Operating Experience Summary

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Scissor Lift Falls Over Inside Tank at Strategic Petroleum Reserve's West Hackberry Storage Site Resulting in Serious Injuries 1

On February 7, 2013, at the Strategic Petroleum Reserve (SPR) West Hackberry Storage Site, a worker was seriously injured when the fully extended scissor lift from which he was working tipped over during an abrasive blasting operation. A Department of Energy (DOE) Accident Investigation Board (Board) was appointed to investigate the event and identify the causes of the event and Judgments of Need (JON). The final report is available at http://energy.gov/ehss/downloads/accident-investigation-february-7-2013-scissor-lift-accident-west-hackberry-brine.

Background

The SPR holds the largest supply of emergency crude oil in the world. The Federally-owned stock is stored in large underground salt caverns along the coast of the Gulf of Mexico at Big Hill and Bryan Mound in Texas and in West Hackberry and Bayou Choctaw in Louisiana. The SPR Project Management Office (SPRPMO), based in New Orleans, is responsible for and oversees the day-to-day operations of the four crude oil storage sites and ensures that various contractors' activities and safety programs are effectively coordinated.

At the time of the accident, the two prime SPR contractors were DM Petroleum Operations Company (DM), the management and operations contractor, and ASRC Gulf States Constructors, LLC (AGSC), the construction services contractor. Performance Blasting & Coating, LP (PBC) was a subcontractor to AGSC, specializing in pipeline, chemical, petrochemical, utility, and marine aspects of the coating industry.

A number of major maintenance projects are routinely performed at the West Hackberry storage site. These projects include maintenance of tanks that store brine used to displace stored crude oil when the oil is withdrawn from underground caverns. The brine tanks must be repaired and repainted every 3 to 5 years to protect them from corrosion. On the day of the event, blasting work was being performed inside Brine Tank 14 (WHT-14), an open-topped tank, 32 feet tall and 110 feet in diameter. Aerial photos of the West Hackberry site and the brine tanks are shown in Figure 1-1 and Figure 1-2.

The Event

On February 7, 2013, the PBC Site Superintendent (PBC Site Sup) conducted the morning safety meeting with the crew assigned to perform the abrasive blasting operation. The

Figure 1-1. West Hackberry Site, Louisiana

Figure 1-2. Brine tank where accident occurred

meeting included a review of the work—blasting and recoating WHT-14—and verification that selected employees were certified to operate a scissor lift. This was the second day of performing abrasive blasting, and the work was to continue removing the coating along the top 4 feet of the tank interior and applying a protective coating to the bare metal wall. The PBC work crew comprised the following workers.

- PBC Site Safety Representative
- PBC Site Supervisor
- Three PBC blasters
- Tank Entry Watch (also called Confined Space Watch or Hole Watch)
- Pot tender
- Coatings inspector

The tank can be accessed in two ways: individuals enter through a single, small access portal (door), and large equipment can be brought in over the open top with a crane. There is a catwalk around the upper exterior wall of the tank that is reached via a permanent stairway. Under the Occupational Safety and Health Administration (OSHA) definition, this tank is a *confined space*; however, the Request for Offer specified that the tank would be provided to the subcontractor for blasting in a state of cleanliness where *non-permitted confined space* entry would be possible.

The Safe Work Permit (SWP) was issued with the following conditions: flammables and combustibles are removed; the lockout/tagout is in place to control electrical energy and all feeder lines; and the tank is reclassified as a *non-permit-required confined space with continuous atmospheric testing*. DM inspected the tank, performed atmospheric testing, and reclassified the tank as required by the SWP.

Two rented scissor lifts were inside the tank. Blaster 1 was assigned to work from the smaller Skyjack Model SJIII 3226 (similar to the one pictured in Figure 1-3), and Blaster 2 was assigned to work from the larger JLG Model 2646ES. Both scissor lifts were designed to be raised to heights up to 26 feet. Blaster 1 completed the PBC *Aerial Man Lift Preventive Maintenance Checklist* for his assigned Skyjack and did not note any unsatisfactory conditions.

After less than an hour into work, the HW felt the blast hose supplying air and abrasive to Blaster 1 "pulse," indicating that the nozzle had opened to begin blasting another section. He looked up to see Blaster 1 and the scissor lift falling to the floor and immediately sounded the air horn, the designated emergency signal, according to PBC procedures. The scissor lift came to rest extended toward the middle of the tank floor with Blaster 1 lying partially out of the platform guardrails, still attached to the platform by his fall protection harness (Figures 1-4 and 1-5).

