OPERATING EXPERIENCE SUMMARY

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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.

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 2003-14

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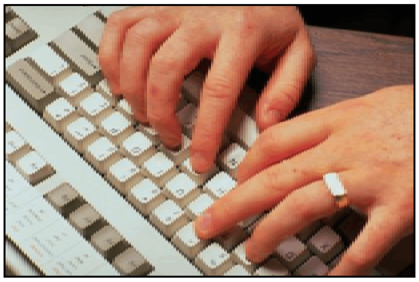

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EVENTS

1. TECHNICIAN INADVERTENTLY SHUTS DOWN PRIMARY VENTILATION SYSTEM

On March 21, 2003, at the River Protection Project 241-AP Tank Farm, a health physics (HP) technician attempting to return an inoperable continuous air monitor (CAM) to normal operation inadvertently activated an interlock that shut down the primary tank exhauster fan. The technician was not authorized to perform this function and did not use a procedure while operating the CAM. The loss of tank ventilation resulted in an operational hold on waste-disturbing activities. Subsequent air samples of the affected tanks revealed no abnormal accumulations of flammable gases. (ORPS Report RP--CHG-TANKFARM-2003-0011; final report filed June 13, 2003)

On March 6, the tank farm primary stack CAM failed a source check and was declared inoperable. The CAM was replaced on March 20, but it failed a post-installation functional test. HP technicians stopped the testing and notified the shift manager. Several minutes later, the CAM re-set and displayed "Source Check." Technicians left the monitor in this condition and declared it inoperable, but did not place any signs or otherwise indicate that it was inoperable.

On the day of the event, the HP technician entered the tank farm and recorded sampler readings at the stack because of the failed stack CAM. He noticed that the CAM was displaying a cabinet alarm and attempted to restart the vacuum pump and return the CAM to normal operation. The CAM did not respond, so he de-energized it and turned it back on, causing it to enter a diagnostic mode that tested the high radiation alarm. When the alarm initiated, it activated an interlock that turned off the primary stack exhauster fan. Operating personnel notified shift managers and initiated a limiting condition for operation for the tank farm because there was no primary tank exhaust stack ventilation.

Investigators determined that the technician was not adequately informed of the status of the exhaust stack CAM and assumed that its alarm interlock with the exhauster was bypassed. They also determined that the technician did not properly communicate his intended actions to the shift manager and attempted to restore the CAM to service without a procedure (skill of the craft).

The exhauster fan tripped as a direct result of the operator failing to ensure that the alarm interlock was bypassed before attempting to restore the CAM to operability.

As a result of the investigation, facility managers issued a radiological control standing order to HP technicians on interim controls for performing work on leak detector and ventilation CAMs. Technicians were also briefed on self-checking and peer-checking techniques.

The following topics were added to the training curricula for HP technicians.

- Self-checking and peer-checking techniques;
- Obtaining shift office approval before working on a CAM or the stack sampling system;
- Understanding the CAM system configuration before working on the CAM;
- Completing HP logbook entries on CAM configuration and other exhauster support systems and components; and
- Defining the conditions under which HP technicians can troubleshoot CAMs and stack sampling components.

A similar event occurred at the 241-AP tank farm in 2002, when an operator inadvertently turned off the primary exhaust fan during a CAM inspection. Before he took the CAM out of service, a HP technician bypassed the HEPA differential pressure interlock instead of the CAM interlock. After finishing the inspection, the technician reinitialized the CAM, which activated a high radiation alarm. Because the technician bypassed the wrong interlock, the CAM high radiation alarm automatically de-energized the primary exhaust fan. The Central

Command and Control manager ordered an unplanned entry into limited conditions for operation. (ORPS Report RP--CHG-TANKFARM-2002-0038)

PREVENTABLE ERRORS

- After failing its source check, the CAM was left "as is" and without local warning signs of its unavailability.
- Inadequate checks were in place to prevent the technician from attempting to restore the CAM to operability.
- The technician did not receive authorization to work on the CAM or communicate his plan to restore the CAM to the Command and Control Center.
- The technician did not use a procedure when attempting to clear the CAM alarm and return the CAM to service.

This safety-significant event illustrates the importance of knowing equipment status, using approved procedures, and ensuring clear communication between facility operating personnel and line managers. Pre-shift briefings, equipment status boards, comprehensive shift turnovers, and out-of-service postings are effective means for preventing inadvertent equipment operation.

