

CSB Safety Bulletin

U.S. Chemical Safety and Hazard Investigation Board

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Dangers of Purging Gas Piping into Buildings

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When new fuel gas piping is put into service – or when existing piping is returned to service after interruptions – it is typically necessary to purge the lines of air.[1] U.S. fuel gas safety codes require that new piping installations be pressure-tested with air or an inert gas prior to initial operation, and this activity requires purging during the introduction of natural gas.[2] Purging is commonly done by one of two methods: (a) fuel gas is used to directly displace the air, or (b) inert gas is used to displace the air and then fuel gas is used to displace the inert gas. With this Safety Bulletin, the U.S. Chemical Safety Board (CSB) draws attention to serious dangers that can arise during fuel gas purging operations and highlights five key lessons the agency recommends for improving safety in the workplace.



The ConAgra Slim Jim plant in Garner, North Carolina, where unsafe gas purging caused an explosion in June 2009 that killed three workers and sent 71 to the hospital.

Who's at Risk...

Personnel who manage, install, maintain, repair, inspect, or place into operation fuel gas piping and equipment, including:

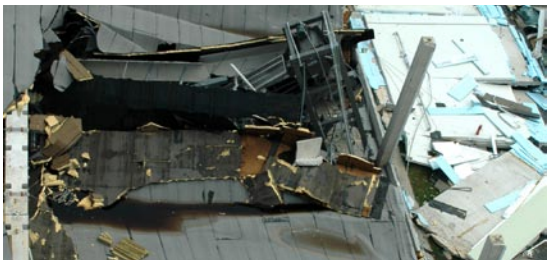
- Plumbers
- Gas installers
- Maintenance workers
- Contract supervisors
- Industrial facility managers

[1] *National Fuel Gas Code*, NFPA 54, ANSI Z223.1 defines a piping purge as "to free a gas conduit of air or gas, or a mixture of gas and air," at 54-15 (2009 Ed.). The National Fire Protection Association (NFPA) develops widely recognized consensus fire protection codes and standards. Another widely recognized family of fire protection codes is published by the International Code Council which includes the *International Fuel Gas Code* (2009 Ed.). Both codes address safety guidance and requirements for the installation and operation of fuel gas piping and equipment.

[2] *National Fuel Gas Code*, NFPA 54, ANSI Z223.1 at 54-61 to 63 (2009 Ed.); the *International Fuel Gas Code* at 68 (2006 Ed.). The fuel gas codes require that piping beyond specified lengths be purged with an inert gas based upon the nominal pipe size.



Interior of ConAgra facility following structural collapse.





Aerial views of ConAgra facility after explosion.

KEY LESSONS

1. *Purging new or existing gas piping into buildings can be highly hazardous due to the possible accumulation of gas above the lower explosive limit (LEL)*[3] *and the associated danger of fire and explosion. Wherever practicable, directly vent purged gases to a safe location outdoors, away from people and ignition sources.* This can be done using a temporary hose or piping or permanently installed vent pipes, depending on the facility design.
2. *Purging indoors should only be done in limited circumstances where purging outdoors is not practicable.* In such cases:
   - nonessential personnel should be evacuated;
   - all ignition sources should be controlled or eliminated;
   - ventilation should be adequate to maintain the gas concentration well below the lower explosive limit at all times.
3. *Never rely on odor alone to detect releases of fuel gases.* An odorant[4] is typically added to fuel gases, such as natural gas and propane, to warn workers and consumers of releases. However, the perception of odor is highly subjective and varies from one person to another. People also become desensitized to odor during prolonged exposures. Additionally, new gas pipes and containers can react with or otherwise remove the odorant, an effect known as "odor fade."
4. *Always use combustible gas detectors*[5] *to monitor the gas concentration during purging operations.* To provide the most accurate information about combustible gas levels, sampling should be conducted frequently or continuously at appropriate locations.[6]
5. *Ensure personnel involved in gas purging operations are fully trained and knowledgeable about safe gas venting practices, the proper use of gas detectors, and the danger of relying on the sense of smell alone to detect gas releases.* Include training on the problem of odor fade in new gas piping systems.

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[3] LEL, also known as the Lower Flammable Limit (LFL), is defined as "that concentration of a combustible material in air below which ignition will not occur." *Recommended Practice for Handling Releases of Flammable and Combustible Liquids and Gases*, NFPA 329 (2005).

[4] Natural gas is primarily composed of methane, an odorless and colorless gas. In order to heighten an individual's ability to detect natural gas, small quantities of odorant are added. T-butyl mercaptan (typically described as having a "skunk-like" odor), is one such odorant.

[5] Combustible gas detectors measure combustible/flammable gas concentration in the atmosphere, which is indicated on the device as a percentage of the lower explosive limit (LEL).

[6] The evaluation of appropriate locations for combustible gas monitoring should include consideration of the purge location, characteristics of the gas (lighter or heavier than air), stratification or mixing of the gas, and existing ventilation. See the International Society for Automation (ISA) RP 12.13, *Recommended Practice for the Installation, Operation, and Maintenance of Combustible Gas Detection Instruments* (2003) and the American Petroleum Institute (API) 2009, *Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries* (2002).

