OPERATING EXPERIENCE SUMMARY

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OE Summary 2003-09

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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.

To issue the Summary in a timely manner, EH relies on preliminary information such as daily operations reports, notification reports, and conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Frank Russo, 301-903-1845, or Internet address Frank.Russo@eh.doe.gov, so we may issue a correction.

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Operating Experience Summary 2003-09

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EVENTS

1. FIRES IN LABORATORY FUME HOODS

Fume hoods are engineering barriers that protect laboratory personnel by removing vapors, gases, and dusts of toxic, flammable, and corrosive materials. Laboratory fume hood fires and explosions (OE Summary 2003-07) can result in significant damage to the hood and its contents and collateral damage to the general lab area, as well as personnel injury. Fortunately, these types of events are not a frequent occurrence, with only ten events reported in ORPS since the beginning of 2000. However, four events involving sustained fires and flashes have occurred during the past 5 months. The following is a summary of two recent events that resulted in damage.

On March 22, 2003, at the Pacific Northwest National Laboratory, a researcher arrived at work and discovered a small fire in a fume hood. The researcher put out the fire with a portable fire extinguisher and unplugged a laboratory hotplate that seemed to be the source of the fire. (ORPS Report RL--PNNL-PNNLBOPER-2003-0004)

In addition to the hotplate, the fume hood contained small plastic containers of natural uranium, which were damaged. Other items in the hood included a balance; small oven; garbage container; analytical balance; sieves; liquid containers; and a sample beaker. There was little damage to the hood, with most of the damage occurring to the contents (Figure 1-1).

The researcher had left a beaker containing an aqueous solution of water, trace amounts of natural uranium, and an organic buffer of tris (hydroxymethyl) aminomethane on the hotplate the night before, but the hotplate was turned off.

Preliminary inspection by investigators indicates that the fire may have been caused by a malfunction within the hotplate (Figure 1-2). Both switches on the hotplate were in the off position, but the researcher noticed that one of the lights on the hotplate was illuminated when

Figure 1-1. Fire damage within the fume hood

she discovered the fire, indicating that the hotplate was energized.

On December 27, 2002, at the National Renewable Energy Laboratory (NREL), maintenance personnel discovered a fire in a chemical fume hood. The fire was contained within the hood, but some smoke and soot entered the lab area before the fire self-extinguished. Firefighters ensured the fire was out. There were no injuries, and damage was limited to the fume hood and its contents. (ORPS Report GO--NREL-NREL-2002-0001)

On the day of the fire, a senior scientist had transferred pipettes containing a pyrophoric liquid, believed to have been inerted, from an inerted glovebox into the left-front area of the fume hood (Figure 1-3) next to some Kimwipes®

Figure 1-2. Damaged hotplate and beaker

Figure 1-3. Left-front area of the hood

(absorbent towels) moistened with methanol and hexane (a highly flammable liquid). Established procedures require these materials to be segregated. The fire started approximately 20 minutes after the scientist left the lab.

Investigators believe that once the fire started, it quickly heated a plastic squeeze bottle containing hexane causing it to be expelled from the container and ignite. This produced a dramatic flare-up of the fire, which consumed a squeeze bottle containing methanol, generating sufficient heat to ignite other plastic bottles, trays, hoses, and tubing in this area of the hood. A removable access panel on the left side of the hood fell out, allowing an influx of air to push the intense heat and flames toward the right side of the hood near a heating mantel and hot plates, igniting process tubing and hoses (Figure 1-4).

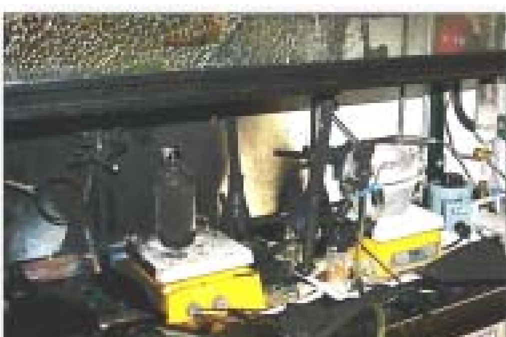

Figure1-4. Hot plates and equipment

Investigators theorized that the most likely cause of the fire was a delayed reaction involving an unreacted pyrophoric liquid, tris-(trimethylsilyl)phosphine (TTMSP), which was inside one or more of the pipettes. To validate this theory, they staged a test to reproduce the ignition scenario. Under carefully controlled conditions, 0.5 ml of TTMSP was drawn into a pipette inside the glovebox and some of the solution was deposited on a Kimwipe. These materials were placed inside an inerted transfer container to prevent ignition, then transferred to an empty chemical fume hood for the test.

