OPERATING EXPERIENCE SUMMARY

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U.S. Department of Energy

Office of Environment, Safety and Health

OE Summary 2003-07

April 7, 2003

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 2003-07

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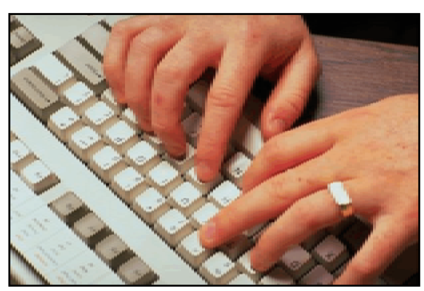

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TWO WORKERS INJURED IN CONSTRUCTION ACCIDENT

On March 20, 2003, at a building construction site at the Sandia National Laboratories in Albuquerque, two construction workers were injured when an unsecured steel beam, being used with a chainfall to lift a metal stairway, slipped sideways and fell. The beam struck the worker controlling the chainfall in the right foot, inflicting a serious crushing injury. The metal stairway also fell and struck a second worker, lacerating his left shin. A Type B accident investigation is being conducted. Relevant lessons learned and corrective actions arising from this accident will be published in a future edition of the Operating Experience Summary. (ORPS Report ALO-KO-SNL-NMFAC-2003-0005)

EVENTS

1. NEAR MISS WHEN CHEMICAL REACTION VESSEL EXPLODES

On January 8, 2002 at the Los Alamos National Laboratory, researchers were conducting an experiment involving chlorine dioxide (ClO_2) in a reaction vessel when it unexpectedly exploded, damaging the fume hood in which it was contained, as well as the ceiling and walls of the room. No one was injured. Laboratory management convened an accident investigation similar to a Type B to evaluate the event. (ORPS Report ALO-LA-LANL-CHEMLASER-2002-0001; update/final report filed September 26, 2002)

Chlorine dioxide is a yellow to reddish-yellow gas that decomposes rapidly in air. It is a respiratory irritant; however, the chlorine gas into which it decomposes is even more hazardous, and can cause acute damage to the upper and lower respiratory tract. Because it is highly reactive, chlorine dioxide is always made at the place where it is used. Chlorine dioxide is widely used as a bleaching and disinfecting agent.

Researchers had been conducting the experiment since June 2001 to develop a storable form of ClO_2. To make a storable form, the researchers generated ClO_2 by reacting a gaseous mixture of 4 percent chlorine and nitrogen with sodium chlorite in a reactor bed, in accordance with a hazard control plan. The ClO_2 then passed into a Parr® metal reactor vessel at 0°C and 2 psi pressure (a typical setup is shown in Figure 1-1) to form a semi-stable hydrate that precipitates from solution and forms crystals composed of six water molecules in a polyhedral configuration, with a ClO_2 molecule bonded at the center.

The researchers wanted to produce a more concentrated hydrate, so they began to increase the concentration of chlorine in the gaseous mixture from 4 percent to 10 percent, and eventually to 100 percent.

The day of the accident, the researchers were attempting to produce rich slurry using 100 percent chlorine gas. One of the researchers noticed that the temperature within the reactor, normally about 23°C at the start of the reaction and increasing to 50-60°C as the ClO_2 was produced, had spiked to 80°C, and called to the second researcher to get out of the laboratory. Seconds after they left, the vessel exploded, causing significant damage to the laboratory. The occupa-

Figure 1-1. A typical Parr vessel system

tional health unit evaluated the researchers and released them to work with no restrictions. All non-essential personnel were evacuated from the adjacent operations area, and co-located workers were evaluated for potential exposure to chlorine gas.

The estimated 68 grams of liquid ClO_2 exploded at about 75,000 psi, equivalent to 30 to 40 grams of TNT. The Parr vessel, with a maximum allowable working pressure of 3,000 psi, was deformed (Figure 1-2), and its propelled lid and locking rings destroyed the fume hood, penetrated the plaster walls and ceiling (Figure 1-3), and knocked out a section of hollow concrete block on the top of the wall. If the researcher had not been monitoring the temperature readout or had not immediately recognized the unsafe condition, the two researchers would most likely have been severely injured.

