OPERATING EXPERIENCE SUMMARY

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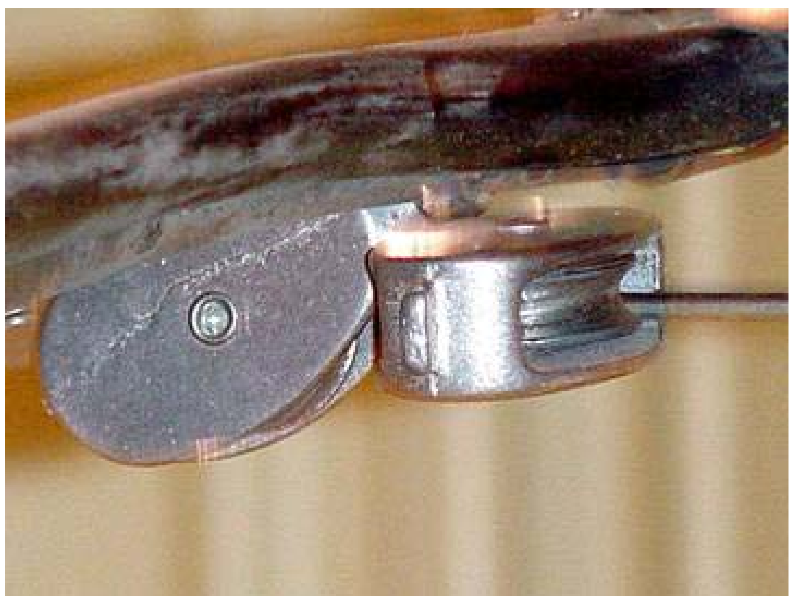

U.S. Department of Energy

Office of Environment, Safety and Health

OE Summary 2003-16

August 11, 2003

The Office of Environment, Safety and Health (EH), Office of Analytical Studies, 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.

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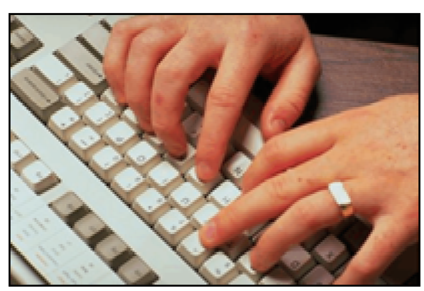

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TYPE B INVESTIGATION OF WORKER EXPOSURES

On August 5, 2003, at the Los Alamos National Laboratory, two workers inventorying items in a cage in a high contamination area became contaminated on their upper bodies, and nasal smears indicated positive intakes. The continuous air monitor alarmed, and the workers left the room and were successfully decontaminated. One worker had a maximum skin contamination level of 50,000 disintegrations per minute (dpm) alpha; the other had a maximum of 15,000 dpm alpha. Preliminary nasal smear results were 1,700/2,400 dpm alpha and 155/2,500 dpm alpha, respectively. Health physics staff placed both workers on prompt-action bioassay. Following the critique the next day, DOE representatives announced the formation of a Type B committee to investigate the incident. The room where the event occurred is inaccessible until the investigation commences. After the investigation is complete, relevant lessons learned and the corrective actions will be published in the OE Summary. (ORPS Report ALO-LA-LANL-TA55-2003-0017)

EVENTS

1. ACCUMULATION OF DUST CAUSES EXPLOSION AT MANUFACTURING PLANT

Investigators from the U.S. Chemical Safety Board (CSB) announced that a massive blast at the West Pharmaceutical Services manufacturing plant in Kinston, North Carolina, was caused by the explosion of fine plastic powder (dust) used to manufacture rubber medical devices. The dust had accumulated in the ceiling areas of the plant. The CSB is an independent federal agency charged with investigating industrial chemical accidents. The CSB news report on this event can be accessed at www.chemsafety.gov/news/2003/n20030602.htm

On January 29, 2003, the explosion ripped through the manufacturing plant (Figure 1-1), killing six workers and injuring dozens more. The dust explosion of fine plastic powder occurred above an area where rubber strips were coated with moistened polyethylene powder. The powder when dry is as fine as talcum and is capable of forming an explosive mixture in the air. Although investigators have not been able to determine the ignition source, the five conditions necessary for a dust explosion were met: fuel (dust), oxygen, dispersion, confinement, and ignition.

