U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

Urgent Recommendations

Whereas:

Background and Findings

1. On June 9, 2009, the ConAgra Slim Jim production facility in Garner, North Carolina, experienced a catastrophic natural gas explosion that caused four deaths, three critical life-threatening burn injuries, an amputation, and other injuries that sent a total of 67 people to the hospital.

2. The explosion caused serious structural damage to the approximately 87,000 square foot south packaging and warehouse area of the Garner plant, including wall and roof collapse, which had the potential to cause additional deaths and serious injuries. 37% of the roof area experienced collapse and 60% of the roof area was either collapsed or so heavily damaged as to be unstable.

3. The explosion damaged piping from the plant's large ammonia-based refrigeration system, causing a release of toxic anhydrous ammonia gas to the atmosphere, which was detectable offsite. Three responding firefighters were sent to the hospital for exposure to ammonia. During emergency response activities, additional ammonia was discharged from the system, contaminating local surface waters upstream of a water supply. A total of approximately 18,000 pounds of ammonia was released to the environment.

4. The U.S. Environmental Protection Agency (EPA) and the North Carolina Department of Environment and Natural Resources (DENR) obtained ammonia readings of up to 10,000 parts per million (ppm) in the discharged waters and 150 ppm in the air above, and noted a resulting fish kill.

5. The accident caused serious economic harm to the community by suspending the operations of the plant, which is a major regional employer. When operations resumed, several hundred employees of the plant were laid off.

6. The accident occurred during the installation and commissioning of a new 5-million BTU per hour gas-fired industrial water heater, manufactured by Energy Systems Analysts, Inc. (ESA). Several days prior to the accident, a new three-inch steel gas line was tied into a "T" junction in a six-inch natural gas supply line located on the roof of the plant. The new gas line ran horizontally over 120 feet along the roof and then descended to a utility room, where the new water heater was located.

7. After installation of the new gas piping, both the new piping and the existing gas supply line (which provided natural gas to a boiler) were pressure-tested with air to check for leaks. Following the successful pressure-testing, ConAgra employees purged the gas supply line of air, venting the purged gases directly from the boiler room via a hose to the outdoors, avoiding the possibility of flammable gases accumulating inside the building.[1] However, the air was not immediately purged from the new piping leading to the new water heater.

8. On the day of the accident, an ESA worker was attempting to purge the new gas piping of air by opening the supply of gas, prior to the start-up of the water heater. ConAgra did not have a uniform procedure for gas line purging and did not require ESA to vent the purged gases to the outdoors. ESA reported that it was common practice to purge fuel gas piping directly into the room or area when installing gas-fired equipment. Because of the difficulties in lighting the hot water heater, personnel perceived that the gas line was not effectively purged of air. Therefore the gases were purged indoors within the centrally located utility room intermittently over a two-and-a-half hour period. The utility room was ventilated by an exhaust fan, but no assessment was made of the adequacy of the ventilation in comparison to the rate of the gas release; such a determination could have been most accurately verified using a combustible gas detector.

9. A number of 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 release of gas into the building. Instead personnel relied primarily on their 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.

10. 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 because they were aware of the indoor purging and they did not perceive the gas odor to be at a hazardous concentration. The ESA and ConAgra employees were not aware that as a result of the purging, a dangerous release of natural gas had occurred into the building, exceeding the lower explosive limit (LEL).

11. The sense of smell must never be relied upon as the sole or primary warning for a gas release, due to various factors including: (a) subjectivity and large individual variation in the detection and perception of odors; (b) odorant suppression, conjugation, and cross adaptation; (c) odor fatigue, and (d) odor fade, the tendency of new pipes and containers to react with or absorb the trace amounts of sulfur-containing odorants that are added to otherwise odorless fuel gases, such as natural gas and propane.

[1] The boiler room was near an outside wall, making it particularly straightforward to vent the purged gases outdoors using a hose. ConAgra did not have written procedure requiring purging outdoors until after the explosion.

12. The vicinity of the utility room contained numerous potential ignition sources, including multiple unclassified electrical devices.