KEYWORDS*: Continuous air monitor; configuration control, procedures, ventilation, exhauster*
ISM CORE FUNCTIONS*: Develop and Implement Work Controls, Perform Work Within Controls*

2. WORKER CUTS ENERGIZED CONDUCTOR MISTAKENLY MARKED FOR REMOVAL

On April 1, 2003, at the Oak Ridge National Laboratory (ORNL) Melton Valley Completion Project, an ironworker received a mild electrical shock while cutting a conduit with a hand-held hydraulic shear. An electrician had mistakenly spray-painted the conduit, which contained an energized 120-volt electrical conductor, as being de-energized for demolition. Following the incident, electricians opened the circuit breaker associated with the cut conductor. The ironworker was taken to the hospital, but sustained no injuries from the shock. (ORPS Report ORO--BJC-X10ENVRES-2003-0002; final report filed July 15, 2003)

Before demolition began, workers de-energized the affected circuits by air-gapping them at the circuit breaker panel. The following day, the electrician marked the conduit with yellow spray paint to indicate deactivation. He painted the conduit based on his memory of the electrical isolation activities performed the previous day and stated that he "just made a mistake" when he marked the energized conduit as de-energized. An independent verification was not performed after he spray-painted the conduit. Adjacent sections of conduit the electrician had spray-painted were marked correctly. All demolition work in the facility was stopped, pending identification and implementation of appropriate corrective actions.

Normal industry demolition practice is to isolate the entire building from any power sources. Investigators determined that work planners for this job had decided to isolate the electrical power sources only to those circuits selected for demolition in this work package. The decision to depart from normal practice and use partial electrical isolation should have included additional controls to counter the increased risk from the presence of energized circuits in a demolition work environment. For example, additional technical reviews and independent verifications of lockout/tagout processes should have been performed.

Investigators also determined that the demolition subcontractor's site manager independently added conduit removal to the scope of work, which was not in the plan-of-the-day, without communicating the change to the project team. Thus a review of the work controls (i.e., hazards analysis) was not performed, including a zero-energy check of each circuit (as required by the work plan). They also learned that the worker who cut the conduit wore only the standard hardhat, safety glasses, steel-toed shoes, and leather gloves instead of electrically rated personal protective equipment (PPE).

Although the direct cause of this incident was marking the wrong conduit, investigators determined that the root cause of the incident was a management problem. The site manager did not follow the detailed plan-of-the-day or the work instructions provided with the work package. Cutting electrical conduit was not included in the plan-of-the-day and, in violation of the work instructions, workers were allowed to cut the conduit without first performing a zero-energy check.

Contributing causes included the following.

- The subcontractor supervisor added new activities (sectioning and removal of electrical conduit), which were not included in the plan-of-the-day, without communicating this change to the project team.
- The changed work scope was not evaluated to determine if the proper hazard controls were in place or if additional controls were needed.
- The energy isolation approach for the work was changed from total isolation ("cold and dark") to a partial isolation of the electrical systems.
- The work controls for the task did not take into account the added hazards resulting from the partial isolation of electrical systems.
- An independent verification of the air-gapping of circuits and subsequent marking of de-energized conduit were not performed.
- Work controls identified for the electrical decommissioning and demolition work were not properly implemented.

The principal corrective action resulting from this event was to implement total isolation of electrical service to the building before resuming demolition work. Specific work instructions will be added on how to perform independent verifications and how to perform zero-energy checks, including the use of voltage-checking equipment and instruments. Training will be conducted on the revised work instructions. Before work resumes, a meeting with all appropriate project team members will be held to ensure a common understanding of the demolition work to be performed, the sequence of activities, and the necessary interface communications among groups.

A similar event occurred on August 15, 2002, during demolition work at the Rocky Flats Environmental Technology Site, where an electrician cut into an energized 120-volt wire inside a conduit that had been marked with green tape, signifying the circuit was de-energized. Procedures required a zero-energy check and review of circuits to ensure correct labeling (green tape). (ORPS Report RFO--KHLL-PUFAB-2002-0052)

Electrical safety issues are a continuing theme in articles published in the Operating Experience Summary (OES). Two recent summary articles contain valuable information on controlling electrical hazards. "Electrical Safety Problems Continue in the First Half of 2003," published in OES 2003-13 dated June 30, 2003, described the characteristics and frequencies of the different types of electrical safety events occurring in the DOE complex, presented a list of commonly-made electrical safety errors, and provided lessons learned. OES 2002-18, dated September 9, 2002, contained an article entitled "Electrical Intrusion Events Continue to Occur across the DOE Complex." This article described five electrical intrusion events that were reported in ORPS in the first 15 days of August 2002.

