Operating Experience Summary

Office of Health, Safety and Security

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Type B Accident Investigation Results—Serious Hand Injury While Lubricating Crane Cable

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On October 6, 2009, at the Savannah River Site (SRS) Salt Waste Processing Facility (SWPF), a subcontractor apprentice crane operator was lubricating a crane boom cable on a 225-ton mobile crane when the lubricating rag came in contact with the cable and his hand was pulled into a sheave pinch point. The apprentice's left hand and fingers were crushed between the wire rope and the sheave that it passes over when being rolled onto its drum (Figure 1-1). The injury resulted in the apprentice losing three fingers on his left hand and required skin grafts to the hand. SRS management appointed a Type B Accident Investigation Board to investigate this event. (ORPS Report EM-SR--PSC-SWPF-2009-0010; final report issued February 9, 2010)

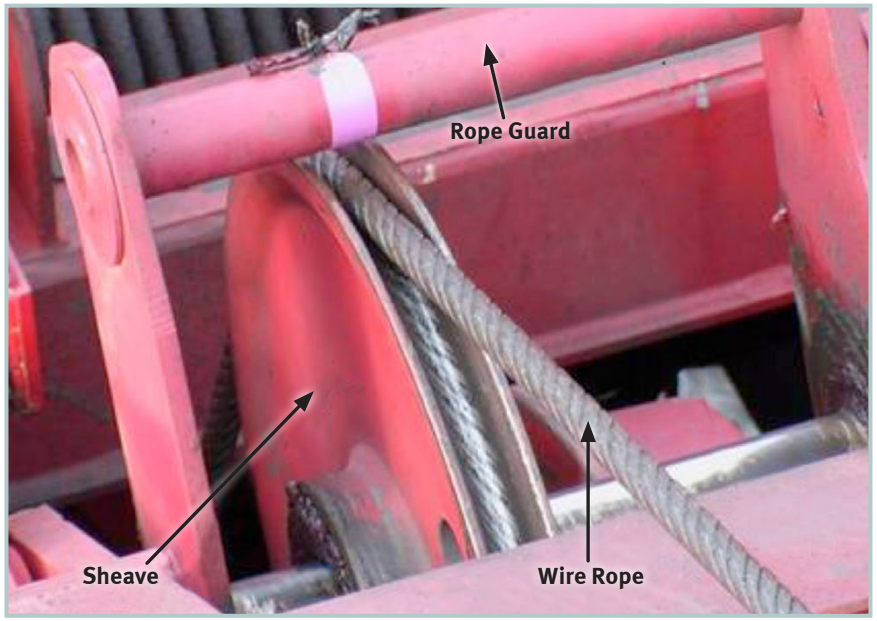

Figure 1-1. Wire rope, sheave, and rope guard

On the day of the accident, a vendor's mechanic performing repairs to the crane noticed that the boom wire rope on the crane needed to be lubricated. He notified the subcontractor's construction staff, and the shift supervisors decided to include the wire rope lubrication in the activities planned for the evening shift.

When the work began, the apprentice positioned himself near the sheave to perform the lubrication and signaled the crane operator to lower the boom. Lubricating while booming down has the rope moving away from the sheave and is the method shown in the crane operator's manual (Figure 1-2). As the boom came down, the apprentice worked oil into the wire rope, using a rag held in his gloved hand. After the initial lubrication, the apprentice told the crane operator that he thought the wire rope needed additional oil and that he wanted to lubricate the wire while the boom was traveling up, rather than down.

