OPERATING EXPERIENCE SUMMARY

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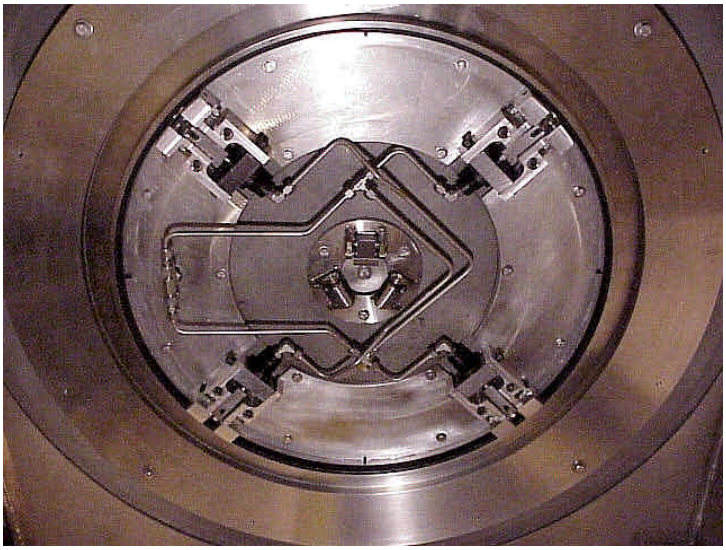

U.S. Department of Energy

Office of Environment, Safety and Health

OE Summary 2003-15

July 28, 2003

The Office of Environment, Safety and Health (EH), Office of Performance Assessment and Analysis publishes the Operating Experience Summary to promote safety throughout the Department of Energy (DOE) complex by encouraging the exchange of lessons-learned information among DOE facilities.

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EVENTS

1. ZERO-ENERGY CHECK REVEALS ENERGIZED SWITCH

On March 21, 2003, at the Hanford Waste Receiving and Processing Facility, an electrician performed a zero-energy check on a pressure switch he believed was de-energized and found it was energized with 110-volt power. A complex lockout/tagout (LOTO) process involving more than 75 circuits was not carried out correctly because electrical drawings marked with highlighters were misinterpreted. Because this condition was discovered during a zero-energy check, workers were not exposed to the energized pressure switch in this near-miss event. (ORPS Report RL--PHMC-WRAP-2003-0002; final report filed May 7, 2003)

Facility personnel were performing modifications to the low-level glovebox line that included replacing a glovebox exit port like the one shown in Figure 1-1. Facility managers wanted to isolate power to the low-level glovebox line while other facility equipment remained operational. When designing the LOTO for the modifications, a system engineer reviewed engineering drawings showing all the potentially involved circuits. He highlighted those that were to be locked out but used two different colors to mark up the drawings and did not provide a color-code key.

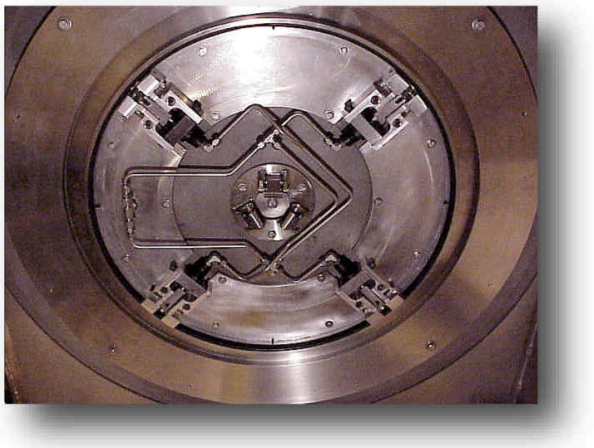


Figure 1-1. Glovebox line exit port

Twenty-nine separate lockouts, including both circuit breakers and fuses, were required to safely perform the modifications. Because of the complexity of locking and tagging numerous circuits, electricians did not perform zero-energy checks on each component when they locked and tagged it. Instead they performed a separate zero energy check before they modified or removed each component.

When the electrician found the energized pressure switch, work was stopped. As an immediate action, the system engineer reviewed the lockout boundary. He identified 10 circuits that were not included in the original lockout and modified the LOTO to include them. All of these circuits were passive monitoring circuits that could not cause any mechanical movement of glovebox equipment, and the only hazard they presented was electrical shock.

