Office of Environment, Safety and Health • U.S. Department of Energy • Washington, DC 20585

OPERATING EXPERIENCE SUMMARY

Office of Environment, Safety and Health

Summary 2001-11

December 3, 2001

The 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.

To issue the Summary in a timely manner, EH relies on preliminary information such as daily operations reports, notification reports, and, time permitting, 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 Frank Russo, 301-903-1845, or Internet address Frank.Russo@eh.doe.gov, so we may issue a correction.

The OE Summary can be used as a DOE-wide information source as described in Section 5.1.2, DOE-STD-7501-99, *The DOE Corporate Lessons Learned Program*. Readers are cautioned that review of the Summary should not be a substitute for a thorough review of the interim and final occurrence reports.

Operating Experience Summary 2001-11

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EVENTS

1. UNEXPECTED LASER BEAM REFLECTION CAUSES EYE INJURY

On October 29, 2001 at Argonne National Laboratory–East, a researcher working in the chemistry laser laboratory sustained an eye injury from the reflected beam of a Class IV (highest energy) laser system. The researcher was not wearing protective eyewear, and sustained a small burn to his retina. He was transported to the LaGrange Hospital for an initial examination, followed by a more thorough examination by an ophthalmologist. (ORPS Report CH--AA-ANLE-ANLECHM-2001-0001)

Two researchers, a graduate student and a visiting scientist with more than 15 years of experience working with lasers, were working in a chemistry laser laboratory with a Class IV multiple-laser system operating at full power. The researchers were experiencing instability in the beam of their femtosecond (10^{-15} second pulse frequency) titanium-sapphire laser system. This instability not only complicated experimental efficiencies, but also created a potential safety issue because the beam could wander sufficiently off-axis and strike a mount, causing a specular reflection (as from a polished metal mirror). While replacing a mirror element, one researcher heard a noise that the other researcher did not hear. The first researcher left the laboratory and found he had trouble reading a sign with his right eye. It was later determined that the researcher had sustained non-reversible damage to the retina of his right eye.

Three main causes for the accident were recognized. First, the laser was operating at full power during a major mechanical manipulation of the optics. Second, appropriate laser eyewear was not being worn, in violation of laboratory procedures. Third, the staff failed to consider all potential sources of hazardous eye exposure during major repositioning of an element in their work planning for the adjustment of optical elements.

After conducting a review of this incident, a laser review group presented the following proposed change to the optics alignment procedure, and this change was accepted by the Chemistry Laser Safety Committee. The optics that were to be aligned would be pre-aligned to approximate positions while the laser is blocked. Wearing the proper eyewear and using the infrared viewer, personnel would unblock the beam and determine its trajectory. Because two hands are needed to adjust the optics, a head-mounted infrared viewing device was purchased so that the researcher would have adequate eye protection while viewing the laser beam and manipulating the optics.

The major lesson learned from this incident is that all personnel involved in performing laser beam alignments must wear eyewear that is rated for the wavelength and optical density of the laser. During laser system alignments the potential accident consequences dictate that safety considerations be the primary concern. Laser Safety Officers should be consulted for difficult alignments, because they have a broad range of experience and can perform an independent appraisal of the proposed work procedures.

On February 5, 1999, at Los Alamos National Laboratory, a laboratory employee received a laser burn to his left eye from a diffusely reflected beam from a Class lV titanium-sapphire laser. . The employee's left eye suffered a permanent retinal periphery burn. Fortunately, the damaged area of the retina measured only 0.1 millimeter, and no loss of visual acuity occurred. The employee and another employee were replacing optics in a pre-existing optical train external to the laser. Neither wore protective goggles, as required by a special work permit. The second employee was not injured. (ORPS Report ALO-LA-LANL-FIRNGHELAB-1999-0001)

The American National Standards Institute (ANSI) Standard Z136.1-1993 defines a Class I laser as the least hazardous, and a Class IV laser as the most hazardous. The standard provides guidance for the safe use of lasers and laser systems by defining hazard control measures for each of the four laser classes.

Control measures for working with lasers include (1) engineering controls, such as beam housings, interlock systems, beam shutters, and attenuators; (2) administrative controls, such as procedures, warning signs, labels, and training; and (3) personal protective equipment, such as eyewear, gloves, and special clothing. This standard is endorsed in part by DOE O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, attachment 2, the Contractor Requirements Document.

These occurrences highlight the need for compliance with procedures and related safety practices when working with lasers. When personnel must work near exposed laser beams, extra precautions should be taken to avoid scattering the beam, especially with Class IV lasers, which can cause severe eye damage, skin burns, and ignite combustible materials. If the option is available, such lasers should be operated at reduced power levels when aligning optics or when there is a risk of eye exposures.