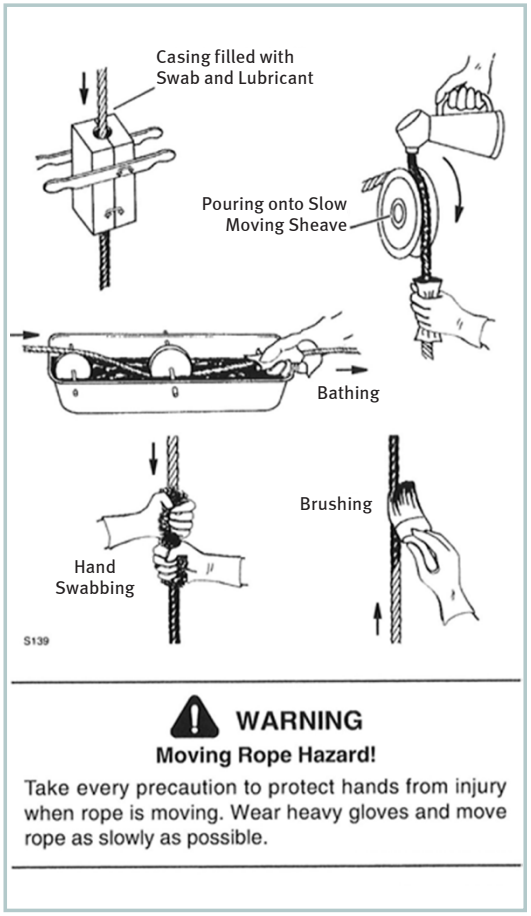

Figure 1-2. Lubrication methods shown in operator's manual

When the crane operator received a boom up hand signal, he started to slowly raise the boom, but almost immediately he heard the apprentice yell "boom down, boom down." After lowering the boom and locking down the crane, the crane operator went to the assistance of the apprentice and saw that his hand was caught between the sheave and the wire rope.

In reviewing the sequence of events, the Board determined that a work order was not developed specifically for maintenance on the wire rope, so safety personnel were not contacted to perform a job hazards analysis that would have identified the hazards of the maintenance activity and the controls needed to mitigate them. The Board concluded that construction supervisors did not realize that wire rope lubrication was a maintenance activity that required a specific work order and a defined scope of work before workers performed the task.

Because the wire lubrication task was not included in the work order, neither a specific method to perform the work (e.g., spraying lubricant, pouring oil directly on the wire rope, using a paint brush to apply oil to the wire rope) nor appropriate controls from the crane operator's manual or industry best practices were identified. The Board learned that both the foreman (who conducted the pre-job briefing) and the crane operator had limited experience with the task, and both had experience only with spray lubricants. When the apprentice said he had experience with pouring oil on the rag and then working the oil into the wire, neither the foreman nor the crane operator questioned his method.

Although there was discussion during the pre-job briefing about keeping hands away from pinch points and the sheaves, the Board determined that there was no discussion about where the apprentice would be positioned, whether the wire rope would be moving while lubricating it, or using a lubricating method outlined in the operator's manual. The Board concluded that the pre-job briefing did not ensure that the workers understood the scope of work, its associated hazards, and their ability to safely conduct the work.

In interviews, the Board learned that other apprentice crane operators performed wire rope lubrication while positioned beside the muffler, which is farther away from the sheave (Figure 1-3), but when the apprentice arrived at the crane with the supplies needed to lubricate the wire rope, he positioned himself near the sheave, lubricating the rope as the boom came down.

Figure 1-3. Position normally used during wire rope lubrication

When the apprentice told the crane operator that he thought the wire rope needed additional oil after the boom came down and that he wanted to lubricate the wire rope while booming up, the crane operator did not find it unusual. The crane operator's experience was with using a spray lubricant on the wire rope, and in that method it did not matter whether the crane was booming down or up as there was no contact with the wire rope. However, booming up causes the rope to move toward the sheave, where the apprentice was positioned, and is contrary to guidance in the operator's manual. The Board concluded that an opportunity was missed to call a safety time out and review

the process and hazards before allowing the apprentice to lubricate the wire rope while the boom was being raised.

The Board determined that the root cause of this accident was that an unsafe method was used to apply lubricant to the wire rope. The following were among the contributing causes that the Board identified.

- The wire rope lubrication was not recognized by construction supervisors as a maintenance activity that required a specific work order.
- A task-specific job hazards analysis was not developed for implementing controls to mitigate hazards associated with the wire rope lubrication activity.
- The pre-job briefing did not ensure that the workers understood the scope of work, associated hazards, and methods specified in the crane operator's manual to perform the work activity in a safe and compliant manner.
- The hazards associated with lubricating the wire rope while it was traveling toward the sheave were not recognized and a safety time out was not initiated.
- Lubricating the wire rope while the rope was moving toward the sheave was not in accordance with the guidance in the crane operator's manual.

The Board identified the following Judgments of Need to address these issues.

