms, a number of semi-conductor plants employ three (3) seismic switches (sensing means) distributed around the facility and perform 2 of 3 voting in their life safety system. If a seismic switch goes bad, they are still seismically protected by the remaining two units. If one unit signals a false positive alarm (dropped tool, dropped air cylinder, etc.) the plant will not be shut-down because the two (2) vote criteria is not satisfied. The sensors are programmed to automatically reset after several seconds, returning to a state of readiness for the next seismic event.

It is recognized that, in this case, the user’s life safety system may not be seismically qualified. However, the user is shutting down media flow almost immediately upon acceleration exceeding the shut off criteria (i.e. 0.3 G according to the Santa Clara County Toxic Gas Ordinance) and, once tripped, erroneous signals or failure of the owner’s LSS cannot restore toxic gas flow. Likewise, a user with natural gas lines, life safety system (or facility/fire management system) and rapidly closing shutoff valves (with manual reset) could justify using the non-seismically qualified PLC to ‘trip’ the valves closed.

ESS’ Saturn S-001 Seismic Switches employ ASCE 25 compliant (third-party tested by Wyle Laboratories and certified by the Office of the State Architect, California) sensing means which are factory programmed to closely follow the mid-point between the ASCE 25 ‘must actuate’

and ‘must not actuate’ curves. Refer to the purple curve in Figure 4, below. As indicated in Figure 4, using ESS’ seismic switches the owner can raise or lower the ASCE 25 response for their system. If a future fragility analysis indicates that the facility is able to withstand higher acceleration levels, then the owner’s ESS seismic switch could be re-programmed in-situ to follow the upper (blue) ASCE 25-97 response curve. Conversely, if the fragility analysis indicates that the site is not as robust as initially expected, then the seismic switch can be re-programmed in-situ to follow the lower (yellow) ASCE 25-97 response curve. In contrast, off-the-shelf ASCE 25 devices are not user-adjustable.

