OPERATING EXPERIENCE SUMMARY

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OE Summary 2003-08

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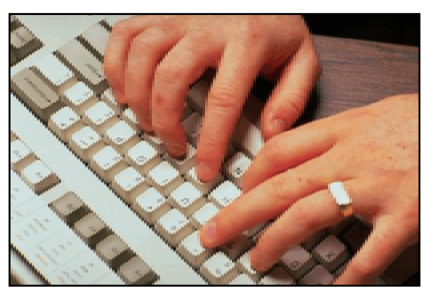

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EVENTS

1. NEAR MISS: POWERED AIR-PURIFYING RESPIRATOR MAY FAIL IF BUMPED

On February 19, 2003, in a high radiation and airborne contamination area at the Idaho National Engineering and Environmental Laboratory, a worker's powered air-purifying respirator (PAPR) failed, and the facepiece on his hood began to fog. The worker apparently bumped into something, knocking the charging port cover off the blower assembly, which caused the PAPR to shut off. No injuries or contamination occurred, but because of the loss of breathing air, this event constitutes a near miss to an intake. (ORPS Report ID--BBWI-TAN-2003-0002; update/final report filed April 3, 2003)

The worker was on top of a head tank vacuuming sediment. He and a co-worker were wearing Bullard® PA20 PAPRs (see Figure 1-1). When the power for the blower assembly shutdown, it caused a loss of filtered air to his hood. Following unsuccessful attempts to restore air flow, the worker left the area and was evaluated for contamination or injury.

Figure 1-1. A Bullard PA20 PAPR blower assembly

The blower assembly, which is worn around the waist at the small of the back, contains the power supply (battery), blower unit, filter, charging port, and on/off switch. It is important that the charging port cover be in place for the blower unit to operate because it completes an electrical connection.

A critique took place the next day. A point that was raised during the critique was that Bullard PAPRs, in use at Idaho since July 2002, lack a positive locking mechanism for the charging port plug. As a result, they have been known to come disconnected if bumped, shutting off the power unit. Workers who had experienced this before stated that they cycled the switch off and on to restore air flow. However, in this event, the worker was unable to restore air flow and was uncertain whether he should remove the hood or leave the contamination area when the facepiece began to fog.

Supervisory personnel acknowledged that the pre-job briefing failed to direct workers on emergency actions in the event of respirator failure. In this particular work evolution, the potential for this type of PAPR failure was increased due to the congested work area.

Critique members also identified concerns with the respirator training program. They determined that the training program does not include practice in donning and doffing respirators and that the training plan is not yet approved.

Site management issued a lessons-learned statement on the use of the Bullard PA20 PAPR. This statement can be found at the DOE Lessons Learned web site (URL http://www.eh.doe.gov/ll) under identifier 2003-INEEL-076. Site personnel will work with Bullard representatives on modifying the design of the PAPR so that the blower assembly is less likely to disconnect from the power unit when bumped. In addition, the training program and job safety analysis are being revised to include direction in PAPR use and evaluation of work areas to ensure that respiratory protection is appropriate for the task and the surrounding area.

DOE Standard DOE-STD-1098-99, *Radiological Control*, Article 533, "Use of Respiratory Protection," states: "Individuals using respiratory protection shall ...be trained to leave the work area when experiencing respirator failure; [and] ...be trained to remove their respirators to avoid lifethreatening situations when exiting an area after respirator failure [see 29 CFR 1910.134 and ANSI Z88.2]." This standard can be found at the following URL: http://www.eh.doe.gov/techstds/standard/std1098/std109899.pdf.

This event illustrates the importance of analyzing work areas before work begins to identify situations in which prescribed personal protective equipment may not work as designed. Workers should understand what actions to take when in an emergency situation. If a tool or piece of equipment cannot fulfill its design function, it should be evaluated for removal and replacement or modification.

KEYWORDS: *Powered air-purifying respirator (PAPR), high contamination area, breathing air*

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

2. MISLABELED CIRCUIT BREAKER CREATES WORKER SAFETY HAZARD

On February 24, 2003, at the Hanford Environmental Restoration Disposal Facility, an electrician performing a zero-energy check discovered an energized circuit he believed to have been locked and tagged out. A labeling error resulted in the wrong circuit breaker being locked and tagged out and independently verified. Because the zero-energy check revealed the error, no injuries or property damage resulted from this event. (ORPS Report RL--BHI-ERDF-2003-0001; final report filed April 9, 2003)

Electricians were preparing to replace a broken cover on a disconnect switch located in a manhole (Figure 2-1). The switch provides local isolation of power to a motor-operated valve (MOV). They installed a lockout/tagout on the circuit breaker labeled as supplying power to the MOV inside Manhole 24 before they started work. One of the electricians completed a confined space entry checklist, then entered the manhole. He noticed that the MOV indicator light was on and realized that the circuit was still energized. A zero-energy check, required by the lockout/tagout procedure, confirmed that the power was still on.