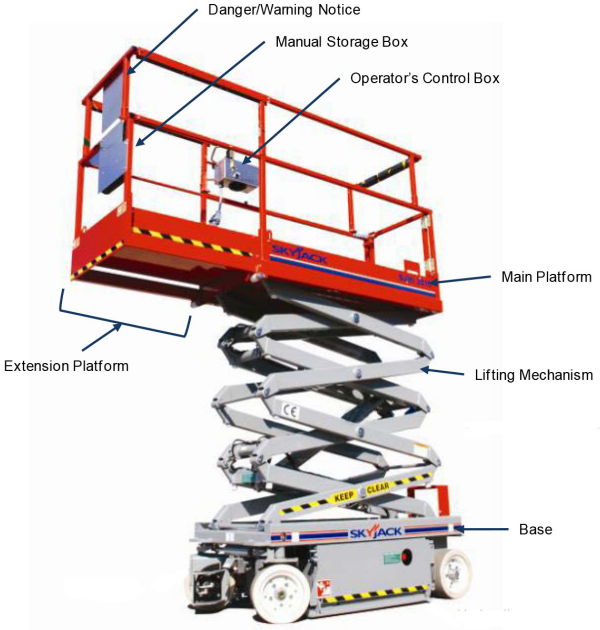

Figure 1-3. Skyjack SJIII 3226 Scissor Lift

The Response

The significance of the air horn (required by PBC procedure) sounding was not recognized by the non-PBC personnel who heard it (e.g., the Protective Force Officer at the Main gate). However, the PBC Site Safety Representative (SSR) recognized the air horn and responded immediately. There was no rescue/retrieval equipment staged at the tank. The PBC SSR donned the required fall protection (but no respiratory protection) and entered the tank, telling the HW that he (the SSR) would handle notifications. Using his cell phone, he called the PBC Site Superintendent (SS) and Facility Safety Supervisor (FSS), who was a licensed paramedic. His actions were in accordance with the PBC Safety Execution Plan. However, SPR requires immediate notification of the Control Room Operator (CRO), who activates the site Emergency Response Team (ERT) and calls 911, but the immediate notification was not done.

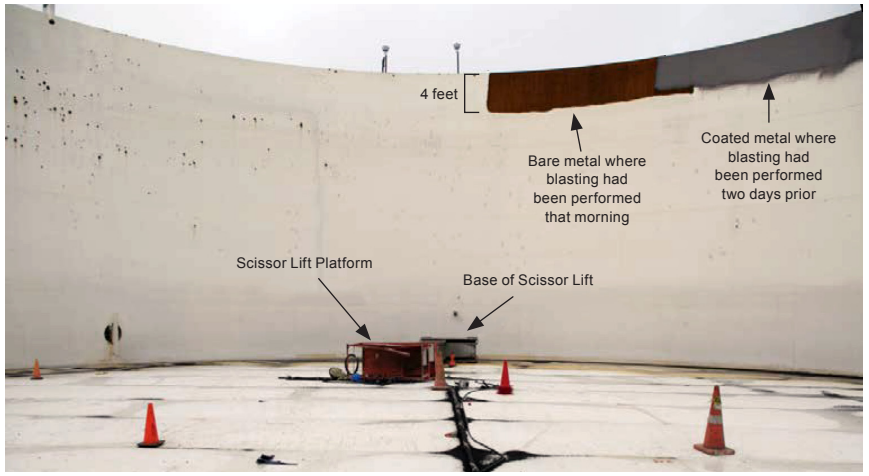

Figure 1-4. Position of scissor lift in relation to completed paint blasting and coating at top 4 feet of tank

There was confusion regarding roles and responsibilities during this emergency. Failure to call the CRO immediately delayed 911 notification, activation of the ERT, and arrival of an ambulance. As a result of the SSR contacting ERT and 911, ERT members arrived and took over the care of the injured worker until the ambulance arrived. The ambulance took the injured Blaster 1 to a local hospital where he was diagnosed with multiple fractures.