13. Nonessential personnel were neither aware of the water heater start-up nor instructed to leave the plant during the gas line purging activity. Over 200 people who had no role in the installation were in the packaging and warehouse area of the plant at the time of the explosion.

14. Following the June 9 explosion, ConAgra established a procedure for gas line purging to require (a) direct venting of purged gases via a hose or piping to a safe location outdoors; (b) exclusion of personnel and ignition sources from the vicinity of the vent; (c) continuous air monitoring using combustible gas detectors; and (d) evacuation of nonessential personnel from the facility.

Similar Incidents

15. On August 1, 1997, a very similar gas purging incident occurred in Cary, North Carolina, near the ConAgra Garner facility. A worker was attempting to purge air out of a natural gas line into a laundry room during the start-up of a commercial dryer in a fitness center. An explosion occurred; the roof of the room collapsed and six workers were injured, including two who were severely burned.

16. On February 1, 1999, explosions and a fire occurred at the Ford Rouge power plant in Dearborn, Michigan, killing 6 workers, injuring 38, and causing approximately $1 billion in property damage. Investigations determined that a primary natural gas explosion had ignited a secondary coal dust explosion. The natural gas explosion occurred when a gas pipe, which was being removed from service, was purged into a boiler instead of directly to the outdoors. Due to a valve misalignment, gas accumulated to an explosive level inside the boiler where it contacted an ignition source, such as hot fly ash residue. In a safety bulletin, the U.S. Occupational Safety and Health Administration (OSHA) noted that one cause of the accident was the venting of gas into the boiler instead of to the atmosphere.

17. Other notable purging incidents include a serious natural gas explosion that occurred on May 19, 2008, during the construction of a 30-story Hilton Hotel in San Diego, California. The explosion damaged three floors of the building and injured 14 workers, including three who suffered severe burns.

18. The California Division of Occupational Safety and Health (Cal/OSHA) cited a construction contractor at the Hilton Hotel, Sherwood Mechanical Inc., alleging that "piping being purged of air was not vented from the enclosed space to the outside atmosphere, and the vent was not closed following the purging of air from the piping." Cal/OSHA also cited the contractor for alleged failure to test the atmosphere for flammable gases and for allowing sources of ignition in an atmosphere exceeding 25% of the lower explosive limit (LEL), contrary to California state safety regulations. Odor fade may also have been a factor.

19. On August 7, 2007, two plumbers in Cheyenne, Wyoming, were reported to be severely burned by an explosion during the purging of a natural gas line into the interior of a new hotel under construction. The plumbers stated they were unable to smell the odorized gas as it filled the room.

20. Odor fade was also implicated in an October 2005 explosion at Triumph Foods in St. Joseph, Missouri, which killed one worker and injured 19 others, three severely. OSHA citations state that natural gas entered the building through an open valve on a new piping system; other published accounts indicate the gas was not detected by personnel due to a loss of odorant and was ignited, possibly by hot work, causing the explosion.

21. Following a November 2005 explosion that burned two plumbers at a school in Porterville, California, the Southern California Gas Company issued a safety bulletin about the problem of odor fade, particularly during the installation of new gas piping. The bulletin warns against sole reliance on smell to detect gas leaks and recommends venting purged gases outdoors and using gas detection equipment.

Codes and Standards

22. The installation of natural gas systems within industrial and other facilities is covered under voluntary consensus codes developed by the National Fire Protection Association (NFPA), the American Gas Association (AGA), and the International Code Council (ICC), which are commonly adopted as regulations by various states and localities throughout the country. The State of North Carolina has adopted the ICC's International Fuel Gas Code, with certain amendments.