Figure 1-2. The deformed Parr vessel

The accident investigation team concluded that the researchers had not recognized that ClO_2 could condense under the modified conditions of the experiment. The researchers had changed the experiment to maximize ClO_2 generation without analyzing the hazards or revising the hazard control plan.

Figure 1-3. The shroud over the Parr vessel protruding from the ceiling

The hazard control plan stated that gaseous ClO_2 can become explosive at 10 percent concentration, but it did not specify the temperature or pressure limits, nor did it specify the conditions under which ClO_2 could condense, becoming far more volatile. The hazard control plan also stated that ClO_2 could spontaneously decompose at concentrations of 10 to 20 percent, but stated that the decomposition was "not particularly violent."

The following are the most pertinent Judgments of Need identified by the Board.

- Managers, supervisors, and workers need to identify hazards and perform work in accordance with Integrated Safety Management principles.
- Controls for managing chemical hazards need to be developed and implemented.
- Any changes or modifications to processes, authorization basis documents, and designs need to be evaluated for potential hazards before they are implemented.
- The laboratory should institute the use of an independent peer review when modifying designs and configurations to ensure that all potential hazards are identified and addressed.
- Hazard analyses need to be communicated to all personnel who are involved in a work evolution.
- Laboratory procedures need to clearly prescribe operating conditions, such as temperature, pressure, and chemical composition, for experiments, particularly those in which miscues can result in explosive hazards.

Another event involving a near miss resulting from an unanticipated chemical reaction occurred on February 23, 2001, at the Pacific Northwest National Laboratory. A laboratory technician was preparing etching solution in a vial, enclosed within a fume hood, and substituted ethanol for methanol. The vial ruptured after he left the room, spraying a mixture of nitric acid, hydrochloric acid, and ethanol in the fume hood. The technician failed to notice that the Metals Handbook he was using warned not to use ethanol to prepare the etching solution because the maximum allowable volume ratio of 5 percent ethanol to nitric acid could not be maintained. (ORPS Report RL--PNNL-PNNLNUCL-2001-0007)

These events illustrate the importance of developing comprehensive hazard analyses and procedures for chemical work. If any process change or unexpected condition arises, workers should make sure that all potential hazards are addressed. Modifications or substitutions to materials in chemical reactions can cause unforeseen hazards with the potential for significant damage or severe personnel injury.

KEYWORDS: *Chemical reaction, explosion, chlorine dioxide, reaction vessel, near miss*

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

2. *MIXING CHEMICALS CAN CREATE STORAGE HAZARDS*

In January 2003, at the Lawrence Livermore National Laboratory, a researcher's mixture of 2 percent potassium dichromate in concentrated sulfuric acid leaked from its container, wetting adjacent containers, soaking into the wood floor of a cabinet, and spilling out onto the floor of the room. The leaking chemicals presented a safety hazard in the laboratory that could result in injury, illness, fire, or property damage. (SELLS Identifier LL-2003-LLNL-06)

The researcher had blended the potassium dichromate with concentrated sulfuric acid in a 1-gallon plastic product container (Figure 2-1) to make an effective glass cleaner (a standard laboratory practice). The researcher stored the mixture under a laboratory sink without using a secondary containment tray. Several other containers, including aerosol cans of WD-40® (a flammable petroleum distillate) and glass cleaner with flammable propellants, were stored next to the plastic container.

Figure 2-1. Leaking container of solution (with yellow cap)

The leaking acid/dichromate solution pooled on the floor of the cabinet and caused charring of the wood from chemical exposure. Over time, the solution worked its way underneath the cabinet door and spilled onto the floor of the room (Figure 2-2).

Figure 2-2. Chemical leak and spillage on floor

An Environment, Safety and Health Response Team determined that there was a significant risk of the acid/dichromate container failing completely, if disturbed, because of its condition. They were also concerned that corrosion of the adjacent aerosol containers caused by the leaked solution could result in a fire. They summoned the Laboratory fire department to address these concerns.

