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Safety Measures

Thermally Activated Emergency Isolation Valves for Oil & Gas Applications

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The recent annual *World Energy Outlook* report from the Paris-based International Energy Agency ([IEA](#)) predicts the United States will displace Saudi Arabia as the world's largest oil producer by 2020. Meanwhile, the ExxonMobil 2013 *Outlook for Energy* report forecasts:

- The United States will become the world energy leader by the end of the decade
- Liquid Natural Gas (LNG) will surpass coal as a fuel source globally by 2025.
- North America will become a net exporter of all sources of energy by 2035.

With so much domestic growth in LNG, LPG (liquid petroleum gas), and oil—as well as alternative energy sources such as ethanol—worker, facility and regional

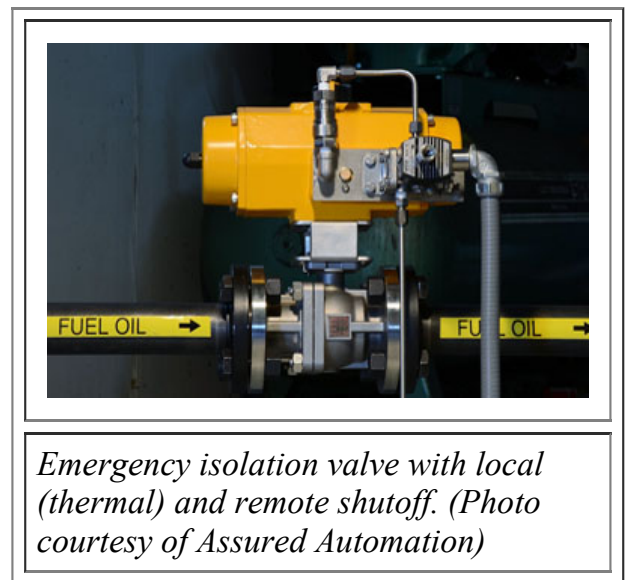
safety will be a top priority to help assure secure fuel storage and distribution. And though each new facility designs its own safety systems, guidance is available from standards bodies and insurers.

The Role of Thermally Activated Emergency Isolation Valves

Thermally activated Emergency Isolation Valves (EIVs) are critical components in refinery, terminal and distribution safety systems. Thermal activated shutoffs work like fuses in the piping that carry extracted fuels. When a fire occurs, the fuel flow is shut down, preventing the fuel from feeding the fire.

Historically, thermal shutoffs relied on fusible links made of metal alloy. Once the alloy melts, a spring-armed plug is released, which stops the flow of fuel. The problem with the fusible link design is that once triggered, the unit needs to be replaced and, likewise, cannot be field-tested.

However, new technology for thermal shutoffs uses a Nitinol shape memory alloy system, originally developed for NASA space station applications. Nitinol's shape memory effect changes



Emergency isolation valve with local (thermal) and remote shutoff. (Photo courtesy of Assured Automation)

Lessons Learned

The following list of recent fires reinforces the necessity and value of emergency shutdown procedures and technologies:

Jan. 13, 2013 fire at Chevron's El

certain metal alloys from one shape to another with temperature changes—a direct result of a transformation of the alloy’s crystal structure. The shape memory element senses the ambient temperature and, through a phase induction change, rapidly produces the force and motion to operate the shutoff.

When the thermal shutoff senses temperatures above the shape memory alloy’s actuation level, the shape memory element simultaneously vents pneumatic actuator air pressure and closes upstream supply pressure. A manual reset allows routine performance testing for safety maintenance programs.

Hydrocarbon Processing Plants

“The standard insurance recommendation report for a gas processing facility includes a request for a Process Hazards Analysis and an Emergency Shutdown System with multiple emergency isolation valves,” says Jesse Wilson, president of [Allrisk Engineering Inc.](#) in Auburn, Wash. “Emergency isolation valves are the risk mitigation ‘bread and butter’ for most Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) facilities.”

The entire gas plant, as well as many of its processing subsystems, are mechanically isolated and de-energized by the Emergency Shutdown (ESD) System. ESD systems are independent of the basic process control system; however, they can be triggered by critical process control variables, such as product flow and pressure. ESD systems can also be initiated manually by operators located in the field or in the control room.