As soon as the container was opened, the Kimwipe ignited, but the liquid inside the pipette was still visible, and some observers believed it was no longer reactive. However, when some of the liquid was expelled from the pipette and came in contact with the air, a vigorous "jet flame" erupted from the pipette. Although brief in duration, the flame ignited the remaining sections of the partially burned Kimwipe. Based on the results of this test, investigators believe this type of reaction was the most likely cause of the fire.

Investigators also determined that there have been inconsistencies by researchers in the inerting and transfer process for pyrophoric materials because there is no formal written procedure for the process. This will be corrected by revising the laboratory safe operating procedure to include a written procedure for inerting and transfer that includes redundant inerting steps. Other corrective actions from this event included the following.

- Require the use of covered stainless steel isolation containers for the storage of pipettes and syringes.
- Replace plastic secondary containment trays with non-combustible trays.
- Provide high-walled stainless steel containment trays for storage of plastic squeeze bottles containing flammable liquids.

The Office of Environment, Safety and Health encourages the proper storage and segregation of flammable materials within fume hoods. Although housekeeping and cleanliness were not identified as an issue in either of these events, they are also important safety practices. A cluttered work area can affect air flow and hamper the ability to work safely. It is also important to minimize the amount of combustible materials in the area because of the use of burners, hotplates, and ovens that provide ignition sources. Figure 1-5 is an example of an accident waiting to happen.

Figure 1-5. Example of poor housekeeping

In addition to housekeeping issues, the following general fume hood safety rules should be practiced.

Fume Hood Safety Practices

- Check the hood air flow before and during use.
- Do not use perchloric acid in a fume hood unless the hood is specifically designed for this purpose.
- Do not use the hood as a storage cabinet for chemicals.
- Place heat-generating equipment in the rear of the hood.
- Always wear personal protective equipment; fume hoods do not prevent accidents or chemical splashes.
- Keep the sash face clean and clear.
- Keep the sash at the proper height and, if procedures allow, close it when finished or when leaving chemicals or experiments unattended.
- Ensure items within the hood do not block or disrupt air flow.
- Remove all unnecessary materials (especially containers of waste or solvents) when conducting experiments.
- Minimize fire hazards within the hood.
- Ensure that a functioning portable fire extinguisher is readily available.
- Periodically review laboratory procedures for responding to fires and other emergencies.

These events underscore the importance of ensuring laboratory fume hoods are maintained in proper working condition, experiment procedures are developed and followed, and laboratory safety rules are adhered to, including the use of appropriate personal protective equipment. Also, conducting controlled tests similar to that performed by the investigators at NREL can be a valuable part of the investigation process for determining the cause of an event.

KEYWORDS: *Fire, fume hood, chemical hood, laboratory*

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

2. ENERGIZED POWER LINE DAMAGED DURING EXCAVATION

On April 2, 2003, at the Spallation Neutron Source (SNS) construction site in Oak Ridge, Tennessee, a trackhoe struck an energized 277-volt electrical line, damaging it and pulling the conductor out of a circuit breaker box. Buried utilities in the excavation area were not identified, located, or marked because excavators did not obtain a permit before work began, in violation of site procedures. There were no injuries and no significant impact on other construction activities at the site. (ORPS Report ORO--ORNL-X10SNS-2003-0001)

Construction drawings identified the location of the electrical line, which was buried approximately 12 feet below grade. If an excavation permit had been requested and reviewed, this event could have been prevented. Although the circuit breaker did not trip, the conductor was damaged when the trackhoe pulled it from the circuit breaker box. Site management took disciplinary action against the workers and supervisors who did not following safe work procedures.

Investigators determined that the task supervisor and excavators involved in this event had reviewed and signed a job hazard analysis (JHA) before work began, which properly identified the hazards associated with the work and specified the requirement for an excavation permit. The permit requirements included the following.

- Identify and locate all utilities, using as-built drawings and other tools and equipment as necessary.

- After marking, de-energizing, and locking out the affected lines, determine the actual physical locations of the lines by hand-digging.

- When the lines have been physically located, they can be re-energized until the mechanical excavation equipment comes within 5 feet of the line.

- When the 5-foot zone is reached, de-energize the line and lock it out before continuing excavation.