Fire department responders, wearing supplied-air respirators and chemical-resistant suits, removed the leaking plastic container and the aerosol containers. They spread neutralizer on the area to contain the spill. The contents had been marked on the container, which greatly aided responders in dealing with the cleanup. The floor of the cabinet was subsequently removed and disposed of as hazardous waste.

The material safety data sheets for the chemicals involved in this spill contained the following guidance.

- Sulfuric acid (52 to 92 percent) should be separated from acids, alkalis, reducing agents, and combustibles. Sulfuric acid is incompatible with combustible materials, metals, acids, and alkalis.
- Potassium dichromate (2 to 5 percent) should be separated from combustible, organic, or other materials that readily oxidize. It is incompatible with reducing agents and organic compounds, and should not be stored on wood floors.

The following laboratory recommendations resulted from this event.

CHEMICAL STORAGE RECOMMENDATIONS

1. ***Place liquid chemicals in appropriate containment trays and segregate by compatibility.***
2. ***Check for compatibility before mixing chemicals and use appropriate containers.***
3. ***Use a proper storage locker (e.g., acid cabinet or flammable storage cabinet).***
4. ***Minimize the amount of hazardous materials in the work area. Large containers cost slightly less per unit to purchase, but may represent an unnecessary risk.***
5. ***Conduct routine assessments for chemical storage and compatibility within the laboratory.***

This event illustrates the need to safely store hazardous liquid chemicals. Liquid storage containers can fail for many reasons, and their contents can spread a significant distance if a secondary containment is not provided. The use of a secondary containment can minimize the impact of leaks or spills in the workplace. Acids, in greater than bench-top quantities, should be stored in acid-rated storage cabinets. Before mixing chemicals, personnel should ascertain chemical compatibility and determine if the container material will safely hold the new solution because containers that are stable for their original contents may not be safe when exposed to other chemicals. A glass container probably would have prevented this event.

KEYWORDS: *Chemicals, mixing, storage, leaks, spills, acid*

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

3. BANNED RESPIRATOR HOODS PURCHASED AND USED

On March 4, 2003, at the Hanford Central Plateau Remediation Project, an Industrial Hygiene (IH) technician observed workers in airborne radioactive material areas using a model of powered air purifying respirator (PAPR) hood that had been banned from the site in 1999 because of a potential defect. A failure in the procurement process allowed the banned respirator hoods to be purchased for use onsite. None of the suspect hoods failed during use. (ORPS Report RL--PHMC-CENTPLAT-2003-0005)

In October 1999, a Hanford environmental restoration contractor filed an occurrence report (ORPS Report RL-BHI-GENAREAS-1999-0005) and issued an internal lessons learned statement describing a potential defect in respirator hoods manufactured by Mine Safety Appliance (MSA) Company. MSA placed a protective paper sticker on the facepiece of each respirator hood to prevent it from being scratched. The process used to apply the sticker produced a crease, weakening the facepiece. In some cases, the crease caused the facepiece to crack, compromising the integrity of the respirator hood. The Hanford internal lessons learned statement about the potentially defective hoods was considered significant enough to be further disseminated by other contractors in the DOE complex, including those at the Miamisburg Closure Project and the Ames Laboratory.

As a result of this discovery, Hanford Site contractors asked MSA to provide them with respirators that did not have the protective facepiece cover. In response, MSA began providing respirator hoods without the cover that had a Hanford-specific identifying part number (#10019415), and the Hanford Site technical authority banned the use of any hood that had a facepiece cover. MSA continued to manufacture the original model of the hood for other customers, designated with the original part number (#486485). Both respirators are certified by the National Institute for Occupational Safety and Health (NIOSH).