PREVENTION STRATEGIES

- Mark circuits at the same time they are air-gapped.
- Perform an independent verification when air-gapping and marking are completed.
- Perform a zero-energy check.
- Use electrically rated personal protective equipment.
- Ensure hazard controls and analysis are implemented when work scope changes.
- Do not permit workers to violate work instructions created for their safety.

A lessons-learned report on the topic of electrical intrusions (HQ-EH-2002-01) can be accessed from the website for the Society for Effective Lessons Learned Sharing at the following URL: http://tis.eh.doe.gov/ll/listdb.html.

Information on electrical safety practices in DOE can be found in the EH Office of Performance Assessment and Analysis document *Electrical Safety Report*, dated May 21, 1999, and in the DOE Handbook DOE-HDBK-1092-98, *Electrical Safety*, available at http://tis.eh.doe.gov/techstds.

These events underscore the importance of paying attention to detail and taking individual responsibility for working safely in the presence of electrical hazards. In the April 2003, Oak Ridge event, several preventable breakdowns in work planning and execution occurred. Supervisors need to be responsible for enforcing electrical safety policies and directives, and for providing a safe work environment for the workers they supervise.

KEYWORDS: *Electrical intrusion, electrical hazards, work planning, electrical shock, zero-energy check, work instruction violations*

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

3. ELECTRICAL CONDUIT PUNCTURED BY STEEL ROD

On May 6, 2003, at the Hanford Office of River Protection tank farms, a construction laborer accidentally punctured an electrical conduit with a pointed steel bar while excavating a trench near an electrical substation. The punctured polyvinyl chloride conduit, which was not identified by ground scans or drawing reviews, contained an energized 480-volt electrical conductor. The conductor was not damaged, and there were no injuries from this near-miss event. (ORPS Report RP-CHG-TANKFARM-2003-0021, final report filed June 26, 2003)

The laborer was using the digging bar to break up a section of controlled density fill (CDF), a flowable mixture of fine aggregate (usually sand and cement) used as backfill. He was chipping the CDF when the bar glanced off it, striking the conduit located just below the surface of the soil. The laborer was not wearing electrically rated personal protective equipment (PPE) because he did not know he would be working near an energized line. After the incident, the shift supervisor issued a stop work order, the facility was placed in a safe condition, and danger tape was installed around the incident site to preserve investigatory evidence.

Utility locators had performed a ground-penetrating radar scan of the area about a month before the incident. However, the scan did not show there was a conduit in the work area, perhaps because of the proximity of a concrete slab. Work planners also reviewed a line-crossing list and a composite drawing, but neither document showed the conduit. After the incident, investigators found an electrical drawing showing the conduit that apparently had been overlooked earlier and which was not included in the original work package.

Investigators determined that the work package was inadequate because it failed to identify the electrical hazard or the controls required. They also determined that the laborer did not violate any of the work package requirements.

Investigators determined that the direct cause of this occurrence was personnel error (inattention to detail). CDF is used to support and protect electrical lines or piping runs. Although the location of the conduit was not identified during work planning, the presence of CDF should have led the laborer to question whether electrical lines or piping runs were in the area.

The root cause of this incident was a procedure problem (defective or inadequate procedure). The contractor's excavation, trenching, and shoring procedure, as well as the work planning documentation for this task, were deficient. These documents prohibited the use of pry bars or striking tools and required hazard controls (i.e., voltage-rated PPE) only when work was being performed within 2 feet of direct-buried cables and did not address cables encased in conduit.

The corrective action resulting from this incident requires all construction activities, inside and outside the tank farms, to be performed as if energized lines are present regardless of ground scans or engineering drawing indications. All contractor and subcontractor construction craft personnel will be required to use voltage-rated PPE and non-conductive tools during construction activities to ensure that there is at least one barrier between a worker and a hazardous electrical energy source at all times.

A search of the ORPS database for other incidents involving workers using hand tools and causing inadvertent damage to underground electrical conductors revealed two recent, similar occurrences. On December 6, 2002, at the Idaho Advanced Mixed Waste Treatment Facility, workers digging holes for fence posts using a hand-held post digger struck and severed an energized, 480-volt electrical conductor and its conduit. Failures in the work planning process and incorrect assumptions concerning the depth of the buried conduit led to this near-miss event. (ORPS Report ID--BNFL-AMWTF-2002-0008)

On October 1, 2001, at the Pinellas Star Center, Grand Junction, Colorado, a worker using a hand auger contacted and drilled through a buried 110-volt electrical cable. In violation of the contractor's health and safety program, a line locate was not performed before excavation in an area where underground utilities could be present. (ORPS Report ID--MCTC-GJPOTAR-2001-0003)

Typical errors that resulted in electrical intrusion events across the complex are discussed in *A Review of Electrical Intrusion Events at the Department of Energy: 2000–2001*. This report, published by the Office of Performance Assessment and Analysis in June 2002 is available at http://tis.eh.doe.gov/paa.

