SAFETY ALERT

Public Safety at Oil and Gas Upstream Facilities

Notice: The purpose of this is *Safety Alert* is to:

- Remind upstream (exploration and production) oil and gas facility owners and operators of public safety hazards associated with their facilities, and their obligations under the Clean Air Act general duty clause (GDC), and
- Provide information on hazard mitigation efforts that can be undertaken to improve safety at normally unoccupied facilities.

The statements in this document are intended solely as a hazard advisory. This document does not substitute for or change any applicable statutory provisions or regulations, nor is it a regulation itself. The hazard mitigation measures it provides may not be appropriate for every situation.

Public Safety Hazards Associated with Oil and Gas Upstream Facilities:

Oil and gas storage facilities can present potentially deadly hazards to the public.

In 2011, the U.S. Chemical Safety and Hazard Investigation Board (CSB) investigated accidents at normally unoccupied upstream oil and gas facilities involving members of the public entering facilities without knowledge of site hazards.[1] The CSB investigation highlights several incidents at these facilities that occurred when members of the public introduced ignition sources to tanks containing flammable hydrocarbon vapors, resulting in fires and explosions.

The CSB obtained information on 26 incidents at oil and gas storage facilities between 1983 and 2010. These incidents resulted in 44 fatalities and 25 injuries to members of the public (Figure 1). As these incidents occurred prior to any comprehensive national requirement to report such incidents, these numbers may undercount the actual number of upstream oil and gas facility incidents. The CSB now requires owners and operators of facilities to report accidental releases of extremely hazardous substances resulting in death, serious injury or substantial property damage.[2] Using publicly available media reports, EPA identified an additional 10 fires or explosions at oil and gas facilities affecting members of the public between 2011 and 2018 (Appendix B).