The direct and root causes of this incident have been categorized as personnel error (procedure not used or used incorrectly). Investigators determined that subcontractor personnel did not follow the required excavation permit process or its associated procedures. Apparently the person who should have requested the excavation permit decided to begin excavating without it. When investigators questioned him, he said that he decided on his own to proceed without a permit and provided no rationale to support this decision.

Corrective actions resulting from this occurrence are expected to include the following.

- Each subcontractor will designate a competent individual to prepare and present requests for excavation permits signed by contractor superintendents.

- Subcontractor superintendents will certify by their signatures on the permits that they have reviewed current, red-lined drawings for underground electrical and mechanical utilities.

- All installations of underground electrical and mechanical utilities must be reviewed for documentation by a resident engineer/inspector before they are covered.

- When excavation permits are closed out, subcontractors must provide redline mark-ups of affected drawings showing the conditions that were changed.

- Affected workers and supervisory personnel will receive training on these corrective actions and other related changes.

This event is the most recent in a series of similar events at the SNS construction site, dating back to September 21, 2001. On that date, a construction subcontractor digging fence post holes with a power auger struck and severed an energized 120/240-volt electrical conductor, causing a 4-hour power outage at an administrative trailer. (ORPS Report ORO--ORNL-X10SNS-2001-0001) On February 12, 2002, a construction subcontractor using a trackhoe to slope the sides of an excavation struck and damaged an energized 120/240-volt electrical conductor. The subcontractor did not obtain an excavation permit. (ORPS Report ORO--0RNL-X10SNS-2002-0001) On April 29, 2002, a construction subcontractor using a trackhoe to dig a trench to bury electrical conduit struck and damaged an energized temporary electrical line. (ORPS Report ORO--ORNL-X10SNS-2002-0003) On November 15, 2002, a construction subcontractor using an excavator to assist in dirt removal from a hand-digging operation struck an energized temporary 240-volt electric line with the bucket of the excavator and severed the line. (ORPS Report ORO--ORNL-X10SNS-2002-0004)

No injuries resulted from any of the five electrical intrusion events at the SNS construction project cited above. A comparison of the causative factors described in the five ORPS reports revealed that the direct cause for all five events was categorized as personnel error, either (1) procedure not used or used incorrectly or (2) inattention to detail. Another common theme for these five events was that the contractor did not provide adequate oversight of the subcontractor. The corrective actions resulting from these events focused on training and on strengthening the processes and procedures related to excavation permits; the lockout/tagout process; identifying, locating, and marking buried utilities; and related matters.

The Office of Environment, Safety, and Health issued a report entitled *A Review of Electrical Intrusion Events at the Department of Energy: 2000-2001* in June 2002. It is available at http://tis.eh.doe.gov/paa/reports.html. A lessons-learned report on this topic (HQ-EH-2002-01) can be accessed from the website for the Society for Effective Lessons Learned Sharing at http://tis.eh.doe.gov/ll/listb.html. Another useful reference for information on avoiding buried utilities is chapter 5, "Excavation Task Team Best Practices," of the Common Ground Alliance Report *Study of One-Call Systems and Damage Prevention Best Practices,* dated August 1999. This report is accessible from http://www.commongroundalliance.com/docs/s8/p0002/090499_composite.pdf.

These events underscore the need for continued vigilance in avoiding intrusions into energized electrical conductors. Basic procedural requirements, such as seeking an excavation permit, should be followed at all times. This event and previous similar occurrences at the site point out the need for (1) providing adequate oversight of subcontractors and (2) sharpening the focus on the processes and procedures required for identifying, locating, and marking buried utility lines. However, even if these processes and procedures are improved, they can be negated by an individual's decision not to seek an excavation permit. In a larger context, beyond the excavation permit problem, the corrective actions identified from the earlier events at the site, if followed, would have prevented this occurrence. A way must be found to improve the "staying power" of corrective actions identified after such occurrences.

KEYWORDS:
Electrical intrusion, backhoe, excavation, damaged electrical lines, lockout and tagout, electrical safety

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

3. BOLT BAG CONTENTS DROP FROM TOWER CRANE INTERNAL HOIST

On April 16, 2003, at the Hanford Waste Treatment Plant construction site, a carabiner holding a bolt bag opened, dropping the bag 60 feet from a tower crane platform and spilling its contents, including a scrap piece of angle iron. The piece of angle iron struck a support member about 20 feet above the ground as it fell, bounced outside of the tower cross-section, and landed on the roof of a temporary structure occupied by three workers. The remaining contents fell to the ground near the base of the crane, and no one was injured. (ORPS Report RP--BNRP-RPPWTP-2003-0004)

Workers had repaired the tower crane ladder and were using a pulley to bring tools and materials down to the base of the tower. Figure 3-1 shows a diagram of the rope and pulley system mounted inside the tower crane. Windy conditions caused the bolt bag to get hung up on the top of a cross brace in the tower internal structure. Every time the worker raised the bolt bag to attempt to free it, the wind blew it back over the brace. As the worker "whipped" the rope to free the bolt bag, the carabiner apparently struck something and opened, releasing the bag. Figure 3-2 shows the carabiner involved in this incident.