Figure 1-1. Aerial photo showing the magnitude of the explosion

Investigators determined that the ventilation system drew fine dust particles into the space above an unsealed, suspended ceiling, where the particles settled and accumulated. They examined numerous ceiling tiles that were scorched on the upper surface, confirming that the explosion occurred within the overhead space. Eyewitnesses heard a sound like rolling thunder as the dust explosion propagated through the ceiling space, devastating the plant.

As part of the manufacturing process, rubber used to produce medical products is rolled into flat strips. To keep the strips of rubber from sticking they are coated with a polyethylene powder in a water slurry. After the rubber dries, a talcum powder-like coating remains on the surface of the strips. During the drying process, fans blew some of the fine powder into the air and much of the dust settled in the processing area, where workers routinely cleaned it off equipment, walls, and floors. However, some dust migrated through small openings in the suspended ceiling, drawn by air conditioning intakes located overhead. The dust accumulated on tiles, conduits, ducts, and light fixtures, which were out of normal view of the workers.

Weeks before the explosion maintenance workers had seen layers of dust coating surfaces above the suspended ceiling but did not recognize it as an explosive hazard. One worker told investigators that "We never had any training. We were never told that the dust could explode." By installing a suspended ceiling years earlier, the company inadvertently created an area where dust could accumulate out of view and a space where a dust explosion could occur and spread.

A more recent event involving a dust explosion occurred on July 22, 2003, at a Blythewood pharmaceutical packaging company in Columbia, South Carolina, where seven workers were injured in an explosion in a warehouse after dust from plastics ignited. One employee was treated for burns, and the others suffered minor injuries. A safety investigation continues.

A dust explosion is very similar to a gas or vapor cloud explosion. When a combustible material (in this case a very fine plastic dust) is dispersed in the air, it forms a flammable cloud in which a flame can easily propagate through it. Overpressure produced by a dust explosion can be as high as 12 psi, which is capable of turning a building to rubble. Preventing dust explosions falls into two basic categories: preventing the ignition and preventing the formation of a dust cloud. Preventing ignition involves controlling or eliminating open flames, hot surfaces, or electric/electrostatic sparks. Preventing an explosive dust cloud involves maintaining dust concentration outside of combustible range, using inert gases, and practicing good housekeeping (cleaning and removing dust).

RECOMMENDATIONS FOR PREVENTING DUST PARTICLE ACCUMULATION

- Ensure that ceilings in areas where explosive dusts may be present are sealed.
- Practice good housekeeping to ensure that flammable dust from ongoing processes does not accumulate to the extent that it can reach explosive conditions, particularly when fuel, oxygen, dispersion, confinement, and ignition are present.
- When entering a building that has not been occupied or cleaned for extended periods (as in decommissioning), carefully remove any potentially explosive dust that has accumulated.

A lessons-learned report was issued by Fluor Hanford (SELLS Identifier: 2003-RL-HNF-0002) on this event to help educate Fluor Hanford and DOE employees of the dangers involved with dust-producing operations. Contrary to the CSB investigators citing a general lack of industry knowledge about dust explosions, the lessons-learned report states that many National Fire Protection Association requirements are intended to prevent just such events, indicating that at least some people recognize the hazard.

Events involving dust explosions have also occurred within DOE.

