CASE STUDY

HOT WORK CONTROL AND SAFE WORK PRACTICES AT OIL AND GAS PRODUCTION WELLS

Photo courtesy of Smith Co. Sheriff's Office

This Case Study describes a fatal explosion in a rural oil production field in Raleigh, Mississippi on June 5, 2006. Three contractor workers died and a fourth was seriously injured. The explosion occurred when flammable vapor inside two tanks was ignited by welding activities on a nearby tank.

CSB issues this Case Study to emphasize the importance of using safe hot work procedures and to provide hazard awareness training.

PARTRIDGE-RALEIGH SMITH COUNTY OILFIELD

RALEIGH, MS

JUNE 5, 2006

KEY ISSUES:

- HOT WORK CONTROL
- SAFE WORK PRACTICES AT OIL & GAS PRODUCTION WELLS

REPORT NO. 2006-07-I-MS

JUNE 2007

1.0 Incident Description

1.1 Sequence of Events

This Case Study examines an explosion at the Partridge-Raleigh oilfield in Raleigh, Mississippi. The incident occurred at about 8:30 a.m. on June 5, 2006, when Stringer's Oilfield Services contract workers were installing pipe from two production tanks to a third (figure 1). Welding sparks ignited flammable vapor escaping from an open-ended pipe about four feet from the contractors' welding activity on tank 4. The explosion killed three workers who were standing on top of tanks 3 and 4. A fourth worker was seriously injured.

In the weeks preceding the incident, Stringer's workers had relocated tanks 3 and 4 from other oilfield sites on the Partridge-Raleigh property to the #9 well site. On the day of the incident, the four workers were completing the piping connection between the tanks.

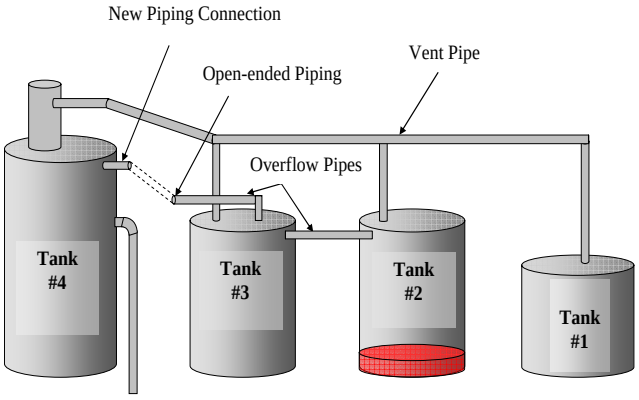

Figure 1. Tanks involved in the incident

To connect the piping from tank 3 to tank 4, the workers had to weld a pipe fitting onto the side of, and a few inches below the top of, tank 4. To prepare for the welding operation, they removed the access hatch at the base of tank 4 and entered the tank to remove the crude oil residue. Then they flushed the tank with fresh water and allowed hydrocarbon vapor to evaporate for several days. They did not clean out or purge tanks 2 and 3.

On the day of the incident, the welder inserted a lit oxy-acetylene welding torch into the hatch and then into the open nozzle on the opposite side of tank 4 to verify that all flammable vapor was removed from the tank before welding began. The welder was not aware that this act, called "flashing" the tank, was an unsafe practice.

Next, the foreman (F) climbed to the top of tank 4 (figure 2). Two other maintenance workers, (M) climbed on top of tank 3; they then laid a ladder on the tank roof, extending it across the 4 foot space between tank 3 and 4, and held the ladder steady for the welder (W). The welder attached his safety harness to the top of tank 4 and positioned himself on the ladder.

Almost immediately after the welder started welding, flammable hydrocarbon vapor venting from the open-ended pipe that was attached to tank 3 ignited. The fire, which immediately flashed back into tank 3, spread through the overflow connecting pipe from tank 3 to tank 2, causing tank 2 to explode. The lids of both tanks were blown off.

The three workers standing atop the tanks were thrown by the force of the explosion and fell to the ground. The welder was also thrown off the ladder, but he was wearing a safety harness that prevented him from falling to the ground.