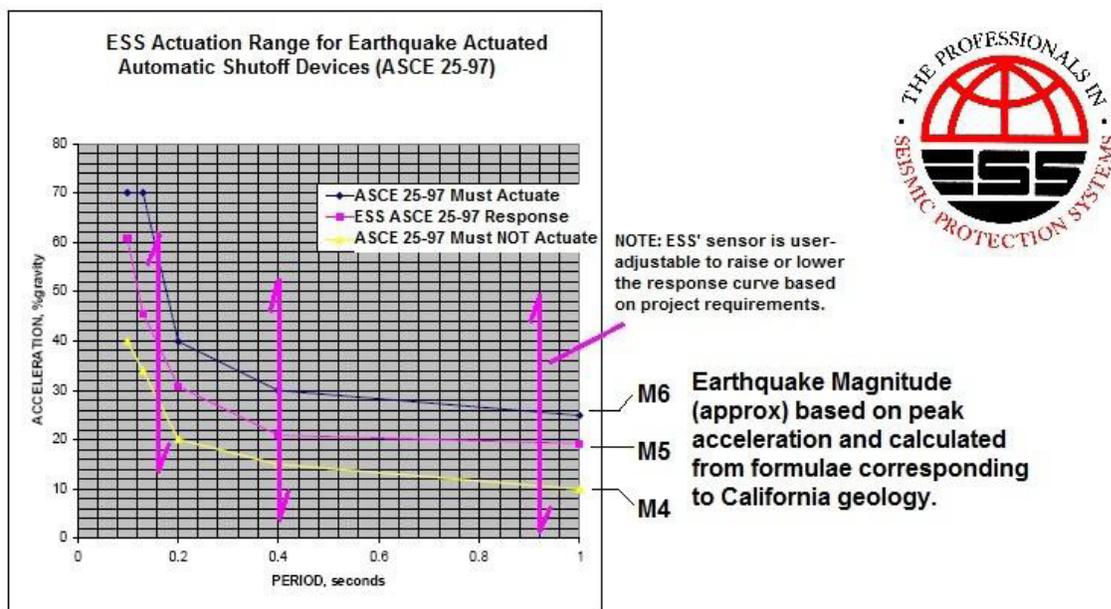


Figure 4: Field-adjustable ASCE 25 sensing means

The seismic switch (sensing means) may be installed horizontally (standard) or vertically. Vertical mount is subject to the response of the wall. Where the wall is in contact with the ground (i.e. below grade) then there is a reasonable expectation that the sensed motion correlates to the free-field ground motion. This paper will not address issues such as potential amplification as seismic waves reach, or travel through, unbounded surfaces. The point is considered moot by the author as the free-field and ground level (from high-rise buildings) acceleration time history data used by the EAAGS committee to develop the ASCE 25-97 response criteria were subject to unbounded conditions and, therefore, to some degree the ASCE 25 curves take into account the unbounded condition. Practical constraints such as the risk for flooding, electrical code compliance, etc. may force the selection of a wall-mount location. Mounting the seismic switch low on a wall that is connected to a slab-on-grade building foundation can also approximate ground motion. **Voting (2/3) can significantly reduce concerns relating to the issue of less-than-optimal mounting locations.**

Some users do not want to deal with an external power adapter or want greater autonomy from their seismic switch upon loss of primary 110 Vac or 220 Vac power. Larger seismic switches, *a la* the Apollo 2100, are available for this purpose. The larger enclosure is also more ‘conduit friendly’ which the mechanical contractor and electricians can appreciate.



Figure 5: Apollo 2100 Seismic Switch

For the Saturn S-001 and the Apollo 2100, the user supplies primary power (usually 110 Vac or 220 Vac, specified at order) and the seismic switch provides:

- Early Warning (Advisory) Alarm on smaller quakes.
- Shutoff Alarm on larger quakes
- Trouble Alarm (Power and/or Sensor Fault).

Output alarm signals are via dry, isolated Form C relay contacts rated to 6 Amps / 220 Vac.

Primary power exceptions can be accommodated. For example, one of the Apollo 2100 units shown above (Figure 5, far right) operates from 100 Vdc supplied by the dam owner.

Action: Decide if you will just use one seismic sensor and install it in a secure, low-traffic, low-vibration location where no one will contact the unit except once per year during annual testing. Otherwise, install multiple units (nominally 20 m apart), run power to each location, run alarm signals from the seismic switch(es) back the life safety system, program the life safety system ladder logic to perform the voting operation (1/1, 2/2 or 2/3), and send the shutdown signal to your existing actuated valves if the voting criteria are satisfied.

5.2 Seismic Switch and Shutoff Valve(s)

In the case where there is no LSS then a device to control the seismic shutoff valve is required. If the owner has reliable power (read: UPS-backed) and only one or two solenoid-operated valves to control, then a seismic switch may be considered. Voting is generally not employed with this approach. However, 1/2 (OR-logic) or 2/2 (AND-logic) voting can be achieved by wiring the solenoid holding voltage through the seismic switch contacts in series or parallel.

Action: Install the seismic switch(es) on a large inertial seismic mass such as the building foundation or tank ring wall. Alternatively, an isolated (from structure) free-field concrete housekeeping pad is acceptable. Provide power for the seismic switch. The seismic switch has a small internal battery for about 1 hour of autonomous operation. Feed the owner's solenoid holding voltage (i.e. 12 Vdc, 24 Vdc, 120 Vac, or 240 Vac) through the seismic switch alarm relay contacts to the solenoid(s) on the pneumatic, hydraulic, or electric actuator(s). When the shaking exceeds the programmed ASCE 25 level, the seismic switch interrupts the holding voltage causing the actuator (usually via stored spring energy) to close the valve. When the seismic switch is reset, the owner's holding voltage is restored to the shutoff valve. If the valve is automatic, it will re-open immediately upon restoration of power. If it is manual, then typically there is a handle that must be used to re-open the valve. Figure 6 shows applications following the described topology.

NOTE: Automatic reset is helpful when the valve is to be installed in a difficult to reach or otherwise, hazardous location (i.e. at elevation). However, automatic reset is not compliant with the ASCE 25 Standard. The owner/engineer should 'sign off' on the exception.



