Understanding the Hazard

Lack of Seismic Gas Shutoff Valves

Natural Hazards

Housing flammable gas and/or ignitable liquid inside a building located in an active earthquake area creates a fire and explosion hazard. The risk posed by the presence of these fuels can be mitigated if their flow is interrupted during an earthquake.

UTH topic categories:

- Construction
- Equipment
- Fire Protection
- Human Element
- ▶ **Natural Hazards**
- Process Hazards

This series of publications is designed to help you understand the everyday hazards present at your company's facilities. For more information on how you can better understand the risks your business and operations face every day, contact FM Global.

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The Hazard

The lateral forces associated with a major earthquake often damage the integrity of gas systems, allowing gas to leak into the air. Escaping flammable gas provides ample fuel to support an explosion or supply a major fire. Typically, this flow of fuel continues unabated—a situation that frequently is worsened by concurrent breakage of unbraced automatic sprinkler piping, delayed public fire service response resulting from the need to focus on rescue operations, and the loss of fire service water supplies.

Experience consistently has shown that gas release from inadequately secured systems is very likely in areas of strong ground shaking (Modified Mercalli Intensities [MMIs] of VIII or greater) and often occurs in areas of more moderate ground shaking. This extreme level of fire exposure may be mitigated by installing a seismic gas shutoff valve (SGSV) to interrupt the flow of flammable gas.

Science of the Hazard

Forces generated during a strong earthquake are concentrated in a horizontal direction. Buildings, equipment and piping systems differ in their mass, density and stiffness, causing them to move at differing rates. This differential movement puts stress on connections affixed to more than one object (such as a gas connection from the roof of a structure to a gas-fired device). Of course, contents also can be displaced if not anchored. Objects with relatively high centers of gravity can topple, almost ensuring connections will be severed.

During periods of high ground shaking, movement of unanchored equipment likely will damage gas and electrical connections. Even if anchored, differential movement relative to the structure may be sufficient to damage rigid connections. Anchoring all equipment supplied with flammable gas and joining piping to equipment with flexible connections will eliminate the most common source of gas system damage.

The complexity and cost associated with total protection of gas distribution systems, coupled with the burden of maintaining the protection as gas-fired equipment is moved, replaced and added, make this a difficult solution in many cases. But, if the gas flow can be stopped near its source, the small amount of flammable gas left in the pipes will dissipate quickly and safely within most large industrial and commercial buildings.

What you can do at your facility

Now:

- Install earthquake-actuated shutoff valves where flammable gas or ignitable liquid is piped into buildings.
- Incorporate earthquake incident response into emergency response team activities.

Soon:

- Survey flammable gas or ignitable liquid equipment and piping inside buildings for adequate restraint and flexibility.
- If deficiencies are observed, contact FM Global for an earthquake review addressing fire following earthquake.
- Review Understanding the Hazard: *Lack of Earthquake Bracing on Sprinkler Systems* (P0042).
- Implement corrective measures as soon as possible to resolve any seismic upgrade recommendations for fire following earthquake and fire protection systems.
- Conduct earthquake-specific training for your emergency response team.
- If you have specific earthquake concerns, contact your FM Global client service team to learn about additional engineering service opportunities.
- Minimize future problems by requiring FM Global review of new construction projects, fire protection installations and modifications to protection.
- Develop minimum seismic design standards and specifications for all construction and new equipment installations.
- Develop an earthquake recovery plan.

Loss Experience

Because large earthquakes affecting a significant number of FM Global clients are relatively infrequent, our actual property loss experience has been minimal. The 1994 Northridge, Calif., USA, earthquake was centered in an area with many insured sites; however, it occurred at approximately 4:30 a.m. PST on a holiday Monday, so few locations were operating. Although fire experience for FM Global was negligible, some 110 total fires were reported and approximately 14,000 natural gas leaks were logged. Many locations concurrently lost their water supplies due to rupture of the mains and depletion from breakage within buildings served.

Prior to the Northridge event, FM Global earthquake services engineers had visited some 45 locations (comprising 185 buildings) in areas of strong to very severe shaking to evaluate, among other factors, the adequacy of gas systems to resist seismic damage. These locations, plus an additional 17 sites (consisting of 18 buildings), were revisited within days following the earthquake.

Prior to the event, engineers had identified gas system deficiencies at 12 locations in the approximately 300-mi.^{2} (777-km^2) area that experienced shaking intensity of MMI VIII or greater; gas leaks occurred at all 12 sites as a result of the earthquake. One leak resulted in a fire, which broke out when an adjacent gas-fired water heater ignited escaping gas from an unanchored boiler (a recommendation had been made by FM Global engineers to correct this deficiency, but had not been implemented). Due to the lack of combustible material in the area of this fire, damage was minor.

Similarly, a 1998 National Institute of Standards and Technology (U.S. Department of Commerce) report states that the local utility, Southern California Gas Company, was asked to reset SGSVs serving 841 buildings following the Northridge earthquake; gas line breaks were discovered in 162 of these structures.

In the United States, natural gas (methane) historically has been a factor in 15 to 50 percent of fires following earthquakes. The combination of uncontrolled release of flammable gas, impaired water supplies and public fire services stretched thin by many simultaneous calls creates an environment for devastating loss.