KEYWORDS: *Laser, eye injury*

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

2. TYPE B INVESTIGATION OF WORKER BURNED BY HOT WATER

On September 7, 2001, an Oak Ridge National Laboratory worker was burned by the accidental spray of hot water from a tunnel washer at Building 9210 (the "Mouse House") at the Y-12 Plant. The worker suffered burns to her legs, feet, and wrist, and was hospitalized for more than a week. The Oak Ridge Operations Office conducted a Type B investigation of the accident. (ORPS Report ORO--ORNL-X10ATY12-2001-0006)

Figure 1. Tunnel washer and carts with cages and cage tops

The tunnel washer, shown in Figure 1, is used to clean animal cages and laboratory equipment that are passed through it on a conveyer belt while being sprayed with hot detergent or rinse water. Prior to the accident, the worker was working alone, cleaning pans, cage tops, and beakers. As she tried to move clean items through a narrow pathway between the washer and cages and cage tops stored next to the washer, either she or the cart she was using bumped into a filter assembly for the washer. This opened a latch holding the end cap for the filter assembly, and the worker was sprayed and scalded by water heated to 194º F and under 30 to 40 pounds per square inch (psi) of pressure.

No one heard the worker's initial cries. The worker left the room unassisted as hot water continued to spray from the filter assembly and collapsed in the hallway, where she was found wet from mid-torso to feet. She sustained first- and second-degree burns to 20 percent of her body. The most severe burns were to the lower part of her legs, particularly where her socks had become soaked in hot water.

The investigation board concluded that the direct cause of the accident was the inadvertent opening of the filter access assembly. The end cap on the assembly was a last physical barrier containing the hot pressurized water, and the latch holding it in place could be opened by just 10 pounds of force (see Figure 2).

Investigators determined that the filter assembly and other hot water components could have been installed away from work areas. The current latch and cover configuration, installed in 1997, appears to have been selected for ease of access for maintenance rather than worker safety.

Figure 2. End cap and latch for filter assembly

Other hazards and weaknesses found in the investigation include the following.

- The workspace around the washer was overcrowded with carts and tables holding equipment waiting to be washed. No one was responsible for controlling the storage of cage tops from the time they were collected to the time they were cleaned.
- The 194º F temperature of the wash water exceeded laboratory guidance, which stated that a water temperature of 143º F to 180º F was sufficient for washing.
- There was no automatic cutoff to stop leakage from the filter assembly.
- There were no emergency alarms to report such leakage to others outside the room.
- The potential hazards posed by the equipment were not identified and controlled prior to procurement, at installation, or during operation.
- Line management failed to recognize the need for professional safety and health staff to review the design and installation of high-temperature, high-pressure equipment.

Further information on this accident and its investigation are found in DOE/ORO-2121, *Type B Accident Investigation Board Report of the UT-Battelle, LLC, Contractor Employee Injuries from a September 7, 2001 Burn Accident at the Oak Ridge National Laboratory*, October 2001. Type A and B accident reports can normally be accessed through the DOE Accident Investigation Program website (http://tis.eh.doe.gov/oversight/missions/air/air_overview.html), although this access is currently unavailable. In the interim, contact Dennis Vernon at (301) 903-4839 for copies of reports.

3. ELECTRICAL SHOCK RESULTS FROM INADEQUATE LOCKOUT/TAGOUT AND SAFE ENERGY CHECKS

On October 6, 2001, at the Hanford Spent Nuclear Fuels Project, an electrician received a 550-volt electrical shock from a moisture detector and alarm circuit while disconnecting electrical leads to remove a pump at the 105KW Basin. The moisture detector and alarm circuit were not properly isolated. The electrician was transported to a local hospital for evaluation and released without restrictions the same day. (ORPS Report RL--PHMC-SNF-2001-0044)

Workers were in the process of removing the Integrated Water Treatment System Pump, which required disconnecting the electrical wiring to the motor. The work package provided no direction on lockout/tagout, but gave instructions on where to perform wire disconnects. The pump motor had already been electrically tagged out for the mechanical portion of the work by a single circuit breaker at a motor control center. Two shift operations managers performed technical reviews to authorize the electrical work tagout. They both used the same electrical drawing, which showed the pump and two peripheral leads; one appearing to be a switch, and the other indeterminate (later determined to be a moisture detector and alarm circuit). The drawing indicated that the pump motor and switch were powered from the existing tagged-out breaker, while the indeterminate leads were shown terminating at a symbol represented by a diamond with a circle in it. The shift managers released the work package after erroneously assuming that the indeterminate load was powered from the same motor control center breaker and that the existing tagout was adequate.