Volunteers from the local fire department and personnel from the county sheriff's office quickly responded to the incident site following an eyewitness' 9-1-1 emergency call. Emergency Medical Technicians provided first-aid to the victims. Two victims—the foreman and one of the maintenance workers—died from their injuries at the scene, and the third maintenance worker died while in transport to the hospital. The welder survived, but suffered a broken ankle and hip.

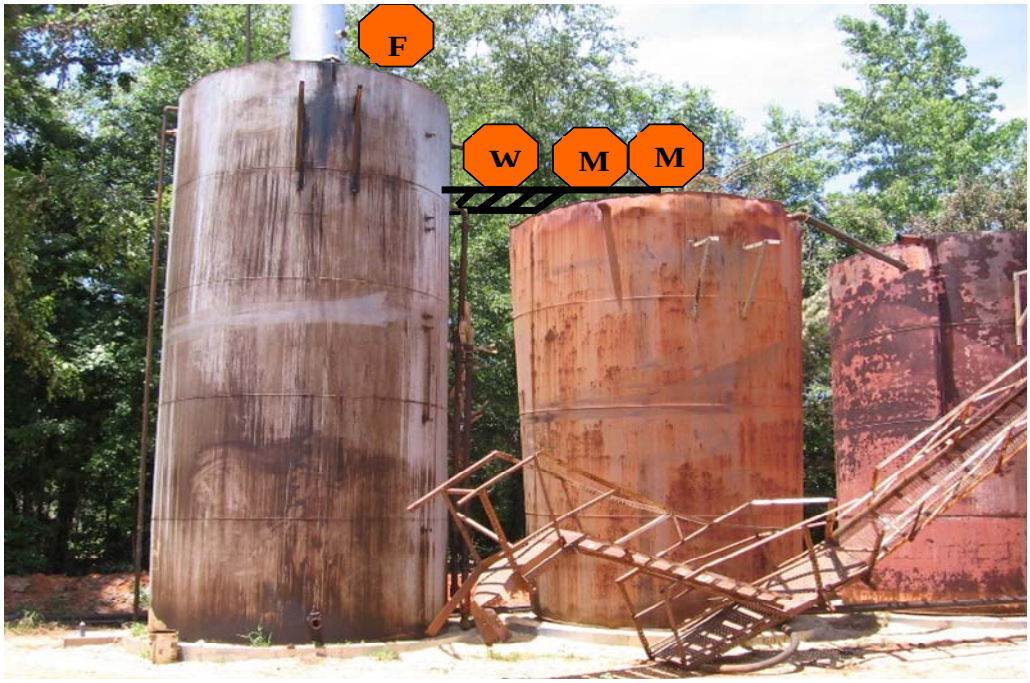

Figure 2. Workers' location prior to incident

(Note: the ladder was blown clear by the explosion)

Witnesses observed flames as high as 50 feet above tank 2, but no flames above tanks 3 or 4. The fire department applied foam to the burning oil fire inside tank 2 and extinguished the fire in about 30 minutes.

The top of tank 2 (Figure 3) landed about 250 yards away, and the top from tank 3 (Figure 4) landed about 50 feet away. Approximately 1000 gallons of crude oil remained inside tank 2 after the incident; tank 3 contained about 650 gallons of residue. Tanks 1 and 4 sustained no visible damage.

Figure 3. Tank 2 lid

Figure 4. Tank 3 lid

1.2 Unsafe Work Practices

Several unsafe work practices contributed to the fatalities and injuries in this case including:

- A gas detector was not used to test for flammable vapor.
- "Flashing" tanks containing hydrocarbons with a lit oxy-acetylene torch to determine the presence of flammable vapor is unsafe and extremely dangerous.
- The open pipe on the adjacent tank was not capped or otherwise isolated.
- A makeshift work platform—a ladder placed between the tanks—was used.
- All tanks were interconnected and some of the tanks contained flammable residue and crude oil.

2.0 Companies Involved

2.1 Partridge-Raleigh, LLC

Partridge-Raleigh, LLC is an independent petroleum producer that operates stripper wells[1] on leased parcels of land in Alabama and Mississippi. Partridge-Raleigh is located between Jackson, MS and Hattiesburg MS, and began operating 30 Smith County oilfield wells in 1997. Recommissioning after two leaking tanks were replaced was nearly complete at the #9 well when the explosion occurred.