Work was stopped immediately, and a subsequent review of the as-built electrical drawings revealed that the breakers on the electrical panel were not labeled correctly. The equipment label for "Manhole MH-24 MOV" was installed on the circuit breaker for circuit #3A instead of circuit #13A (Figure 2-2 shows the labels that were switched). The electricians identified the correct breaker, locked and tagged out the circuit, performed a zero-energy check, and completed the repair.

Investigators learned that both lockout/tagout installers and work planners used the equipment labels on the circuit breaker for source information instead of the as-built electrical drawings. They also determined that the breakers had been installed and labeled during facility construction in 1998. The mislabeling was not discovered earlier because the breakers were not routinely operated. Workers normally used the disconnect switch adjacent to the MOV to isolate the power, but electricians had to isolate power at the circuit breaker to repair the switch.

Although acceptance testing was performed in 1998 to confirm that the system was consistent with the as-built drawings following installation, the labels were applied after the testing. Investigators determined that the labeling error resulted from the procedure not being followed correctly during label application. Electricians compared

Figure 2-1. Disconnect switch for motor-operated valve

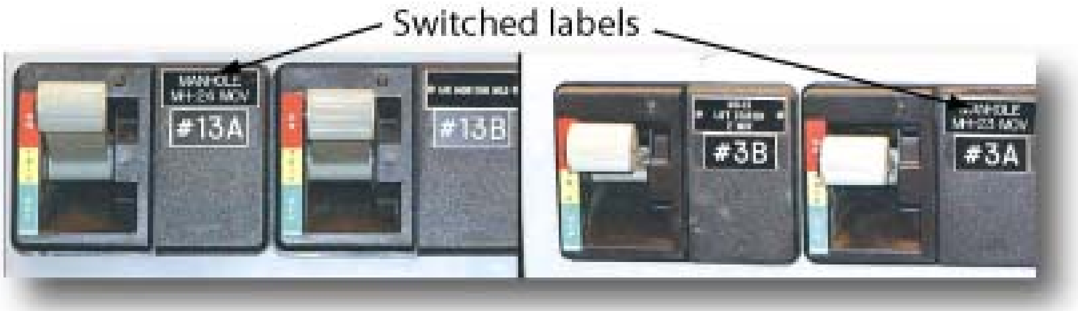

Figure 2-2. Corrected labels for breakers #13A and #3A

the as-built drawings with the labels in all the electrical panels to determine if others were mislabeled. They found no additional mislabeled circuits, but some labels had to be replaced because they were loose or had fallen off.

Corrective actions resulting from this occurrence include the following.

- Conduct self-assessments at other remedial action and waste disposal sites to ensure proper configuration control.
- Check all facility electrical panels against as-built drawings to ensure that the circuits are properly labeled.
- Ensure that there is a uniform label format, and re-attach or replace any missing labels.
- Prepare and disseminate a formal Lessons Learned report.

A search of the Occurrence Reporting and Processing System database for other events associated with mislabeled components revealed several other occurrences. On May 31, 2000, at the West Valley Plant, electricians were relocating electrical conduit and receptacles. A lockout/tagout was installed on the circuit breaker feeding the circuit identified on the receptacle to be moved. Before starting work the electricians noticed that pilot lights on a battery pack connected to the receptacle were still illuminated, indicating that the receptacle circuit was still energized. A subsequent investigation revealed multiple errors in the labeling of circuits and their circuit breakers. (ORPS Report OH-WV-WVNS-VFS-2000-0002)

On February 28, 1997, at the Rocky Flats Environmental Technology Site, electricians were directed to remove an existing 120-volt outlet in a building being decommissioned. The electricians installed a lockout/tagout at the local circuit breaker for the circuit identified by a brass tag on the outlet. A zero energy check performed at the outlet before starting work indicated that the circuit was still energized. Investigators determined that the brass tag on the outlet identified a different circuit from the one that included the outlet. (ORPS Report RFO--KHLL-NONPUOPS3-1997-0002)

Information on good practices in labeling equipment, components, and piping can be found in Chapter XVIII, *Equipment and Piping Labeling*, of Attachment I to DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities. This DOE Order can be accessed on the worldwide web at http://www.directives.doe.gov/serieslist.html*.