- An individual received minor burns on his hands, arms, and abdomen at the INEL Research Center after a small quantity of metal powders ignited. The individual was mixing the powders by shaking them in a sealed plastic container. Investigators believe that a dust cloud of fine metal particles in the container was ignited by static electrical discharge and exploded. (ORPS Report ID--LITC-TOWN-1995-0002)
- A coal dust explosion and fire occurred at a coal-fired steam generating facility at the Idaho Chemical Processing Plant, resulting in structural and equipment damage. An operator was transferring coal into a day bunker without closing a slide gate barrier between the explosive air-coal dust mixture

in the bunker and the boiler fire box. (ORPS Report ID--WINC-ICPP-1991-0015)

These events illustrate the dangers of explosive dust and the insidious hazard posed by the unknown accumulation of dust, which many may consider rather benign. Personnel need to understand and recognize that many flammable materials, when finely divided, can be explosive. Housekeeping is an effective method of identifying and removing potential hazards. Good housekeeping is NOT simply limited to proper handling of waste and trash, but involves both cleanliness and order. Poor housekeeping contributes to the threat of a fire occurring and for a small fire to grow. Accumulation of dust, lint, flammable liquids, and oil residues in the facility allows for easy ignition and the possibility of a flash or fast-spreading fire or explosion.

KEYWORDS: *Explosion, dust, plastic, chemical safety, injury, fatality, housekeeping*

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

2. WORKER INJURED BY ELECTRICAL SHOCK

On May 27, 2003, at the Los Alamos National Laboratory, a machinist received an electrical shock from a mobile welding cart when he simultaneously contacted the energized cart and another piece of equipment. The worker became part of the path to ground and received a substantial shock that resulted in numbness to his left arm numb that lasted for several days. Improper wiring on a plug connecting the power supply to the welding cart resulted in 260 volts AC on the body of the welding cart. The ground and one of the power leads in the welding cart plug had been reversed. The worker suffered no health effects other than the prolonged numbness, pain in his left arm, and a headache. (ORPS Report ALO-LA-LANL-NUCSAFGRDS-2003-0002; final report filed July 30, 2003)

Immediately following the incident, an electrical technician de-energized the wall disconnect switch and locked and tagged it out. He also installed a lockout/tagout on the welder plug. When the technician performed diagnostics on the welding cart and its power source, he determined that the cart was still energized. Upon further investigation, the technician determined that the ground lead and one of the power leads within the welding cart plug had been reversed.

Investigators determined that an electrician had modified the power supply for the welder to increase the voltage from 240 to 480 volts. He also installed of a safety disconnect switch, a pin-and-sleeve welder plug (where the wiring error occurred), conduit and wire, and a 480-volt, 3-phase circuit breaker. Figure 2-1 shows the incorrectly wired welder plug, with the ground and one of the power leads reversed. A post-modification test of the completed installation, including the welder plug wiring, was not performed. Testing was not required by laboratory requirements or standards, and a verification check was not required by contractor procedures. After the electrician incorrectly completed the modification, the (now energized) welding cart sat undisturbed for nearly 2 weeks, presenting a potential electrical shock hazard.

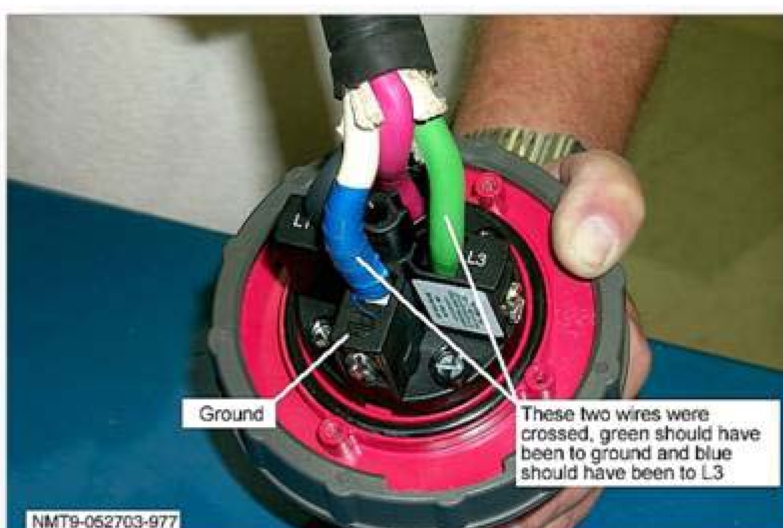

Figure 2-1. Incorrectly wired welder plug

Investigators determined that the direct cause of this incident was personnel error (inattention to detail). The electrician who wired the welding cart plug said he was distracted and inadvertently reversed the positions of the two leads. The electrician did not verify that the wiring was correct, and neither an independent verification nor continuity checks were performed. Investigators identified a second personnel error (communications problem) as a contributing cause. The requirements for a disconnect switch were not identified in the original work package, and this change in the scope of work and the subsequent need to install a new pin-and-sleeve welding cart plug contributed to the cause of the incident.

