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WWW.ENERGY.CA.GOV / LNG / SAFETY

Commission Homepage
Natural Gas Page

LNG Information

LNG Main Page
FAQs About LNG
LNG Safety
Documents About LNG
State Energy Policy
LNG Interagency Permitting Working Group
LNG Projects
Public Participation
Worldwide LNG
LNG Resource Links
Photo Gallery
Glossary

Liquefied Natural Gas Safety

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LNG is natural gas that has been refrigerated into a cryogenic liquid so that it can be shipped long distances in carriers. Once an LNG carrier reaches a receiving terminal, the LNG is unloaded and stored in large tanks until it is revaporized and piped into the natural gas distribution network. LNG is a hazardous liquid, because it is cryogenic and, as natural gas, it is combustible.

LNG hazards result from three of its properties: cryogenic temperatures, dispersion characteristics, and flammability characteristics. The extremely cold LNG can directly cause injury or damage. A vapor cloud, formed by an LNG spill, could drift downwind into populated areas. It can ignite if the concentration of natural gas is between five and 15 percent in air and it encounters an ignition source. An LNG fire gives off a tremendous amount of heat.

A large array of laws, regulations, standards, and guidelines are currently in place to prevent and lessen the consequences of LNG releases. These requirements affect LNG facilities' design, construction, operation, and maintenance.

To address terrorist risk, the Ship and Port Facility Security Code was adopted in 2003 by the member countries of the International Maritime Organization (IMO), an agency of the United Nations responsible for maritime matters concerning ship safety. This code requires both ships and ports to conduct vulnerability assessments and to develop security plans. To heighten security of LNG facilities at American seaports, Congress passed the U.S. Maritime Transportation Security Act of 2002, which requires all ports to have federally-approved security plans. Detailed security assessments of LNG facilities and vessels are also required.

The Department of Transportation (DOT), Research and Special Programs Administration, issues and enforces federal safety standards for land-based LNG facilities, although the Federal Energy Regulatory Commission (FERC) can impose more stringent safety requirements than DOT's when warranted. The U.S. Coast Guard (USCG) issues and enforces regulations for waterfront facilities handling LNG.

All of these federal agencies oversee all land and sea-based LNG operations, with some overlapping authorities and some new responsibilities. The recent reactivation of LNG facilities on the East Coast and in the Gulf Coast and permitting of new facilities, have resulted in new methodologies (risk-based decision making) and processes (security workshops, scoping meetings) to assess and communicate safety risk to the public.

Accidents

Explosions and Fires

- **October 1944, Cleveland, Ohio** - At the Cleveland peak-shaving plant a tank failed and spilled its contents into the street and storm sewer system. The resulting explosion and fire killed 128 people. The tank was built with a steel alloy that had low-nickel content, which made the alloy brittle when exposed to the extreme cold of LNG.

- **1964 and 1965 Methane Progress.**- While loading LNG in Arzew, Algeria, lightning struck the forward vent riser of the Methane Progress and ignited vapor which was being routinely vented through the ship venting system. A similar event happened early in 1965 while the vessel was at sea shortly after leaving Arzew. In both cases, the flame was quickly extinguished by purging with nitrogen through a connection to the riser.

- **1969, Portland, Oregon** - An explosion occurred in an LNG tank under construction. No LNG had ever been introduced into the tank. The cause of the accident was attributed to the accidental removal of blinds from natural gas pipelines which were connected to the tank. This led to the flow of natural gas into the tank while it was being constructed.

- **January 1972, Montreal East, Quebec, Canada** - A back flow of natural gas from the compressor to the nitrogen line occurred during defrosting operations at an LNG liquefaction and peak shaving plant. The valves on the nitrogen were not closed after completing the operation. This caused over-pressurization of the compressor and the natural gas entered the control room (where operators were allowed to smoke) through the nitrogen header. An explosion occurred when an operator tried to light a cigarette.

- **February 1973, Staten Island, New York**- While repairing the interior of an empty storage tank, a fire started. The resulting increase in pressure inside the tank was so fast that the concrete dome on the tank lifted and then collapsed down inside the tank killing the 37 construction workers inside.

- **October 1979, Cove Point, Maryland** - A natural gas leak caused an explosion killing one plant employee and seriously injuring another and causing about $3 million in damages.

- **April 1983, Bontang, Indonesia** - A rupture in an LNG plant occurred as a result of overpressurization of the heat exchanger caused by a closed valve on a blowdown line. The exchanger was designed to operate at 25.5 psig. When the gas pressure reached 500 psig, the exchanger failed and the explosion occurred.