Figure 6: Saturn S-001 Seismic Switch and shutoff valves

5.3 Seismic Controller and Shutoff Valve(s)

For industrial applications the seismic switch solution described in the preceding section is the exception and not the rule. More often the owner has risk, control or power requirements that necessitate a more substantial device- a seismic controller. In the case of motorized actuators and ¼-turn valves, there is a reasonable expectation that the system must perform during strong motion. On large diameter lines it can take 20 seconds to 90 seconds to close the valve. Thus, the seismic controller must be seismically qualified. That seems like an obvious statement but, plant engineers often forget that the systems installed at the plant that work under normal operating conditions can not be relied upon during a strong motion event. **Using a seismic controller, backup power, control features, and voting can be provided within the context of the seismic solution- requiring no connection to the owner's infrastructure beyond the need for power.** Most owners make provision to receive signals from the seismic controller for trouble & status conditions (like loss of power, low level & high level seismic alarms, valve open or valve closed, etc.) Once the seismic controller platform is selected it becomes preferable to

specify 24Vdc actuated shutoff devices. Upon loss of primary 110/220 Vac power, the seismic controller can maintain the valves in the open state via an internal 24Vdc UPS. For the past several decades 24Vdc solutions have proven to be efficient and optimal for directly powering actuated valves, communicating with owner telemetry and powering active seismic components within the controller. The seismic controller can power and control up to four (4) solenoid or motor-operated valves. Designing the site-specific seismic shutoff system is an iterative process and there are many decisions involved. An abbreviated list of starting questions include:

- How many pipelines will be controlled? Size? Media?
- Actuate an existing valve or install new valves?
- Is venting of residual pressurized gas required?
- What is the primary power source (AC, solar) and voltage potential (110/220 Vac)?
- Is the primary power source UPS-backed?
- Is instrument air available near the shutoff valve location?
- What signals/alarms are to be transmitted to the LSS?
- Is remote LSS control of the actuators required?
- Where will the seismic controller be installed? Outdoors? Bypass? Padlockable?
- Upon loss of primary 110/220 Vac power, how long must the system be able to detect an earthquake and close the valve? 8 hours, 24 hours, 48 hours?
- How far is the seismic controller from the shutoff valves?

Armed with this information, valves and actuators of the proper type and size can be selected.



Figure 7: Seismic controllers

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The seismic controller will be sized based upon actuator power and system autonomy requirements. Examples of indoor (external indicators & controls) and outdoor (blind with internal indicators & controls) seismic controllers are shown in Figure 7, above.

Seismic controllers generally contain a 24Vdc UPS, user-programmable seismic sensor, solenoid and/or motor circuit protection and motor controls (as applicable). The 24Vdc UPS is scaled to meet project operational requirements; typically, 8 hours to 24 hours. Factors considered by the manufacturer in sizing the 24Vdc UPS include the actuator full load amps, stroke time, number of actuators, energized relays, energized holding solenoids and other active components within the MSC unit.

Outdoor seismic controllers are typically housed in a 'blind' stainless steel enclosure. The indicators and controls are mounted inside the seismic controller at a pushbutton station. A typical pushbutton station mounted on the inside of the seismic controller is shown in Figure 8.



Figure 8: Push-button station for a seismic controller

Examples of actuated valves employed in ASCE 25 compliant systems are shown in Figure 9, below.