On February 20, 2003, 75 of the banned PAPR hoods were purchased and delivered to the Hanford project. Because the lessons learned from the 1999 incident were not effectively documented and communicated, the contractor procurement representative who ordered the respirators did not know about the potential defect or that these particular hoods had been banned from the Hanford Site. A process was in place for a contractor subject matter expert to review and approve all respirators procured, but this process failed because the designated person was not available to approve the procurement. Sixty-nine of these hoods were used between February 20 and March 4, 2003, when the IH technician noticed workers using them. None of the workers who used these hoods reported any problems with them.

The recurrence of this previously identified problem was the result of inadequate formalization, dissemination, and implementation of corrective actions from the earlier discovery. The discovery of the potential defect in the hood facepieces in 1999 was not effectively communicated to the appropriate procurement and IH personnel within the contractor's organization. The IH technician for this facility was on leave when the hoods were delivered, and did not discover the presence of the banned hoods until she returned.

An entry has been made in the DOE Lessons Learned Database about the March 4, 2003 discovery with the identifier 2003-RL-HNF-0010. The DOE Lessons Learned Database is accessible at website http://tis.eh.doe.gov/ll.

Corrective actions taken or planned as a result of this discovery include the following.

- Collect all MSA PAPR hoods with facepiece stickers to ensure that they will not be used.
- Notify all affected workers of the identifying characteristics of the defective MSA PAPR hoods.
- Issue a notice from the contractor technical authority directing all respirator issuers to check inventories of MSA PAPR hoods and remove from service those with the potential defect.
- Re-evaluate the contractor's procurement processes for respirator equipment to tighten controls.
- Issue an advisory to procurement personnel containing the correct part number to use for ordering MSA PAPR hoods.
- Prepare and disseminate a Lessons Learned report DOE-wide to alert other DOE sites of the potential problem with MSA respirators containing hoods with protective paper on the facepieces.

Facility managers, as well as personnel responsible for respiratory protection programs, should check respirator inventories and remove from service any potentially defective hoods. Personnel who wear respirators should know how to recognize the defective hoods and implement correct practices for examining, wearing, and operating respirators. Respiratory protection equipment and the requirements for respiratory protection programs are addressed in Occupational Safety and Health Administration (OSHA) Standard 29

CFR 1910.134, *Respiratory Protection,* and American National Standards Institute standard, ANSI Z88.2-1992, *Respiratory Protection.*

This event underscores the need to ensure the "staying power" of corrective actions resulting from occurrences. The re-appearance at the Hanford Site of the previously banned respirator hoods was caused by inadequate formalization, dissemination, and implementation of the corrective actions identified from the earlier discovery. Formalized, long-lasting directives need to be issued to Industrial Hygiene personnel, procurement personnel, supervisors, and potentially affected workers to preclude recurrence of this problem. Periodic training programs for all affected parties should include reminders on such matters to ensure that the corrective actions taken have the breadth and depth required to remain effective for long periods of time.

KEYWORDS: *Powered air purifying respirator (PAPR), respirator hood, hood facepiece, manufacturing defect, personal protective equipment (PPE)*

ISM CORE FUNCTIONS: *Develop and Implement Hazard Controls, Perform Work within Controls, Provide Feedback and Continuous Improvement*

4. UNSAFE USE OF HYDRAULIC POWER UNIT RESULTS IN NEAR MISS TO SEVERE INJURY

On March 7, 2003, at the Waste Isolation Pilot Plant, a maintenance worker was struck and injured by an extension rod for a portable hydraulic jack ("Porta Power" unit) that was being used to straighten the push plate on a front loader bucket to replace a pivot pin. The extension rod, which was not compatible with this Porta Power model, slipped off the end of the piston and hit the worker in the chest and shoulders. (ORPS Report ALO--WWID-WIPP-2003-0001)

Two maintenance workers had heated the push plate and were applying pressure to it with the Porta Power (Figure 4-1). They needed to add an extension to the end of the Porta Power cylinder to extend its working range (Figure 4-2). Although some Porta Power models have threaded cylinders and couplings to join the

