Operating Experience Summary

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Inside This Issue

Helping the field succeed with safe and reliable operations.

Risk-Taking and Shortcuts Result in Welder Fatality at BP Pipeline

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On March 17, 2006, at the Sangachal gas and oil terminal in Azerbaijan, a welder caught on fire and died while attempting to repair a defective weld from the inside of a section of 30-inch pipe. The job was performed after shift, without an approved work permit, and without benefit of a hazards analysis. The pipe is part of the South Caucasus Pipeline operated by British Petroleum (BP) for gas export. (Source: BP Accident Summary PowerPoint; www.safteng.net)

An experienced work crew had welded a 30-inch gate valve into a run of pipeline. The pipeline had been buried 9 months earlier, but was excavated to allow the pipe to be cut and the valve to be welded in place. Figure 1-1 shows the large gate valve and section of pipe in the excavation. After the gate valve was installed, radiographic inspections showed weld defects.

On the day of the accident, specialist welders were attempting to repair the defective weld but concluded that they could not make the repair. The work shift had ended so they left. Another welder, who was part of the pipeline crew, then attempted to repair the weld from outside the pipe, but he was also unsuccessful. The welder and his support crew next decided to attempt the weld repair from inside the pipe, and the crew cut a slot in the pipe near the failed weld so an air hose could be inserted for ventilation.

The welder entered the pipe feet first through a large above-ground ball valve. Figure 1-2 shows the ball valve and entrance point. The welder had a rope and welding cable tied to his body

Figure 1-1. Gate valve (green) and pipe section under tarp where fire occurred

Figure 1-2. The ball valve and point of entry into the 30-inch pipeline

and carried a small pen light for illumination. He had to travel about 13 feet horizontally in the pipe before the pipe dropped below grade at a 45-degree angle for 21 feet. He then entered a 10-foot section of horizontal pipe to access the valve and weld location.

The welder had completed about 20 cm of the weld when the work crew heard him call out that he was burning. The crew attempted to pull the welder from the pipe, but the rope and welding cable became disconnected from the welder and pulled free. The crew heard no further sounds from inside the pipe as they saw smoke pouring from its open end. Rescuers later confirmed that the welder had died. Figure 1-3 shows the location of workers at the time of the accident.

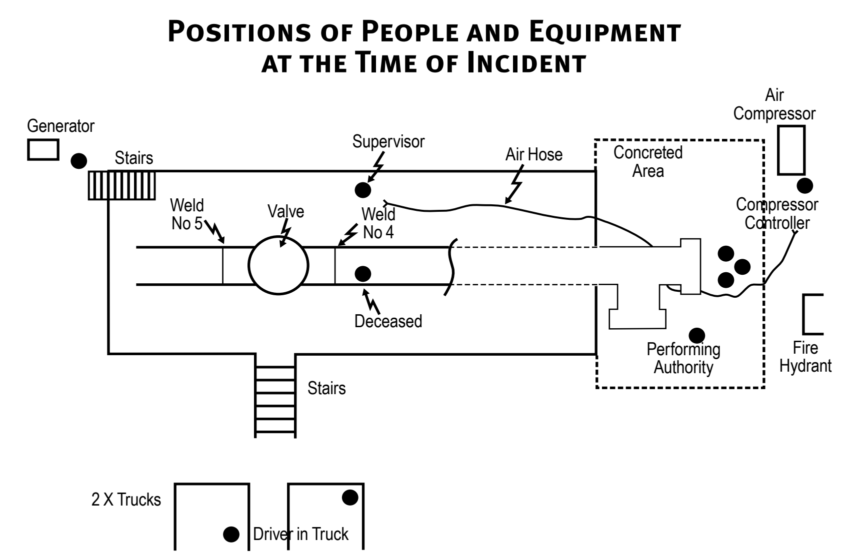

Figure 1-3. Location of personnel and equipment

Investigators identified the following causal factors, as well as corrective actions associated with each of them.

Lack of Effective Supervision

- The supervisor did not stop the welder from entering the pipe. He even helped in the un-permitted activity.
- The activity took place after the end of shift when supervisor presence was limited. The safety advisor, area authority, and deputy construction manager had left the site.
- Contractor and BP line management were unaware that the un-permitted activity had been undertaken.

Corrective Actions

- Conduct a review to ensure that adequate levels of line and safety supervision are onsite at all times.
- Assess all levels of supervision to determine if they are competent to fulfill their roles, including performing regular audits of site work and permits.
- Clarify the role of the construction manager as the owner of the Permit to Work system and the final approver of permits.