Investigators also identified a management problem as a contributing cause. Task managers did not communicate to crafts personnel their expectations concerning self-checking and independent verification of the work performed. Investigators identified the root cause of the incident as a management problem. They determined that deficiencies in the work control process related to work planning, training, and work oversight (all management responsibilities) caused the incident.

Corrective actions resulting from this event included developing and implementing the following.

- A new procedure for independent verification and testing for all completed electrical work packages.
- A new procedure on formality of operations, focusing on identifying an appropriate work scope, recognizing and responding to work scope changes, conducting pre-job briefings, and documenting a process for returning systems/equipment to service after maintenance or modification.
- A new refresher training course about this incident, focusing on the work control process, formality of operations, and maintaining a safe work environment.
- A new training course for work control personnel on management expectations for the proper development and execution of work requests.

A search of the ORPS database revealed several other recent occurrences in the DOE complex where undetected wiring errors created electrical hazards. On May 27, 2003, at the Oak Ridge National Laboratory, a worker received a mild electrical shock when he came in contact with an electrical conductor that he thought was de-energized. Investigators determined that a 120-volt AC receptacle inside a cabinet had been incorrectly wired, with the ground lead and one of the power leads reversed. (ORPS Report ORO--ORNL-X10SNS-2003-0002)

On January 27, 2002, at the Argonne National Laboratory East, electricians discovered a 110-volt AC potential on a cabinet frame and on a piece of equipment located in the cabinet that was plugged into an electrical receptacle with an isolated ground. Further investigation revealed that the receptacle had been incorrectly wired, with the ground lead and one of the power leads reversed. (ORPS Report CH-AA-ANLE-ANLEPFS-2002-0001)

GOOD PRACTICES FOR ELECTRICAL MAINTENANCE / MODIFICATIONS

Check each sub-task as it is completed.

Require independent verification of tasks as they are completed.

Perform continuity checks on modified circuitry.

Consciously reject distractions during the performance of tasks where there are safety implications if the task is not completed correctly.

Ensure that the work scope defined in the work package is understood and followed.

Identify departures from the defined work scope and stop work when they occur.

Perform integrated testing of completed tasks.

These events underscore the importance of self-checking of tasks, independent verification of completed work, and acceptance testing of equipment after maintenance or modifications. Because none of these processes was performed in the LANL incident, the incorrectly wired welding cart plug created an accident waiting to *happen, and this hazardous condition existed for nearly 2 weeks. The worker who received a substantial shock in the LANL incident was very fortunate. If his chest had been in the electrical discharge path instead of just his arm, he could have received a much more serious injury.*

KEYWORDS: *Work controls, self-checking of work, independent verification, acceptance testing, formality of operations, electrical safety, electrical shock*

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

3. UNPLANNED EQUIPMENT MODIFICATION LEADS TO BRIDGE CRANE DAMAGE

On July 7, 2003, at Argonne National Laboratory–West (ANL–W), a crane operator was positioning a bridge crane for a lift when the power cord support cable snagged on a support pulley causing one of two hard-wired power supply cords to pull out of its junction box. The main power supply breaker opened under fault and power was lost to the bridge crane, and several areas of the building. Material handlers stopped work and notified a supervisor of the problem. No loads were suspended on the crane at the time of the event and no personnel were injured. The support pulleys were recently installed to replace worn power cord support rings that slid along the support cable. (CH--AA-ANLW-AL-2003-0002)

The ANL–W bridge crane was manufactured by American Wright Overhead Crane and designed with power cord support rings that slide along a support cable. In March 2003, facility personnel initiated a work request to repair or replace the support rings because they were showing signs of wear. However, electricians were unable to find identical replacement rings and recommended they be replaced with pulleys. Although this represented an equipment modification, an Engineering Task Authorization) (ETA) was not initiated as required by facility procedures. Pulleys were being used in similar applications at other facilities, so management approved the change. The pulleys were tested, the cable support system appeared to work satisfactorily, and the work request was closed. Facility personnel operated the crane without incident on numerous occasions before July 7.