- Ensure that pre-job briefings are conducted in a way that ensures employees understand work scope and associated hazards and are ready to conduct work activities in a safe and compliant manner.
- Ensure that safety personnel are involved in the planning and execution of construction site work activities.
- Define and communicate approved method(s) for conducting crane wire rope lubrication.
- Reinforce the use of safety time outs, particularly when work scope or conditions change or when unanalyzed or unmitigated hazards are identified.

The Type B accident report can be accessed at http://www.hss.energy.gov/csa/csp/aip/accidents/typeb/Type_B_SWPF_2009.pdf.

Schedule a Job-Site Review to Identify Hazards and Address Them

The Human Performance Improvement (HPI) "Job-Site Review" tool can be useful if pre-job briefings do not clearly identify the work scope and hazards or detail the methods for performing the task, as was the case in this event. Using this HPI tool can improve workers' situational awareness when they first arrive at the job site, encourage a questioning attitude, and promote understanding of the work environment, hazards, and critical indicators.

A job-site review involves walking down the job site before work begins to identify conditions that either are inconsistent with those discussed in the pre-job briefing or were not identified during the briefing and provides an additional opportunity to eliminate hazards before work begins. Performing a job-site review would have given both the crane operator and the apprentice an opportunity to identify potential safety hazards (e.g., standing too close to the sheave) and take appropriate steps to mitigate them before work began.

Another element of the "Job-Site Review" tool provides an opportunity for workers to talk with others who have performed the same or similar tasks and discuss previously identified hazards and needed precautions. In this event, for example, workers who had experience performing the lubrication task likely would have alerted the apprentice to the dangers of standing near the

sheave, directed him to position himself near the muffler when performing the task, and questioned him about the lubrication method he chose. They also might have warned him that lubricating the wire when the boom was going up was dangerous and was not a method approved in the operator's manual.

For more information on the "Job-Site Review" tool, see Volume 2 of the Department of Energy Human Performance Improvement Handbook at http://www.hss.energy.gov/nuclearsafety/ns/techstds/standard/hdbk1028/doe-hdbk-1028-2009_volume2.pdf.

Lessons Learned

This event shows the importance of ensuring that all work tasks are specifically identified in work orders and that appropriate steps are taken to identify hazards and methods to control them. Pre-job briefings also must identify the work scope and hazards, detail methods for performing the task, and ensure that work will be performed in accordance with information in the operator's manual or best industry practices. Participation in a review at the job site before work begins is another method of identifying hazards, and provides an additional opportunity to implement controls before beginning work.

KEYWORDS: Type B, injury, crane, cable, wire rope, lubrication, sheave, drum, boom

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

Are You Working on the Right Equipment? The Danger of "Look-Alikes"

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Figure 2-1. Two examples of identical equipment side-by-side in work area

"Look-alike" equipment can be found in many facilities, both in industry and across the Department of Energy (DOE) Complex. Figure 2-1 shows two examples of "look-alikes." Work procedures often lock out or require safe conditions only for equipment that is destined for repair, leaving live, identical equipment in close proximity. "Look-alike" equipment and components are easy to mistake one for another, so extra care is needed to mitigate the increased potential for a serious accident and injury.

Two recent DOE events reported to the Occurrence Reporting and Processing System (ORPS) database highlight the risk to workers when they inadvertently remove "look-alike" equipment rather than the planned equipment. There were no injuries in either event; however, both events could have caused an electrical shock or worse.

"Look-Alike" Water Treatment Units

On March 31, 2010, at Hanford, millwrights tasked with removing the drive motor from one of four water treatment units inadvertently removed the motor from the wrong unit. The millwrights were supposed to remove the Unit 4 motor for overhaul, but removed the motor for Unit 1 instead. The circuit breaker for Unit 1 was already in the open/off position, and the electricians had performed zero energy and safe condition checks; however, the unit had not been locked out. (ORPS Report EM-RL--MSC-S&W-2010-0001; final report submitted May 14, 2010)

The task work package identified the lockout/tagout (LOTO) boundary, and the Operations Supervisor and crafts personnel went to the equipment Motor Control Center and correctly identified the circuit breaker for Unit 4 before work began. Electricians performed a zero energy check, determined there was no voltage present on the load side of the circuit breaker for Unit 4, and applied their locks and tags.