Inadequate Work Control

- There was no permit in place and no risk assessment was performed for entering the confined space of the pipe.
- There was no effective means to ensure that jobs were formally reviewed if they continued beyond the end of shift.

Corrective Action

- Revise the control-of-work system to ensure positive verification of Permit-to-Work validity at the end of the shift and to ensure that proper line and safety supervision is present before a job extends into overtime.

Team Culture Led to Risk-Taking

- Misplaced priorities led to a shortcut on the job.
- The crew members did not intervene to stop the job.

Corrective Actions

- Evaluate work crews that have been together for a long time to see if they have developed traits such as overconfidence and informality.
- Reinforce the obligation of all workers to stop the job if they believe it is unsafe by having each worker sign a personal contract to do so.
- Additional corrective actions related to welding included banning welding inside a pipe without obtaining the approval of the Project Director.

As can be seen from events reported in ORPS, the lack of effective supervision and inadequate work controls are problems frequently identified during investigations of events within the DOE complex. What is not always identified, however, is how team culture and work attitudes can influence decision-making on the job, sometimes leading to unnecessary risk-taking.

This accident underscores the importance of performing work in accordance with all required permits (e.g., hot work, confined space) and with proper authorization to ensure that hazards have been analyzed and appropriate safety measures have been identified and implemented. The risks and consequences associated with the welding job had not been adequately reviewed or assessed by the piping crew or their supervisor. Instead, they decided to proceed with the repair and met with tragic results.

BP's Prevent Events

Management

- Do you have adequate supervision at all times and are they competent?
- Does your control of work system ensure that all jobs are reviewed at the end of shift to confirm if the permit is valid for overtime?
- Does your workforce know that working inside a pipe can only take place with a confined space permit?

Supervisors and Workers

- Have you done everything you can to ensure that your teams do not cut corners to complete a job and always challenge unsafe work?
- Do you exercise increased vigilance before a holiday or work break to prevent cutting corners, particularly after normal working hours?

KEYWORDS: *Fatality, risk, confined space, welding, hot work, shortcuts, team culture, fire, human performance*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls*

Good Practice: Comprehensive Chemical Lifecycle Management Program

2

On April 11, 2006, at the Oak Ridge National Laboratory, one of two aerosol cans of graphite lubricant ruptured inside a flammable material storage cabinet. Researchers working nearby discovered the can and notified their laboratory space manager. Fortunately, this event occurred late in the evening, and no one was injured. (ORPS Report SC-ORO--ORNL-X10EAST-2006-0002)

The manufacturer of the graphite product, Acheson Colloids, Inc., stated that there are two possible scenarios that would result in a can rupture: ambient temperatures at or above 120°F; and propellant leaking from the can and reacting with other substances. The temperature in the room was estimated to be 65°F. Investigators noted, however, that the can was rusted on its bottom edge (Figure 2-1). They also determined that the product's shelf life of 2 years (as stated on the manufacturer's Product Data Sheet) had been considerably exceeded, as the can was purchased in 1994. Figure 2-2 shows the internal corrosion and the failure points on the can.

Two other cans of graphite lubricant have exploded at DOE facilities in the past: in 2001, at the Nevada Test Site; and in 1995, at Pacific Northwest National Laboratory. In both cases, the cause of the explosions is believed to be a failure of the can due to corrosion. Both cans had been stored for several years, and neither had been subjected to excess temperatures. (Lessons Learned Identifiers 2001-NV-NLVBN-036 and 1995-RL-PNL-0027; retrievable at the DOE Lessons Learned web site)

Figure 2-1. Bottom of aerosol can

Figure 2-2. Internal corrosion

Facility managers are aware of the need for maintaining inventories of the chemicals they are using or storing. However, many sites do not have a formalized chemical safety and lifecycle management (CSLM) program. One such program at the Savannah River Site was used as the model for the revised draft DOE-HDBK-1139/2-2006, *Chemical Safety and Lifecycle Management*, and is worth sharing with the Complex.

Safety is the main focus of the CSLM program at Savannah River. However, the program also offers cost savings by reducing accidents and making the best use of procurement dollars spent on chemicals. Listed below are some recommendations from the Handbook that sites may wish to consider when developing their own CSLM programs.

- Wherever possible, substitute chemicals that are less hazardous, toxic, or volatile. (In the case of the graphite lubricant, for example, the product is also available in a non-aerosol brush-on form.)