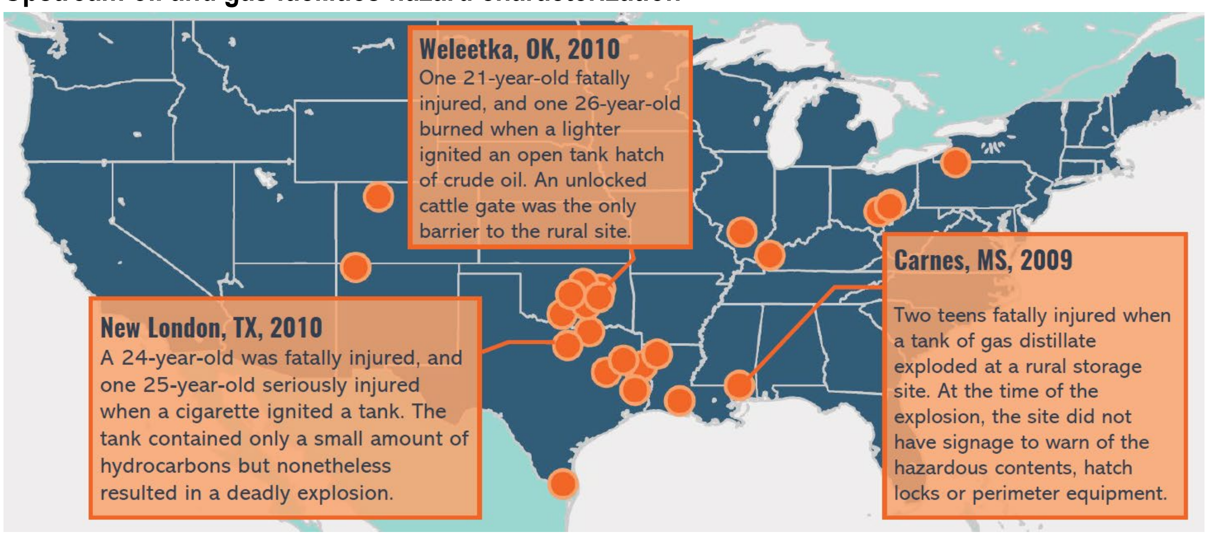
Recreational use of oil and gas sites

Though located in rural areas, the upstream oil and gas facilities investigated by the CSB were nonetheless located near residential communities. The CSB selected three incidents to further investigate from the 26 incidents they identified between 1983 and 2010. Specifically, incidents occurring in: Carnes, Mississippi in 2009, resulting in the death of two teenagers; in New London, Texas in 2010, resulting in one fatality and one serious injury; and in Weleetka, Oklahoma, in 2010, resulting in one fatality and one serious injury (Figure 1). All victims of the three incidents were using the oil and gas storage sites recreationally at the time of the incident. The CSB determined the fatal explosions in Mississippi, Oklahoma, and Texas, could have been prevented by 1) physical deterrence in accessing the site; 2) mitigation of flammable vapors; 3) improved signage; and 4) using safer tank technology.

The CSB subsequently conducted a survey at the high school attended by the victims of the October 2009 explosion in Carnes, Mississippi to better understand perceptions regarding the safety of oil and gas storage facilities, as well as the frequency of using storage facilities for recreational use. Respondents to the survey stated they would be more likely to avoid the sites if hazard signs were present, or if access was made more difficult with fences and locks. Survey respondents also indicated they believed oil and gas sites are convenient places to gather and participate in recreational activities, made easier by mostly unhindered access.

Figure 1. Incidents reviewed by the CSB in the 2011 oil tank safety investigation. The CSB collected information on 26 incidents occurring between 1983 and 2010. The CSB's investigation focused on three incidents in Carnes, Mississippi, New London, Texas and Weleetka, Oklahoma.

Upstream oil and gas facilities hazard characterization



Upstream oil and gas facilities contain large quantities of crude oil and other hazardous substances. Operations involving the production, handling, and storage of highly flammable, explosive, and toxic substances can present significant hazards to members of the public who trespass on oil and gas sites. Though hazards may vary regionally by oil and gas composition, the following describes the hazardous substances at oil and gas storage facilities most frequently[3] responsible for incidents.

Flammable liquids are typically grouped by their flashpoints and characterized as liquids that can burn. Flammable liquids will generally ignite and burn easily at normal temperatures (<199.4°F).[4] Flammable liquids themselves do not burn, rather; it is the mixture of the vapors produced by the compounds with air that allows them to burn.

Flammable gases are gases ignitable at 68°F and can burn at concentration mixtures of 13% or less in air.[5] Flammable hydrocarbon vapors can accumulate in the space between the liquid and the tank roof, with potential for release to the atmosphere when liquid levels change.[6] Some flammable gases that may be present at oil and gas storage sites include hydrogen sulfide, methane, butane, ethane, ethylene, isobutane, propane, and propylene.

Hydrogen sulfide (Sour Crude Oil or Gas)
Crude oil and produced water (often containing oil and water mixtures) tanks may also contain hydrogen sulfide (H_2S), a hazardous and deadly gas.[7] Some of these oil and gas facilities produce both "sour crude oil" and/or "sour gas" which contains hydrogen sulfide, carbon dioxide or mercaptans, all of which are harmful to human health.[8] H_2S is a poisonous gas, and at low concentrations, has the odor of rotten eggs, though at higher, lethal concentrations, results in olfactory fatigue (i.e. inability to detect an odor). The health effects of H_2S depends on the duration, frequency, and intensity of exposure, as well as the susceptibility of the individual. H_2S is a serious and potentially lethal hazard, so awareness, detection and monitoring of H_2S is essential.[9] Slightly heavier than air, H_2S can accumulate in enclosed, poorly ventilated, and lower lying areas.

H_2S is not only toxic, but also highly flammable and explosive. The explosive range of H_2S in air is 4.5 to 45.5% concentration; notably higher than the occupational permissible exposure limit (PEL).[10] At upstream oil and gas facilities, the risk of H_2S exposure is often associated with the areas near the tank thief hatch[11] and through exposure occurring during tank opening for sampling and measurement, or through vents located on the roof of the stock oil tanks in the production battery. These sour crude oil and gas facilities can be identified by the presence of a windsock which assists with wind direction and the direction of sour gas movement in the air column. For more information, consult the Occupational Safety and Health Administration (OSHA) factsheet on H_2S.[12]

Regulatory Requirements for Oil and Gas Upstream Facilities:

Upstream oil and gas facility owners and operators should be aware of relevant safety and security requirements, including applicable laws and regulations, industry codes, standards, and guidelines. Upstream oil and gas facilities may be subject to multiple federal, state, and/or local regulatory requirements based on a variety of factors. Owners and operators should consider implementing basic site security and access controls even where not required under any specific law, regulation, or code.