23. The National Fuel Gas Code (NFPA 54/ANSI Z223.1) and the International Fuel Gas Code describe practices for purging newly installed or modified fuel gas systems of air and for venting of the purged gases. The codes state identically, "The open end of piping systems being purged shall not discharge into confined spaces or areas where there are sources of ignition unless precautions are taken to perform this operation in a safe manner by ventilation of the space, control of purging rate, and elimination of all hazardous conditions."[2]

24. However, the NFPA and the ICC codes do not explicitly require purged gases to be safely vented outdoors away from personnel and ignition sources, even where it is feasible to do so. In addition, the codes do not (a) define adequate ventilation or hazardous conditions, (b) require the evacuation of nonessential personnel during the purging of fuel gas lines into occupied buildings, or (c) require the use of combustible gas detectors near open vents where gases are purged.

[2] The AGA and the NFPA jointly develop the National Fuel Gas Code through an American National Standards Institute (ANSI) committee process. The ICC licenses provisions of the International Fuel Gas Code from the AGA, including provisions related to gas purging.

25. At the time of the ConAgra accident, the North Carolina Fuel Gas Code contained identical purging provisions to the National Fuel Gas Code and the International Fuel Gas Code. Three months later, in September 2009, the North Carolina Building Code Council adopted emergency changes to the state code to prohibit indoor venting during fuel gas purging operations. When venting outdoors is not possible, strict safeguards are now required including evacuation of nonessential personnel, elimination of ignition sources, use of combustible gas detectors, and adequate ventilation to maintain the gas concentration below 25 percent of the LEL. The revised state code also requires training for personnel involved in gas purging and prohibits attempting to rely on odor to monitor gas concentrations.

26. OSHA regulates the storage and handling of liquefied petroleum gases (LPG), such as propane and butane, under 29 CFR 1910.110 but does not have a specific standard for natural gas. The OSHA standard for LPG was based on the 1969 edition of NFPA 58.

27. The OSHA LPG standard, which did not apply to the natural gas installation at ConAgra, states that "ventilation shall be considered adequate when the concentration of the gas in a gas-air mixture does not exceed 25 percent of the lower flammable limit."[3] During LPG transfer operations, gas or liquid vents are required to be located outdoors at least 50 feet from the nearest building.

28. The most recent (2008) edition of NFPA 58 includes additional requirements for safe purging of LPG vapor, including that vented product must be conveyed outdoors "under conditions that result in rapid dispersion" or else combusted.

29. NFPA 921, Guide for Fire and Explosion Investigations, includes a detailed discussion of the problem of odor fade from odorized gases, due to absorption by piping, containers, or soil, or reaction with piping contaminants. However, the NFPA and ICC fuel gas codes, which are followed by piping installers, do not include similar warnings.

30. The NFPA and the AGA jointly publish the *National Fuel Gas Code Handbook*, which contains non-mandatory guidance and commentary on the code. The commentary on purging states that "outdoor discharge eliminates any associated hazard and is the preferred method when practical." However, this guidance is not explicitly incorporated in the code, which does not discuss venting gases outdoors. The *Handbook* also includes a detailed discussion of odor fade, odor fatigue, and other conditions that reduce the effectiveness of odor for warning of gas leaks.

31. The AGA publishes a detailed technical guidance document, *Purging Principles and Practice*. During purging operations, the guidance urges the elimination or control of all possible sources of ignition, the use of vent pipes to convey purged

[3] In other contexts such as confined space entry, various regulators and organizations have established even lower safety limits for atmospheres that may contain flammables, such as 10% of the LEL. See for example OSHA Standards for Shipyard Employment, 29 CFR 1915.13(b)(3).

gases to the outside atmosphere away from buildings, and the use of appropriate gas detectors. However, principles in this voluntary guidance are not explicitly included in the National Fuel Gas Code.

32. In November 2008, the committees responsible for the National Fuel Gas Code established a task group to strengthen the code language on purging practices, noting that "the code requirement should not focus on the sensing of odorant but provide coverage in the code or annex on how to properly purge including the use of CGI [combustible gas indicators] or require purging only to the outdoors, large system seasoning, or other methods/factors." However, specific code revisions had not been proposed by the time of the explosion at ConAgra.

Standard and Basis for Urgent Recommendations

33. Under 42 U.S.C. §7412(r)(6)(C)(ii), the Board is charged with "recommending measures to reduce the likelihood or the consequences of accidental releases and proposing corrective steps to make chemical production, processing, handling and storage as safe and free from risk of injury as is possible …."

