# Factual Update

July 27, 2020

## Incident Summary

- On October 26, 2019, a release of water containing hydrogen sulfide—a toxic gas—occurred at a facility called a "waterflood station" which is used to improve the extraction of oil from underground oil reservoirs. The release fatally injured an employee and his wife. This facility is operated by Aghorn Operating, Inc. (Aghorn).

## Background Information

- There are two stages of oil extraction from underground oil reservoirs, primary and secondary. Primary recovery utilizes the natural pressure in underground oil reservoirs to cause oil to flow to the surface of drilled wells [1] [2]. However, as the oil is extracted from the reservoir the pressure driving the oil to the surface decreases. To counteract this pressure decrease, companies can choose to perform secondary recovery. Secondary recovery involves the use of equipment to raise the pressure in the reservoir. This is typically done by injecting water, gas, or a water-gas mixture back into the reservoir through what are known as "injection wells" [1].

- "Waterflooding" is one type of secondary recovery which increases the pressure in underground oil reservoirs by pumping water, under high pressure, into a series of injection wells. This technique can increase the amount of oil recovered by 30% [1] [2]. The October 26 incident occurred at an Aghorn waterflood station.

- Figure 1 illustrates the Aghorn oil extraction and waterflood process. Oil and water are extracted from underground reservoirs and sent to a tank battery, where the water is separated from the oil. The water, called "produced water" after it is separated from the oil, typically contains other components including hydrogen sulfide, a toxic gas known to be present in oil and gas reservoirs in the area.[a] After being separated from the oil, the produced water is transferred by a pipe to the waterflood station, and the oil is sent offsite to be processed.

[a] Tests at the well locations that feed produced water to the waterflood station contained 554 ppm of hydrogen sulfide gas.

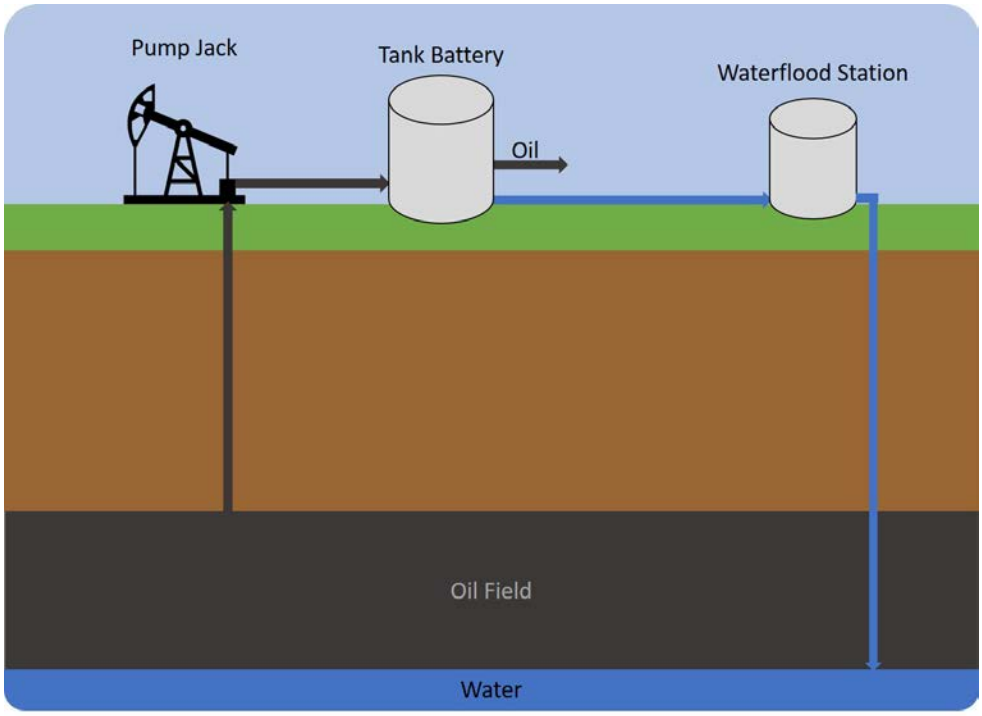


*Figure 1. Illustration of Aghorn oil extraction and waterflood process. Oil and water are extracted from underground reservoirs and fed to a tank battery that separates the water from the oil. The produced water is fed to the waterflood station, which then pumps the water back into the reservoir to increase the reservoir pressure. (Credit: CSB)*

- The produced water is collected in a water tank at the waterflood station (Figure 2).[a] The tank is connected by a pipe to a "pump house" where positive displacement pumps pressurize the produced water to approximately 900 pounds per square inch (psi) and inject it back into the oil reservoirs. Aghorn told the CSB that an Aghorn employee inspects the waterflood station twice a day during routine rounds, and will also respond to the facility if there is an alarm.[b]

[a] A second larger tank at the waterflood station is used as a reserve tank during maintenance.