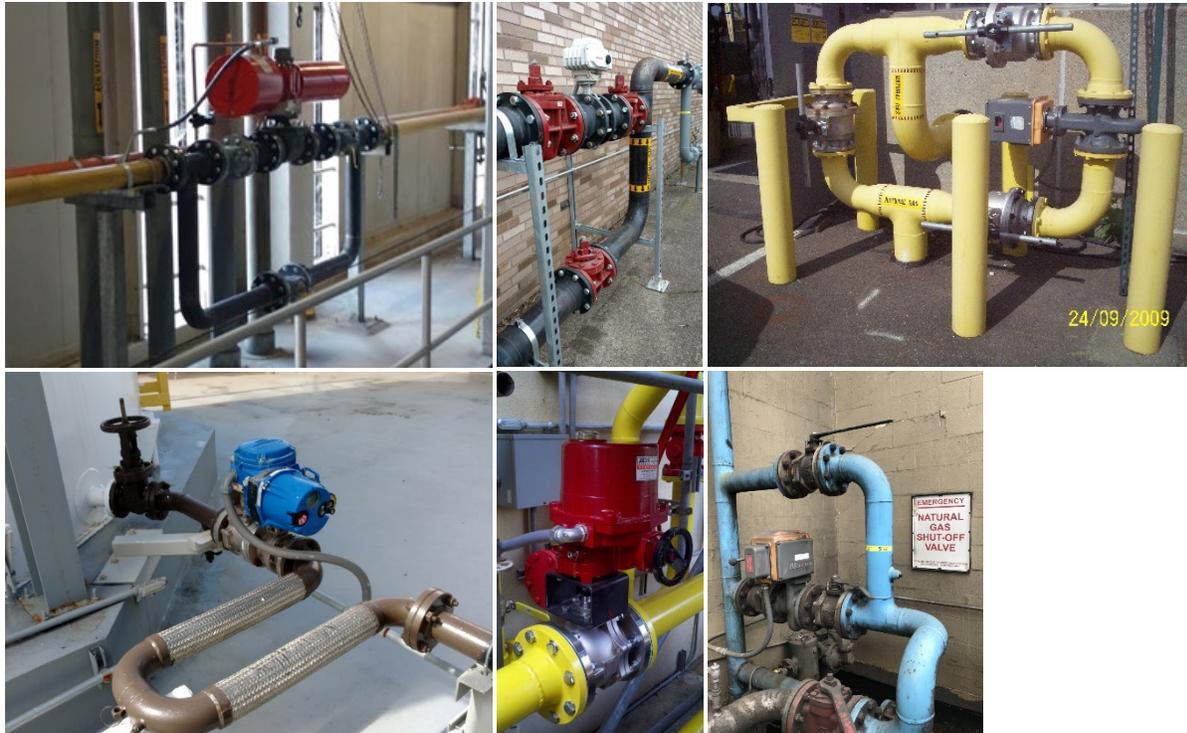
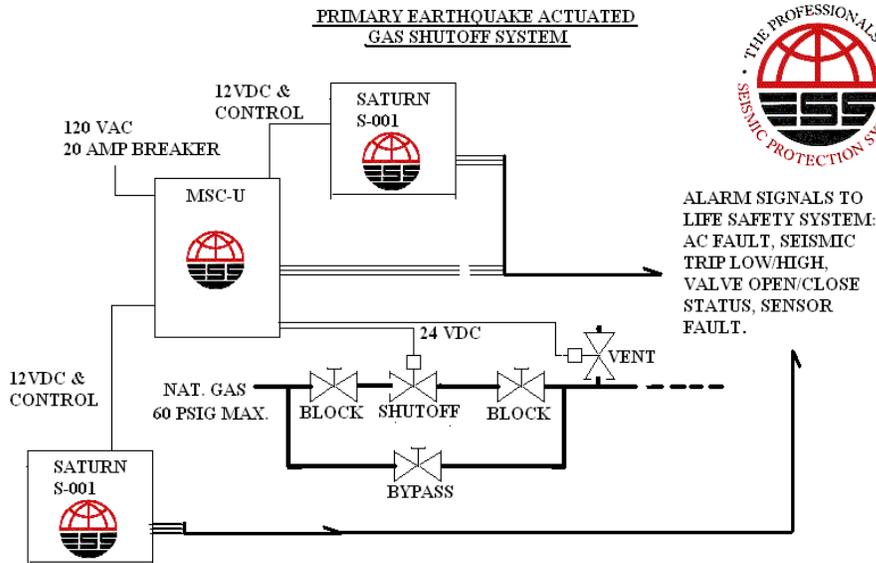


Figure 9: Actuated valves employed in ASCE 25 compliant systems

The manual blocking and bypass valves that are shown in some of the above photos are indicative of a forward-thinking owner/engineer. The bypass valve permits periodic testing (exercising) of the seismic shutoff valve without interrupting gas flow to plant operations. Also, the bypass valve can readily restore gas to plant operations if the shutoff valve fails. The manual isolation valves allow removal of the seismic shutoff valve for repair- again, without interrupting plant operations. Without the blocking and bypass valves, a failure of the shutoff valve (solenoids do eventually fail) can become a ‘fire drill’ for the entire plant. Without a bypass valve the testing of the earthquake actuated shutoff system is mostly limited to plant shutdowns which may be several years apart for facilities operating 24/7.