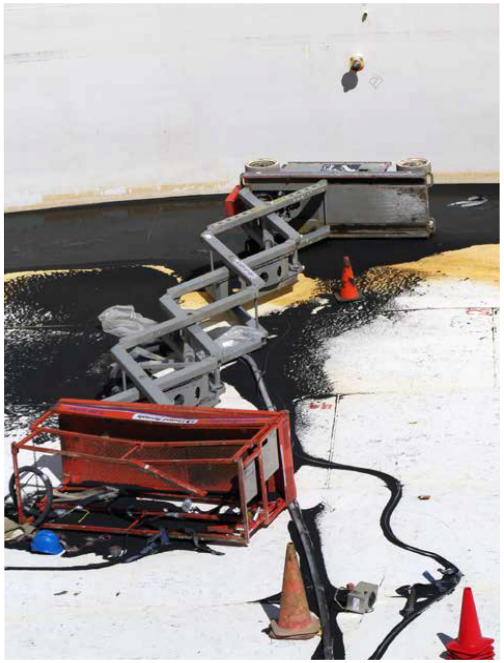

Figure 1-5. Scissor lift after the event

The Investigation

Immediately after the accident, West Hackberry site personnel took control of the scene, collected written witness statements, and preserved the accident scene to the maximum extent possible. Security was posted around the clock from the time the ambulance left the scene until the Board completed its investigation and released the scene 2 months later.

The Board followed the DOE accident investigation procedures specified in DOE Order 225.1B, *Accident Investigations*, examining the site, interviewing witnesses, and collecting and reviewing documents. The Board determined the following causes.

Causes

The Board concluded that the *direct cause* of the scissor lift accident was that lateral forces exceeded the capability of the scissor lift to remain upright. The Board suspected that a considerable portion of the blasting hose was in the air and was being supported by the scissor lift work platform just before the accident, resulting in significant lateral forces on the work platform guardrails. As a result, the Board employed experts to assist in re-creation of the scene and to perform a force analysis.

The Board determined that there were two *root causes*.

- The *local root cause* was the organizational-wide failure to recognize, understand, and manage operating conditions within the safe operating limits specified by the equipment manufacturer.
- The *systemic root cause* was that SPRMO, DM, and AGSC failed to adequately implement several of the seven Guiding Principles of Integrated Safety Management, specifically Clear Roles and Responsibilities; Competence Commensurate with Responsibilities; Identification of Safety Standards and Requirements; and Hazard Controls Tailored to Work Being Performed.

Examples of specific deficiencies included the following.

- Responsibilities of the PBC site supervisor and site safety representative for supervising and overseeing the work were unclear.
- Responsibilities of the DM and PBC employees regarding emergency response operations were unclear.
- Responsibilities at the SPRPMO for review of field site plans and work documents were unclear.
- AGSC and PBC employees were inexperienced in overseeing and conducting blasting work inside a tank using scissor lifts.
- PBC failed to evaluate and designate, in writing, who the OSHA competent person was for the project.
- Job-specific safety documents developed by PBC, approved by AGSC, and reviewed by DM and the SPRPMO did not include detailed lateral force limitations.

The Board identified the eight *contributing causes* listed below.

1. Safety documents, such as the Job Hazard Analysis, were generic and did not identify and analyze lateral force as a hazard.
2. Supervisors and safety personnel were not aware of the lateral force hazard.
3. Scissor lift operators were not trained to be aware of the lateral force hazard.
4. Scissor lift operators were allowed to operate the scissor lift without regard to the lateral force hazard.
5. Oversight organizations were not technically knowledgeable about specific operational limitations and specific safety requirements for scissor lifts.

6. Work planning depended on *skill of the craft* due to a lack of adequate safe work procedures and competent supervision.
7. The length of the blast hose was not sufficient to prevent excessive lateral loading of the elevated work platform.
8. The operators were inexperienced in using scissor lifts for blasting jobs inside tanks.

Discussion

The Board determined that multiple deficiencies in work planning, hazard analysis and controls, equipment analysis and selection, and training/qualification contributed to the accident.

Effective work planning depends on clearly defined roles and responsibilities of management, contractor, and subcontractor personnel, including supervisory functions, and the competencies required of those roles. All roles/responsibilities should be clearly identified in work planning, and assurance must be given that assigned personnel have the knowledge, competence, and opportunity to carry out their functions.