Investigators determined that the direct cause of this incident was personnel error (procedure not used or used incorrectly). Procedures require both the lock and tag author and the technical reviewer to identify the LOTO boundary. The lock and tag author apparently assumed that the circuits highlighted in a different color did not need to be locked out because they were low-voltage, direct-current circuits. The technical reviewer accepted this incorrect assumption. Investigators identified a management problem (inadequate administrative control) as a contributing cause. Although the system engineer highlighted the circuits that needed to be locked out, he used two different colors and did not provide a key to explain the color-coding.

Investigators determined that the root cause of the incident was a management problem (policy not adequately defined or disseminated). The LOTO policy allows for a graded approach depending on the complexity of the LOTO to be installed, but does not specify that a technical expert should verify the adequacy of the isolation boundary. If the system engineer who highlighted the electrical drawings had served as the technical reviewer, he could have ensured that the marked up drawings were not misinterpreted.

The principal corrective action for this incident was to modify the procedures to require a sys-

tem expert review of complex or unusual LOTOs during both design and installation. Instructions will be prepared on the correct method for marking drawings used in lock and tag processes. These instructions will require using a color-code key if a drawing is highlighted using more than one color. The modified procedure, the instructions on how to mark up drawings for lock and tag processes, and a lessons-learned document on this incident will be required reading for system engineers and designated lock and tag administrators.

LOTO inadequacies are a continuing problem at DOE facilities. The cumulative monthly count of LOTO events involving electrical systems across the DOE complex has shown an increase since at least January 2002. The principal consequence of an improper LOTO is the threat of injury from stored energy or uncontrolled electrical hazards. The most effective barrier against electrical hazards is to de-energize the source and lock and tag it out. A summary article entitled *Lockout/Tagout Violations and Lessons Learned* was published in the Operating Experience Summary, Issue 2003-06. This article described typical LOTO incidents that occurred in early 2003, provided a list of "Lockout Traps and Pitfalls," and presented a table of LOTO-related lessons learned for work planners, lockout installers, and individual workers. This article can be accessed at http://tis.eh.doe.gov/paa/oesummary. Guidance on LOTO issues in a DOE context can be found in DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts,* which is available at http://tis.eh.doe.gov/techstds.

AVOIDING LOTO INCIDENTS

- Prepare work packages that use simple (not complex) LOTO processes.
- Increase the level of technical verification of the LOTO design as the level of LOTO complexity increases.
- Increase the comprehensiveness of the verification of LOTO installation as the LOTO complexity increases.
- Ensure effective communications between those who mark up electrical drawings for LOTO purposes and those who prepare the LOTO.
- Always require zero-energy checks before starting work on systems, equipment, or components that could contain hazardous energy sources.
- Be willing to disrupt other facility operations in the interest of worker safety.
- Encourage workers to take personal responsibility for working safely.

These events underscore the need to thoroughly research, correctly prepare, and properly install LOTOs to protect workers from electrical hazards. Annotated drawings need to be clearly understood by lockout planners and subject matter experts should be used to verify isolation boundaries are adequate. A properly prepared and installed LOTO is the first line of defense against electrical hazards; the zero-energy check is the final line of defense.

KEYWORDS: *Lockout/tagout, LOTO, hazardous energy exposure, zero-energy check, verification, isolation boundary*

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

2. *NEAR MISS –PRESSURIZED AIR HOSE WHIPS VIOLENTLY*

On April 3, 2003, at the Rocky Flats Environmental Technology Site, an air hose used with hydrolasing equipment by subcontractor decontamination and decommissioning (D&D) workers (as depicted in Figure 2-1) unexpectedly became pressurized with 125-psi compressed air and whipped around violently until an operator trapped it with his foot and brought it under control. Miscommunication with a compressor operator while the hydrolasing equipment was shutdown for equipment changes resulted in the accidental pressurization of the air hose. No injuries resulted from this near-miss event, although in trapping the hose, the relief operator

put himself at risk for severe injury. (ORPS Report RFO--KHLL-771OPS-2003-0005; update/final report filed June 12, 2003)

Figure 2-1. Rocky Flats workers hydrolasing a wall

A relief operator decided to shorten the air hose, simultaneously with a maintenance shutdown of the hydrolasing operation, to reduce floor clutter in the area. Because it was very noisy in the area (over 100 decibels), the relief operator contacted a radio relay person to direct the pump/compressor operator to shut down the water pump and the air compressor. The air hoses were then disassembled.