After a pre-job briefing, the Operations Supervisor took a trainee to the equipment location to explain the work process and stopped at Unit 1 to discuss the job. When the electricians and millwrights saw them at Unit 1, they incorrectly assumed that was the unit they were to work on. The electricians performed their part of the work task (i.e., safe condition and zero energy checks), removed their LOTO, and turned the package over to the millwrights, who then removed the Unit 1 drive motor. A short time later, the Operations Supervisor and Planner checked the work and realized that the wrong motor had been removed.

Investigators determined that the breakers for the water treatment units were adequately labeled, but there was no labeling on the drive units. They also determined that, although there was a picture of all four units with an arrow pointing to Unit 4 in the work package, the picture was not used as a reference before work began or when validating the equipment to be removed. Investigators concluded that had labeling been in place to properly identify the units, the millwrights likely would have removed the correct motor.

"Look-Alike" Pumps

On March 4, 2010, at Idaho National Laboratory, a maintenance technician, assigned to electrically disconnect a makeup pump motor for an inactive pressurized water loop, inadvertently disconnected the makeup pump motor for an active pressurized water loop. The pump was not operating at the time, but if it had started up automatically, 480 volts would have been applied to the electrical leads the technician was disconnecting, and he could have received an electrical shock or serious injury. (ORPS Report NE-ID--BEA-ATR-2010-0004; final report issued April 15, 2010)

Investigators determined that the electrician did not read the entire equipment designation on the supply cable label and began the work task based only on the last number of the designation. The identification of the equipment in the work order was not the same as identified on the label for the equipment the electrician disconnected. Investigators also determined that the work order included photos illustrating the pump that was to be disconnected, but the photos were not referenced in the work instructions.

> It is important to remember that hazardous energy control measures cannot protect you if you work on the wrong piece of equipment.

Similar Events

On March 29, 2009, at the East Tennessee Technology Park, a cable splicer, attempting to remove the links from the power side of a circuit interrupter, placed a wrench near a bolt, heard a buzz, and felt a tingling. The worker immediately dropped the wrench, which came in contact with an energized 13.8kV bus bar and caused an arc flash. The worker, who was tasked with removing high-voltage bus links, mistakenly went to an energized cabinet rather than to the de-energized one where the work was to be performed. In addition, he did not perform a zero energy check before beginning work to ensure that he was working on a de-energized component. This event was the topic of an article in OE Summary 2009-07. Figure 2-2 shows the damage caused by the arc flash that occurred when the wrench contacted the energized bus bar. (ORPS Report EM-ORO--BJC-K25GENLAN-2009-0001; final report issued May 19, 2009)

The dangers of working on "look-alike" equipment are not unique to electrical equipment, as the following recent occurrence at the Lawrence Livermore National Laboratory illustrates.

On August 12, 2010, during a fire protection system upgrade, two plumbers accidentally uncoupled a pressurized hydraulic supply line for an elevator instead of a depressurized and drained 2-inch steel, sprinkler water supply line they were tasked with uncoupling. The plumbers were sprayed with hydraulic fluid until they re-tightened the pipe coupling. Both the supply pipes and couplings were identical in appearance and ran beside each other. Neither pipe was labeled as to its system or function. (ORPS Report NA--LSO-LLNL-LLNL-2010-0037)

Figure 2-2. Damage caused by arc flash

Alerting/Prevention Techniques and Good Practices

Working on the wrong piece of "look-alike" equipment has resulted in many workplace injuries and fatalities and has become a big enough problem that the National Fire Protection Association (NFPA) added an article about it in the 2009 edition of NFPA 70E. Article 130.7(E)(4), *Alerting Techniques*, "Look-Alike Equipment," recommends the use of alerting techniques, including signs, barricades, or attendants to prevent workers from entering "look-alike" equipment. When performing work, using the following alerting techniques will help workers identify the equipment they are supposed to work on.

- Barricade the work zone with tape to indicate areas that are off limits (Figure 2-3).
- Mark the equipment with distinguishing tape or tags to indicate safe or unsafe work areas (Figure 2-4).
- Mark areas that contain hazards with tape or tags to warn workers to keep out (Figure 2-5).
- Assign an attendant to ensure that work is performed only on the correct piece of equipment.

Figure 2-3. Example of barricaded work zone

Alerting techniques, although important, are not the only measures that are needed to avoid the dangers of working on "look-alike" equipment. Additional preventive techniques and good practices include the following.