During its investigation, the Board realized that the safety submittal review process was a type of check-off that the required documents had been submitted. Discussion was limited to generic hazards, such as eye injury, hearing loss, falls, inhalation of toxic vapors/dust/fumes, and heat stress, instead of specifically addressing equipment hazards, although fall protection was identified as required safety equipment. Since most of the safety documents referred to *aerial lifts* or *elevated work platforms*, scissor lifts remained unanalyzed and presented an unrecognized threat. The only physical hazard with a high probability of occurrence identified was *aerial equipment*, but no time or attention was paid to detail the actual hazards involved.

The Danger Equation

Working at height + scissor lift with weight limits + blasting activity = DANGER

In its assignment of JONs, the Board stated that contractors must strengthen their safety document review process to ensure that subcontractor safety document submittals are reviewed by individuals with sufficient technical competence to determine the adequacy of submitted documents. In addition, the Board said that the SPRPMO must formalize and document its safety document review process. When implemented, the process needs to ensure that submittals are reviewed by individuals with sufficient technical competence to determine the adequacy of those submittals, and it needs to include documented authorization or non-authorization of the completed review. The process should include hold points and sufficient review windows; and clear roles and responsibilities should be clarified.

The Board also noted that job safety analyses (JSA) were not developed by work crews but by off-site JSA developers. They also used software that allowed the JSA developer to select from a pre-developed list, thus limiting the critical thinking needed for effective hazard analysis. That lack of critical thinking, that is, of mentally walking through the job, meant that the process failed to identify the "danger equation" of combining discrete activities into one task (i.e., identifying that performing an activity with blowback force while working at height on a scissor lift with posted weight limits presented unplanned-for dangers). See Figure 1-6 on the following page.

The JSA developers made several incorrect assumptions. First, they assumed that operators were familiar with the equipment manufacturers' manuals, which they themselves had not

Figure 1-6. Manufacturer-applied label shows 0 mph wind and 90 lb side force limitations

read. However, because the manuals arrived with the rental equipment, there was limited opportunity to review and learn all the material before work started. The SkyJack manual was 52 pages long and the JLG manual more than 100 pages long. No one verified that the blasters had read and understood all of the manufacturers' warnings. Second, the JSA developers erroneously relied on *skill of the craft* and assumed the scissor lift operators would know more than they did. For example, there was no guidance provided as to how to support the weight of the hoses while elevated, or to help them calculate the length of hose needed to extend across the tank and up to the working heights. Third, the JSA developers failed to identify or include the multiple warnings clearly posted in the operating manuals and on labels on the lifts. Thus an opportunity was missed to focus the lift operators' (Blasters') attention on the potential dangers ahead. The failure to include or discuss the warnings also indicated how little the JSA developers understood about the actual work to be performed. And finally, the JSA developers did not require scissor lift model-specific training/certification.

The Board also determined that the hazard analysis was inadequate. Selection of scissor lifts was a poor decision considering their operating restrictions concerning lateral force, including attachment of hoses to the work platform. When the platform carrying the Blaster was elevated, the combined weight of the blasting hose, blasting media, and breathing hose had to rest on something, and, in this case, they rested on the lift railing. Other equipment exists that could have been effectively used for the job.

After hazards have been identified, controls are put into place to mitigate those hazards when there is effective work planning. Controls include both engineering and administrative controls.

- Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions in order to provide this high level of protection. Guardrails around the work platform are an engineering control. With properly designed and installed guardrails, OSHA does not require workers on a scissor lift to wear personal fall protection equipment. The PBC Blasters did wear fall protection harnesses attached by a lanyard to the scissor lifts; however, the attachment point of the lanyard to the scissor lift involved in the accident was not load-rated for fall protection use.
- Administrative controls include policies, procedures, JSAs, training, pre-job briefs, lessons learned, manufacturer's instructions, labels, safety inspections, selection of qualified personnel, roles and responsibilities, supervision, and oversight.
- The multiple reviews of the Safety Plan did not recognize the unsafe condition of tying breathing and blasting hoses to the guardrails of any platform or of either the drag/lateral force incurred when a hose is extended across the tank from the doorway and up to a height of 28 feet or the kickback that occurs when a hose is turned on.

