OPERATING EXPERIENCE SUMMARY

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OE Summary 2002-19

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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, 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.

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EVENTS

1. TYPE B INVESTIGATION OF WORKER INJURED IN FALL WHILE ASCENDING SHORING SYSTEM

On April 2, 2002, at the Savannah River Site, a carpenter was climbing a shoring end-frame when he lost his grip on the rung and fell backward, striking his head on a concrete wall 88 inches away. He suffered a fractured skull and broke his right ankle. He was admitted to a hospital and treated for his injuries. A Type B investigation was immediately convened to evaluate the accident. (ORPS Report SR--WSRC-CMD-2002-0002; final report issued July 17, 2002)

The carpenter was part of a team of three that was erecting a shoring assembly underground to support concrete forms for a floor. At the time of the accident, the shoring structure had reached a height of 20 feet, and would eventually reach a height of 60 feet. Figure 1-1 shows the accident scene. The shoring consisted of 4-foot by 5-foot and 4-foot by 6-foot sections connected with cross-bracing to form tower assemblies.

Figure 1-1. The accident scene marked with dimensions

The carpenters had just returned from a water break. They were connecting the tower assemblies with lengths of pipe. Two of the carpenters were to climb the towers and haul up materials handed up by the third and then install the bracing.

The carpenter who was injured had begun to climb the end frame of a tower assembly and had stepped up to the second rung of the shoring, approximately 52 inches from the floor, when he apparently lost his grip, fell backwards off the shoring and struck his head on the concrete wall behind him. His head struck the wall 1 to 2 feet from the floor. One of the team members called for assistance, and the other stayed with the injured worker.

Emergency medical personnel arrived at the scene a few minutes later, assessed the worker, and secured him for transport to a hospital trauma center. Medical imaging and X-rays indicated that the carpenter had suffered a fractured skull and broken right ankle.

The site manager immediately called a Type B Investigation Board to evaluate the accident. The Board found that the carpenter's personal protective equipment consisted of hardhat, gloves, fall protection harness, and tool belt. The harness and tool belt weighed about 30 pounds. The Board also inspected the carpenter's gloves and work boots. They found both were in satisfactory condition and provided some slip protection.

The Board concluded that the shoring assembly had been constructed in a sufficiently stable manner to support safe climbing. They also determined that the carpenters all had the experience and knowledge necessary to perform this task. The Board concluded that the accident occurred simply because the carpenter lost his grip on the rung.

In a similar occurrence at Brookhaven National Laboratory on August 3, 2000, an electrician was climbing a stepladder to change a fluorescent light bulb when he fell backward, landed on his feet, then fell and hit his back and head on the floor. He had been holding onto the ladder with both hands. A subsequent Type B investigation found that all safety procedures had been followed and that the electrician was performing a routine task he had performed many times before. The official cause of the accident could not be conclusively determined. (ORPS Report CH-BN-BNL-NSLS-2000-0002)

These occurrences illustrate that workers need to remain focused and attentive, even while performing routine tasks.

KEYWORDS: *Shoring, fall, head injury*

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

2. BREAKER ARCS UNEXPECTEDLY WHEN CLOSED

On March 14, 2002, at the Savannah River Site, electric power was being restored to three breakers in a transformer room. One breaker was closed without incident. When the second breaker was closed, a loud bang was heard, and sparks and smoke were observed coming from the third breaker, which was still open. Electrical and operations personnel verified that conditions were normal following the breaker trip. No personnel were injured. (ORPS Report SR--WSRC-SRDD-2002-0003)

The direct and root causes of this event were a phase-to-ground fault on one of the phases of the breaker. This fault is believed to have been caused by a combination of several conditions. The building had a high concentration of moisture over an extended period of time, as evidenced by the deteriorated condition of the cables, bus indicator boards, and current transformers. Investigators determined that maintenance procedures governing the shutdown of the facility were less than adequate; an electrical power supply providing sufficient heat to keep the electrical panels dry would have prevented much of the equipment degradation.

An additional contributing factor is the fact that the facility is over 50 years old, so it is likely that the electrical system will experience continuing failures as it reaches the end of its useful life. Because of the prohibitively high cost of restoring the electrical distribution system to service, facility management has chosen to abandon this system and replace it with a temporary 240/120V electrical feed that would provide power directly to specific lighting distribution panels for surveillance, maintenance, and decontamination and decommissioning (D&D) activities.