Also, valuable insights into how to avoid labeling problems are provided in DOE-STD-1044-93, *Guide to Good Practices for Equipment and Piping Labeling*, accessible at URL http://tis.eh.doe.gov/techstds/search/frame2.html.

These events underscore the importance of performing zero-energy checks before starting work on circuits that are assumed to be de-energized. Even for simple systems, a lockout/tagout that seems straightforward, properly installed, and verified can be ineffective if circuit breakers or electrical components are mislabeled. Also, the planning for lockout/tagout processes should rely on original sources (e.g., as-built electrical drawings) where possible, and should not rely solely on labels on circuit breakers or electrical components. The as-built drawings are the first line of defense in lockout/tagout planning, and the zero-energy check is the last line of defense. Both the drawings and the zero-energy checks are important; neither should *be omitted when preparing to work on electrical systems.*

KEYWORDS: *Lockout/tagout, mislabeled components, zero-energy check, as-built electrical drawings*

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

3. CATASTROPHIC FAILURE OF HOOK RESULTS IN NEAR MISS

On February 26, 2003, at the Idaho National Engineering and Environmental Laboratory (INEEL), an instructor applied excessive hydraulic force to a sling during a training demonstration, breaking a 60-pound hook holding the sling and propelling a 20-pound fragment to the other end of the test bed. The fragment penetrated the test bed's protective caging (Figure 3-1), struck and broke an overhead light, hit the building wall, and fell to the floor. The fragment did not strike any personnel, and no injuries resulted from this near-miss event. (ORPS Report ID--BBWI-CFA-2003-0006)

Figure 3-1. The torn protective cage

The instructor was demonstrating the effects produced when a sling is stressed to failure for equipment operators and another instructor. During the training session the instructor broke four smaller slings, then decided to test a 4-inch-wide, 1-inch-thick web sling rated at 43,000 pounds of load. This was the largest sling the instructors had ever attempted to break, and he did not realize it was rated 17,000 pounds greater than the hook. When the sling did not fail at its design load limit, the instructor continued to increase the hydraulic force. The hook failed when hydraulic pressure reached 127,000 pounds-force. Figure 3-2 shows the expelled hook fragment. After informing facility managers of the incident, equipment operators locked and tagged out the power to the sling test machine. They also locked and tagged power to the broken light fixture and roped off the area surrounding the debris.

The sling-test machine used at INEEL is a National Swage Sling Tester (Model CN-135) that can apply up to 270,000 pounds of load to a sling and is equipped with large, removable pins to attach slings for pull testing. Sometime before this incident, equipment operators attached hooks to the pins to make it easier to connect slings for testing. The hooks (manufactured by The Crosby Group) are approximately 19 inches high and 13 inches wide with a 6-inch eye. They weigh approximately 60 pounds and are rated at 26,000 pounds of pull capacity. Instructors were not aware of these ratings and assumed the hooks were stronger than the slings under test. The manufacturer does not supply hooks with the sling test machine, and their documentation contains no recommendations on using hooks to attach slings. Figure 3-3 shows the pin and hook arrangement used on the sling test machine.

Although the sling-break demonstration is not a part of formal sling-test training, investigators learned that it has become a common training practice at the facility. However, facility managers were not aware of the practice, and there is neither an approved procedure nor a formal training guide to direct the instructor's activities

Investigators determined that the hook failed as a direct result of the instructor applying hydraulic pressure that was significantly greater than the design load limit of the hook. They also identified four other factors that contributed to this near-miss event.

1. Equipment operators did not determine the rated load limits of the hooks before installing them on the sling-test machine. They as-

Figure 3-2. The expelled hook fragment

sumed the hooks were stronger than the slings being tested.

2. Equipment operators did not consult the original equipment manufacturer before installing the hooks. This resulted in a modification to the sling test machine that lowered its load-testing capacity.

3. Instructors were conducting destructive sling testing without using an approved procedure or training guide. Typically, these types of documents stipulate precautions and impose operating limits that are intended to prevent accidents from occurring.

4. Equipment operator instructors were conducting destructive sling testing without facility management knowledge or approval. Effective supervision and oversight may have prevented this accident from occurring.