GAS PURGING LED TO 2009 EXPLOSION AT CONAGRA SLIM JIM FACTORY

On June 9, 2009, a major natural gas explosion heavily damaged the ConAgra Slim Jim meat processing factory in Garner, North Carolina, just south of Raleigh. Three workers were crushed to death when a large section of the building collapsed. The explosion critically burned four others and sent a total of 71 people to the hospital including three firefighters who were exposed to toxic anhydrous ammonia from the plant's refrigeration system. Approximately 18,000 pounds of ammonia were released to the environment and 100,000 square feet of the plant were damaged. Due to the severity of the structural collapse, there was the potential for numerous additional deaths or serious injuries.

The accident occurred during the installation of a new fuel gas-fired industrial water heater in an interior utility room of the plant. Five days prior to the accident, a new section of three-inch steel piping – which would provide natural gas to the heater – was tied into a six-inch natural gas supply line located on the roof. The new natural gas piping ran horizontally over 120 feet along the roof and then descended into the utility room.

On the day of the accident, a worker from Energy Systems Analysts (ESA), the water heater manufacturer, was attempting to purge the new gas line by using natural gas to directly displace the air. This was done by removing threaded fittings, creating one or more pipe openings near the heater. The worker then opened a quarter-turn valve to control the release of purged gases. ESA reported that it was the company's normal practice to purge fuel gas piping directly into the room or area when installing gas-fired equipment. Code officials and other parties told the CSB that they believe this practice to be common.

The purged fuel gas was vented indoors into the utility room, which was ventilated by an exhaust fan. However, no assessment was made of the adequacy of the ventilation in comparison to the rate of the gas release; whether a dangerous accumulation of flammable gas had occurred could have been most accurately verified by taking direct measurements inside the utility room using a combustible gas detector. Because of the difficulties in lighting the water heater, personnel perceived that the gas line was not effectively purged of air. Therefore, purging was conducted intermittently over a period of up to two-and-a-half hours.



Gas-fired water heater and piping, indicating points where gas was likely released into the building.



Damage to vegetation hundreds of feet away from the ConAgra plant due to the ammonia release that followed the explosion.

ESA and ConAgra employees were aware of the natural gas purging activities inside the utility room. However, no appropriate combustible gas detectors were used to warn of a potential accumulation of gas in the building. Instead personnel relied primarily on the sense of smell to determine when the piping had been effectively purged of air and whether or not an unsafe release of natural gas occurred.

Some ConAgra employees smelled gas in the packaging area; others did not. Personnel who were in and out of the utility room noticed the gas odor, but most were not seriously concerned and considered the purging activity to be a normal part of the start-up process. The ESA and ConAgra employees were not aware that as a result of the purging, a dangerous accumulation of natural gas had occurred into the building, exceeding the lower explosive limit.

The vicinity of the utility room contained numerous potential ignition sources, including a number of unclassified electrical devices. Nonessential personnel were not aware of the water heater start-up or instructed to leave the plant during the gas purging activity. Over 200 people who had no role in the installation were in the building when the natural gas found an ignition source and exploded at approximately 11:25 a.m.

Following the June 9 explosion, ConAgra established new procedures for gas purging. These procedures require direct venting of purged gases via a hose or piping to a safe location outdoors, exclusion of personnel and ignition sources from the vicinity of the vent, continous air monitoring using combustible gas detectors, and evacuation of nonessential personnel from the facility.

SIMILAR INCIDENTS

Research conducted by the CSB during its investigation of the ConAgra explosion uncovered a number of similar incidents around the country that involved the purging of gas lines, including:

- An explosion at a 30-story hotel under construction in San Diego, California, on May 19, 2008, that injured 14 workers, including three who suffered severe burns;
- An explosion at a hotel in Cheyenne, Wyoming, on August 7, 2007, that severely burned two plumbers;
- An explosion that burned two plumbers at a school in Porterville, California, on November 16, 2005;
- An explosion on August 1, 1997, at a fitness center in Cary, North Carolina, a short distance from the ConAgra facility, which collapsed the roof, severely burned two people, and injured four others.

In addition, OSHA inspection records identify other related fuel gas purging incidents have occurred causing deaths and serious injuries.



PHOTO: DIRK HANSEN

Explosion seriously damages three floors of a Hilton Hotel under construction in San Diego in May 2008, injuring 14.

CONCLUSION

As a result of the findings from the ConAgra explosion and other recent similar incidents, this Safety Bulletin emphasizes five key lessons to prevent fires and explosions from purging fuel gas into buildings. These tragic incidents can most effectively be prevented by purging flammable gases to a safe location outdoors. Where this is not practicable, important safety precautions should be in place, including removing nonessential personnel, eliminating ignition sources, and ventilating the space so that the atmosphere is substantially below the LEL. Combustible gas detectors should always be used to monitor the gas concentration during purging operations – never rely on the sense of smell alone. To effectively implement these practices, workers must be fully trained and knowledgeable about safe purging practices and the hazard of odor fade in new gas piping systems.

The U.S. Chemical Safety and Hazard Investigation Board (CSB) is an independent federal agency charged with investigating industrial chemical accidents. The agency's board members are appointed by the president and confirmed by the Senate. CSB investigations look into all aspects of chemical accidents, including physical causes such as equipment failure as well as inadequacies in regulations, industry standards, and safety management systems.

The Board does not issue citations or fines but does make safety recommendations to companies, industry organizations, labor groups, and regulatory agencies such as OSHA and EPA. Please visit our website, www.csb.gov.

No part of the CSB's conclusions, findings, or recommendations may be admitted as evidence or used in any action or suit for damages; see 42 U.S.C. § 7412(r)(6)(G).