A search of the Occurrence Reporting and Processing System identified several events involving degraded electrical equipment. One occurred on January 30, 2002, at the Rocky Flats Environmental Technology Site, where asbestos abatement workers heard a loud noise and saw yellow smoke coming from a breaker panel. An initial visual inspection indicated a fire, and all three phases had gone to ground. Investigators determined the direct cause of this incident was a ground fault on an ungrounded electrical distribution system. A work package was prepared to troubleshoot and repair an existing ground fault. Sustained over-voltages from a ground fault condition can break down cable insulation or exacerbate existing insulation weaknesses and result in a second-level phase-to-ground-to-phase fault. This second-level fault can cause arcing and flash hazards, injury from explosion, shock, flying solid or liquid metal, or fire. Investigators concluded that the fire in the feeder breaker panel resulted from this second-level phase-to-ground-to-phase fault. (ORPS Report RFO--KHLL-SOLIDWST-2002-0008)

At the Pacific Northwest National Laboratory on May 16, 2002, a worker received an electric shock while he was attaching a sensor head to a radar unit. A team of subject matter experts investigated the event and concluded that a deteriorated electrical connection between the receptacle frame and the wire-mold frame created inadequate grounding. Medical personnel evaluated the worker and cleared him to return to work. (ORPS Report RL--PNNL-PNNL-2002-0005)

These occurrences illustrate the hazards posed by deteriorating electrical equipment, particularly in a facility undergoing D&D. Facility management should ensure appropriate maintenance to protect electrical equipment, even for facilities that are in shutdown mode.

KEYWORDS: *Breaker, arc, phase-to-ground fault, electrical*

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

3. *FALLING LOAD BLOCK CAUSES NEAR MISS*

On May 30, 2002, at the West Valley Site, an overhead crane load block (hoist hook) was being lowered through a floor hatch when it fell through to the floor below, followed by a length of the crane wire rope. An operator standing near the falling load block had to move out of the way of the falling wire rope to avoid being hit. No personnel injuries resulted from this event. (ORPS Report OH-WV-WVNS-CF-2002-0002; final report filed August 19, 2002)

Decontamination and decommissioning operators were preparing to lift a gearbox and place it into a waste box liner. The crane operator was in a crane room enclosure and in visual contact with an operator located in the crane room extension one level below. He lowered the load block through the floor hatch into the extension to hook onto a sling attached to a gearbox. When the hook was approximately 2 feet off the extension floor, the 120-pound load block dropped to the floor. The operator stepped away from the fallen load block as the 20-pound wire rope came off the hoist drum and fell to the extension floor. Operators immediately secured the work area and notified the supervisor.

Each end of the wire rope is secured to the hoist drum by a swagged fitting in a "keyhole," with the load taken by friction forces as long as two wraps of the wire rope are maintained on the drum. Investigators found that the wire rope had detached from the hoist drum because too much of it had been unwound from the drum. During the design of the enclosure crane, the required lift height for the hoist was specified as 20 feet. The specified height failed to consider the 3–foot, 8-inch thickness of the concrete slab between the enclosure room and the extension. The design's insufficient lift height resulted in the wire rope on the hoist being too short to allow the load block to extend to the extension floor. During a previous operation of this crane, operators lowered the load block approximately 5 feet above the extension floor without incident.

DOE-STD-1090-2001, *Hoisting and Rigging* (formerly *Hoisting and Rigging Manual*), chapter 8, "Hoists," states in section 8.5.4, "Do not lower a loaded wire-rope hoist drum beyond the point where less than two full wraps of wire rope remain on the drum." OSHA 29 CFR 1910.179, *Overhead and Gantry Cranes*, states in section (h)(2)(iii)(a) that "No less than two wraps of rope shall remain on the drum when the hook is in its extreme low position."

Investigators identified the following three deficiencies.

1. The crane operator was not cautioned that the crane did not have a lower-limit switch by labels, operator aids, procedures, or a crane-specific daily checklist. For infrequently operated cranes like this one, relying on personnel to know equipment limitations based on a one-time training activity is an unreasonable expectation.