Partridge-Raleigh employed five workers at the Smith County oilfield, and used oilfield service contractors to perform most of the well commissioning work including installing tanks, pumps, and piping.

[1] Stripper wells are wells that were closed and subsequently put back into production using recovery methods such as flooding the well with salt water or injecting it with pressurized gas.

2.2 Stringer's Oilfield Services

Stringer's Oilfield Services (Stringer's) is located in Columbia, Mississippi, and employs about 45, including, mechanics, welders, crane operators and laborers. Stringer's provides oilfield construction services and was under contract to Partridge-Raleigh to install the tanks and associated piping at the #9 well.

3.0 Incident Analysis

The U.S. Chemical Safety Board (CSB) studied physical evidence and on-scene photographs, and interviewed witnesses to determine the cause of the June 5 explosion.

3.1 Flammable Vapor Source

The explosion was fueled by flammable hydrocarbon vapor venting from an open-ended, three-inch diameter pipe extending from an adjacent tank to the tank where the welding was taking place. As the morning sun warmed tanks 2 and 3, the flammable vapor inside expanded, forcing it out through the overflow pipe. The pipes were not equipped with isolation valves and although the pipe was capable of being capped, no cap was installed (see Figure 1).

3.2 Ignition Source

The explosion was ignited by the welding being done on the side of tank 4. The CSB confirmed through interviews and examination of the tanks that the welder had applied two small tack welds to the pipe fitting on tank 4 shortly before the explosion (figure 5).

The welder stated that within seconds of applying the tack welds a fire ignited and an explosion occurred.

The CSB concluded that the welding sparks ignited flammable vapor venting from the open-ended pipe of tank 3. Flames from this ignition spread into tank 3, causing it to explode. Then vapor inside tank 2 ignited followed by the explosion of the tank.

Figure 5. Tack weld and connection being welded to tank 4

4.0 Key Findings

The CSB identified the following key findings:

4.1 Lack of Hot Work Safety

Stringer's did not require the use of safe hot work procedures such as those found in API 2009, "Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries" in preparing and conducting the welding operation on the day of the incident.

Stringer's workers did not isolate tanks 2 and 3, which contained flammable vapor, prior to beginning the welding operation. Additionally, the open-ended pipe of tank 3 was left uncapped and provided the source of hydrocarbon vapor. Workers did not clean tanks 2 and 3 or cap the end of the pipe prior to beginning the welding job on tank 4. If the residual oil in tank 2 had been removed and both tanks flushed with water, the flammable vapor source could have been eliminated.

A flammable gas detector was not used to ensure the absence of flammable vapor in the work area and inside tank 4 prior to welding. Instead, workers used an open flame, or tank "flashing" to verify that flammable vapor was not present in the tank. Interviews revealed that "flashing" was a common practice. If a gas testing device had been used to check for flammable vapor, it most likely would have been detected. By using the flash method, the workers could have triggered a fire or explosion.

4.2 Makeshift Work Platform

The contractor crew did not use safe work procedures for working on elevated surfaces, such as the tanks.

Rather than construct a scaffold for the welder, the contractor crew used a ladder laid flat from atop an adjacent tank and extended it over to the tank being welded. The makeshift work platform required two crew members to stand on top of tank 3 to brace the ladder in place while the welder worked. The other crew member stood on top of tank 4. Two of the fatalities could have been avoided if the workers were not standing on top of tank 3.

5.0 Safe Hot Work Guidelines

Several organizations provide guidance for safely performing hot work in the oilfield and/or on petroleum tanks. The National Fire Protection Association's (NFPA) standards and the American Petroleum Institute's (API) recommended hot work practices address safety precautions for hot work. Following the NFPA standards or API recommended practices would likely have prevented the explosion.