The seismic controller can perform 2/2 or 2/3 voting with seismic switches to avoid false positive shut offs from dropped tools, cultural vibration sources, etc. The 2/3 voting scheme (shown in Figure 10 with venting) has been implemented for a nuclear fuel processing facility, paper mills, and other users where there is the potential for trapped pressurized NG downstream from the blocking valve to ‘feed’ a fire. The ASCE 25 shutoff criteria is selected for each seismic sensing means (seismic controller and two seismic switches). The owner runs primary 120/240 Vac power to the seismic controller location. The seismic controller provides 12 Vdc power & control to the remote seismic switches and 24 Vdc power & control to solenoid and/or motor-operated valves. The MSC can ‘make’ or ‘break’ solenoid holding voltages or send a ‘close call’ command to a motor-operated valve when the seismic controller and one of the remote seismic switches simultaneously sense acceleration exceeding the ASCE 25 criteria. Fault alarms, valve status signals and seismic trip alarms are fed to the client’s LSS via dry, isolated Form C contacts.

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NOTES:

1. BOTH MSC UNIT AND ONE OF THE SATURNS MUST TRIP TO SHUT OFF GAS.
2. PANELS SHOULD BE INSTALLED 30+ FEET APART TO AVOID COMMON TRIP FROM LOCALIZED INDUSTRIAL VIBRATION (I.E. LARGE DROPPED MASS, ETC.)
3. IN AN EXTENDED OUTAGE SHUTOFF VALVES WILL CLOSE WHEN THE MSC BATTERIES DISCHARGE. BATTERY CAPACITY SIZED FOR 8 HOUR MINIMUM AUTONOMY.
4. SATURN EXTERNAL CHARGERS ARE PLUGGED INTO OUTLETS MOUNTED IN THE MSC-U PANEL. RIGID CONDUIT BETWEEN MSC-U AND EACH SATURN.

Figure 10: Diagram for seismic controller and seismic switch voting

Features to expect in a seismic controller include:

- User programmable acceleration setpoints (0.025 g to 0.5 g) compliant w/ ASCE 25
- Separate Low Level Advisory Alarm for early warning
- Peak XYZ ground acceleration data available on small or large events
- Self-diagnostics
- Integral 24Vdc UPS back-up
- Accurate, maintenance free solid-state tri-axial sensor
- Seismic Trip, Seismic Detected, Power Fault, Sensor Fault & Intrusion alarm signals
- Valve Open, Valve Closed signals
- Form C alarm relay contacts (user-selectable) rated 4 Amp, 250 Vac
- User terminal strip for easy field wire termination
- Visual system status indicators
- Local reset (after inspection)
- Local valve open & close control (after inspection)
- Pre-machined mounting plate for faster installation.
- Condensation control

Features you may want added to your seismic controller include:

- NEMA 4X stainless steel enclosure
- Pad-lockable handle on enclosure door
- Remote reset (OK for some non-NG applications. Not ASCE 25 compliant).
- Remote valve open and close call commands (OK for some non-NG applications, Not ASCE 25 compliant).
- Protective rain/sun cover
- Internal lighting
- Logical 'AND' operation with flow or pressure controllers (OK for some non-NG applications, Not ASCE 25 compliant, mostly used in the water industry to maintain fire suppression capability)
- 220 Vac or solar powered.
- Extra alarm relay contacts for signaling ancillary equipment (pumps, compressors, etc.)

5.4 Expected Seismic Controller Performance

Minor Earthquake Performance: An advisory alarm will be sent to the LSS via dry, isolated Form C relay alarm contacts located in the seismic controller unit. Valves are not likely to close. Peak acceleration data can be downloaded from the seismic controller. The seismic controller advisory alarms can be reset via local key-switch controls as shown in Figure 8, or remotely via a momentary contact closure. NOTE: ASCE 25 is mute on the reset of advisory alarms.

