The National Institute for Occupational Safety and Health (NIOSH)

Promoting productive workplaces through safety and health research NIOSH

Driller and Service Rig Helper Die in Fracturing Tank at Gas Well Site–Pennsylvania.

FACE 9217

SUMMARY

A 39-year-old male driller and a 28-year-old male service rig helper (the victims) died after entering a fracturing tank located at a well within a natural gas storage field. The workers had been assigned the duty of monitoring the fluid level and wellhead pressure at the well during the final stages of an hydraulic fracturing operation. The victims' last contact with co-workers occurred on the evening of the incident when they relieved the two day shift crewmen at the well. They were found inside the tank the next morning when the same two crewmen returned to the jobsite to begin the day shift. There were no eyewitnesses to the incident and the reason for entering the tank was unknown. The exact nature of the atmosphere in the tank at the time of the incident is unknown. After the victims were discovered by other workers they were recovered by a county hazardous material (haz-mat) team using self-contained breathing apparatus. NIOSH investigators concluded that, in order to prevent future similar incidents, employers should:

- **cover openings in fracturing tanks with physical barriers to prevent unauthorized or casual entry**
- **develop and implement confined space entry programs at all job sites where workers are exposed to confined space hazards**
- **evaluate the alternative job procedures used in the instance of equipment malfunctions to ensure that the alternative procedures do not increase employees' risk of injury.**

Additionally, manufacturers and owners of fracturing tanks, as well as operators of gas wells, should:

- **devise improved methods of monitoring the fluid volumes returning from the wellbore during the "flow-back" phase of hydraulic fracturing operations.**

INTRODUCTION

On June 4, 1992, a 39-year-old male driller and a 28-year-old male service rig helper (the victims) were found by co-workers inside a fracturing tank at a gas well located in a natural gas storage field. On June 8, 1992, the county coroner notified the Division of Safety Research (DSR) of these fatalities, and requested technical assistance. On June 11, 1992, a quality assurance specialist and a safety engineer from DSR conducted an investigation of this incident. Representatives of the employer, co-workers, the storage field operator, the county coroner, and the county haz-mat team were interviewed. Photographs and measurements of the incident site were obtained. Also, tests of the tank atmosphere, as it existed on June 11, 1992, were performed.

The employer in this incident was a gas well drilling and service company that had been in business for 30 years. The company employed 400 workers, including 48 drillers and 5 service rig helpers. The employer, a contractor, had entered into an agreement with the storage field operator to supply workers to monitor the wellhead pressure and fluid level in the fracturing tank during the final stages of the hydraulic fracturing operation. The employer had a comprehensive corporate safety program, but no confined space entry program was in effect at the jobsite at the time of the incident. The employer conducted formal first-aid training and weekly safety talks concerning various jobsite hazards, although confined spaces were not discussed. The employer had no history of fatalities.

INVESTIGATION

The incident site was the work area of a natural gas well at which an hydraulic fracturing operation was in the final stages of completion. Hydraulic fracturing is a process in which cracks are produced in the gas-bearing strata of an existing well by the injection of fluid under high pressure. Selected grades of sand or other granular material are added to the fluid in quantities designed to fill the fractures and act as a propping agent, holding the fractures open after the applied hydraulic pressure has been released. This process enhances the fluid-flow characteristics of the gas-bearing strata.

The well is allowed to stand approximately 4 hours after the fracturing fluid has been injected. The fracturing fluid is then allowed to vent or “flow back” from the wellbore under residual pressure. The fluid is normally recovered by allowing it to flow from the wellhead through tubing into a small tank (blow-back tank) which is open to the atmosphere. The blow-back tank allows gases entrained in the returning fluid to vent to the atmosphere, and reduces the amount of frothing or sudsing of the fluid. From the blow-back tank, the fluid is piped into a larger tank commonly known as a fracturing (frac) tank or wheely tank. This is a large, 21,000-gallon tank mounted on wheels and provided with a fifth wheel for towing from jobsite to jobsite by a semi-tractor. The fracturing tank involved in the incident measured 37 feet in length, 8 feet in width, and varied in height from 8 feet at the rear to 11 feet at the front.

The victims’ only assignment (at this jobsite) was to monitor the wellhead pressure and fluid level of the fracturing tank at 2-hour intervals during their 12-hour shift. The victims had been assigned to monitor the fluid level by taking depth measurements of the fluid in the fracturing tank. The procedure for the measurement was to use a steel measuring tape as a dipstick by inserting it into a 12-inch-diameter measurement port, located on the top of the tank, until it contacted the tank bottom. The tape would then be withdrawn and the fluid level reading would be taken from the wet mark on the tape. This could be accomplished from outside the tank.

There were no eye witnesses to the incident; however, evidence and interviews with co-workers indicate that on the day of the incident, the victims had arrived on the jobsite just before the beginning of their assigned 7 p.m. to 7 a.m. shift. The co-workers going off duty after their 7 a.m. to 7 p.m. shift informed the victims that the blow-back tank had been bypassed because it was suspected to be leaking and that the fracturing fluid was flowing directly from the wellhead to the recovery tank. The co-workers advised them not to enter the fracturing tank since the blow-back tank had been bypassed, and the fumes coming from the tank were strong. The co-workers then left the jobsite.