Clean Air Act General Duty Clause
The Clean Air Act (CAA) General Duty Clause (GDC) requires the owners and operators of facilities, including upstream oil and gas facilities using extremely hazardous substances, to identify hazards, design and maintain a safe facility, and minimize the consequences of accidental releases. An effective way for upstream oil and gas facilities to comply with the GDC is to operate in accordance with "recognized and generally accepted good engineering practices" or ***RAGAGEP***.[13] RAGAGEP includes codes and standards published by standards setting organizations. In some cases, compliance with certain design codes or standards may also be required by state or local authorities. Key RAGAGEP for preventing hazardous chemical releases at unmanned oil and gas facilities includes American Petroleum Institute (API) Standard 12R1: Inspection, Operation, Maintenance, Inspection and Repair of Tanks in Production Service, specifically Annex G in the Sixth Edition published in March 2020.[14] Specifically, Annex G of 12R1, "Unmanned Upstream Facility Design and Safety Considerations," provides guidance for all produced fluids at exploration and production facilities, intended to prevent explosions or accidental discharges and releases resulting from the introduction of ignition sources by the public, including guidance on facility security assessments; vapor mitigation strategies; barricades; and signage.

Hazard Mitigation Efforts That Can Be Undertaken to Improve Safety at Normally Unoccupied Facilities:

Safer tank design technologies

Safer tank technology and design options offer a way for upstream oil and gas facilities to reduce the need for lower level hazard control options by removing the circumstances under which an explosion or fire may occur. Safer tank options include measures such as: restrictions on open vents; flame arrestors; pressure/vacuum valves; floating roofs; and vapor recovery units.

1. ***Restrictions on the use of open vents for flammable hydrocarbons.*** Oil-gas pressure process separators usually contain an atmospheric vent to reduce build-up of hydrocarbon vapors. Many oil and gas production tanks use open vent tank designs in the storage of flammable liquids; however, open vents without flame arrestors should only be used with tanks without a flammable vapor space.[15]
2. ***Flame arrestors*** are devices that extinguish a developing flame outside of the tank and prevent a flame from entering a vapor space within the tank. The device forces a flame through a narrow channel, preventing the flame from growing.[16] API Standard 2000, Venting Atmospheric and Low-pressure Storage Tanks,[17] suggests flame arrestors should be used for tanks storing flammable substances.
3. ***Pressure/Vacuum valves*** are common for fixed roof tanks to reduce evaporation and product losses. These valves are designed to prevent an overpressure or vacuum from occurring by isolating ignition sources, so they are unlikely to flash back to the vapor space.[18]
4. ***Floating roofs*** are a design feature wherein a roof floats on top of a flammable liquid, reducing the accumulation of hydrocarbon vapors. Floating roofs can be either external, or internal, the latter in which a floating roof is covered by a fixed roof to further reduce hydrocarbons and protect floating roofs from the elements.[19] Though ideal for tanks with roofs greater than 30 feet in diameter, floating roofs can also be installed in new or existing tanks as small as 8 to 10 feet in diameter.[20]
5. ***Vapor Recovery Units*** on tanks prevent external ignition sources from entering the vapor space by removing flammable vapors from tanks and recovering available liquid hydrocarbons. Typically, vapors are drawn out of the tank to a separator to remove remaining liquid hydrocarbons, while gas is condensed in a compressor.[21] Vapor recovery units are both good for the environment by reducing gas emissions to the atmosphere, and economically beneficial by recovering hydrocarbons and sale of compressed gases.[22]