As the operator who had been relieved was leaving, he noticed that water was collecting at the containment dam. He began to vacuum the water from the area, unaware that the water pump and air compressor had already been shut down. Shortly afterward, he discovered that the primary waste drum on the waste stream separator had filled with water and was spilling into the secondary containment drum. The operator also saw that the air-driven diaphragm pump was not operating, and directed the compressor operator to start the air compressor so the water could be pumped from the drums.

At the same time, the hydrolasing technical supervisor heard the air compressor stop and directed the pump/compressor operator to restart the compressor. This pressurized the air hose and caused it to whip back and forth. As the relief operator approached the whipping air hose, both a health and safety representative and a radiological control technician saw him. They called out to him and tried to wave him away, but he did not stop.

The air pressure decreased, and the relief operator trapped the air hose with his foot and grabbed it with his hand. The health and safety representative immediately warned him of the hazard of approaching a 125-psi air hose whipping about uncontrolled.

Investigators determined that when the pump/compressor operator shut down the air compressor, he did not shut off the water supply line from the hydrolasing water recycling system to the water pump. As the air pressure dropped, the pneumatic diaphragm pump that circulates lubricated water through the water pump casing stopped working, and clean water spilled into the pump room. The secondary containment liner contained all of the spilled water (less than 20 gallons).

Investigators also determined that the relief operator erred when he attempted to secure the whipping pressurized air hose. The operator did not heed the warning to stop, and his actions could have led to his being seriously injured.

The following work planning and control issues contributed to this incident.

- The high noise level in the area prevented effective communication. The team used a radio relay person to convey information instead of establishing a direct line of communication. The team did not have access to a dedicated channel on the radios, and garbled and lost transmissions were often the result.

- The procedure did not address the use of the compressor as a secondary isolation control, so there was no means to control compressor operation.

- The procedure did not address locking and tagging out non-electrical systems during maintenance – in this case, the hose changeout – which would have prevented

the compressor from being restarted inadvertently.

- No one told the pump/compressor operator the reason for shutting down the compressor; he simply did as asked.
- The added maintenance activity (changeout of the air hose) was not discussed at the pre-job briefing.
- The project foreman was not working directly with the team, but was working in the compressor area and training a second foreman.

The corrective actions that were taken to prevent recurrences of this event include the following.

- Hydrolasing operations personnel will be assigned radios on a separate frequency with high-noise headsets to facilitate communication.
- Procedures were modified to require operators to repeat back instructions before carrying them out and to address the use of secondary isolations, pre-job briefings, and shift turnovers.
- Foremen must be available to supervise projects at all times.
- The hydrolasing job hazard analysis, standard operating procedure, and work package have been modified to require a positive lockout/tagout while the equipment undergoes maintenance.
- Additional isolation valves will be added to air hoses to facilitate easier lockout.
- Facility personnel conducted a dry run of hydrolasing operations.
- Facility management issued a lessons-learned document to subcontractor personnel describing the hazards posed to workers who attempt to control a pressurized hose and warning that violators will be disciplined.

The danger associated with air hose whip is illustrated in a 1999 event reported by the Mine Safety and Health Administration, where a 28-year-old miner was killed and another miner was seriously injured when they were struck by an air hose. The victim and two coworkers had loosened a misaligned coupling on a pressurized air line to straighten it when it came apart, allowing the hose and coupling to violently whip. The full report on this incident can be found at www.msha.gov/FATALS/1999/FAB99M08.htm.

A number of events involving near misses caused by uncontrolled pressurized devices have been reported to ORPS, including the following. On December 10, 2002, at the Lawrence Livermore National Laboratory, a worker was using a high-pressure liquid abrasive cutter when a high-pressure hose came loose and whipped around, striking him on the hand. A retaining clip at the end of the nozzle failed, and further investigation showed that the worker was holding the cutter, although the operational safety plan described the cutter's use only in a secured position. The worker was wearing protective equipment and suffered only a cut on his hand. (ORPS Report OAK--LLNL-LLNL-2002-0039)

APPROACHES FOR SAFELY WORKING WITH ENERGY-CONTAINING SYSTEMS

- Pre-job planning should ensure that controls are in place and accessible for containing energy (e.g., isolation valves).
- Procedures for work involving pressurized or energy-containing equipment should address lockout/tagout.
- Personnel should perform only the tasks specified in the work package.
- Foremen should personally supervise activities.
- Clear communication among all personnel involved in the work evolution is essential.
- Supply shutoff valves should be located (as near as possible) at the point of operation.
- Hose ends should be secured to prevent whipping if an accidental break occurs.