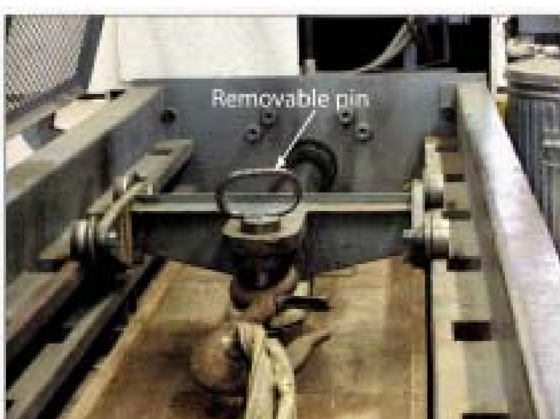

Figure 3-3. Arrangement of pin and hook

The following corrective actions were among those assigned at the post-incident critique to various facility personnel and managers.

- Review the incident and evaluate the need for testing slings to destruction.
- Evaluate the need to magnetically test accessories used with the sling tester.
- Conduct an independent review of the process for conducting sling testing using hooks instead of the installed pins, and review the need to prepare policies and procedures for safely operating the sling test equipment.
- Conduct a configuration management review to determine what accessories are acceptable to use with the sling tester and their impact on the machine's design load limits.
- With the help of subject matter experts, prepare and issue a lessons learned report for this event.

This event demonstrates the adverse consequences of installing components that do not satisfy the design requirements of the original equipment. The equipment operators inadvertently introduced an additional weak link when they attached the under-rated hooks to holding pins of the sling test machine. Equipment operators who were present when the hook broke narrowly escaped serious *injury. This event also illustrates the importance of using procedures that contain precautions and limits when operating industrial equipment. DOE guidance on testing slings and rigging accessories can be found in DOE-STD-1090-2001,* Hoisting and Rigging, *at the following URL: http://tis.eh.doe.gov/techstds/standard/standfrm.html.*

KEYWORDS: *Slings, sling testing, hook failures*

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

4. ELECTRICAL NEAR MISS CLEANING HVAC SYSTEM

On March 12, 2003, at the Hanford Waste Treatment Plant construction project, a craft sheet metal worker was vacuuming a heating, ventilation, and air conditioning (HVAC) unit when the metal wand of the vacuum cleaner damaged an energized wire for a compressor motor oil heater and shorted it to ground. The worker did not receive an electrical shock, but he saw an arc flash, heard a "pop," and knew a short had occurred. Multiple failures in the work control process, including an inadequate lockout/tagout installation and lack of knowledge about the electrical design of the HVAC unit, led to this incident. (ORPS Report RP-BNRP-RPPWTP-2003-0002)

Craft sheet metal workers were conducting monthly preventive maintenance on HVAC units. Work included changing the air filters, checking the motor oil level, performing a visual inspection, and vacuuming dust out of the units. During the pre-job briefing, work planners directed the sheet metal workers to use the manufacturer's circuit breakers inside the unit, instead of a site disconnect near the unit, to electrically isolate it. This decision was based in part on informal discussions work planners had with lockout/tagout personnel, who thought they were discussing a different HVAC unit. The work planners knew that isolating the circuit on the site disconnect would activate an alarm at the fire station because the circuit also supplied power to a smoke sensor. However, neither the work planners nor the workers knew that the manufacturer's circuit breakers isolated only part of the system or that an oil heater and a cooling fan remained energized.

Investigators determined that the HVAC unit is designed so that the circuit energizing both the oil heater and the cooling fan bypass the main circuit breakers for the unit. The oil heater was continuously powered by this circuit. When the metal vacuum cleaner wand struck the heater wiring located at the base of the HVAC compressor, it shorted to ground (see Figure 4-1). Investigators also determined that, although the cooling fan was not continuously energized, its operation was controlled by a thermostat. Had the thermostat reached its setpoint, the unguarded fan would have started up, creating another hazard to the workers.

Figure 4-1. Wiring that was shorted to ground

Investigators analyzed the work control deficiencies associated with the incident in terms of the first three Integrated Safety Management System core functions. Their analysis is as follows.

Define the Scope of Work – The work package and planning documents did not adequately define the scope of work. Work planners gave the craft sheet metal workers a one-page work card that addressed changing the air filters, checking the oil level, and performing a visual inspection of the equipment. The card did not address vacuuming because this was considered "skill-of-the-craft." This same work card had been used before without incident, but this time the workers used a metal wand on the vacuum cleaner, creating an unanticipated hazard. Also, the workers were vacuuming in proximity to fan blades that could have started moving at any time, and this hazard was not addressed in the work card. Figure 4-2 shows the HVAC compressor enclosure with the exposed fan blades.