Prior to starting work, the electrician performed safe energy checks by verifying that no power was present downstream of the tagged-out motor control center breaker. The electrician also assumed that all power to the pump originated from the tagged-out breaker. The electrician then went to the specified junction box to disconnect the wires. Inside the box were wires that were butt-spliced and, therefore, no bare wires were exposed. The electrician removed the insulation from the butt-splice and cut through the splice without making safe energy checks before cutting the wires. He first removed the power leads to the motor without incident. Then he moved to the moisture detector and alarm circuit wires. Although he began work wearing insulated gloves, the electrician removed them because the detector and alarm circuit leads were smaller than the motor wires, and needed additional dexterity. While the electrician was attaching identification tags to the wires, he accidentally touched the junction box, completing a circuit and receiving a shock. He alerted his partner, who measured 550 volts on the wire.

A formal root cause analysis was performed on the event. The analysis determined the root cause to be a combination of inadequate drawings and inadequate training of the shift operation managers on reading the drawings. A contributing cause was poor conduct of maintenance by the electrician in the method used to perform safe energy checks.

The drawing did not include a legend that explained what was meant by a diamond with a circle in it. A second drawing (not used in determining tagout) showed the moisture detector and alarm circuit leads going to a transformer that was powered from a 110-volt source. Had the drawings clearly illustrated this, the shift operation managers could have determined that an additional tagout was necessary. Also, the shift operation managers were not sufficiently trained on reading electrical drawings to understand the unclear termination of the moisture detector and alarm circuit wiring on the drawing they used. Finally, had the electrician performed safe energy checks in accordance with expectations (i.e., rather than simply checking the load side of the tagged-out breaker, also checking the wires after removing the insulation prior to cutting), he would not have received an electrical shock.

Although final corrective actions have not been determined for this occurrence, certain lessons learned can be derived from this incident.

- Electrical tagouts should not be established using electrical drawings that are unclear or confusing.
- Persons not sufficiently trained in how to properly interpret the symbols used in electrical drawings should not prepare electrical tagout instructions.
- Safe energy checks should include all wires to be worked, and personnel performing them should not presume that one isolation point isolates all wires. If leads are insulated, safe energy checks should be performed when the insulation is removed and prior to cutting the leads.

KEYWORDS: *Electrical, lockout/tagout, electric shock*

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

4. LANL EMPLOYEE FALLS THROUGH FALSE CEILING

On October 15, 2001, at the Los Alamos National Laboratory (LANL), a facility engineer working in a laboratory space at the Materials Science Complex, fell through a false ceiling from a height of 12 feet and broke bones in both ankles (See Figure 1). The engineer was taken to the Los Alamos Medical Center, treated, and released the same day. (ORPS Report ALO-LA-LANL-MATSCCMPLX-2001-0004)

Although the site has a generic work plan that identifies hazards involved in working from elevated surfaces, this space was not posted as requiring fall protection. At the time of the accident, the facility engineer was collecting equipment nameplate data for a preventive maintenance program in a high bay workshop that had been converted into laboratory space. The laboratory space has a false ceiling made up of 2-foot by 3-foot ceiling tiles, and the area above the false ceiling contains facility heating and cooling systems, ventilation equipment and ducting, and electrical conduit.

Figure 1. Photo showing missing ceiling tile through which worker fell

The ceiling area is locked and controlled to limit access. In order for personnel to reach equipment in this area, plywood walkways two feet wide and wood board walkways 10 inches wide were installed (See Figure 2). The employee has stated that, just before the fall, he was backing up onto a 10-inch wide walkway after checking a nameplate. He misstepped onto a ceiling tile and fell through it, landing on the floor in a hallway 12 feet below.

Figure 2: General view of walkways of area above false ceiling

The facility representative indicated that the engineer was alone at the time of the incident, without fall protection, and that the walkways did not comply with OSHA requirements such as installed toe boards and handrails. Management reportedly did not realize that this space did not meet the OSHA requirements, and the incident presented the potential for a more serious injury. The U.S. Department of Labor, Bureau of Labor Statistics data indicate that there were 640 fatalities from falls in the workplace during the year 2000. The facility representative also stated that there could be other spaces at LANL with similar conditions.

Corrective actions underway include the following:

- securing the area until adequate planking is laid above the false ceiling that complies with OSHA requirements,
- surveying other areas for the existence of similar conditions , and
- disseminating lessons learned information on the event through meetings, news bulletins, and management councils

Working in ceilings, crawlspaces, and attic areas can be dangerous. In some cases, these areas may not be designed with provisions to support personnel who might have to access them to perform work. Also, the wearing of fall protection may not always be possible in confined spaces because ropes could become tangled with installed equipment (e.g., conduit, pipes, ducting) and adequate tie-off points may not be available. Workers need to understand the hazards and be aware of their surroundings and their footing as noted by the following near-miss events.