The following basic precautions are from NFPA 326, "Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair" (NFPA, 2005), and NFPA 51B, "Standard for Fire Prevention During Welding, Cutting, and Other Hot Work" (NFPA, 2003):

- Isolate the area to be welded from any piping or tanks that contain flammable or combustible liquids, vapors, or residues by installing caps, blinds (blanks),[2] plugs or other devices to physically isolate the piping including vents.
- Perform a flammable gas test before and during welding using a flammable gas detector.
- Remove flammable or combustible liquids, vapors, and residues from tanks and all associated piping.
- Issue written hot work permits.
- Ensure that work is performed by trained personnel who understand the hazards and are qualified and trained.
- Use extreme caution when working on a tank or container that holds or has held flammable, combustible materials, or that contains vapors related to the substances that are or were previously stored.
- Ensure that everyone involved in the work clearly understands hazards associated with welding on or near flammable material storage tanks, and the safeguards to prevent injury.

[2] Blinds or blanks are one-piece circular units inserted into a pipeline to prevent flow.

API Recommended Practice 2009, "Safe Welding, Cutting and Hot Work Practices in the Petroleum and Petrochemical Industries" (API 2002) stresses the need for hot work procedures and hot work permits to control hazards during welding, cutting, and other hot work. API 2009 states, "A hot work permit shall be obtained before starting any work that can involve an ignition source." A written permit is required and should include

- inspecting the work area for hazards,
- conducting flammable gas testing and approving hot work activities, and
- approving hazardous work activities by a competent person skilled at hazard recognition.

Neither Stringer's nor Partridge-Raleigh required hot work permits. The contractor welder involved in the incident told the CSB that he was unaware that tanks nearby contained flammable hydrocarbon liquid or vapor.

In addition to no hot work permit, Stringer's had no hot work procedure for welding activities at the worksite. Interviews with Stringer's managers and employees revealed that most welders hired by the company were expected to have knowledge or experience of how to weld; however, knowledge of safe hot work practices was not considered. Stringer's did not provide hot work safety training to its employees.

If Partridge-Raleigh and Stringer's had used a permit system for managing hot work, the hydrocarbon liquid and/or vapor inside the tanks would probably have been identified and measures would likely have been taken to remove or isolate the hazard.

6.0 Lack of a Written Safety Program

Partridge-Raleigh did not have established safety requirements for personnel at the oilfield. Stringer's had not established a formal safety program for its employees, and Partridge-Raleigh did not require Stringer's to have one.

6.1 Site Safety Program

API 74, "Recommended Practice for Occupational Safety for Onshore Oil and Gas Production Operations" (API 2001), recommends that a site safety program be in place before work is performed at a worksite and lists elements that should be addressed in a comprehensive site safety program (Table 1).

RECOMMENDED SAFETY PROGRAM
• Injury and illness rates
• Experience of personnel for required job task
• Safety staffing
• Safety training program
• Emergency response plan
• Safety equipment provided by contractor
• Safety and work tasks procedures
• Contractor plan for complying with regulatory requirements
• Safety orientation plan

Table 1. Safety information that should be included in a site safety program

7.0 Regulatory Analysis

7.1 OSHA

The Occupational Safety and Health Administration (OSHA) is charged with regulatory oversight and enforcement of workplace safety in the oilfield. Mississippi is located in OSHA Region IV, which is headquartered in Atlanta, GA. OSHA has an area office in Jackson, Mississippi.

7.1.1 OSHA Requirements for Burning and Welding

Stringer's and Partridge-Raleigh did not adhere to OSHA requirements and precautions for burning and welding. OSHA Standard 29 CFR 1910.252 contains requirements in a number of areas including the use of guards to confine heat, sparks and slag generated during welding; special precautions when welding in the presence of explosive atmospheres; and requirements for cleaning used drums, barrels, tanks or other containers prior to welding. The June 5 incident could have been prevented if these OSHA requirements had been followed.

7.1.2 Emphasis Programs

In fiscal years 2004,[3] 2005,[4] and 2006,[5] OSHA identified the oil and gas field services sector as one of seven industries requiring special focus and established a goal to reduce high numbers of injuries, illnesses, and fatalities. As part of its five-year Strategic Management Plan, OSHA stated that it would use "focused targeting of outreach, education, and enforcement activity" to achieve this goal. Many of the inspections of the seven targeted industries are due to Local Emphasis Programs (LEP's), which area and regional offices develop to address specific hazards.