Improved signage

Warning signage and proper labeling of hazards at upstream oil and gas facilities is key to improving safety for workers, emergency responders, and the public. Signage should be displayed at the entrance to the facility, on fences, gates, or another highly visible location, along with facility contact information. The National Fire Protection Association (NFPA) Code 30, the Flammable and Combustible Liquids Code,[23] requires a summary of the emergency plan be posted in a strategic location, accessible to emergency responders (21.6.5.6, 2018 edition). NFPA 30 also requires facilities to perform a security vulnerability assessment, including an assessment of the overall facility, evaluation of vulnerabilities, assessment of threats and consequences, identification of mitigating factors, and conducting a security gap analysis. NFPA 30 security requirements for unsupervised storage tanks include securing and marking tanks to identify fire hazards and tank contents for the general public (21.7.2.2, 2018 edition). API 12R1, Installation, Operation, Maintenance, Inspection, and Repair of Tanks in Production Service, recommends the placement of hazard warning signage at the entrance of the facility, as well as on stairways, barricades and ladders.[24]

API 12R1 also recommends additional signage at the entrance of facilities including:

- "No Trespassing;"
- "No Smoking;"
- "Flammable vapor;"
- "Combustible gas;" and
- "Poison/Toxic gas."

The OSHA Hazard Communication Standard (HCS) requires pictograms (Appendix C),[25] on labels to alert users of the chemical hazards to which they may be exposed. Many HCS pictograms are potentially relevant to oil and gas storage facilities; however, it is important to note that unlike workers, pictograms may not be readily interpreted by members of the public who have not been trained in HCS.

Physical barriers

Facilities should conduct a site vulnerability assessment to determine the level of security needed to deter unauthorized access to oil and gas production tanks and process vessels.[26] The following describes additional physical boundary options applicable to all facilities.

- ***Thief Hatch locks*** can prevent unauthorized access to the tank thief hatch (sampling measurement port opening) while also controlling evaporative losses and exposure to toxic and flammable gasses.
- ***Improved fencing and locks surrounding tanks.*** The CSB found during its investigation that normally unoccupied facilities often lacked physical security measures or used ineffective cattle gates. API 12R1 categorizes security precaution based on facility risk level, identifying high-risk facilities as those in populated areas or deemed high-risk by the facility security assessment. High-risk facilities should opt for a lockable, perimeter boundary or fencing, with warning signs, surrounding the entire facility, including the pad, tanks and other equipment. API 12R1 notes that the fence and gate should be at least 7 feet high and chain link material. Fencing and facility entrances with panic hardware installed can allow for operator egress in the event of an incident while the facility is occupied.
- ***Improved barriers on ladders and stairways.*** The API 12 series standards contain requirements for stairways and ladders for specific tank types. For low-risk facilities, a gate at the point of tank access is recommended, with three cross rails on the stairway.

Conclusions:

This *Safety Alert* has highlighted the hazards associated with normally unoccupied upstream oil and gas facilities, facility responsibilities under the CAA, and safer tank technology to prevent incidents involving hazardous substances at oil and gas storage facilities. While several methods to prevent incidents at oil and gas storage facilities are presented here, operators should consult RAGAGEP for the most up-to-date design and operational guidance. Ultimately, it is the responsibility of facility owners and operators to conduct a site vulnerability assessment in order to determine methods to reduce the risk of an incident and prevent unauthorized access.