2. The initial hoisting and rigging training course failed to address the requirement to maintain a minimum of two wraps of wire rope on the hoist drum on cranes when a lower-limit switch is not installed. The crane-specific training did communicate that the hoist lacked a lower-limit switch, but not that the load block could not reach the extension floor. Although crane operators are required to requalify every 2 years to maintain their hoisting and rigging qualification, on-the-job training on specific cranes is conducted only once.

3. Neither the pre-job briefing nor the operations procedure stated operational limitations on the crane. Prior to this event, no one checked the lowest safe point of travel for the load block during daily or periodic inspections. This hoist is operated infrequently, and any equipment limitations should have been reviewed before operation.

Although personnel were qualified to inspect and operate the crane, communication of hoist limitations was lacking in the area of postings, operating procedures, crane checklists, and training materials. This event was followed by a comprehensive review of all similarly designed site cranes or hoists (i.e., those lacking lower-limit switches). Site personnel developed a list of similar cranes and hoists and reviewed it against the applicable standards to determine if lower limits were required.

As a result of this occurrence, site management implemented the following corrective actions.

- Revise the initial hoisting and rigging training course to include instructions for operation of hoists without lower-limit switches.
- Brief operations and maintenance supervisors on the lessons learned from this event.
- Repair the crane and install a lower-limit switch.
- Install a lower-limit switch on another extension crane.
- Develop and issue a lessons learned bulletin to the DOE complex.

West Valley site management identified several lessons learned. For example, procedures and plant postings should communicate precautions and limitations of equipment to operations and maintenance personnel. Pre-job briefings should review specific equipment limitations and safety precautions. Safety mechanisms, such as personal protective equipment, permits, procedures, or postings, can help prevent accidents or injuries, but they cannot ensure personal safety. An individual's awareness of his or her surroundings and in-progress activities is essential to personal safety and prevention of injuries when the unexpected occurs.

KEYWORDS: *Near miss, overhead crane, decontamination and decommissioning, load block*

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

4. SECONDARY ASSAY REVEALS UNEXPECTEDLY HIGH U-235 MASS DEPOSIT

On May 30, 2002, at the Oak Ridge K-31 Facility, contractor personnel discovered a mass deposit of 13.675 kilograms of uranium-235 (U-235) (with a 50 percent plus or minus uncertainty) in a converter scheduled to be removed for transport and dismantling. This amount of U-235 greatly exceeded the inventory identified in facility records and in the documented safety analysis, and posed a criticality accident hazard. (ORPS Report ORO--BNFL-K31-2002-0003)

Before performing any work on the converter, the contractor decided to perform a secondary nondestructive assay (NDA). The previous assay of the converter had been performed 6 years earlier, and contractor personnel knew that a more accurate NDA device was available to measure uranium mass hold-up. The secondary assay revealed the mass deposit of over 13 kilograms of U-235. The documented criticality analysis identified a total mass of 7 to 8 kilograms as that at which moderation controls alone are sufficient to prevent criticality, assuming the deposit is a water-reflected sphere at the maximum density and building enrichment.

Based on the results of the secondary assay, contractor personnel immediately issued a stop-work order. They secured the cell purge system and closed the isolation valves to prevent moisture from entering, as U-235 remains subcritical when dry. They also posted the cell house and roped it off to keep the area isolated until all remaining converters have been re-assayed to determine a more accurate uranium mass measurement. A stop-work order remains in effect to keep the area isolated.

DOE Order 420.1A, *Facility Safety* (URL http://www.directives.doe.gov/pdfs/doe/doetext/neword/420/o4201a.pdf), section 4.3.2, states that DOE nonreactor nuclear facilities with fissionable materials that pose a criticality accident hazard shall be evaluated and documented to demonstrate that the operation will remain subcritical under both normal and credible abnormal conditions. This requirement is taken from the American National Standards Institute's American Nuclear Society (ANSI/ANS)-8.1-1983, R98, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, section 4.1.2, *Process Analysis* (URL http://www.ansi.org/public/std_info.html)

A similar occurrence was reported on April 1, 2002, at the Portsmouth Gaseous Diffusion