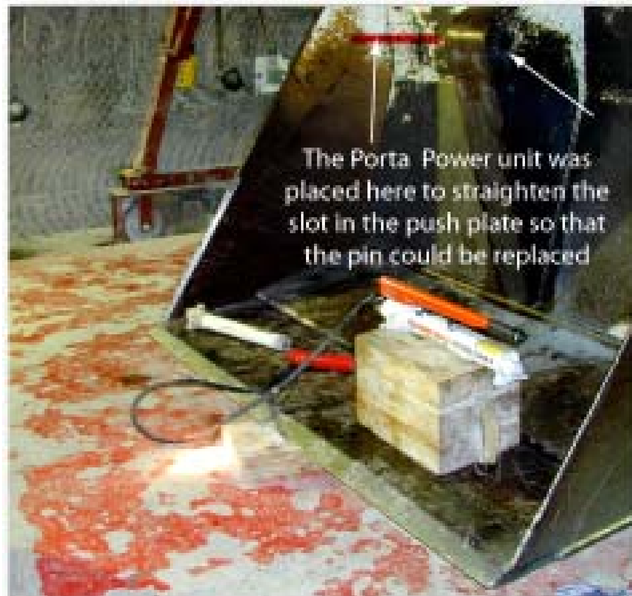

Figure 4-1. The location on the bucket where the Porta Power was used

extension piece, they used an older model that was not threaded. Since there were no threads to hold the pieces together, the workers just aligned the power cylinder and extension, and depended on pressure and friction to keep the two pieces in place. When they applied additional pressure with the Porta Power unit, the extension slipped out of position and struck one of the workers causing scrapes and bruises on his upper chest and left shoulder. He appeared to be disoriented and to have bitten his tongue. A full examination, including x-rays, confirmed that the worker had not

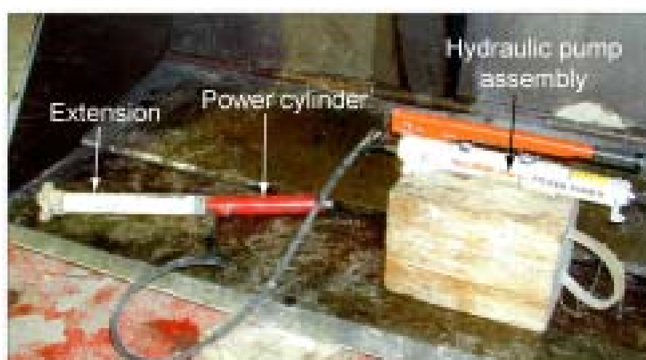

Figure 4-2. The portable hydraulic jack and its extension

suffered any additional injuries.

Investigators determined that the loader bucket was out of service and miners had conveyed a sense of urgency to the maintenance workers to repair it. Although other Porta Power units were available for use, the maintenance workers used an older, unthreaded power cylinder instead of a newer model with the threaded coupling, presumably in their haste to repair the loader. Because they used incompatible equipment components, the workers could not ensure that the two parts would not separate.

Facility managers held safety meetings with the involved workers and other personnel who may need to use Porta Power equipment to stress the importance of using the correct extension with the correct unit.

The Occurrence Reporting and Processing System database contains other events involving improper equipment selection that resulted in a near miss. On April 3, 2002, at the Rocky Flats Environmental Technology Site, during a trailer installation, a construction supervisor operating a jackhammer from a manlift momentarily lost control of the jackhammer. He regained control before it could fall to the ground and potentially strike a worker who was positioning a grounding rod below the manlift. The worker suffered a minor shoulder strain when he grabbed the rod, but was otherwise uninjured. (ORPS Report RFO--KHLL-WSTMGTOPS-2002-0006)

A contributing cause to the Rocky Flats event was an error in equipment selection. The jackhammer bit used to drive the ground rod into the ground, although designed for this task, had a very shallow recessed end that that would allow it to rebound off of the end of the rod. Construction personnel could have accessed a different bit with a deeper recess to ensure optimal engagement of the rod end and secured the jackhammer to the manlift to prevent it from slipping.