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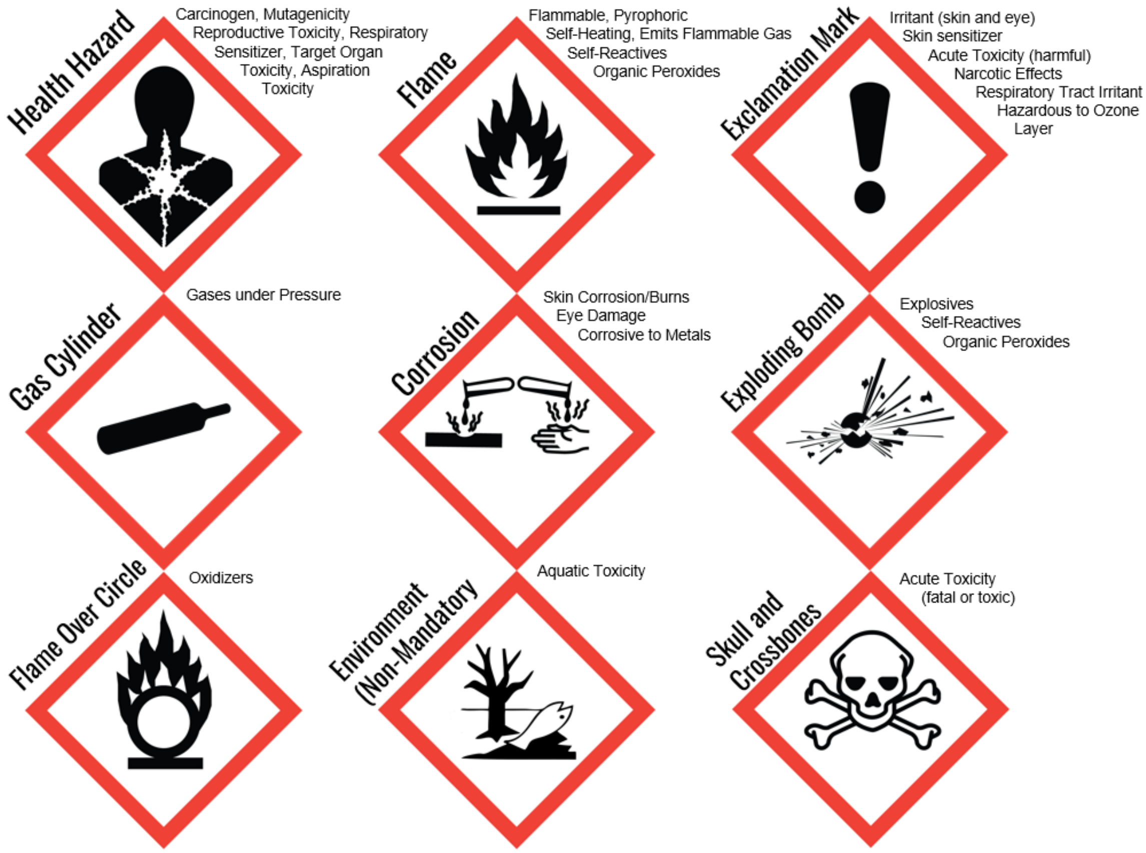
Appendix A. Relevant oil and gas facility codes and standards.