Moderate Earthquake Performance: At the onset of the earthquake, advisory alarms will be sent to the LSS via dry, isolated Form C relay alarm contacts. As the shaking increases, the likelihood of the seismic shutoff valve(s) closing increases. At sites with multiple seismic units (i.e. seismic controller and seismic switches for 2/3 voting) one, or more, seismic devices may not 'trip' on marginal events due to local soil conditions, wave propagation dynamics and sensor error (3 % for ESS products). Peak acceleration data can be downloaded from the seismic controller and each seismic switch. The seismic controller can be reset via local key-switch controls or remotely via a momentary contact closure. For NG applications, and in general, valves should be opened locally after site inspection; either at the seismic controller via key-switch command, or at the valve via the actuator's integral controls depending upon the equipment in service.

Major Earthquake Performance: At the onset of the earthquake, advisory alarms will be sent to the LSS via dry, isolated Form C relay alarm contacts. As the shaking increases the ASCE 25 and voting criteria will be satisfied resulting in automatic valve closure. Upon reaching the fully

closed position, limit switches inside the 24Vdc actuator will change state signaling the seismic controller that the valve has stroked fully closed. Form C relay contacts in the seismic controller will re-transmit the 'Valve Closed' signal to the LSS. As soon as possible after the earthquake, the owner should 'follow up' by manually shutting off the gas supply via manual blocking valves. After verifying that plant systems are intact (sometimes days or weeks later), the seismic devices can be reset via local key-switch controls or remotely via a momentary contact closure- and the manual valves re-opened. For NG applications, and in general, valves should only be opened after site inspection. Following opening of the NG valves another inspection for gas leaks should be immediately performed.

Action: Since a suitable off-the-shelf ASCE 25 device is not available, an engineered ASCE 25 compliant system is the next alternative. In the absence of a risk-informed, performance-based analysis and seismic risk study, choose compliance with the ASCE 25 'sensing means' criteria (Figure 1). Decide if your application should follow the upper ASCE 25 response curve, lower response curve or somewhere in between (Figure 4). Answer the questions on page 11. Select the options required for your application from page 15. Contact a distributor or manufacturer for assistance in actuator selection. Install the equipment as depicted in Figures 3, 6, 7 and 9. Have a qualified technician perform startup and commissioning services. Annually inspect and test the equipment.

6 Qualifications

6.1 Vast Experience

Earthquake Safety Systems, a California Corporation established in 1988, has vast experience in earthquake actuated shutoff systems. Our MSC-W Master Seismic Controller, is favored by cities and water districts for its use of a high-end digital seismic sensor with field adjustable set-points, ease of annual testing and minimal maintenance. The MSC-series product line is recognized by the FM Global Insurance company, each panel is individually registered by UL, and perhaps most importantly, end-users are able to control virtually any commercial pneumatic, hydraulic or electric actuator from our product.

ESS' system stays current with technology by integrating the best commercial products in the areas of seismic sensing, solenoid/motor operated valves and 24Vdc UPS backup.



6.2 ASCE 25 Certified

The complete MSC panel (not just the sensor) has been shake tested and certified to be in compliance with ASCE 25 response criteria- actuating between the upper (Must Actuate) and lower (Must Not Actuate) response curves. The certification is based on tests performed by a national 3rd party laboratory and certified by the California Office of the State Architect.



ESS instrumentation has also been successfully shake tested & environmentally tested (temperature extremes) by a U.S. National Laboratory for use at a facility handling fissile materials.

6.3 Earthquake Proven from Washington to California

The MSC is an **earthquake proven** product based on its positive response to:

Northridge M6.7 Earthquake, 1994, Providence St. Joseph Med Ctr, Natural Gas Shutoff

Nisqually M6.8 Earthquake, 2001, Boeing Natural Gas Shutoff,

Alum Rock M5.6 Earthquake, 2007, Philips Lumileds Toxic Gas Shutoff

Rancho Cucamonga M3.0 Earthquake, 2009, School District Early Warning Alarm

Inglewood M4.7 Earthquake, 2009, Chlorine Gas Shutoff

Ferndale M6.5 Earthquake, 2010, HCSD Water Tank Shutoff

Ridgecrest M7.1 Earthquake, 2019, Searles Valley Minerals, Gas Shutoff (MSC & Apollo instruments on separate systems 2 miles apart)

Ridgecrest M6.4 Earthquake, 2019, Searles Valley Minerals, Gas Shutoff (MSC & Apollo instruments on separate systems 2 miles apart)