- Purchase only the minimum necessary amount of a chemical.
- Use a Just-in-Time inventory strategy for high-consumption chemicals.
- Develop an automated tracking system for all chemicals onsite that:
  - covers procurement, use, storage, transfer, and final disposal;
  - includes data from the Material Safety Data Sheet such as product composition, the Chemical Abstracts Service registry number, physical and health hazard information, and hazard ratings;
  - includes regulatory information such as reportable quantity, threshold quantity, and threshold planning quantity; and
  - contains the data for verifying a facility's safety basis.
- Appoint a CSLM program steering committee consisting of subject matter experts in areas such as transportation, industrial hygiene, environmental regulations, and fire protection, as well as representatives of key user organizations. The steering committee serves as a linkage among users, line organizations, and technical experts and is under the leadership of a CSLM Manager.

By maintaining all relevant data in a single, real-time information system, sites can prevent the commonly seen problem of "stovepiping," where different organizations have their own level of "ownership" of a chemical or process and fail to interface with each other, leading to varying interpretations, overlapping requirements, and inefficiency.

The draft Handbook is currently in revision and will be posted on the *DOE Documents and Guidelines* page of the Chemical Safety Program web site http://www.eh.doe.gov/chem_safety/library/doe_reg.html. This page also includes three articles written by DOE chemical safety experts that were published in *Chemical Health and Safety* on managing time-sensitive chemicals.

It is understandable that facility personnel retain purchased chemicals for lengthy periods in an effort to minimize costs; however, the risk of outdated chemicals becoming unstable and reacting to produce an explosion must be analyzed and mitigated.

The Office of Environment, Safety and Health believes that sites that do not have a formalized chemical lifecycle management program can benefit from Savannah River's successful experience in developing their own program.

KEYWORDS: *Explosion, shelf life, lifecycle management, chemical, propellant*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Work Controls*

Inadequate Job Planning Results in Sulfuric Acid Spill

3

On March 8, 2006, at the Hanford Effluent Treatment Facility (ETF), a small amount of 4 percent sulfuric acid accidentally sprayed from a piping system during a planned maintenance activity. The spilled acid was immediately controlled, and the small amount of released acid was contained within a chemical berm. Although some of the acid sprayed onto a pipefitter's PPE, he was not injured. (ORPS Report: EM-RL--PHMC-200LWP-2006-0001; final report filed April 20, 2006)

The system had been isolated and drained in accordance with an approved Tagout Authorization Form (TAF). In addition, the workers had performed a walkdown of the system, installed authorized worker locks, and performed a safe-to-work check before work began. An investigation revealed that the Lock and Tag (L&T) preparer and L&T technical reviewer had overlooked a check valve during the preparation of the TAF, and the valve prevented the system piping from draining completely.

The work involved installing a metal blind flange cover over an existing Teflon® flange to reduce the potential for leakage. Figure 3-1 shows the flange. A shift operations manager prepared the TAF, which included instructions for boundary isolation and for draining the piping system. A technical reviewer walked down the TAF. Both the preparer and reviewer referred to a Piping and Instrument Diagram (P&ID) while performing their tasks.

Before work began, a maintenance person-in-charge, the pipefitter, and an assigned operator conducted additional walkdowns, and the pipefitter and operator hung their Authorized Worker Locks on the lockbox for the job. The person-in-charge conducted a pre-job briefing and discussed the PPE requirements (lab coats, long gloves, eye protection, and face shields) with the pipefitter and the operator. He also told them that residual acid could be present in the piping when the flange was removed.

Figure 3-1. Blind flange with catch bucket

The pipefitter and operator performed a safe-to-work check, visually verifying that there was no liquid at an open drain valve that was lined up in accordance with the TAF. Following the visual verification, work began on the blind flange. When the pipefitter loosened the top bolt on the flange, acid began to spray out from the flange over an area of approximately 1.5 feet. The pipefitter backed away from the spray and retightened the bolt to stop the leak. When the leaking subsided, the pipefitter found a small amount of acid on his lab coat and shoes and on the cuff of his coveralls.

During the critique, investigators learned that there was a pump discharge check valve in the piping. The check valve, which allows flow in only one direction, caused liquid to be retained in the downstream piping. Figure 3-2 shows the check valve in a vertical run of pipe. In addition, there was approximately 27 feet of vertical head from where the blind flange was being worked on to where the line was vented.