Plant, where the leased facilities manager reported that the amount of U-235 repackaged into 55-gallon drums may have been underestimated. This discrepancy could impact drum storage areas with nuclear criticality safety requirements specifying that drums must contain less than 350 grams of U-235. This issue was discovered when historical (pre-1997) data collected using a segmented gamma scanner were compared with data gathered using the current method, a low-density waste assay monitor. The newer data indicated U-235 mass quantities that exceeded those measured previously by as much as a factor of 20. This raised a question about whether nuclear criticality mass limits had been exceeded because U-235 values were underestimated. (ORPS Report ORO--BJC-PORTENVRES-2002-0007)

These occurrences illustrate the importance of maintaining a questioning attitude while performing work. Performing a secondary assay alleviated concerns associated with relying on 12-year-old techniques and instrumentation when more recent statistical analysis methods are available that can ensure that measurement uncertainties are accounted for in the assay estimation. Overall, the contractor's decision to perform a secondary assay on the converter at Oak Ridge prevented a criticality safety barrier from being compromised.

KEYWORDS: *Nuclear criticality, fissile mass, NDA, U-235*

ISM CORE FUNCTION: *Develop and Implement Hazard Controls*

5. FAILURE TO USE SHORING OR SLOPING IN TRENCH COMPROMISES WORKER SAFETY

On July 18, 2002, at the Idaho National Engineering and Environmental Laboratory, a safety engineer noticed signs of hand excavation in a 6-foot-deep trench that had not been shored. The Occupational Safety and Health Administration (OSHA) standard for construction, 29 CFR 1926.652, *Requirements for Protective Systems* (URL http://www.access.gpo.gov/nara/cfr/waisidx_01/29cfr1926_01.html), states that protective measures such as shoring, sloping, or trench boxes must be used when workers are hand-excavating in a trench greater than 5 feet deep. (ORPS Report ID--BBWI-ATR-2002-0005)

The previous day, a backhoe had excavated a trench approximately 4 feet deep to prepare for repair work on a buried conduit carrying pneumatic lines for an overhead water storage tank level indication system. Hand excavation was then required at one end of the trench to expose the conduit. No shoring was required for the other end of the trench.

As the excavation proceeded beyond the west end of an adjacent building without finding the break in the conduit, the work crew encountered a high soil berm on the south side of the trench. Excavation beyond the west end of the building would cause the depth of one end of the trench to increase to approximately 6 feet. The maintenance organization chose not to remove the high soil berm because it contained buried pipe.

The work control document required that a safety professional inspect the trench and specify necessary safety controls. The safety engineer visited the excavation site on July 17 and specified on the work control document the need to restrict work to the shallower end of the trench and to install a trench box before proceeding with work on the deeper end of the trench. The close proximity of the trench to the building precluded workers from excavating at the OSHA-specified slope of 1½:1.

Additional digging was required to allow the trench box to be installed. On the morning of July 18, maintenance supervision met with the environment, safety and health (ES&H) manager to discuss the need to perform additional digging with a backhoe to widen and extend the trench to the west to allow installation of a trench box. The ES&H manager agreed, providing no personnel enter the trench until after the trench box was installed. The maintenance supervisor understood this requirement and proceeded to excavate using only the backhoe.

Later that day, another maintenance supervisor came on shift. He understood that shoring would be required to extend the trench west and to repair the conduit, but did not understand that no hand excavation would be allowed to expose the broken conduit. The broken conduit was exposed, using hand excavation, a few feet beyond the west end of the adjacent building. Afterward, a safety professional noticed that hand excavation had taken place in the west end of the trench without the trench box having been installed.

Excavation work was immediately stopped, and the ES&H manager ordered a safety stand-down to discuss the event. A training session was conducted during the stand-down that emphasized the importance of clearly communicating and defining the work scope, including setting boundaries to identify when the work scope will be exceeded.

Several corrective actions were taken before excavation resumed at the facility. Jobsite training was conducted for maintenance supervisors and foremen to discuss the requirements of the site's excavation procedures and to clarify when trench boxes are required before workers may enter into an excavation area. All work orders involving trenching were evaluated and modified to clarify inspection requirements and to specify shoring/sloping requirements. In addition, the site's automated work order system was modified to automatically add shoring/sloping and safety inspection requirements to work orders in which excavations are identified as a job hazard.