Standard/Specification/Publication/Recommended Practice/Codes *Consult the relevant standards organization for most up-to-date edition*
American Petroleum Institute (API)
• API Specification 12B. Specification for Bolted Tanks for Storage of Production Liquids.
• API Specification 12D. Specification for Field Welded Tanks for Storage of Production Liquids.
• API Specification 12F. Specification for Shop Welded Tanks for Storage of Production Liquids.
• API Specification 12J. Specification for Oil and Gas Separators.
• API Specification 12P. Specification for Fiberglass Reinforced Plastic Tanks.
• API Publication 306. An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks. 1991.
• API Publication 307. An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks. 1992.
• API Publication 315. Assessment of Tankfield Dike Lining Materials and Methods. 1993.
• API Publication 322. An Engineering Evaluation of Acoustic Methods of Leak Detection in Aboveground Storage Tanks. 1994.
• API Publication 325. An Evaluation of a Methodology for the Detection of Leaks in Aboveground Storage Tanks. 1994.
• API Publication 334. A Guide to Leak Detection for Aboveground Storage Tanks. 1996.
• API Publication 340. Liquid Release Prevention and Detection Measures for Aboveground Storage Facilities. 1997.
• API Publication 341. A Survey of Diked-Area Liner Use at Aboveground Storage Tank Facilities. 1998.
• Recommended Practice 575. Guidelines and Methods for Inspection of Existing Atmospheric and Low-pressure Storage Tanks.
• API 650. Welded Tanks for Oil Storage.
• API Standard 2000. Venting Atmospheric and Low-pressure Storage Tanks.
• API Standard 653. Tank Inspection, Repair, Alteration, and Reconstruction.
• API 5L. Specification for Line Pipe.
• API Standard 12R1: Inspection, Operation, Maintenance, Inspection and Repair of Tanks in Production Service. Sixth Edition, March 2020.
• API Recommended Practice 49. Drilling and Well Servicing Operations Involving Hydrogen Sulfide.
• API Recommended Practice 54. Occupational Safety for Oil and Gas Well Drilling and Servicing Operations.
• API Recommended Practice 74. Occupational Safety for Onshore Oil and Gas Production Operation.
• API Publication 761 3rd Edition. (2001). Model Risk Management Plan Guidance for Exploration and Production (E&P) Facilities; Guidance in Complying with EPA's RMP Rule (40 Code of Federal Regulations, Part 68).
American Society of Mechanical Engineers (ASME)
• B16.5. Pipe Flanges and Flanged Fittings.
• Boiler and Pressure Vessel Code.
• A36. Standard Specification for Carbon Structural Steel.
• A53. Specification for Carbon Steel Pipe.
• A105. Standard Specification for Carbon Steel Forgings for Piping Applications.
• A106. Seamless Carbon Pipe Specification.
• A181. Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
• A123. Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
• A216. Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
• A283. Standard Specification for Carbon Steel Plates.
• A285. Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength.
• A307. Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.
• A1011. Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
• D3299. Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
• D4097. Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
National Association of Corrosion Engineers (NACE)
• RP0372-1981. Method for Lining Lease Production Tanks with Coal Tar Epoxy.
National Fire Protection Association (NFPA)
• NFPA 1. Fire Code.
• NFPA 10. Portable Fire Extinguishers.
• NFPA 30. Flammable and Combustible Liquids Code.
• NFPA 37. Installation and Use of Stationary Combustion Engines and Gas Turbines.
• NFPA 70®. National Electrical Code®.
• NFPA 101®. Life Safety Code®.
• NFPA 326. Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair.
• NFPA 400. Hazardous Materials Code.
• NFPA 2112. Flame-Resistant Garments for Production of Industrial Personnel Against Flash Fire.
• NFPA 2113. Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire.

Appendix B. Additional oil and gas facility incidents identified by EPA: 2011-2018.

Year	Location	Incident Summary
2011	Hickory, Pennsylvania	Tank explosion near residential homes. A tank caught fire at a gas well compressor and exploded a half-mile away from residential homes. The facility did have a locked gate and no injuries were reported. The tank was near empty but still contained flammable vapors.
2011	New Harrisburg, Ohio	Tank explosion near residential homes. An oil well tank exploded near two homes. The tank and tank lid landed in the middle of one residential home yard, approximately 220 feet from the well site. Additionally, a tank pipe landed in the second residential home, approximately 350 feet from the well head. No injuries reported.
2012	Bolivar, Ohio	Oil and natural gas well tank explosion on residential property. One 19-year-old worker was fatally injured when a conventional oil and natural gas well exploded. The well was located on a residential property with the occupied home located 100 yards from the explosion.
2012	Ghent, New York	Community evacuation. A community was evacuated after a tank exploded resulting in a fire that destroyed a facility containing 20,000 gallons of mineral oil, motor oil, two propane tanks and polychlorinated biphenyls (PCBs). Residents within a half-mile were evacuated and those within a 15-mile radius were told to remain indoors, close their windows and turn off their air conditioners.
2013	Van Zandt, Texas	Injuries to members of the public. Two people were hospitalized, both age 24, after trespassing at a storage tank facility. Both individuals were smoking on top of storage tanks when the tank exploded and caught fire.
2016	Frio County, Texas	Community evacuation. Gas condensate tanks exploded triggering an evacuation of residents in the surrounding area.
2017	Waukomis, Oklahoma	Trespassing resulted in a fatal injury. A 33-year-old man was fatally injured when he trespassed at an oil tank battery, which exploded after an ignition source was intentionally introduced.
2017	La Salle, Texas	Community evacuation. A tank explosion injured two oil field workers and resulted in a quarter-mile evacuation zone in the community around the facility.
2018	Oklahoma City, Oklahoma	Community evacuation. A 7,000-gallon oil tank caught fire and burned out for one day until the fuel supply was exhausted. Businesses in the surrounding area were evacuated.

Appendix C. Hazard Communication and Globally Harmonized System pictograms.



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