These events demonstrate the potential hazards of working with pressurized equipment. Work packages need to clearly define the work that will be performed and the controls needed to perform the work safely, and personnel should not deviate from them. The event at Rocky Flats also illustrates the value of lockout/tagout in protecting workers from energy-containing systems.

KEYWORDS: *Pressurized hose, hydrolasing, lockout/tagout, maintenance, near miss*

ISM CORE FUNCTIONS: *Define the Scope of Work, Develop and Implement Hazard Controls, Perform Work within Controls*

3. PIPE LEFT IN UNSAFE CONDITION FALLS AND STRIKES WORKER

On April 23, 2003, at the Fernald Environmental Management Project, two decontamination and decommissioning (D&D) workers were removing a pipe and flange from the side of a tank when 70-pound section of piping containing a 4-inch gate valve fell from several feet above and struck one worker on his hard hat. The worker suffered a cervical strain. (ORPS Report OH-FN-FFI-FEMP-2003-0005; final report filed June 9, 2003)

Because details leading to the event are unknown, investigators were unable to conclusively determine how and from where the pipe fell. However, based on the data collected, the investigators were able to infer how this incident most likely occurred. Figure 3-1 shows the area that was being demolished.

The 4-foot-long section of 4-inch-diameter pipe was probably cut from one of several that penetrated the south wall of the building at an approximate height of 17 feet. Workers had size-sheared the pipes into 10-foot lengths in mid-December 2002. When the pipe was sheared free, most likely in January 2003, it fell unnoticed on top of a tank in the demineralizer area (Figure 3-2).

Figure 3-1. D&D work area

The valve appears to have caught on a vacuum line running above the tank near a crossbeam and was on top of the tank and the crossbeam. Investigators believe the crossbeam hid the pipe from view. Figure 3-3 shows the piece of pipe that fell.

Figure 3-2. Tank beneath the crossbeam where pipe apparently fell

Figure 3-3. Pipe and gate valve that struck the worker

As the workers removed the pipe and flange from the tank, the valve apparently caught on one of these components and dislodged. The pipe then slid, fell, and struck the worker, causing him to stagger under the impact.

The co-worker, who saw the valve fall, caught the pipe after it struck the worker. He then dropped it on the floor, checked for injuries, and notified the supervisor to obtain medical assistance. The injured worker later indicated that his neck hurt. The Fernald medical doctor sent the injured worker offsite for further examination to confirm that there were no spinal column injuries or ligament damage.

The causal analysis and corrective actions for this event were based on the investigators' deductions. The most likely causal factors included the following.

- The workers conducted their walkthrough from ground level, looking up. They did not view the area from above, so they did not see the valve sitting on top of the tank.
- The subcontractor work control documents did not provide written direction or guidance on identifying falling-object hazards during walkthroughs.
- The workers decided which components to dismantle first, not the foreman.
- The workers did not accompany the foreman on his pre-shift walkthrough to assess hazards and determine work assignments.
- The subcontractor D&D work plan did not address the possibility of falling objects during and after shearing operations.
- Neither the shear operator nor the spotters noticed that the pipe did not fall to the ground as expected when it was initially sheared.

To prevent recurrence, the subcontractor revised its activity hazard analysis for hydraulic shearing to direct that spotters ensure that cut pieces are brought completely to ground level and that components remaining in place are in a stable configuration. When shearing is complete, the personnel involved in the shearing must inspect the area, including areas below, to make sure that pieces are not left behind.