- On November 26, 2001, at the Mound Plant Tritium Facilities, a radiological control technician working in a ceiling crawl space stepped on a ceiling light fixture, pushing it out, and fell through the opening up to his chest. He suffered abrasions to his abdomen. The technician stepped off a catwalk onto what he believed was a pipe. The area above the ceiling was not lighted. (ORPS Report OH-MB-BWO-BWO01-2001-0012)

- On June 7, 2001, at the Los Alamos National Laboratory Waste Management Facility, a radiological control technician taking smears inside a storage trailer, fell approximately 4 feet from the back of the trailer when he inadvertently stepped out the back of the trailer. He broke his right arm between the shoulder and the elbow. (ORPS Report ALO-LA-LANL-WASTEMGT-2001-0008)

- On March 27, 2000, at the Oak Ridge Research Reactor Facility, an electrician performing maintenance in an elevated space above a ceiling stepped off a plywood walk-board and his leg penetrated a particleboard floor and a ceiling tile up to his thigh. He sustained a minor scrape to his knee. (ORPS Report ORO--BJC-X10ENVRES-2000-0007)

- On March 24, 2000, at the Mound Plant Tritium Facilities, a radiological control technician working in a ceiling crawl space stepped on a recessed light fixture (pushing it out) and fell through the opening, catching himself with his arms. He scraped and bruised his leg and sides. The ceiling was 9 feet above the floor. (ORPS Report OH-MB-BWO-BWO01-2001-0012)

These events underscore the need for work planning that considers the hazards of working from elevated work surfaces and for effective management safety oversight that identifies and eliminates fall hazards when practicable.

KEYWORDS: *Elevated surfaces, fall protection*

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

5. NON-SPARKING TOOLS SUBJECT TO BERYLLIUM SURFACE CONTAMINATION

On November 13, 2001, at the Oak Ridge National Laboratory (ORNL) steam plant, an industrial hygienist inspected two sets of non-sparking beryllium copper tools in response to a Lessons-Learned Alert about such tools at the Oak Ridge Y-12 Plant. He found that all tools and interior toolbox surfaces had levels of removable beryllium contamination exceeding DOE's release criterion specified in 10 CFR 850, "Chronic Beryllium Disease Prevention Program." Beryllium contamination on tools has since been found at the ORNL fire department. The non-sparking beryllium copper tools used at Y-12 and ORNL are commonly available and used, indicating that similar beryllium contamination issues may be widespread. (ORPS Report ORO--ORNL-X10UTILITY-2001-0002).

Figure 1. New hammer at Y-12 Plant with beryllium contamination at 1.5 micrograms/100 cm^2

Maintenance in areas of fire or explosive hazards such as near natural gas lines requires the use of non-sparking tools.

Beryllium-copper alloys have been widely used to make non-sparking tools such as wrenches, hammers, and axes. "BeCu" is often stamped on them (see Figure 1). A small percentage of beryllium in the alloy hardens the copper and adds corrosion resistance.

Recently, industrial hygienists at the Y-12 Plant found that most surface swipe samples of beryllium-copper tools had beryllium contamination above the 0.2 micrograms/100 cm^2 release criterion set by 10 CFR 850.31(b)(1). DOE's beryllium rule established that criterion for equipment to be released to the general public or to be used in non-beryllium DOE facilities. Tools with oxidized surfaces had the highest contamination levels (see Figure 2). Ampco Metals and NGK Berylco Metals are two manufacturers of the beryllium-copper tools sampled at the site. Y-12 Plant managers have decided to replace what beryllium-copper tools they can with tools of other non-sparking materials, and will dispose of the old tools on site. When suitable tool replacements cannot be found, such as when the material hardness of beryllium copper is needed and cannot be provided by other alloys, the existing tools will be stored and used with new precautions. A Lessons-Learned Alert based on this discovery was sent throughout DOE in August 2001. (DOE Lessons Learned Database, No. Y-2001-OR-BWXTY12-0801)

ORNL industrial hygienists implementing these lessons learned found that non-sparking tools at the ORNL steam plant and fire department had similar surface contamination. The highest level recorded was 33.5 micrograms/100 cm^2. NGK Berylco Metals was one of the manufacturers of the tools.

Figure 2. Oxidized wrenches found at the Y-12 Plant with beryllium contamination levels of 2.98 micrograms/100 cm^2 (above) and 21.0 micrograms/100 cm^2 (below).

The ORNL and Y-12 discoveries demonstrate that common non-sparking tools made of beryllium-copper alloy can have levels of removable beryllium contamination that exceed the 10 CFR 850.31(b)(1) release criterion. The actual health significance of this type of beryllium contamination may not be determined until the potential for beryllium uptake from such tools is established. However, organizations using beryllium-copper tools should be aware that they pose a potential widespread regulatory non-compliance problem.

KEYWORDS: *Beryllium, beryllium contamination, non-sparking tools, lessons learned*

ISM CORE FUNCTION: *Provide Feedback and Continuous Improvement*