Another similar event involving a Porta Power unit occurred in Australia several years ago and had more serious consequences. On December 4, 2000, the Australian Department of Mines and Energy issued a safety alert on this incident. Two operators were using the unit to remove a bucket pivot pin from a loader bucket with a steel bar between the pin and the power unit. The face of the bar was not square with the pin and the force being exerted by the power unit. The forces applied expelled the steel bar, causing it to become a flying object from which the operators had no protection. The bar hit one operator in the mouth, breaking his jaw and knocking out some teeth. Recommendations included (1) ensuring that the ends of tools are square and fit the purpose intended, (2) provide protection when the possibility exists for projectiles, (3) stand to the side of the unit, and (4) perform a mini-risk analysis appropriate for the job.

These events illustrate the importance of analyzing potential hazards before work begins. Workers should not attempt to substitute incompatible tools simply to get the job done quickly. Workers need to understand that the forces generated by hydraulic power units and their attachments can be extraordinarily high. Unsafe use can result in equipment failure and generation of dangerous projectiles by the release of stored hydraulic energy. Safety always takes priority over production.

KEYWORDS: *Near miss, portable hydraulic jack, Porta Power, injury, personnel error*

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

5. NEAR MISS: ENERGIZED CONDUCTOR CUT DURING DEMOLITION

On February 24, 2003, at the Miamisburg Closure Project, a worker using a reciprocating saw cut into a rigid wall conduit that had been scheduled for removal. The worker noticed a flash, indicating that an energized conductor had been struck, and immediately stopped work. Work planners had failed to identify a second power source providing 110-volt electricity to a conductor in the conduit, and the zero-energy check performed before work began was not comprehensive. The worker did not receive a shock and had no adverse effects from this occurrence. (ORPS Report OH-MB-BWO-BWO04-2003-0002)

Two workers were cutting through pipes and conduit during demolition of systems in a deactivated building. They were standing on the platform of a scissor-lift equipped with rubber wheels that was about 6 feet above the floor. The worker who cut into the conduit was using an Underwriters' Laboratory-approved, hand-held reciprocating saw that was double-insulated and properly grounded. Both workers were dressed in full anti-contamination clothing, including coveralls, leather gloves over rubber gloves over cotton gloves, and plastic booties. Figure 5-1 shows the partially cut conduit still attached to the ceiling.
Investigators determined that the affected conduit contained an energized control circuit conductor connected to a 110-volt power source on the other side of the wall. They discovered a blown fuse associated with the circuit during their investigation. As shown in Figure 5-2, the affected conduit had an air-gap (physical separation) on one end; however, the drawings used during work planning did not show a tee junction (like the one shown in Figure 5-2) in the conduit run or the energized circuit that used the junction. Work planners could not inspect portions of this conduit because a temporary structure enclosed portions of the conduit run.

Investigators identified three causal factors that contributed to this occurrence.

(1) Zero-energy check not comprehensive – An intermittently energized conductor for sump pump operation was not identified.

(2) Inaccurate drawings – The drawings used in the work planning process did not show the 110-volt control circuit in the affected conduit.

(3) Violation of the National Electrical Code – All of the conductors inside the affected conduit were not identified.

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

- All conduit scheduled for removal will be re-examined and re-marked with color coding.

- Workers will be re-trained on the hazards of cutting into energized conduit and on the significance of color-coded conduit.

- Conduit to be removed will have air gaps verified at both ends of the conduit.

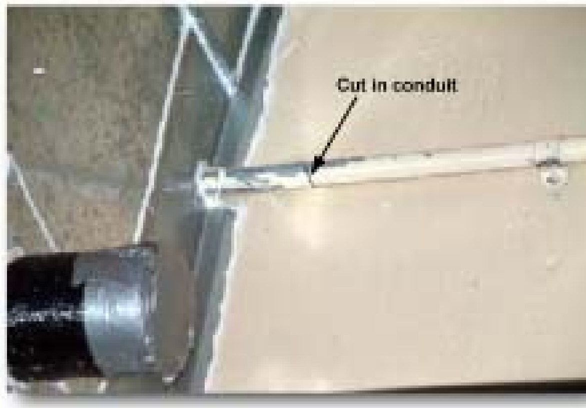

Figure 5-1. Partially cut conduit

- A method for isolation of all utilities in a building will be prepared and approved before demolition activities are resumed.