A search of the Occurrence Reporting and Processing System identified many events involving workers that entered trenches deeper than 5 feet without shoring/sloping or trench boxes. Operating Experience Summary 2002-10 reported an event involving an occupational injury that resulted from a cave-in at an unprotected trench. On March 26, 2002, at the Princeton Plasma Physics Laboratory, a subcontractor foreman suffered two fractures to his lower right leg when a mixture of compacted soil, clay, and rock fell from the north face of the trench and struck his leg. The foreman had entered the 5- to 6-foot-deep trench to determine a potential path for new piping around existing utility lines. (ORPS Report CH-PA-PPPL-PPPL-2002-0001; final report filed September 6, 2002)

These occurrences illustrate the importance of ensuring that workers never enter a trench deeper than 5 feet without the appropriate shoring/sloping or trench box. These protective measures are designed to protect workers from the risk of severe injury in the event of a trench cave-in. The Bureau of Labor Statistics reports that in calendar year 2000, the most recent year for which data are available, 40 fatalities occurred from excavation or trenching cave-ins.

KEYWORDS: *Excavation, trenching, trench box*

ISM CORE FUNCTION: *Perform Work within Controls*

6. INCONSISTENCY BETWEEN OPERATIONAL SAFETY PLAN AND SAFETY ANALYSIS REPORT

On July 24, 2002, at the Lawrence Livermore National Laboratory, the facility manager discovered an inconsistency between the stated limit for flammable solvent in an Operational Safety Plan (OSP) control and the limit specified in the Safety Analysis Report (SAR). The SAR specified a 500-ml flammable solvent limit for a glovebox, but the OSP indicated the limit was 1,500 ml. Although there were no consequences from this discrepancy, an explosion involving a flammable solvent could have dispersed plutonium. (ORPS Report OAK--LLNL-LLNL-2002-0020)

The OSP is a floor-level operating procedure that is derived directly from the SAR. OSP requirements are driven by the accident analyses in the SAR. The SAR specified a limit of 500 ml, but analyzed accident scenarios with as much as 4,260 ml of acetone, leading to ambiguity in the OSP.

The ambiguity in the OSP stemmed from references to differing flammable solvent limits for two workstations. One workstation allowed a total quantity of only 500 ml; another allowed 1,500 ml of a flammable solvent to be "used/ stored." Both workstations have inert atmospheres and are equipped with oxygen alarms to warn of air intrusion. Although never exercised, the provision for the additional 1,000 ml was intended to apply to closed storage of flammable solvent. The total flammable solvent limit for that workstation was promptly changed to 500 ml.

Facility management revised the OSP in 1996 in response to an Unreviewed Safety Question (USQ) determination involving quantities of dispersible plutonium and flammable solvents (ORPS Report OAK--LLNL-LLNL-1996-0049). The revised accident scenario, consisting of an explosion involving plutonium and flammable solvents, was developed from operations described in the original OSPs.

To resolve the USQ, facility management reportedly evaluated the OSPs, completed a USQ evaluation based on quantities of more than 500 ml of flammable solvents, re-evaluated the accident scenario, and submitted it to DOE for review and approval. In addition, facility personnel performed a self-assessment of the SAR accidents and associated assumptions as implemented in building documents and operations.

Between 1996 and 2002, the OSP had been updated or amended 11 times, yet no one caught the inconsistency until July, when safety analysts walked down the facility to prepare for a SAR upgrade. The facility manager reviewed documentation and interviewed knowledgeable personnel, who confirmed that the 500-ml flammable solvent limit had never been exceeded.

Corrective actions included evaluating other OSPs to ensure that they specify appropriate solvent limits and updating the OSP to clearly specify a total quantity limit of 500 ml in the facility. In addition, the facility manager will ensure that corrective actions are entered into the Laboratory's deficiency tracking system to provide a data point for trending purposes.

This occurrence illustrates the importance of ensuring that floor-level procedures, such as OSPs, accurately reflect the accident scenarios and assumptions given in authorization basis documents such as SARs. It is particularly important, now that many facilities across the DOE complex have changing missions, for facility managers to ensure that procedures fully agree with their underlying authorization basis documentation. In this event, even repeated reviews failed to disclose the discrepancy between the OSP and the SAR.

KEYWORDS: *Safety Analysis Report, flammable solvent, accident scenario*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Provide Feedback and Continuous Improvement*