ESD systems typically include gas detectors and heat detectors interlocked with Emergency Isolation Valves (EIVs). EIVs are failsafe, on/off type valves used for emergencies only. Most insurers recommend that each EIV be provided with some type of local thermal actuation device.

Factory Mutual publishes data sheets to assist in designs for emergency isolation and shutdown. The FM Global Property Loss Prevention Data Sheet, titled “Fire and Explosion Protection for Process Structures 7-14,” includes a Piping and Instrumentation Diagram (P&ID), which identifies where in the process automatic and remote manual valves are recommended. The Ignitable Liquid Operations 7-32 data sheet also includes a P&ID, outlining where Safety/Emergency Shutoff Valves are recommended for inert-gas transfer systems.

Joseph Looney of FM Global says safety shutoff valves with pneumatic or electric actuators are used for the startup and routine shutdown of systems, while emergency shutoffs are one-time operated shutoff valves used in emergency scenarios, such as a fire.

Segundo refinery, south of Los Angeles. The refinery can process 279,000 barrels of feedstock a day, and supplies 40 percent of the jet fuel to Los Angeles International Airport and 20 percent of the region’s gasoline.

August 6, 2012 Chevron Refinery Fire in Richmond, Calif., which processes 245,000 barrels of crude oil a day.

Oct. 2, 2012 Exxon Mobil’s Baytown, Texas, refinery fire in the diesel hydrotreater unit. The refinery has a capacity of 584,000 barrels a day, making it the largest operating refinery in the U.S. and one of the largest in the world.

Dec. 11, 2012 natural gas pipeline explosion near Sissonville, W. Va., owned by the NiSource subsidiary Columbia Gas Transmissions. It took about an hour after the initial rupture for officials to stop the flow of gas and shut off the line. The pipeline was not equipped with automatic or remote shutoff valves.

Sept. 9, 2010 natural gas pipeline explosion in a residential area of San Bruno, Calif., owned by Pacific Gas & Electric. It took 60 to 90 minutes to shut off the gas after the explosion, according to San Bruno Fire Chief, Dennis Haag. The tragedy reached a death toll of eight people and 38 homes destroyed. The U.S. Geological Survey registered the explosion and resulting shock wave as a magnitude 1.1 earthquake. Eye witnesses reported the initial blast “had a wall of fire more than 1,000 feet high.” On Jan. 13, 2012, an independent audit from the State of California issued a report stating that PG&E had illegally

Large Propane Storage Facilities

Since Liquid Petroleum Gas (LPG), commonly known as propane, is stored and transported under high pressure, this fuel requires its own set of safety systems. The NFPA 58—Liquefied Petroleum Gas Code requires Emergency Shutoff Valves have all of the following means of closing:

diverted over \$100 million from a fund used for safety operations, and instead used it for executive compensation, bonuses, and PG&E shareholders.

- Automatic shutoff through thermal (fire) actuation;
- Manual shutoff from a remote location; and
- Manual shutoff at the installed location.

Before the shape memory thermal actuators described above were widely available, LPG storage facilities relied on fusible-link thermal shutoffs to automatically shut down LPG flow when a fire occurred. Ted Lemoff, of T Lemoff Engineering, says he has never had any issues or problems with fusible link-based thermal shutoffs in his 25 years of experience. Lemoff has written extensively on the NFPA 58 LPG Standard during his tenure at the National Fire Protection Association (NFPA).

Fuel Transport

Once processed, fuel is distributed to local markets by pipeline, rail car, and trucks. Each transport method requires its own set of safety systems, including automatic thermal shutoffs. [Alloy Custom Products](#), a manufacturer of cryogenic semi-trailers, uses automatic thermal shutoffs for LNG, oxygen, and mixed-use vessels. The company uses shape memory thermal (fire) actuators to automatically shutdown the flow of fuel in the event of fire. These air-operated, self-closing thermal shutoffs are housed in a rear cabinet of the trailer and are used for fire protection in both the loading and offloading of LNG.

The Promise of Safe and Secure Domestic Oil & Gas

Safety in the refinery, delivery and terminal business continues to improve based on lessons learned from experience (see sidebar on page 37).

With increasing reductions in staffing, refinery and terminal facilities are more reliant on automation. However, if a fire damages the control system, an electronic remote shutoff no longer works. These type of systems need:

- Failsafe designs to close valves in the event of power loses; or
- Automated valves with motorized assemblies including spring return and battery backup.