- Walk down the job and ensure that equipment numbering (labels) and nomenclature match the work control documents.
- Conduct a thorough pre-job briefing, with an emphasis on "look-alike" equipment.
- If possible, conduct the pre-job briefing at the equipment location to ensure recognition of correct equipment.
- When photos of the correct equipment are included in the work package, they should be referenced in the work order and the equipment should be double-checked against them before work begins.
- Always ensure that a zero-energy condition has been verified using proper test equipment and methods.

Figure 2-4. Example of alerting technique identifying safe vs. hazardous work area

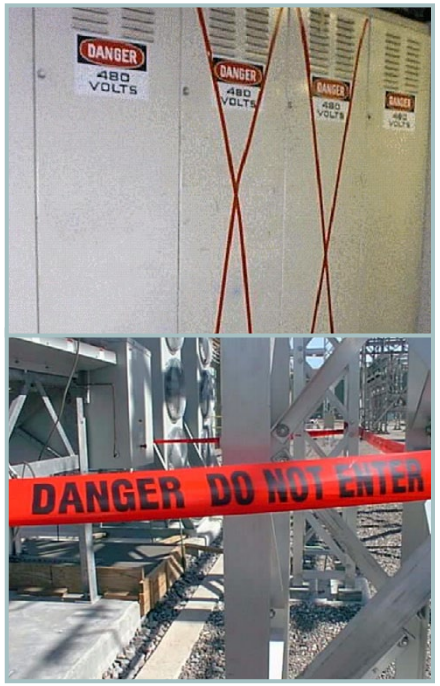

Figure 2-5. Examples of marking hazardous areas with tape

- Always wear appropriate PPE for the hazard, and question anything that does not look right.

> Don't bet your life that the labeling on equipment is correct.
> **Always "Test Before You Touch."**
> – D. Ray Crow, *Senior Member, IEEE; DRC Consulting, Ltd.*

Lessons Learned

When identical pieces of equipment are in proximity to each other, it is easy to inadvertently perform work on the wrong unit, the wrong pump, or in the wrong electrical cabinet. Because of the potential for an injury, it is essential to ensure that the correct equipment is clearly identified in the work order (and work package) and that equipment is labeled correctly so it can be identified in the field. When performing a task in an area where there is "look-alike" equipment, it is essential that workers do not make any assumptions. They must ensure that they have double-checked labels, compared the equipment they intend to work on with photos in the work package, and performed zero energy checks before any work begins.

Alerting techniques such as marking equipment and hazards with tape or tags, using a physical barrier, or having an attendant present before work begins are important elements of protecting workers in areas where there is "look-alike" equipment. In addition, pre-job briefings should stress the importance of accurately identifying the correct equipment before work begins and should be conducted at the work site when possible.

KEYWORDS: Look-alike, water treatment unit, drive motor, zero energy, lockout/tagout, LOTO, pump motor, label, alerting techniques, work planning, photos

ISM CORE FUNCTIONS: Develop and Implement Hazard Controls, Perform Work within Controls

Human Factors – How to Take the First Steps 3

The Human Factors Workgroup associated with Step Change in Safety, a United Kingdom (UK)-based partnership that includes the UK Health and Safety Executive and Trade Unions, recently published *Human Factors – How to Take the First Steps*, accessible on the Department of Energy's Operating Experience Wiki at http://operatingexperience.doe-hss.wikispaces.net/file/view/Human+factors+-+How+to+Take+the+First+Steps.pdf. The eye-catching cover of the publication is shown in Figure 3-1.

The publication's aim is to raise awareness and understanding of human factors in accident causation and to help managers and workers recognize human and organizational factors in the workplace. It provides useful tools that managers and workers at all organizational levels can use in a variety of ways, for example as a basis for toolbox talks and team or safety meetings; for work planning; or to identify first steps toward effecting changes in safety thinking.