But What About…

...installation. How can I tell if the SGSV is installed correctly?

The manufacturer's installation guidelines must be followed to ensure proper SGSV operation. Flow-through SGSVs must be installed in the correct orientation (vertical or horizontal) and gas

Operation and Availability

There are two general categories of seismic gas shutoffs: one-piece flow-through (or in-line) SGSVs and two-piece systems that have a remote seismic sensor and separate valve.

Flow-through SGSVs are mechanical devices typically mounted near the gas meter. In response to an earthquake, a gate is released by movement of a magnetic mechanism, pin or other securing linkage, or a ball is dropped into the gas flow. Flow-through SGSVs most often are used on small natural gas or propane piping (2 in. [51 mm] or less) at low pressures, although several are rated for up to 60 psi (414 kPa) at sizes up to 8 in. (203 mm).

Remote seismic sensors may be connected to one or more valves or controls that should be operated during an earthquake. They commonly are more expensive than flow-through SGSVs, although their flexibility allows connection to non-gas devices, such as valves on pumped ignitable liquid systems, process control computers and pneumatic pumps. An electrical or pneumatic output signal is generated or interrupted, depending on the manufacturer. More costly devices offer sophisticated features, such as calibration to individual installation needs.

must flow through the valves in one specific direction. Leveling and rigid bracing to the adjacent structure typically are necessary. Remote sensor devices should be mounted on a concrete pad on the ground or low on a main structural wall to fairly reflect the shaking intensity to which the site is being subjected. Flow-through SGSVs or remote seismic sensors should not be placed high on a wall or on upper floors because shaking will be amplified at these locations. Other guidelines provided by the device's manufacturer should be followed.

...false tripping of the valves, such as when a heavy truck passes by?

False trips were an early problem with SGSVs. Their initial designs were totally focused on interruption of the gas supply during an earthquake. As a result, they sometimes operated accidentally when shaken by other sources, such as a passing truck or train. In 1997, the American Society of Civil Engineers (ASCE) issued a design guideline (ASCE 25-97) that increased the minimum operating points to address false trip concerns; reported cases of inadvertent operation have virtually vanished for valves designed and installed to meet this standard.

...assurance that SGSVs will work when needed?

Valves available today typically are designed to the latest edition of ASCE 25, which defines operational parameters, including more "must activate" points than the previous edition of the standard. Turkey has implemented a standard almost identical to the ASCE guideline. The City of Los Angeles, Calif., USA, has listed many SGSVs; part of its process is verification of independent laboratory testing to ensure operation is in compliance with the ASCE document. Installing valves that have been independently certified as meeting ASCE 25 criteria is our best advice.

...compliance with jurisdictional codes and requirements?

A representative, though not extensive, review of jurisdictions worldwide did not identify any instances in which SGSVs are not permitted. If local resistance is experienced, escalation to jurisdictional or utility management is advised because some personnel may be guided by historical misconceptions and not formal policy.

Conversely, some governments require installation of SGSVs. The most well-known example is the City of Los Angeles, which has mandated these valves on new construction and major remodels since September 1995, and all buildings sold after February 1998. Some jurisdictions in northern California also require SGSVs, although many allow alternative solutions, such as seismic engineering of the gas system or an automatic excess-flow valve.

...critical gas supply needs?

In a few cases, interruption of the natural gas supply is undesirable. Examples include supplies to generators that provide backup power to hospitals or fire pumps. In these rare cases, omit the SGSV, but ensure the piping system and all points of use are braced and anchored, and adequate flexibility is provided where sections of pipe or connections to equipment can move differentially during strong ground shaking. Complex configurations may require specialized design by an experienced engineering firm.

Need more information?

Ask your FM Global engineer or client service team about the following:

- Manufacturers of SGSVs, contact information and sizes/pressures in which they are available
- Factors specific to your facility that may influence your choice of flow-through SGSVs versus a remote sensor system
- Specific cases where anchorage, bracing and flexibility may be appropriate in addition to an SGSV
- What can be done if an SGSV is not viable

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...excess flow valves instead of SGSVs?

Excess flow valves will not operate for partial gas line breaks or even total breaks on smaller gas lines fed by larger pipes. As a result, they provide little reliability.

Don't Let This Happen To You...

Courtesy of ABS Consulting – EQE Structural Engineers Division

The Great Hanshin Earthquake, commonly called the Kobe Earthquake, occurred in January 1995 in a heavily populated area of Japan. The fire, fueled by escaping natural gas from ruptured pipes, leveled more than 0.4 mi.^{2} (1 km^2) of the city. Most of the region was populated by wood-frame residences, although many of these included light commercial occupancies on the street level. The conflagration was worsened by streets obstructed by falling structures (preventing fire service access) and water mains broken by the shaking.

Modified Mercalli Intensity (MMI)

The MMI scale consists of 12 levels from I (not felt) to XII (total damage).
Little damage occurs below MMI VI. Intensity above MMI X is uncommon. Some MMI descriptions:

VI	Felt by all. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built structures.
VIII	Damage slight in specially designed structures; considerable in ordinary, substantial buildings with partial collapse; and great in poorly built structures.
IX	Damage considerable in specially designed structures; great in substantial buildings with partial collapse.