[b] Aghorn informed the CSB the employee will take readings from the equipment, examine the pumps, and inspect the grounds when they visit the waterflood station.


*Figure 2. Overhead view of the Aghorn Operating waterflood station in Odessa, Texas, on the morning after the incident. (Photo Credit: Ector County Sheriff's Office, highlighting by U.S. Chemical Safety Board)*

- Hydrogen sulfide is a colorless, flammable gas that has an odor similar to rotten eggs [3]. The gas is heavier than air and will collect in low-lying areas. When a person is exposed to hydrogen sulfide for an extended period or at high concentrations, they can lose their ability to smell the gas. This is called olfactory fatigue. OSHA documents warn that the sense of smell should not be used as a detection method for hydrogen sulfide. According to The National Institute for Occupational Safety and Health (NIOSH), a level of 100 parts per million (ppm) is Immediately Dangerous to Life or Health (IDLH) [4].[a] Hydrogen sulfide levels above 500 ppm can cause a person to collapse in about five minutes. When levels exceed 700 ppm, collapse can occur within one or two breaths [5].

- The waterflood station is equipped with a hydrogen sulfide detection system. This system is comprised of eight detectors placed throughout the station, two of which are located inside the pump house. Aghorn informed the CSB that the hydrogen sulfide detection system is designed so that when any of the sensors detect hydrogen sulfide at certain concentrations, a signal is sent to a control board in the pump house which triggers a phone notification to an Aghorn employee and will turn on a light on the top of the pump house (Figure 3).[b]

[a] NIOSH chooses IDLH values (1) to ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment and (2) to indicate a maximum level above which only a highly reliable breathing apparatus, providing maximum worker protection, is permitted. https://www.cdc.gov/niosh/idlh/default.html (accessed on January 30, 2020)

[b] This process is automatic and does not require employee action.


*Figure 3. Light designed to illuminate when hydrogen sulfide is detected at the facility.*

## Incident Description

- On the evening of October 26, 2019, a component of one of the pumps[a] inside the pump house failed (discussed below) resulting in the release of produced water containing hydrogen sulfide. At 6:38 p.m. the pump house control board registered a high oil level alarm. Phone records show that five minutes later, at 6:43 p.m., the alarm system triggered an automatic phone notification to an Aghorn employee.[b] As a part of the normal job duties, the employee drove to the facility to determine the cause of the alarm. After entering the pump house, the employee was overcome by hydrogen sulfide gas.[c]

- Around 9:30 p.m., having not heard back from her husband for a few hours, the employee's wife and their two children[d] drove to the waterflood station in her personal vehicle to check on him. After arriving at the facility, it appears she entered the pump house to look for her husband and was also overcome by hydrogen sulfide gas.[e]

- At 9:58 p.m., emergency responders received a call about a "possible man down" and dispatched an ambulance to the approximate location of the waterflood station. Emergency responders arrived at the facility and observed a smell around the building that led them to believe that there was a hydrogen sulfide release in the area. Based on their assessment of the situation, the emergency responders were evacuating to a safe location when they noticed one of the two children in the back seat of the wife's car. After getting to a safe location, an emergency responder put on protective gear, including a self-contained breathing apparatus (SCBA), returned to the waterflood station, and rescued the two children.

- Additional first responders were called to the scene to assist with the search for the missing employee and his wife. The bodies of both the employee and his wife were found inside the pump house. Produced water containing hydrogen sulfide gas continued to leak from the pump. Several times throughout the night, first

[a] There are three pumps inside of this waterflood station. All three are contained in the structure referred to as the "pump house"
[b] There were no employees present at the facility when the alarm was triggered.
[c] Ector County Medical Examiner Autopsy Report
[d] The two children were age 6 and 9
[e] Ector County Medical Examiner Autopsy Report

responders detected up to 150 ppm of hydrogen sulfide gas as well as one instance of the meter going "over limit."[a]

- On October 27, 2019, following the instruction of Aghorn employees, emergency responders closed a valve that isolated the pump house from the water tank, stopping the flow of produced water out of the pump.