Several OSHA regions or area offices have Special Emphasis Programs (SEP) for oil and gas drilling and servicing. Most inspections have been conducted in Texas, Kansas, Colorado, and Louisiana.

Nationally, OSHA participated in an Industry Review Team study of the incidence rate of fatal injuries in the oil and gas extraction sector. The team's findings[6] referenced Bureau of Labor Statistics' data that revealed that the industry fatality rate for the oil and gas sub-sector is 8.5 times higher than the average for all industries within the United States[7].

7.1.3 OSHA Inspections

OSHA had not inspected Partridge-Raleigh or Stringer's in the three years prior to the explosion. Following the explosion, OSHA cited Stringer's for 13 serious violations as a result of the incident. OSHA did not have an emphasis program in Mississippi and did not conduct a planned inspection at any of nearly 6000 oilfields in the preceding five years in Mississippi.

7.2 OSHA Outreach and Education

7.2.1 OSHA Oil and Gas e-Tool[8]

OSHA's website includes a number of "e-tools" designed to bring together the safety issues, pertinent standards, and recommended practices for specific kinds of

[3] OSHA Demonstrates Successful Enforcement Program in FY 2004, U.S. Department of Labor Press Release, http://www.dol.gov/opa/media/press/osha/OSHA20042376.htm

[4] "Enforcement Activity", U.S. Department of Labor (DoL) OSHA Enforcement Activity FY 2005**,** http://www.osha.gov/dep/enforcement/index.html

[5] "Enforcement Activity", U.S. DoL, OSHA Enforcement Activity FY 2006**,** http://www.osha.gov/dep/enforcement/index.html

[6] "Strategic Direction for Reducing Fatal Oil and Gas Industry Incidents," SPE 94416, 2005 *Journal of Petroleum Technology*

[7] U.S. DoL Bureau of Labor Statistics, "National Census of Fatal Occupational Injuries in 2003," Washington, D.C.

[8] http://www.osha.gov/SLTC/etools/oilandgas/index.html

work. The Oil and Gas Well Drilling and Servicing e-Tool includes instructions for safely performing hot work and other activities at oil wells. If Partridge-Raleigh or Stringer's had consulted the Oil and Gas Well Drilling and Servicing e-Tool, the incident could have been prevented.

7.2.2 OSHA Safe Tank Alliance

OSHA, API, and the NFPA formed the Safe Tank Alliance in 2004, which is intended to develop compliance tools, resources, and share information with employers and employees to help promote safety.[9]

Since the Alliance was formed, its members have participated in several conferences, and have trained or presented to nearly 500 attendees. Alliance members have also hosted workshops on tank safety and produced training materials.

7.3 Mississippi State Oil & Gas Board

The Mississippi State Oil & Gas Board (MSOGB) creates and enforces rules to regulate and promote oil and gas drilling in Mississippi. The board has seven field inspectors responsible for conducting inspections of nearly 6,000 well sites. Their primary task is to enforce compliance with MSOGB rules related to spill control and containment; housekeeping, such as grass control; and access to, and egress from, tanks. Inspections generally do not address health and safety issues.

MSOGB inspectors typically inspect active well sites each year, and are familiar with oil and gas well drilling, producing, and servicing activities.

[9] http://www.osha.gov/dcsp/alliances/index.html

8.0 Other Oilfield Safety Program Resources

Safety resources exist to help employers in oil fields. If used, these resources can help reduce the risk of incidents like the one at Partridge-Raleigh.

8.1 Independent Petroleum Association of America (IPAA)

The Independent Petroleum Association of America (IPAA) has 5,000 members including service providers, oil and gas industry producers, steel tank manufacturers, and drilling companies. IPAA's focus is on environmental and regulatory issues. Partridge-Raleigh is a member of the Mississippi Independent Producers Royalty Organization (MIPRO), which is associated with IPAA. IPAA relies on API to provide safety and health guidance to its members.