- **August 1987, Nevada Test Site, Mercury, Nevada** - An accidental ignition of an LNG vapor cloud occurred at the U.S. Department of Energy Test Site during large-scale tests involving spills of LNG. The cloud was accidentally ignited and damaged and propelled polyurethane pipe insulation outside the fence.

- **June 2004, Trinidad, Tobago** - Workers were evacuated after a gas turbine at Atlantic LNG's Train 3 facility exploded.

- **July 2004, Ghislenghien, Belgium** - A pipeline carrying natural gas from the Belgian port of Zeebrugge to northern France exploded, resulting in 23 known fatalities. The cause of the incident is still under investigation but it appears that a contractor accidentally damaged the pipe.

- **March 2005, District Heights, Maryland** - A Washington Gas company-sponsored study released in July 2005 pointed to subtle molecular differences in the imported liquefied natural gas the utility began using in August 2003 as the cause of a house explosion.

Spills and Leaks

- **Early 1965, Methane Princess Spill** - LNG discharging arms were disconnected prematurely before the lines had been completely drained, causing LNG liquid to pass through a partially opened valve and onto a stainless steel drip pan placed

underneath the arms. This caused a star-shaped fracture to appear in the deck plating in spite of the application of seawater.

- **May 1965, Jules Verne Spill** - LNG liquid spill at Arzew, Algeria, caused by overflowing of a cargo tank that resulted in the fracture of the cover plating of the tank and adjacent deck plating.

- **1971, La Spezia, Italy** - This accident was caused by "rollover" where two layers of LNG with different densities and heat content form. The sudden mixing of these two layers results in the release of large volumes of vapor. In this case, about 2,000 tons of LNG vapor discharged from the tank safety vales and vents over a period of a few hours, damaging the roof of the tank.

- **July 1974, Massachusetts Barge Spill** - After a power failure and the automatic closure of the main liquid line valves, 40 gallons of LNG leaked as it was being loaded on a barge. The LNG leaked from a one-inch nitrogen-purge globe valve on the vessel's liquid header. This leak caused several fractures to the deck plates.

- **September 1977, Aquarius Spill** - During the filling of a cargo tank at Bontang, LNG overflowed through the vent mast serving that tank. The incident may have been caused by difficulties in the liquid level gauge system. The high-level alarm had been placed in the override mode to eliminate nuisance alarms.

- **March 1978, Das Island, United Arab Emirates** - An accident occurred due to the failure of a bottom pipe connection of an LNG tank. The tank had a double wall (a nine-percent nickel steel inner wall and a carbon steel outer wall). Vapor from the outer shell of the tank formed a large heavier-than-air cloud which did not ignite.

- **April 1979, Mostafa Ben Bouliad Spill** - While discharging cargo at Cove Point, Maryland, a check valve in the piping system of the vessel failed releasing a small quantity of LNG. This resulted in minor fractures of the deck plating.

- **April 1979, Pollenger Spill** - While the vessel was discharging LNG at a terminal in Everett, Massachusetts, LNG leaking from a valve gland apparently fractured one of the tank's cover plating.

Safety Studies

- International and National Efforts to Address the Safety And Security Risks of Importing Liquefied Natural Gas: A Compendium, prepared for the California Energy Commission by Aspen Environmental Group, January 2005. (Acrobat PDF file, 84 pages, 588 kilobytes).

- Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water, prepared by Sandia National Laboratories, SAND2004-6258, December 2004. (PDF file, 167 pages, 1.7 megabytes - note file size

- "Consequences of LNG Marine Incidents", R M Pitblado, J Baik, G J Hughes, C Ferro, S J Shaw, Det Norske Veritas (USA) Inc. Presented at a conference held by the Center for Cehmical Process Safety (CCPS) in Orlando, Florida June, 2004. (Acrobat PDF file, 20 pgs, 948 kb)

- Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers; prepared by ABSG Consulting Inc. for the Federal Energy Regulatory Commission under contract number FERC04C40196; May 13, 2004. (PDF file, 128 pages, 811 kilobytes).

- "LNG Safety and Security," Center for Energy Economics at the Bureau of Economic Geology, the University of Texas at Austin. October 2003.

(http://www.beg.utexas.edu/energyecon/lng/documents/CEE_LNG_Safety_and_Security.pdf, 81 pgs, 1 megabyte - note file size)

- "Liquefied Natural Gas (LNG) Infrastructure Security: Background and Issues for Congress," Congressional Research Service - Library of Congress. September 9, 2003. (Acrobat PDF file, 25 pgs, 228 kb)

Commission Homepage | Site Index | Search Site | Glossary | Links | Contact Us

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