The subcontractor also revised its general construction activity hazard analysis to restrict access to areas where D&D work is conducted from elevated areas to prevent personnel from entering the area and being struck by a falling object. Before working in areas where items have been sheared, workers are to walk down the area, including elevated areas, for potential

BEST PRACTICES FOR D&D WORK

- Pre-job walkthroughs should include all personnel involved in the task so that they are aware of all potential hazards.
- Personnel should check for hazards both overhead and at ground level.
- The foreman should direct the flow of work.
- Personnel involved in demolition operations, including spotters, should watch to make sure that cut pieces fall as expected. In the event that pieces cannot be found, others in the area should be alerted as to their presence.
- Sectioned components should be safely brought to ground level or staged in a manner that prevents a falling hazard

falling objects, using scissor lifts to search for them, if necessary. Personnel working in other locations may walk down the area periodically to ensure that potential hazards are not inadvertently missed.

A number of near-miss events have been reported in ORPS involving objects unexpectedly falling onto workers during D&D work. On November 21, 2002, at the Rocky Flats Environmental Technology Site, as D&D workers sheared sections of electrical buss ducting from an I-beam, a 4-foot piece fell 18 feet, striking a worker on the shoulder. The worker's rotator cuff was torn and required surgery. (ORPS Report RFO--KHLL-SOLIDWST-2002-0068; OE Summary 2002-26)

These occurrences illustrate the inherent hazards posed by demolition work and the importance of workers not leaving unsafe conditions that can introduce unknown hazards into the work area. Conducting hazard analyses and walkdowns is particularly important for D&D operations, where unexpected situations can occur. Falling objects can present potential hazards to personnel, and hazard analyses should recognize them and identify means to prevent them. All personnel who will be conducting demolition work should walk down all levels of the areas in which they will be working, paying particular attention to hazards they could encounter.

KEYWORDS: *Near miss, hazard analysis, walkdown, D&D, shear, falling object*

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

4. DUMP TRUCK DAMAGES OVERHEAD POWER LINE

On June 12, 2003, at the Hanford Tank Farms, a truck driver spreading gravel raised the bed of his dump truck and hit and damaged a 120/240-volt overhead power line supplying power to an office in a nearby trailer. The truck driver, who was confident that he had enough clearance, had apparently out-distanced his spotter. No injuries or major equipment damage resulted from this occurrence. (ORPS Report RP--CHG-TANKFARM-2003-0028)

When the raised truck bed made contact with the overhead line, a nearby worker serving as an informal spotter yelled and put his hands up, alerting the driver, who immediately stopped. The driver then slowly backed the truck out from under the line, lowered the raised bed, and circled the truck away from the incident scene. During an interview after the incident, the truck driver said that he thought he had clearance, but did not realize that the power line ran diagonally across the road. He also said he should have turned sooner or lowered the box sooner. If a spotter was established (and this was not clear), the truck moved so quickly that the spotter was left behind, unable to communicate with the driver.

Figure 4-1 shows the incident scene immediately following the occurrence, with the damaged power line passing diagonally over the roadbed where the gravel was being spread. Although the potential for personnel injury existed, the truck driver was able to stop the truck before the energized wires were pulled down.

The overhead electrical line met the minimum height requirements of the relevant electrical code for its application. The minimum line height for this application is 15 feet, 5 inches above the ground per the Institute of Electrical and Electronic Engineers *Standards for Overhead Conductor Clearances*, Part 2, Table 232-1. Workers measured the height of the overhead line at various points, and determined the low-

Figure 4-1. Power line that was damaged by the raised bed of the gravel truck

est point to be 16 feet above the ground. At the location where the line was contacted by the bed of the truck, the line was 18 feet above the ground. The bed of the gravel truck, when fully extended, reaches approximately 19 feet, 7 inches above the ground.

At least two Occupational Safety and Health Administration (OSHA) requirements were violated in this incident. OSHA regulation 29 CFR 1910.333(c)(3)(III)(A) states, in part: "Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized lines shall be operated so that a clearance of 10 feet is maintained." Further, OSHA regulation 29 CFR 1910.550(A)(15)(IV) states: "A person shall be designated to observe clearance of the equipment and give timely warning for all operations where it is difficult for the operator to maintain the desired clearance by visual means."

Investigators determined that both the direct and root cause of this incident were inattention to detail because the driver was not aware that the power line ran diagonally across the roadbed. He simply did not pay enough attention to the location of overhead line and his proximity to it while focused on spreading the gravel, which required him to simultaneously drive at an appropriate speed, raise the truck bed, and control the quantity of gravel spread.