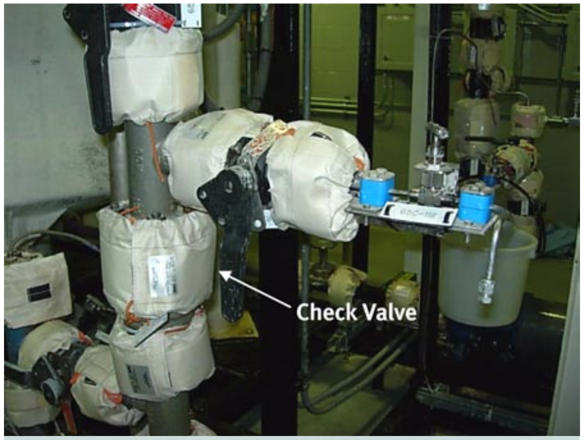

Figure 3-2. Check valve hidden by flange guard

The static head from the liquid in this vertical section of piping was calculated to be 12 psi at the flange.

A simplified diagram of the piping arrangement is shown in Figure 3-3. The diagram shows the drain location selected was on the wrong side of the check valve. Another valve, shown downstream of the check valve, could have been used to drain and depressurize the piping.

Because the TAF identified a drain valve that was located upstream of the check valve, the safe-to-work check did not effectively verify the safety and operational status of the system. The drain valve only drained liquid from a small portion of the piping associated with the pump discharge and recirculation line. This drained liquid was directed to a sump through a temporary hose. Operators had allowed the piping to drain to the sump for about 30 minutes before they noticed a small rise in the sump level. They assumed this level change was the drainage from all the piping covered by the TAF.

There were two main concerns associated with this event: why the check valve was not identified during planning; and why opportunities to identify the error were missed during walkdowns of the TAF. Investigators believed it was important to address these concerns. Their investigation, and the subsequent causal analysis, examined the factors influencing human performance to identify latent organizational weaknesses that contributed to the event. They identified the following factors and the actions needed to address them.

- Before preparing the TAF, the shift operations manager (tagout preparer) had talked to the shift technical advisor about establishing the isolation boundaries. The shift technical advisor later became the technical reviewer. Because of the earlier discussion on the boundaries, the technical reviewer had a preconceived idea about the appropriate boundaries, and this could have affected the independence of his technical review. Also, the tagout

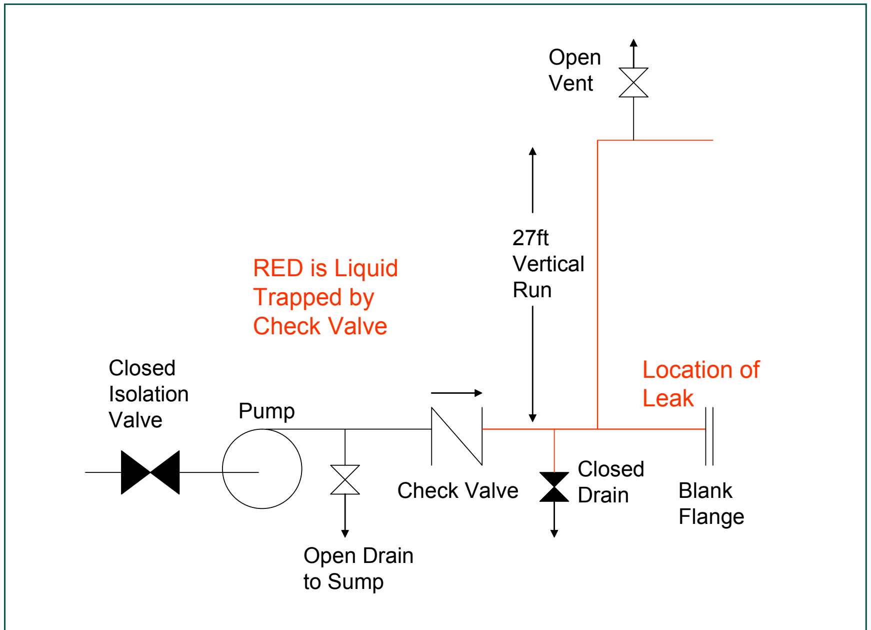

Figure 3-3. Simplified diagram of piping arrangement

preparer was working the day shift when he prepared the TAF. The level of distractions during the day shift contributed to the tagout preparer missing several details.

Action: The L&T authorization letter will be revised to establish management expectations for independent review and for minimizing distractions during TAF preparation.

- The tagout preparer used an 11-inch by 17-inch P&ID, and the technical reviewer used an 8½-inch by 11-inch version. Using the smaller P&ID made details such as the check valve more difficult to see, thus increasing the chance for error. Although full-sized, controlled drawings were in a file cabinet, workers didn't use them because they were not allowed to mark up controlled drawings. A copier was available that would have provided full-sized copies, but not all workers knew about the copier. Also, although workers needed access to the electronic Hanford Document Control System (HDCS) to obtain the most recent version of the drawing, not all L&T administrators had been trained to use the HDCS.