8.2 Petroleum Equipment Suppliers Association (PESA)

Petroleum Equipment Suppliers Association (PESA) is a trade association of equipment manufacturers, well site service companies, and supply companies that serve the drilling and production segments of the petroleum industry. PESA's Quality, Health, Safety, & Environment Committee (QHSEC) Audits are conducted every one to three years, depending on previous auditing scores for a site. However, Stringer's is not a member of this association.

Along with regular training activities, PESA provides supplemental training that is available and implemented through an online, computer-based system. PESA has trained several thousand workers who require hot work permitting knowledge. PESA's HSE manual, which covers hot work permitting, is available to members.

8.3 Association of Energy Service Companies (AESC)

The Association of Energy Service Companies (AESC) provides services and products to the oil and gas industry. AESC promotes training through API Contractor Workshops and Fort Worth Annual Safety Conferences. AESC also circulates educational material focusing on accident prevention. However, Stringer's is not a member.

AESC published *Recommended Safe Procedures and Guidelines for Oil and Gas Well Servicing*, commonly referred to as the "Greenbook." The guide, which can be used to implement health and safety procedures, includes information on

- hot work;
- gas-detection instruments;
- fall protection and work surfaces; and
- safety training.

9.0 Conclusions

Partridge-Raleigh and Stringer's did not use available guidelines for hot work safety such as that provided in NFPA 326, NFPA 2005, API 2009, and API 2002.

Training offered by trade associations and member organizations provides guidance that would be useful to workers in the oil and gas servicing industry.

A written site safety plan and work procedures would have assisted workers in identifying and eliminating hazards prior to beginning the welding operation.

Stringer's and Partridge-Raleigh's use of hot work guidance provided by API and NFPA, and adherence to OSHA regulations, could have prevented this incident.

10.0 Recommendations

10.1 Stringer's Oil Field Services, Inc.

2006-07-I-MS-R1:

Develop and implement written procedures to ensure safe work practices during hot work, tank cleaning, and work at elevated locations.

10.2 Partridge-Raleigh, LLC

2006-07-I-MS-R2:

Establish written health and safety performance standards and performance metrics such as those found in *Recommended Practice for Occupational Safety for Onshore Oil and Gas Production Operations*, API RP -74.

10.3 Mississippi State Oil & Gas Board

2006-07-I-MS-R3:

Establish a program to identify and refer to the federal Occupational Safety and Health Administration (OSHA) potentially unsafe health and safety conditions observed during board field inspections of well sites and drilling operations. Ensure that the program includes:

- Written procedures that define how the referrals will be implemented; and,
- Training of field inspectors so that they are able to recognize the potentially unsafe health and safety conditions that should be referred to OSHA.

10.4 Occupational Safety and Health Administration, Jackson, MS Area Office

2006-07-I-MS-R4:

Implement a Local Emphasis Program (LEP) to inspect companies in the oil and gas production and extraction sector.

11.0 References

American Petroleum Institute (API), 2001. *API Recommended Practice 74-Recommended Practice for Occupational Safety for Onshore Oil and Gas Production Operations*, Washington, DC: API.

American Petroleum Institute (API), 2002. *API Recommended Practice 2009-Safe Welding, Cutting and Hot Work Practices in the Petroleum and Petrochemical Industries*, Washington, DC: API.

Association of Energy Service Companies (AESC), 2000. *Recommended Safe Procedures and Guidelines for Oil and Gas Well Servicing*, Houston, TX: AESC.

National Fire Protection Association, NFPA 326, 2005. *Standard for the Safeguarding of Tanks and Containers for Entry*.

National Fire Protection Association, NFPA 51B, 2003. *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

Society of Professional Engineers (SPE), SPE Paper 94416, *Strategic Direction for Reducing Fatal Oil and Gas Industry Incidents, Journal of Petroleum Technology*, July 2005. Presented at SPE/EPA/DOE Exploration and Production Environmental Conference, March 2005.

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U.S. Chemical Safety and Hazard

Investigation Board

Office of Congressional, Public, and Board Affairs
2175 K Street NW, Suite 400
Washington, DC 20037-1848

(202) 261-7600

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