Figure 4-2. Compressor with fan blades above

Analyze the Hazards – The hazards for this preventive maintenance work were not adequately identified and analyzed. The generic Job Hazards Analysis (JHA) identified only outdoor work, electrical shock, and rigging hazards. These hazards were not addressed in terms of the specific work activity because the work scope was not well defined; in fact, this task involved no rigging work. The JHA referred the workers to a lockout/tagout procedure, but did not address whether locking and tagging out the circuit was required. Job-briefing notes based on the JHA indicated that the lockout/tagout requirement applied to the electrical power source for the HVAC unit. A responsible safety authority did not review or approve the JHA.

Develop and Implement Hazard Controls – Site lockout/tagout personnel were not formally asked to evaluate the need for a lockout/tagout, so they did not examine the HVAC wiring diagrams. In addition, a competent authority did not evaluate the method used to protect workers from electric shock hazards. Also, there was no discussion about controlling mechanical hazards from the fan, which could have become energized. Lockout/tagout personnel should have reviewed and approved the process proposed for de-energizing the equipment, examined the electrical drawings, and walked down the equipment.

Lockout/tagout deficiencies across the DOE complex in recent months were summarized in an article in Operating Experience Summary 2003-06, published March 24, 2003, titled *Lockout/Tagout Violations and Lessons Learned*. This article described the frequency and characteristics of the recent lockout/tagout events and provided lessons learned from examining the events and their causes. In addition to a list of six specific lessons learned gleaned from recent events, the article also includes a list of nine "Lockout Traps and Pitfalls," including such topics as inadequate facility design data, component labeling problems, departure from standard lockout practices, and schedule pressures.

These events underscore the need to develop and apply effective work planning and work control processes in the interest of maintaining a high level of safety assurance for workers. The manufacturer's circuit breakers inside the Carrier™ HVAC unit (Model Number 50HJQ016-610PC) involved in this event de-energize only one of the two power sources to the unit. Facility managers and workers who are responsible for maintaining these or similar units should review the wiring diagrams for internal circuits that bypass the main circuit breakers and take appropriate precautions when working on the units. Work planning and work control processes should be patterned after the five core safety management functions defined in DOE Policy 450.4, Safety Management System Policy.

KEYWORDS: *Electrical safety, lockout/tagout, HVAC electrical design, energized circuits*

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

5. *HYDRAULIC SHEAR FAILURE CAUSES WORKER INJURY*

On April 8, 2003, at the Savannah River Site, the blade of a handheld hydraulic shear blade failed and struck a nearby construction worker in the chest and face. The worker received sutures in the chest and chin. (ORPS Report SR--WSRC-FDP-2003-0001)

The operator of the hydraulic shear was cutting a lid hinge bracket (shown in Figure 5-1) with a Centaur™ Rescue Tool (Model CEN C9), also known as the Jaws of Life for its use in extricating people trapped in motor vehicles. The tool can generate cutting forces up to 99,000 pounds. The manufacturer specifies that the tool can be used only in a perpendicular position to the item it is cutting. Holding the shear at another angle can cause the cutting jaws to separate, resulting in metal fracturing of the steel blades. This shear was used previously in another facility to cut metal hangers that hung vertically, and no failures or projectiles were reported.

Figure 5-1. The lid and hinge bracket

The operator had difficulty accessing the hinge bracket to cut it, so he was not holding the shear perpendicular to the bracket. The blade fractured, and a piece struck the construction worker, who was standing 14 feet away. The broken shear is shown in Figure 5-2. The construction worker was examined at the site medical facility, then transported offsite for treatment.

Figure 5-2. The broken shear and blade fragment

The vendor, manufacturer, and site subject matter experts examined the tool to determine the reason for its failure and to assist in developing corrective actions. Some of the corrective actions that are under consideration include using an energy blanket to catch projectiles and revising the hazard analysis to require a review of the manufacturer's recommendations on proper tool use. In the meantime, all work involving this model of hydraulic shear was suspended.

The site published a Yellow Alert on this event on the Society for Effective Lessons Learned Sharing (SELLS) web site. This alert can be retrieved at URL: http://tis.eh.doe.gov/ll.

This event illustrates the importance of using tools in accordance with manufacturers' specifications. Failure to do so can cause the tool to fail and present the potential for injury.

KEYWORDS: *Hydraulic shear, metal fracture, injury*

ISM CORE FUNCTIONS: *Analyze the Hazards, Perform Work within Controls*