34. Board procedures authorize the development of an urgent safety recommendation "if an issue is identified during the course of an investigation that is considered to be an imminent hazard and has the potential to cause serious harm unless it is rectified in a short timeframe, or a hazard is identified that is likely to exist in a large segment of industry such that the probability of an incident is significant."

35. The use of gas-fired equipment is ubiquitous in general industry, creating a potential for widespread hazards if purging of gas lines is not conducted in the safest possible manner; several serious explosions have occurred in the past four years.

36. ConAgra, Energy Systems Analysts, and code officials and inspectors contacted by the CSB acknowledged that purging of gas lines into buildings is a common practice. However, in the wake of the Garner, NC, incident, both ConAgra and the North Carolina Building Code Council have revised their safety requirements and direct that fuel gas be purged to a safe location outdoors.

37. Purging of fuel gas into the interior of occupied buildings rather than to a safe location outdoors has intrinsic hazards and can pose a serious risk to large numbers of people. A release of a flammable gas indoors is more likely to form a flammable mixture as a result of poor dispersion in an enclosed environment. An ignition of flammable gas is more likely to result in an explosion inside a building than in the outdoors. An explosion indoors can lead to substantially greater overpressure due to confinement and constriction; thus, an explosion inside an occupied building is likely to result in higher risk to workers than an ignition of the equivalent flammable material in the outdoors. Greater overpressure will increase the likelihood for structural collapse and the creation of projectiles, resulting in significantly higher potential for catastrophic injuries. Building

damage from an explosion can block emergency exits and prevent rescue of building occupants. All of these elevated risks from explosions inside an occupied building were experienced in the ConAgra incident.

38. Purging fuel gas piping to a safe location outside avoids the hazard of an accumulation of a flammable atmosphere inside an occupied building and is an inherently safer approach.

39. Published literature and recent accidents indicate that many utility workers involved in gas line installations are unfamiliar with problems such as odor fade and odor fatigue and continue to rely on the perception of odor as a primary warning for the presence of fuel gases.

40. NFPA code revision procedures provide for the consideration and adoption of a Tentative Interim Amendment (TIA) "to offer to the public a benefit that would lessen a recognized (known) hazard or ameliorate a continuing dangerous condition or situation," such as a hazard that has resulted in fatalities.

Accordingly:

Pursuant to its authority under 42 U.S.C. § 7412(r)(6)(C)(i) and (ii), and in the interest of preventing the serious harm that could result if the hazards underlying the explosion at ConAgra are not promptly rectified, the Board makes the following urgent safety recommendations:

National Fire Protection Association (NFPA), the American Gas Association (AGA) and the Chair of the NFPA 54/ANSI Z223.1 Committee:

2009-12-I-NC-UR1

Enact a Tentative Interim Amendment as well as permanent changes to the National Fuel Gas Code (NFPA 54/ANSI Z223.1) to require that during the purging of gas piping at industrial, commercial, and public facilities:

(a) Wherever practicable, directly vent purged gases to a safe location outdoors, away from personnel and ignition sources

(b) In circumstances where it is not practicable to vent purged gases safely outdoors, use appropriate safeguards such as:

- Evacuating nonessential personnel from the vicinity of the purging;
- Providing adequate ventilation to maintain the gas concentration at an established safe level, substantially below the lower explosive limit; and
- Controlling or eliminating potential ignition sources

(c) Use combustible gas detectors to continuously monitor the gas concentration at appropriate locations in the vicinity where purged gases are released

(d) Train personnel about the problems of odor fade and odor fatigue and warn against relying on odor alone for detecting releases of fuel gases

International Code Council (ICC) and the Chair of the International Fuel Gas Code Committee:

2009-12-I-NC-UR2

Incorporate the revised gas purging provisions of the National Fuel Gas Code, consistent with CSB recommendation 2009-12-I-NC-R1, into the International Fuel Gas Code