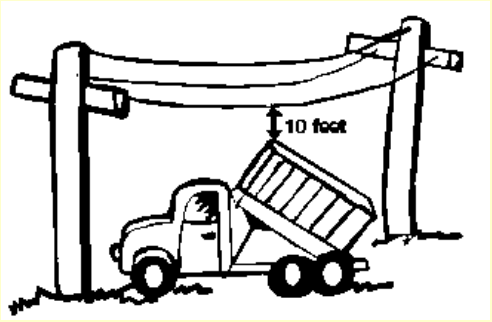
Investigators identified communication problems as a contributing cause of this occurrence because the driver believed a spotter was observing the operation, but the role of spotter had not been clearly assigned to any other worker in the area. A second contributing cause was the failure to adequately define, disseminate, or enforce policies. Subcontractor managers did not clearly establish or implement regulatory requirements for maintaining clearances and roles and responsibilities for spotting functions.

Corrective actions being taken in response to this event include the following.

- Install permanent caution signs on the side of the road near the power line to alert traffic concerning the overhead obstruction.

PREVENTIVE MEASURES

- Review the work area and travel routes to identify overhead electrical hazards
- Communicate known overhead hazards to equipment operators and drivers
- De-energize and ground power lines (if possible)
- Move power lines beyond the safe working distance (if possible)
- Install flagged warning lines to mark the horizontal and vertical clearance distance of the power line
- Use dedicated spotters and observers to assist drivers and equipment operators
- Use proximity detectors
- Above all, know the clearance at full extension of the equipment (e.g., bed, boom, or mast)



- Obtain written confirmation from the subcontractor that regulatory requirements and best management practices for operating heavy equipment near power lines have been reviewed with truck drivers.

- Issue a lessons-learned document on the incident emphasizing requirements, roles and responsibilities, and performance expectations.

- Disseminate the lessons-learned document to site organizations and all appropriate subcontractors.

A search of the ORPS database for recent events involving the raised beds of dump trucks intrud-

ing on electrical conductors revealed the following events. On September 24, 2002, at the Savannah River Site, a subcontractor gravel truck had completed a gravel dump and was lowering the truck bed when it came into contact with a 13.8-kV electrical transmission line. The truck served as a ground for the electrical line, and the resulting electrical discharge blew out one tire on the truck, scorched two additional tires, and started a small grass fire. No injuries resulted from this incident. (ORPS Report SR--WSRC-SUD-2002-0009)

On August 13, 2002, at the Fernald Environmental Management Project, a subcontractor gravel truck with its bed raised was observed within 10 feet of an overhead 480-volt power line. A spotter alerted the driver to the encroachment, and the truck was stopped with the raised bed within approximately 6 feet of the power line. No injuries resulted from this incident. (ORPS Report OH-FN-FFI-FEMP-2002-0031; OES 2002-23)

Contact with energized overhead power lines can have disastrous results. On October 7, 2000, at a job site in Alberta, Canada, a truck driver was electrocuted when the bed of his dump truck contacted a 25 kV power line. The driver had parked his truck underneath the power line after dumping a load of asphalt. The driver was standing on the steps to the cab while he raised the dump bed to remove residual asphalt. When the top of the box contacted a phase of the power line, the tires on the truck and trailer burst into flames. A worker yelled to the driver that the tires were burning. The truck driver stepped down onto the ground and was immediately electrocuted. Investigators determined that there were no warning signs to identify the known hazard of overhead power line and that the driver operated the dump box within the 10-foot safe limit of approach.

The Department of Labor Mine Safety and Health Administration issued an Info-Gram (www.msha.gov/District/Dist_08/powerlin.htm) on a September 2000 event at a surface mine, where the raised bed of a large dump truck contacted an energized 13,200-volt power line. A witness attempted to warn the truck driver to remain in the cab until the power could be verified off; however, he did not heed the warning and exited the truck. Fortunately for the driver, relays in an electrical substation had de-energized the power line or he could have been electrocuted.

These events underscore the need to perform detailed planning for subcontract work, communicate safety expectations to subcontractors, and provide sufficient oversight to ensure that subcontracted tasks are accomplished safely.

KEYWORDS: *Overhead power lines, raised truck bed, electrical intrusion, power outage, spotter*

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