Of crucial importance to the Board's analysis was the determination of the length of hose that was suspended above the tank floor. The Board suspected that a significant portion of the blasting hose was in the air and was being supported by the work platform just before the accident, putting significant force on the platform's guardrails. The Board employed an architectural and engineering (A&E) firm to assist in the re-creation of the position of the hose and work platform during blasting. Computer-aided design was then used to determine that 43 feet, 7 inches of hose length lay on the tank floor, leaving 67 feet, 5 inches supported by the scissor lift platform guardrail. The A&E firm was then able to develop a three-dimensional mockup of the lift and blast hose configuration prior to the lift toppling (Appendix E, Attachment E.3 of the Accident Investigation Final Report). These findings support the Board's theory that a significant portion of the blast hose was suspended above the tank floor and thus contributed to the accident (Figure 1-7).

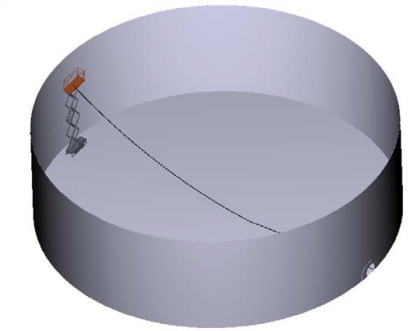

Figure 1-7. 3-D rendering of scissor lift and hose prior to the accident, depicting the length of hose and resulting pull

The A&E firm evaluated the lateral force on the work platform guardrails imposed by the weight of suspended hose using a cable tension formula and standard mechanical force diagrams and calculations. The Board determined that the injured employee had just depressed the "deadman" switch at the blast nozzle when the lift toppled. This implies that blast material and air were flowing through the hose at the time the accident occurred, adding to the amount of suspended weight. Additionally, a 0.75-inch outer diameter supplied-air breathing hose was taped to the scissor lift guard rail. Standard force calculations indicated that the lateral load imposed by the pressurized air ejected from the blast nozzle is 12.82 to 16.75 pounds with a standard 0.50 inch nozzle. In addition, the lateral force on the scissor lift work platform guardrails resulting from securing the blast and supplied air supply hoses

Force Analysis

Lifts are top-heavy particularly when extended and as a result, weight must be at the bottom. Wind of any velocity or a lateral force exceeding 90 pounds can topple the lift. The base of the scissor lift (right wheel) was 105 feet from the service entrance. The middle work platform guardrails (where the hose attached to the lift) were 26 feet from the base of the wheels. Trigonometry was used to calculate the distance and arc, enabling an engineering firm to develop a three dimensional mockup of the lift and blast hose configuration. Based on the calculations and mockup, it was determined that a significant portion (67 feet 5 inches) of the heavy hose was suspended, putting weight on the lift that exceeded safe limits.

Two other things added to the weight: the copper slag blasting material inside the hose and the Blaster's .75 inch outer diameter supplied breathing air hose. Force analysis calculations (provided in the architectural and engineering firm's report) demonstrated that the force exerted on the worker—and ultimately on the work platform—by the multiple forces when the "deadman" switch was depressed ranged from 184.55 pounds with no blasting media present to 470.32 pounds if the hose was full of blasting media. The Side Force Limitation labels clearly posted and visible on the scissor lift warned that winds must not exceed 0 miles per hour and **side force must not exceed 90 pounds**.

– Accident Investigation Report, Appendix E, *Force Calculations on Scissor Lift*

to the work platform guardrails, and the blasting operation, ranged from 184.55 pounds (no media present) to 470.32 pounds (hose 100 percent full of media). *All calculations resulted in amounts far exceeding the maximum posted load of 90 pounds.*

In addition, the equipment was rented, creating an unfamiliar situation. Because the entities involved did not hold or control the maintenance history of the rental lifts, the PBC SSR assumed that the rental company performed all required maintenance. The Blasters were at a disadvantage with unfamiliar rental equipment because the exact makes and models were unknown until delivery. Operators were not required to demonstrate their comprehension of the warnings posted on the equipment. The Board determined that basic scissor lift training was deficient because it was not conducted by a qualified person as defined by OSHA.

The Board was told that, before work started, Blaster 1 completed the inspection checklist for the scissor lift and did not note any unsatisfactory material conditions. However, he was not adequately trained to perform that acceptance inspection. Because there was no competent person present, nothing was said about obvious wear and tear and worn tires and no one asked for the annual inspection or required maintenance reports for the scissors lift.