A search of the Occurrence Reporting and Processing System database revealed several similar oc-

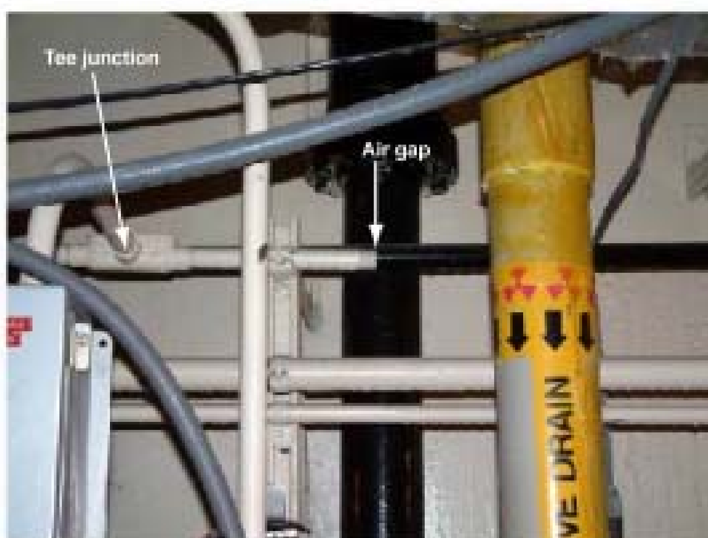

Figure 5-2. Air gap in conduit and tee junction

currences, including the following. On August 15, 2002, at the Rocky Flats Environmental Technology Site, an energized 120-volt conductor (identified by a tag as de-energized) was cut during demolition of a deactivated building. The electrician heard a "pop" when the conductor was cut and immediately stopped work. An error was made in tagging the conductor as de-energized, and procedurally required air gapping was not performed. The electrician was wearing personal protective equipment and using an insulated tool. No electrical shock or personal injury resulted from this event. (ORPS Report RFO--KHLL-PUFAB-2002-0052)

On May 23, 2001, at the Oak Ridge East Tennessee Technology Park, workers observed electrical arcing while cutting conduit in a deactivated building. The cut had been authorized by an electrician who had certified that the conduit wiring was de-energized after checking it with a proximity voltage tester. It was later determined that the voltage tester was not working properly. No injuries resulted from this occurrence. (ORPS Report ORO--BNFL-K33-2001-0006)

In June 2002, the Office of Environment, Safety and Health (EH) issued A Review of Electrical Intrusion Events at the Department of Energy: 2000-2001. This report contains an analysis of 63 electrical intrusion events reported to the DOE Occurrence Reporting and Processing System from January 2000 through December 2001 (URL http://tis.eh.doe.gov/paa/reports.html). Problems identified in this special report include inaccurate as-built drawings, non-compliance with procedures, lack of zero energy checks, and inadequate practices in work planning and execution. 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/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.

These events underscore the need to take all available precautions to avoid intrusions into energized electrical conductors. Work planners should not assume that electrical drawings are correct when preparing work packages for jobs that involve working near energized conductors. Work planners should walk down the conduit and identify all conductors enclosed by the conduit. If temporary structures or passage through walls preclude visual inspection of the entire length of the conduit to be cut, work planners should search for other ways to positively identify all the conductors contained in the conduit. To be effective, air-gapping must be used at both ends of a conduit to be cut, not just at one end. Lockout/tagout processes and properly rated personal protective equipment should be used if there is any possibility of encountering energized electrical conductors during the proposed work evolutions.

KEYWORDS: *Electrical conduit, electrical intrusions, energized electrical conductor, near miss, demolition activities*

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