To prevent the escape of fuel during a fire, thermally activated shutoffs are also needed, such as the shape memory thermal actuators or fusible link-based systems detailed in this article. A complete Emergency Isolation Valve assembly provides:

- Local thermal shutdown for automatic shutdown in the event of fire
- Remote shutdown to isolate subsystems
- Local manual shutdown (optional)
- Optional limit switch and lock-out device

Jean Steckler is a fire protection and safety code team leader at Assured Automation, an assembler of automated valves and flowmeters. She has submitted code modifications to the ICC on gas safety and consulted with the NFPA and FM Mutual. Ms. Steckler can be reached at jeans@aa-fs.com.

Regulations & Standards that Identify Where Thermal Shutoffs Are Required

NFPA 59A: This Standard covers both construction and operation of LNG plants, including:

- Plant siting and layout
- Locations of process equipment
- Storage container design
- Safety assessment and calculation of the extent of exclusion zones
- Fire protection, safety and security
- Maintenance
- Personnel training

Paragraph 12.3.1 of the NFPA 59A – Each LNG facility shall have an ESD [Emergency Shut Down] system(s) to isolate or shutoff a source of LNG, flammable liquids, flammable refrigerant, or flammable gases, and to shut down equipment whose continued operation could add or sustain an emergency.

NFPA 58: Chapter 5 of the NFPA 58—Liquefied Petroleum Gas Code requires Emergency Shutoff Valves with all of the following means of closing:

1. Automatic shutoff through thermal (fire) actuation
2. Manual shutoff from a remote location
3. Manual shutoff at the installed location

Where fusible elements are used, they shall have a melting point not exceeding 250 F (121 C).

NFPA 57 Regulations for Liquefied Natural Gas Vehicular Fuel Systems: Chapter 7 of the NFPA 57 – Liquefied Natural Gas Vehicular Fuel System Code deals with fire protection, safety and security. It covers fire protection, personnel safety and training for LNG vehicles, security and LNG fueling facilities. It requires fire protection for all LNG fueling facilities based on sound fire protection engineering principles, and includes a requirement for equipment and processes for emergency shutdown device system.

OSHA Regulations for Hazardous Materials

The relevant OSHA regulations for Hazardous Materials, referenced by the Standard Number 1910.106, require automatic-closing heat-actuated valve on withdrawal connections:

1910.106(b)(4)(iv)(c)

Flammable liquid tanks located inside of buildings, except in one-story buildings designed and protected for flammable liquid storage, shall be provided with an automatic-closing heat-actuated valve on each withdrawal connection below the liquid level, except for connections used for emergency disposal, to prevent continued flow in the event of fire in

the vicinity of the tank. This function may be incorporated in the valve required in (b) of this subdivision, and if a separate valve, shall be located adjacent to the valve required in (b) of this subdivision.

U.S. Department of Transportation (US DOT) Federal Regulations (49 CFR, part 193)

Provides specific and detailed requirements for storage facility siting and construction. The current 49 CFR, part 193, DOT regulations has adopted the 2001 edition of the NFPA 59A Standard (with minor changes).

U.S. National Transportation Safety Board (NTSB) Recommendation

The U.S. National Transportation Safety Board (NTSB) has recommended to the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) the following regulatory amendment:

Amend Title 49 Code of Federal Regulations Section 192.935(c) to directly require that automatic shutoff valves (ASV) or remote control valves (RCV) in high consequence areas and in class 3 and 4 locations be installed and spaced at intervals that consider the population factors listed in the regulations. (P-11-11)

U.S. Pipeline Safety Act: The Pipeline Safety, Regulatory Certainty, and Job Creation Act reauthorizes federal pipeline safety programs through fiscal year 2015. The Act authorizes US DOT to promulgate regulations requiring the use of automatic and remote-controlled shut-off valves for new or replaced transmission pipelines.

American Petroleum Institute (API)

API 607: Fire test for soft-seated quarter-turn valves.

API 6D: Specification for pipeline valves. Specification for Pipeline Valves, Twenty-third Edition (Identical to ISO 14313:2007), Includes Errata 1, 2, 3, 4, 5, and 6 (2011) and Addenda 1, 2 (2011), 3 (2012)

API 6FA: Specification for fire test for valves.