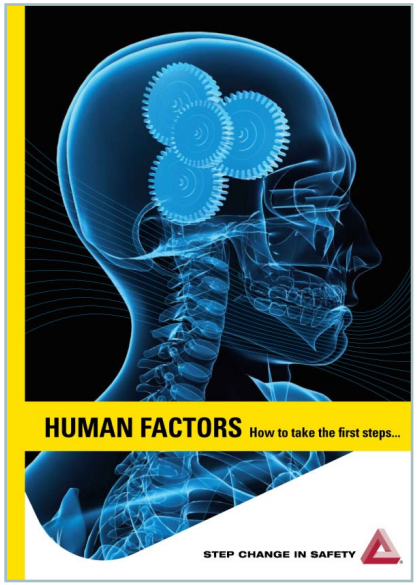

Figure 3-1. Cover of publication

Human Factors – How to Take the First Steps begins by briefly assessing well known historical events, such as the Bourbon Dolphin Capsize (Norway), the Space Shuttle Challenger Loss, and the Texas City Refinery Explosion. It then probes 12 more recent case studies (see the textbox below), assessing the complexities of human involvement in accident causation. Each of the case studies describes the deep-seated human and organizational factors that contributed to the accident—there are some surprises. All 12 studies include a brief discussion of the human factors and barriers involved in the events, as well as the applicable lessons learned. The format also offers a series of questions (e.g., What did people do intentionally? What did people do without meaning to?) safety professionals can use to help prevent human-factors-related incidents in their own organizations.

The publication goes on to discuss organizational safety culture and its influence on human performance and human behavior at work, in particular whether a behavior is judged as "good" or "bad."

Finally, the publication identifies some simple first steps (see the textbox on the following page) that everyone—workers, supervisors, managers, and safety representatives—can take to help manage human factors issues.

The Case Studies

- People will put up with what they're given.
- The best people DO make big mistakes.
- Managers are human too.
- Right job, wrong equipment.
- Assumptions aren't always right.
- Knowing that a hazard is there DOESN'T always protect you...Fact.
- Controls don't always do what you expect them to do.
- Close-enough procedures aren't close enough.
- Time to stop.
- When sleep comes nothing can stop it.
- Find a way to do it – by hook or by crook.
- Helpful guys get hurt.

The First Steps...

for Everyone

I will...

- **Challenge procedures that are difficult to follow**
- **Report any human factors concerns** — *talk to your supervisor about problems you recognise in the case studies.*
- **Take the time to consider how my actions and decisions can affect others now and in the future**
- **Report plant and equipment that is difficult to operate, maintain, inspect and test safely**
- **Encourage others to think about human factors**

for Managing Directors and Management

I will...

- **Appoint a Human Factors Champion** — *someone whose job it is to understand what human factors is about, how it applies to your business and who can help you.*
- **Make a simple plan to tackle human factors issues** — *use this document to help identify where you want to start. Choose one topic and deal with it.*
- **Take the time to listen to the workforce** — *they know best where the problems are. Get their views on the case studies and how they apply to your business.*
- **Give feedback to the workforce** — *tell them what issues you're working on and how you intend to deal with them.*

for Supervisors

I will...

- **Use the case studies to identify human factors topics under my control and deal with them** — *involve your team in the process.*
- **Ensure human factors topics are discussed during work planning, preparation and execution**
- **Incorporate human factors into my incident investigations** — *don't be content with "human error" or "procedural violation" as a conclusion. Look for the reasons behind the actions.*
- **Take the time to listen and give feedback to my team on human factors topics** — *your team knows best where the problems are. Ask their views on the case studies and how they apply to your workplace. Tell them how you are going to deal with any issues.*

for Safety Representatives

I will...

- **Take human factors concerns to the relevant safety forums**
- **Talk to my constituents about human factors issues and concerns in their areas.**

— from *Human Factors – How to Take the First Steps*, May 2010, Step Change in Safety

Once again, *Human Factors – How to Take the First Steps* is accessible on the Operating Experience Wiki by clicking here.

Take a look — YOU can make a difference.

Correction to *Operating Experience Summary* 2010-06, Article 2, "Cold and Dark Does Not Always Mean Safe: Be Alert for Unanticipated Conditions"
http://www.hss.doe.gov/csa/analysis/oesummary/oesummary2010/2010-06-02.pdf

In the last sentence of the first paragraph of the article, our text, which was quoting from the referenced ORPS report, read as follows: "...caused the ground fault circuit interrupter (GFCI) breaker to close, so the worker did not receive an electrical shock."

However, an alert reader notified us that the description was incorrect. The OES article and ORPS report should instead read as follows: "...caused the GFCI breaker to trip, so the worker did not receive an electrical shock."

The article has been corrected. Thank you for your comments and feedback on this publication.

The Office of Health, Safety and Security (HSS), Office of 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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