TYPICAL ERRORS RESULTING IN ELECTRICAL INTRUSIONS

- Relying on inaccurate or out-of-date drawings to locate utilities
- Taking shortcuts because of schedule pressures
- Failing to verify zero energy before cutting electrical conduit
- Assuming that contractors understand the site excavation and penetration permitting processes
- Failing to perform an adequate survey for subsurface hazards

Information on electrical safety practices within DOE can be found in *Electrical Safety Report*, published by the EH Office of Performance Assessment and Analysis, dated May 21, 1999. Information on avoiding damage to underground utilities can be found in *Common Ground, Study of One-Call Systems and Damage Prevention Best Practices*, published by the Common Ground Alliance (August 1999). This report is available at www.commongroundalliance.com. Chapter 4 of the report addresses best practices for locating and marking underground structures.

As these events demonstrate, encountering unexpected underground electrical hazards during excavation is a recurring event throughout the DOE complex. Inadequate drawings and inadequate (or nonexistent) survey scans for underground obstructions are frequent causal factors for these events. Drawing reviews, which are often inadequate, and uncertain ground survey scans cannot be relied upon to reveal all underground hazards during job planning for excavation activities. It is necessary, therefore, to provide hazard controls for workers that can accommodate these inadequacies and uncertainties. The managers at the Hanford tank farms addressed this issue by requiring that all excavation activities be performed as if there were energized lines present.

KEYWORDS: *Electrical conduit, electrical conductor, energized conductor, damaged conduit, severed conductor*

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

4. HAZARDS OF NITROGEN-ENRICHED ATMOSPHERES

On June 25, 2003, following a review of nitrogen asphyxiation incidents that occurred in the United States between 1992 and 2002, the U.S.

Chemical Safety and Hazard Investigation Board (CSB) issued a safety bulletin, *Hazards of Nitrogen Asphyxiation*. During this period there were 85 incidents that resulted in 80 fatalities and 50 injuries.

The Board determined that the majority of these incidents occurred in manufacturing and industrial settings, with some in laboratory and medical facilities. Most of the incidents occurred in and around confined spaces, although several occurred in open areas near equipment and inside buildings. Almost half of the incidents involved contractors, who accounted for more than 60 percent of the fatalities. Causes of the incidents included the following.

- Failure to detect an oxygen-deficient atmosphere in and around confined spaces.
- Mistakenly using nitrogen instead of breathing air.
- Inadequately preparing for rescue.

In March 1998, two workers at a Union Carbide plant were overcome by nitrogen while inspecting the inside of a 48-inch-diameter pipe (Figure 4-1). One of the workers died from asphyxiation and the other was severely injured from oxygen deficiency.

Figure 4-1. Pipe where workers were overcome by nitrogen-enriched atmosphere

Nitrogen injected into process equipment for moisture control had accumulated in the pipe, and the workers had covered the open end of the pipe with black plastic to block sun light while conducting a black-light test. No warning sign was posted on the pipe opening identifying it as a confined space and potential nitrogen hazard.

Following this incident, CSB investigators recommended that the National Institute for Occupational Safety and Health study the feasibility of odorizing nitrogen.

The following are examples of other events.

- A contractor cleaning the inside of a tank collapsed and two rescuers were overcome by nitrogen. All three died. The tank was mistakenly ventilated with nitrogen instead of compressed air. The tank atmosphere was not sampled before entry.
- Four people were killed and six injured at a nursing home when pure nitrogen was mistakenly installed in an oxygen system. A worker replaced the nitrogen-compatible couplings on the cylinder with ones from an empty oxygen cylinder to facilitate installation.
- Two subcontractors, who were cleaning tubes inside a boiler, were asphyxiated when the air they were breathing from compressed air cylinders contained less than 5 percent oxygen. The air had been manufactured with a concentration of oxygen that was too low.

Many people assume that nitrogen is not harmful because 78 percent of the air we breathe is nitrogen gas. However, it is only safe when mixed with the appropriate concentration of oxygen. Because these two gases are odorless and colorless, our senses provide no protection against nitrogen-enriched atmospheres, which can only be detected with special instruments.