Conclusions

Based on the findings of its investigation, the Board concluded that this accident and the resulting injuries were preventable. The Board arrived at 16 conclusions that it considered significant based on the facts and analytical results. The seven conclusions most pertinent to this article are listed below.

- Selection of scissor lifts by PBC and acceptance by AGSC to perform the blasting job were poor decisions because scissor lifts have significant operating restrictions concerning lateral force.
- Job-specific safety documents were deficient because they did not include manufacturer information regarding lateral force hazards that were specific to the scissor lift equipment or the operating restrictions in the applicable ANSI Standard.
- The JSA did not identify hazards associated with abrasive blasting work from a scissor lift, specifically the lateral force restriction.
- Information regarding the lateral force restriction specific to the scissor lift was available in both the operating manual located in a holder on the scissor lift and on a warning label attached to the scissor lift, but that restriction was not incorporated into work controls.
- Scissor lift operator training conducted by PBC was deficient because it was not conducted by a qualified person as defined by OSHA, and it did not include the lateral force restriction that was specific to the scissor lift.
- There was confusion regarding responsibilities for emergency response.
- The SPRPMO and contractor(s) corrective action processes need improvement regarding oversight, training, stop work, and lessons learned.

Judgments of Need

JONs are managerial controls and safety measures that the Board believes are necessary to prevent or minimize the probability or severity of a recurrence of this type of accident resulting in an injury or fatality. JONs are derived from the conclusions and causal factors and are intended to assist managers in developing corrective actions and fostering continuous improvement. The Board recommended 25 JONs, including the 8 most pertinent to this article, which are listed on the following page.

- The SPRPMO must develop a written process that requires all powered equipment used for SPR work to undergo a review before being allowed onto any SPR site. The review should identify the manufacturer's name, make and model, serial number, and current inspection date, and it should ensure that equipment-specific hazards and operational limitations identified in current/up-to-date operational manuals are analyzed for incorporation into work safety-planning documents.
- Contractors must strengthen their safety document review process to ensure that subcontractor safety document submittals are reviewed by individuals with sufficient technical competence to determine their adequacy.
- Contractors must ensure that subcontractors review, understand, and incorporate equipment-specific operator manual and label requirements into work control documents and practices.
- Subcontractors must ensure that equipment-specific operator manuals and label requirements are appropriately reviewed, understood, and incorporated into work control documents and practices.
- Work planning must include the analysis of the hazards associated with the operation of all power equipment and machinery required to perform the job. Contract language shall require the selected vendor to list the equipment in its Work Plan proposal and address, at a minimum, all manufacturer precautions and limitations identified in the operations manuals.
- Subcontractor supervisors, safety personnel, and workers must be properly trained and made aware of equipment operating restrictions and precautions.
- SPRPMO Federal supervisors, safety personnel, and other workers who oversee contractor and subcontractor work must be aware of equipment operating restrictions and precautions.
- Contractor supervisors, safety personnel, and other workers who oversee subcontractor work must be aware of equipment operating restrictions and precautions.

Corrective Actions

Responsible entities, such as those in the following examples, will develop corrective actions to answer the following JONs.

- JON 1 states: *The SPRPMO must develop a written process that requires all powered equipment used for SPR work to undergo a review before being allowed onto any SPR site.*
- JON 2 states: *Contractors must strengthen their contract submittal review process to ensure subcontractor-required submittals are adequate and complete before allowing work to commence.*
- JON 5 states: *Subcontractors must ensure that equipment-specific operator manuals and label requirements are appropriately reviewed, understood, and incorporated into work control documents and practices.*

Additional details can be obtained from the final report at http://energy.gov/ehss/downloads/accident-investigation-february-7-2013-scissor-lift-accident-west-hackberry-brine.

KEYWORDS: Accident Investigation, abrasive blasting, Blaster, tank, Skyjack, scissor lift, fall, injury, lateral/side force, PBC, Strategic Petroleum Reserve, SPR, West Hackberry Storage Site

ISM CORE FUNCTIONS: Define the Scope of Work, Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls, Provide Feedback and Improvement

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To issue the Summary in a timely manner, AU relies on preliminary information such as daily operations reports, notification reports, and conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Ms. Ashley Ruocco, (301) 903-7010, or e-mail address ashley.ruocco@hq.doe.gov, so we may issue a correction. We would like to hear from you regarding how we can make our products better and more useful. Please forward any comments to Ms. Ruocco at the e-mail address above.