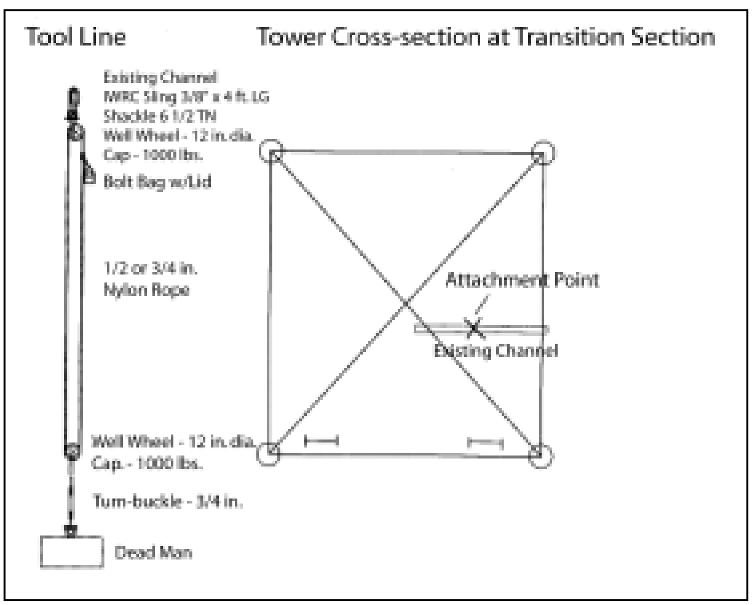

Figure 3-1. Rope and pulley tool line

The items that spilled out of the bag included two, 20-inch-long, 3/8-inch-diameter linkage rods with dou-

Figure 3-2. Carabiner that opened

double nuts on each end and the 14-inch-long, 2-inch piece of angle iron. Figure 3-3 shows the bolt bag and the materials that fell from the bag to the ground, with a 1-foot ruler for perspective.

Investigators determined that the root cause of this event was that the workers selected an inadequate component to use in the pulley system. They used a carabiner with a locking gate that rolled 90 degrees to lock and could open if it contacted another surface instead of a caribiner with a secure, lockable latch. Contributing causes included inadequate procedures for using the pulley system during windy conditions, not stopping work to secure materials when windy conditions arose, and the design of the canvas bag. The canvas bag had no secure points of attachment, and this allowed the rope to directly contact the rolling lock of the gate, causing it to open.

Immediately after this event, the pulley systems in this tower crane and in the other two tower cranes on site were taken out of service, pending the results of the investigation. Longer-term corrective actions to be implemented include the following.

- Install a new, secured rope and pulley arrangement inside the tower crane to facilitate raising and lowering tools and equipment.
- Require all tools and parts being hoisted in the pulley system to be enclosed in a bolt bag with a securable cover.
- Discontinue use of carabiners of the type involved in this incident, and require the bolt bag to be attached to the hoist line with a secure, lockable latch mechanism to prevent accidental loss of the bolt bag during hoisting operations.
- Require personnel involved with tower crane activities to communicate with the operator on weather conditions, including wind speed.
- Require the immediate area at the base of the tower be roped off when the rope and pulley system is about to be used and inform personnel working in the area about overhead activity.

A search of the ORPS database for other events involving falling items that endangered workers revealed several other events in recent years. Within one 24-hour period in June 2002, at the Lawrence Livermore Laboratory National Ignition Facility construction site, three workers were struck by falling items — a ratchet wrench struck a worker on his hard hat, causing a contusion and requiring first aid; a 10-foot piece of

Figure 3-3. The bolt bag and its contents

tubing fell, bounced on the floor, and struck a worker in the face resulting in a chipped tooth that required medical treatment; and a screwdriver fell approximately 20 feet and hit a worker on his hard hat, resulting in no injury. (ORPS Report OAK--LLNL-LLNL-2002-0014)

At the RMI Decommissioning Project in Ohio, on October 2, 2000, an unsecured, 1-pound flashlight fell approximately 30 feet from a moving trolley crane and struck the floor below. Although several workers were within 10 feet of where the flashlight hit the floor, no injuries resulted from this event. (ORPS Report OH-AB-RMI-RMIDP-2000-0006)