  Action: The full-size network printer will be connected to all computers in the ETF shift office to allow drawings to be printed, and personnel will be trained on using the HDCS.

- The check valve did not have a label identifying it as a check valve. Workers are used to seeing a labeling convention in which check valves (CV) are uniquely identified (e.g., 65C-CV-013). However, labels at ETF are not consistent in the use of noun identifiers, and these valves had no noun identifier (i.e., the label identified the valve only as 65C-013).

  Action: Operator aids will be installed to assist in identifying check valves at ETF.

- An error in establishing one of the vent paths occurred because of a configuration control problem. The normal configuration of one of the vent valves is open, as shown in the operating procedures. However, because of a leak in the system, operators had closed the valve several months before the event. The change in valve status was shown on the control room status board, but when the TAF was prepared the normal operating configuration of the acid system was used as the basis for determining the valve position, not the configuration shown on the control room status board.

  Action: Methods for improving the use of the control room status board will be discussed with appropriate personnel.

- The lockout and depressurization of the system included areas of new piping that were not labeled because the work package for installing the new piping system did not contain a standard for labeling. The lack of labeling made it difficult to differentiate the 4 percent sulfuric system from a nearby 4 percent caustic system.

  Action: The sulfuric acid and caustic systems will be inspected to ensure they are labeled in accordance with ANSI standards.

- Workers at ETF had installed flange guards throughout the piping systems to identify and control system leaks. The check valve was not visible in the field because it was hidden by the flange guard, and the valve label was also underneath the flange guard. This situation decreased the probability of identifying the check valve unless someone was specifically looking for it.

  Action: A system walkdown will be conducted to verify that all check valve labels are visible.

Lockout/tagout programs in DOE serve two functions. The first function, defined in both 29 CFR 1910, *Occupational Safety and Health Standards*, and DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, is to protect personnel from injury and protect equipment from damage. The second function is to provide overall control of equipment and system status in order to satisfy the design bases and operational limits.

This event underscores the importance of the lockout/tagout preparer's role in writing clear, concise lockout orders and understanding the existing system configuration. Identification of the check valve was important in determining the appropriate location to drain the system in order to protect the workers from sulfuric acid. Preparers should review the most recent drawings and enlist the support of subject matter experts as necessary. They should also walk down the system to identify potential hazards and verify that the lockout can be performed correctly based on equipment location, proper labeling, and procedures. Walkdowns can also aid in verifying the accuracy of drawings used to establish isolation boundaries. All technical reviews should be performed independently.

KEYWORDS: *Acid, leak, lockout/tagout, check valve, labeling, job planning, flange, piping, independent verification, technical review*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls*

DOE Guidance

DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, chapter XVIII, "Equipment and Piping Labeling," provides guidelines for equipment and component labeling and states that equipment labeling should help ensure that facility personnel are able to positively identify equipment they operate. Labeling is also required by OSHA regulations.

DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts*, states in section 4.5.1 "Installation of a Lockout/Tagout," that the adequacy of protection should be verified by the individual(s) who will work under the lockout/tagout and that verification should include checking that electrical systems show no voltage and that fluid or pneumatic systems are vented or drained.

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Commonly Used Acronyms and Initialisms

Agencies/Organizations	
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CPSC	Consumer Product Safety Commission
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
INPO	Institute for Nuclear Power Operations
NIOSH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
SELLS	Society for Effective Lessons Learned

Units of Measure	
AC	alternating current
DC	direct current
mg	milligram (1/1000th of a gram)
kg	kilogram (1000 grams)
psi (a)(d)(g)	pounds per square inch (absolute) (differential) (gauge)
RAD	Radiation Absorbed Dose
REM	Roentgen Equivalent Man
TWA	Time Weighted Average
v/kv	volt/kilovolt

Job Titles/Positions	
RCT	Radiological Control Technician

Authorization Basis/Documents	
JHA	Job Hazards Analysis
JSA	Job Safety Analysis
NOV	Notice of Violation
SAR	Safety Analysis Report
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question

Regulations/Acts	
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
DD&D	Decontamination, Decommissioning, and Dismantlement
RCRA	Resource Conservation and Recovery Act
TSCA	Toxic Substances Control Act

Miscellaneous	
ALARA	As low as reasonably achievable
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
ISM	Integrated Safety Management
MSDS	Material Safety Data Sheet
ORPS	Occurrence Reporting and Processing System
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
SME	Subject Matter Expert

Title 29--Labor

(This index contains parts 1900 to 1910)

Subtitle B--Regulations Relating to Labor (Continued)

CHAPTER XVII--OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR

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