On the morning of June 4, 1992, the two co-workers arrived to relieve the victims and begin work on the day shift. When they arrived at the site, the victims could not be found. A search of the area revealed that the victims were inside the fracturing tank. Just before 7 a.m., local volunteer firefighters were summoned to the scene. After arrival, the firefighters summoned the county haz-mat team which arrived at the scene at 8 a.m. The haz-mat team, wearing self-contained breathing apparatus (SCBA) and rescue harnesses recovered the victims about 15 minutes later. They were pronounced dead at the scene.

There were no eyewitnesses to the incident, and no known reason for the victims to enter the tank. However, since the blow-back tank had been bypassed, there may have been significant amounts of froth on the surface of the fluid inside the fracturing tank. This would have interfered with attempts to measure the fluid level by causing a false wet mark on the measuring tape. It is probable that the victims attempted to measure the fluid level through a 21-inch by 19-inch access hatch on top of the tank. During this attempt, one of the victims may have slipped and fallen into the tank or may have been overcome by fumes venting from the tank and fallen inside. His co-worker may then have attempted a rescue only to become a victim himself. The worker who located the victims stated to investigators that he had to sweep the froth from the surface of the fluid with a shovel to locate one of the victims.

Gas tests performed during the investigation on June 11, 1992, indicated 19.9% oxygen, 1.5 parts per million (ppm) of hydrogen sulfide, 0.5 ppm of sulfur dioxide, and 0.00% hydrocarbons. This environment, however, may not have been representative of the atmosphere inside the tank at the time of the incident, since the tank had been drained during the recovery of the victims, flushed with water, and additional fluid had been allowed to flow back into the tank when normal operations were resumed.

CAUSE OF DEATH

The county coroner attributed both deaths to asphyxia due to anoxia (severe deficiency of oxygen), accumulation of fumes, or a combination of anoxia and fumes.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should cover openings in fracturing tanks with physical barriers to prevent unauthorized or casual entry.

Discussion: The fracturing tank involved in this incident had an access hatch 21 inches long by 19 inches wide, and the opening was equipped with a hinged cover. Addition of a physical barrier over the opening constructed from steel bar stock or heavy screen fixed to the tank by welding or bolted fasteners could have prevented unauthorized or casual entry. Although it could not be determined why the victims entered the tank, the only access was through this hatch. It is conceivable that one of the victims may have fallen through the opening while attempting to take a measurement of the fluid level and his co-worker may have entered while attempting a rescue. Or, one of the victims may have dropped something inside the tank and tried to retrieve it and the co-worker entered in a rescue attempt. In either case, if the entry port had been barred, no one could have inadvertently fallen through the opening nor would casual entry to retrieve lost objects have been readily possible. The employer began installing physical barriers consisting of steel bars welded in place across the opening shortly after the investigation of June 11, 1992.

Recommendation #2: Employers should develop and implement confined space entry programs at all jobsites where workers are exposed to confined space hazards.

Discussion: There was no confined space entry program in effect at the jobsite at the time of the incident. If a confined space entry program had been implemented, the incident and resulting fatalities may not have occurred. Such a program should include:

- evaluation to determine whether entry is necessary or whether the task can be performed from the outside
- issuance of a confined space entry permit by the employer
- posting of confined space entry warning signs
- testing the air quality in the confined space when entry is necessary to ensure:- oxygen levels of at least 19.5%
  – flammable range of less than 10% of the LEL (lower explosive limit)

  – absence of toxic air contaminants

- training of workers and supervisors in the selection and use of:- respiratory equipment
  – environmental test equipment

  – lifelines

  – rescue equipment

  – protective clothing

- training of employees in safe work procedures in and around confined spaces
- training of employees in confined space rescue procedures

- conducting regular safety meetings to discuss confined space safetyavailability and use of proper ventilation equipment
  monitoring of the air quality when ventilation equipment is in use.

Recommendation #3: Employers should evaluate the alternative job procedures used in the instance of equipment malfunctions to ensure that the alternative procedures do not increase employees' risk of injury.

Discussion: In this incident, the normal procedure of piping fluid from the wellbore to the fracturing tank through the blow-back tank was not used due to a suspected leak in the blow-back tank. Use of the blow-back tank allows gases to vent from the fracturing fluid and provides more time for sudsing of the fluid to settle, thereby reducing the amount of froth on the surface of the fluid in the fracturing tank. Bypassing the blow-back tank may have increased the amount of froth inside the fracturing tank, making it difficult for the victims to obtain an accurate depth measurement while remaining outside the tank and thereby providing them reason for entry into the tank.

Recommendation #4: Manufacturers and owners of fracturing tanks, as well as operators of gas wells, should devise improved methods of monitoring the fluid volumes returning from the wellbore during the "flow-back" phase of hydraulic fracturing operations.

Discussion: The tank involved in the incident was equipped with a level indicator consisting of a float within the tank attached by an arm to a shaft running parallel to the side of the tank. This shaft exited the end of the tank where a pointer was attached. A scale, graduated in barrels and gallons, was painted on the end of the tank such that movement of the float inside the tank translated into movement of the pointer across the scale, yielding a volume measurement. According to employer and storage field representatives interviewed during the investigation, the precision of this measuring arrangement was not sufficient to monitor the fracturing operation and it was therefore necessary to perform the measurement manually with a steel tape measure used as a dipstick. Consideration should be given to improving the accuracy of the measurement system by either refining the scale of the indicator, providing a site glass on the side of the tank, or providing an in-line flow measurement device such as a turbine-type flowmeter, or an orifice meter in the tank inlet.

REFERENCES

NIOSH [1979]. Criteria for a recommended standard: working in confined spaces. Cincinnati, OH: U.S. Department of Health and Human Services. Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-106.

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