These events underscore the need to protect workers against the hazards of falling objects in the workplace. One lesson learned from this event is that the type of carabiner used in their rope and pulley system should have had a positive locking gate, which reduces the possibility of accidental rotation and opening during use. Tools and equipment that could fall and injure workers need to be positively tethered. If an unanticipated difficulty arises (e.g., the bolt bag getting hung up on the internal structure of the tower crane), it is often a mistake to try to "strong-arm" a solution to the problem because, as happened at Hanford, a safety hazard could be created. The work should be stopped and a solution found that does not endanger personnel safety. For example, the worker operating the pulley could have waited until the crane operator descended the tower ladder and retrieved the bolt bag from where it was hung up.

KEYWORDS: *Hoist, falling objects, tower crane, pulley system, bolt bag, wind conditions*

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

4. THE IMPORTANCE OF ACCURATE OCCURRENCE REPORTING

A recent report, published by DOE's Office of the Inspector General (OIG), *Allegations Concerning the Reporting of a Radiological Incident at the Los Alamos National Laboratory* (URL http://www.ig.doe.gov/pdf/ig-0591.pdf), identified inconsistencies in the occurrence reporting process for an incident that occurred at the Laboratory in 2001. The OIG's review was prompted by a request from the National Nuclear Security Administration. Reportedly, the occurrence report was not accurate, and failed to consider the procedural violations that caused the incident. Accurate reporting of events in the Occurrence Reporting and Processing System (ORPS) is important for the sharing of operating experience and lessons learned throughout the DOE complex. (ORPS Report ALO-LA-LANL-TA55-2001-0005; final report filed May 31, 2001)

On February 15, 2001, an unanticipated airborne release of plutonium-238 (Pu-238) occurred from a glovebox because its glove failed. At least two workers became radiologically contaminated as a result, and the lead technician spread contamination.

Workers were loading scrap Pu-238 fuel into a container. Because Pu-238 is thermally hot, special tools or instruments must be used to prevent glovebox gloves from burning through. OIG inspectors learned that even though the Los Alamos hazard control plan for handling Pu-238 requires the use of special tools or instruments, the workers did not use them. In fact, the group leader told the inspectors that another room was set up with the necessary tools and instruments to safely handle Pu-238.

The occurrence report for this event stated that "No procedural violations were found. No cause for the tear was found." However, the workers stated that they had not followed the procedures, and, when the glove was analyzed, the cracks in it were attributed to the temperature of the Pu-238 fuel. In addition, the lead technician spread Pu-238 contamination to a notebook, and thereby to another team member, when he attempted to reset a monitoring device that was alarming. This detail was not mentioned in the occurrence report.

The lessons learned section of the occurrence report stated that "the operator's correct behavior to an abnormal glovebox condition …mitigated the potential consequences of the glove failure," although, in fact, this was not the lesson to be learned from this occurrence.

Rather, this event makes a good case for the need to comply with procedures.

The OIG made the following recommendations to Los Alamos management.

1. Review the facts and circumstances surrounding the glovebox contamination incident and strengthen internal controls to reduce and/or eliminate the possibilities of inadvertent contamination.

2. Review Los Alamos occurrence reporting policies and procedures to ensure consistency and adherence to reporting requirements.

3. Identify and disseminate meaningful lessons learned based upon all available information.

Los Alamos management responded that they had identified 119 corrective actions that needed to occur, and that 108 of these are already complete.

Some of these corrective actions may also relate to an incident that occurred on March 16, 2000. Multiple intakes of Pu-238 occurred in the same facility at Los Alamos, prompting a Type A accident investigation. Four workers received intakes significant enough to warrant chelation therapy. The accident investigation board determined that a leaking compression fitting in a glovebox-airlock dry vacuum line caused the release; however, root causes identified work control and configuration management issues. (ORPS Report ALO-LA-LANL-TA55-2000-0009)

This event illustrates the importance of providing complete, factual details of occurrences in the ORPS database. The lessons that can be learned and corrective actions that are developed from previous experiences are built upon the validity of the data that are shared. The Office of Environment, Safety and Health encourages all sites to be as candid and accurate as possible in reporting occurrences to allow others the benefit of their experience.

KEYWORDS: *Radiation exposure, lessons learned, plutonium-238, airborne release, contamination*

ISM CORE FUNCTION: *Provide Feedback and Continuous Improvement*