Unlike poisonous gases, nitrogen kills by displacing the oxygen we breathe. An oxygen-deficient at-

EFFECTS OF OXYGEN DEFICIENCY ON THE HUMAN BODY	
Percent Oxygen	***Possible Results***
20.9	Normal
19.0	Some unnoticeable adverse physiological effects
16.0	Increased pulse and breathing rate, impaired thinking and attention, reduced coordination
14.0	Abnormal fatigue upon exertion, emotional upset, faulty coordination, poor judgment
12.5	Very poor judgment and coordination, impaired respiration that may cause permanent heart damage, nausea, and vomiting
<10.0	Inability to move, loss of consciousness, convulsions, death

Source: Compressed Gas Association, 2001

mosphere can have serious and immediate effects on the human body as shown in the table. OSHA requires employers to maintain oxygen levels in the workplace between 19.5 and 23.5 percent.

The U.S. Department of Labor, Bureau of Labor Statistics census of fatal occupational injuries reported 17 oxygen-deficiency fatalities during 2001.

Events involving nitrogen-enriched atmospheres have also occurred at DOE sites. The following examples were reported in ORPS.

- At Pacific Northwest National Laboratory, the oxygen level in the room air at a fill station was found to be only 18.4 percent. Workers were filling a liquid nitrogen Dewar without adequate ventilation. (ORPS Report RL--PNNL-PNNLBOPER-1999-0006)

- At Lawrence Livermore National Laboratory, a scientist suffered asphyxia while working near a nitrogen purge system. Nitrogen collected under a black cloth he had placed over his head to eliminate background light while aligning some optics. The scientist recovered fully. (ORPS Report OAK--LLNL-LLNL-1992-0018)

- At Sandia National Laboratory – AL, a relief valve on a liquid nitrogen line opened and vented nitrogen into a building basement causing an evacuation. The nitrogen tank was overfilled by a local supplier. (ORPS Report ALO-KO-SNL-TA1ALBQ-1991-0015)

Nitrogen is used commercially as an inerting agent or to keep material free of contaminants, such as oxygen, which can corrode equipment or present a fire or explosion hazard when in contact with flammable liquids or combustible solids. Because of its wide use in the workplace, it is important that confined areas (Figure 4-2) where gases can accumulate are properly posted to alert workers.

Figure 4-2. Confined area

Care must be taken when working near bulk liquid nitrogen storage tanks. Oxygen can quickly be displaced by leaking liquid nitrogen, which expands to nearly 700 times its liquid volume as it vaporizes.

A copy of the safety bulletin and a one-page safety brochure on nitrogen hazards can be accessed at the U.S. Chemical Safety and Hazard Investigation Board website, www.csb.gov.

The following good practices from the CSB safety bulletin should be followed to prevent nitrogen asphyxiation.

Good Practices to Prevent Nitrogen Asphyxiation

- Continuously monitor for oxygen-deficient, toxic, or explosive atmospheres; particularly enclosures and areas of accumulation.
- Ventilate with fresh air before and during work in areas that could contain elevated levels of nitrogen.
- Use warning systems to alert personnel of ventilation system failures.
- Use warning systems, including flashing lights, alarms, auto-locking entryways, and personnel monitors that indicate low oxygen concentrations.
- Wear equipment to facilitate retrieval from confined spaces (e.g., body harness, lifelines).
- Have trained and equipped personnel standing by and maintaining constant communication with personnel in confined spaces.
- Maintain an uninterrupted supply of breathing air with the correct composition.
- Ensure gas cylinders are clearly labeled as to their contents.
- Ensure personnel understand the unique fittings on cylinders of different compressed gases.
- Develop and implement a training program that covers ventilation systems, safe practices for confined space entry and rescue, gas cylinder and bulk nitrogen storage safety, dangers of nitrogen-enriched atmosphere and preventing mix-ups between breathing air and nitrogen.

The use of nitrogen in the workplace must be recognized as having the potential for creating dangerous atmospheres deficient in life-sustaining oxygen. Workers must be diligent when using nitrogen and other cryogenics that have the ability to displace oxygen. Workers also need to consider how their actions could establish a confined area that causes the atmosphere to degrade overtime, such as in the Union Carbide and Lawrence Livermore events. Precautions must be taken to ensure that there is sufficient oxygen in the atmosphere in areas where a nitrogen-enriched hazard may be present.

KEYWORDS: *Oxygen-deficient, nitrogen, asphyxiation, confined space*

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