## Post-Incident Activities

- Examination of the pump revealed that one of the pump's "plungers" was broken (Figure 4).[b] This is the likely release point of the produced water.

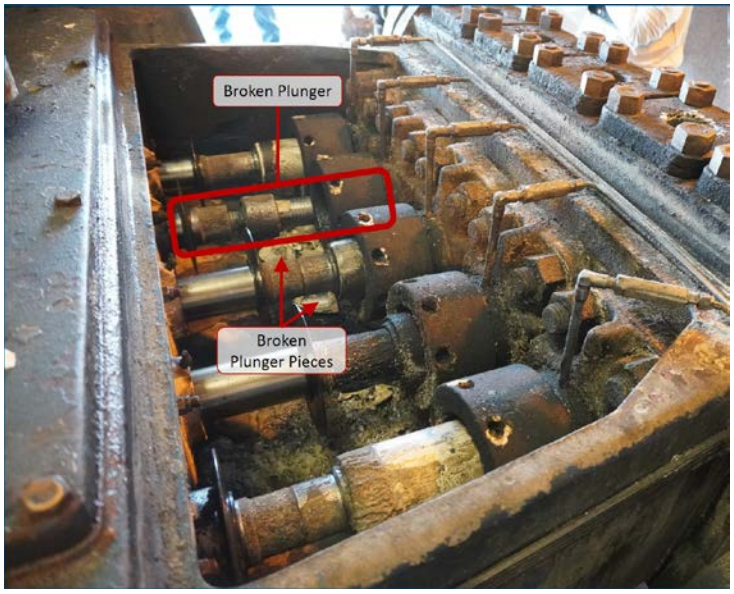


*Figure 4. The plunger, second from the back, appears to have shattered. This was the likely release point of the produced water.*

- Testing after the incident revealed the hydrogen sulfide gas detection system may not have been performing as expected. Emergency responders and the Aghorn employees who responded to the incident did not see the hydrogen sulfide alarm light on the top of the building illuminated.

[a] Going "over limit" means the detector could not accurately measure the amount of H2S gas in the air due to the concentration being over the maximum limit of the sensor.

[b] The type of pump involved in this incident is called a positive-displacement plunger pump. A demonstration of how this type of pumps works can be seen: https://www.youtube.com/watch?v=C2VOcfkGNY4

## Path Forward

As part of its investigation to determine the cause or probable cause of this incident the CSB will analyze several key areas. These areas include but are not limited to:

- Additional testing of equipment and facility systems
- Aghorn safety management systems including:
    - Personal protective equipment requirements
    - Mechanical integrity systems
    - Operating procedures
    - Equipment design

The investigation is ongoing. At the conclusion of the investigation, the CSB will publish a final investigation report which will include findings, analysis, and recommendations if appropriate.

## References

[1] V. S. Vishnyakov, B. Salmanov and E. Ahmad Zeynalov, "Oil recovery stages and methods," in *Primer on Enhanced Oil Recovery*, Gulf Professional Publishing, 2020, pp. 53 - 56.

[2] Office of Fossil Energy, "Enhanced Oil Recovery," [Online]. Available: https://www.energy.gov/fe/science-innovation/oil-gas-research/enhanced-oil-recovery. [Accessed 04 2020].

[3] Occupational Safety and Health Agency, "OSHA Fact Sheet - Hydrogen Sulfide," [Online]. Available: https://www.osha.gov/OshDoc/data_Hurricane_Facts/hydrogen_sulfide_fact.pdf. [Accessed 04 2020].

[4] The National Institute for Occupational Safety and Health (NIOSH), "Table of IDLH Values - Hyrdogen Sulfide," May 1994. [Online]. Available: https://www.cdc.gov/niosh/idlh/7783064.HTML. [Accessed 30 January 2020].

[5] US Department of Labor - OSHA, "Hydrogen Sulfide," [Online]. Available: https://www.osha.gov/SLTC/hydrogensulfide/hazards.html. [Accessed 30 January 2020].