On the day of the event, material handlers were preparing to lift two computer servers from the facility basement through a hatch to the ground floor. They checked the crane, lifted the hatch cover, and rigged the crane to lift a wire basket. The crane operator lowered the basket through the hatch, and the servers were loaded into the basket. The lift was executed without incident and the load was removed from the crane. The crane operator was moving the unloaded crane in position to replace the hatch cover when workers saw sparks flying from above the crane. Electrical power to the room was interrupted and the crane stopped moving. Power was also lost to four other wings of the building.

The workers notified their supervisors, who arrived at the scene to evaluate the situation. They determined that one of two crane power cords had pulled free of the bridge junction box, as shown in Figure 3-1. After tagging and locking open the crane's power supply disconnect switch, electricians restored electricity to the facility. Plant services covered the equipment hatch with planking and plywood.

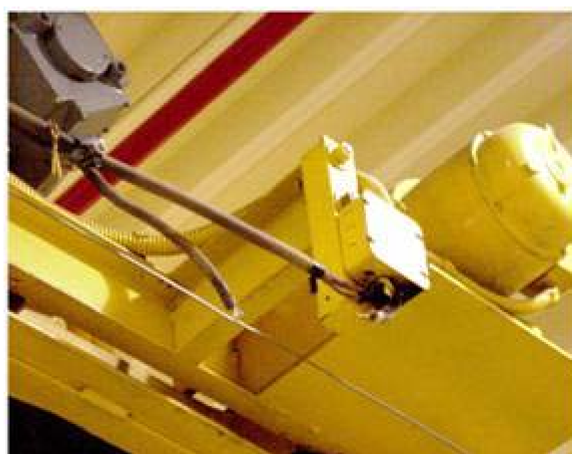

Figure 3-1. Power cord pulled out of the bridge junction box

Personnel investigating the event discovered that the support cable was wedged between the leading pulley roller and the pulley housing.

This prevented the pulley from sliding along the support cable as the crane trolley was being moved by the crane operator. See Figures 3-2 and 3-3. As the crane continued to move, the power cable was stretched until it pulled out of the junction box. This caused the building power supply breakers to open.

Investigators also discovered that electricians had replaced the cable support rings with pulleys without initiating an ETA or consulting the original equipment manufacturer.

Investigators determined that the wedged support cable was the direct cause of this event. This prevented the pulley from sliding along the support cable and caused the power cable to pull out of its junction box during crane movement. A contributing factor was the improper selection of the pulleys used to replace the cable support

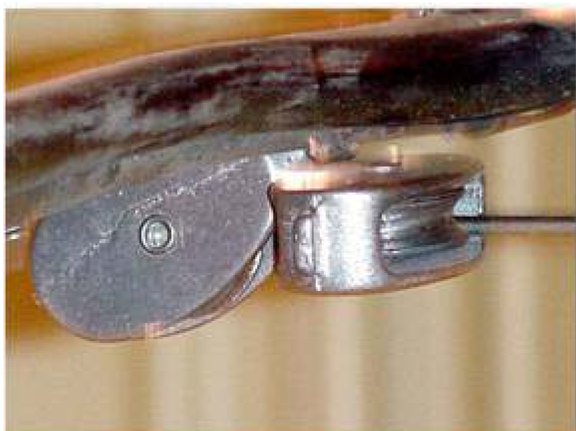

Figure 3-2. Support cable wedged between the roller and housing of the pulley

rings. It appears that the pulleys were not adequately sized or designed to prevent the support cable from wedging between the pulley roller and the pulley housing. Investigators identified the root cause of this event as the failure of both workers and management to follow facility procedures when performing equipment modifications. Equipment is considered to be modified when replacement parts are used that are not identical or “like-for-like” to the parts being replaced. Procedures require facility personnel to initiate an ETA when performing equipment modifications.

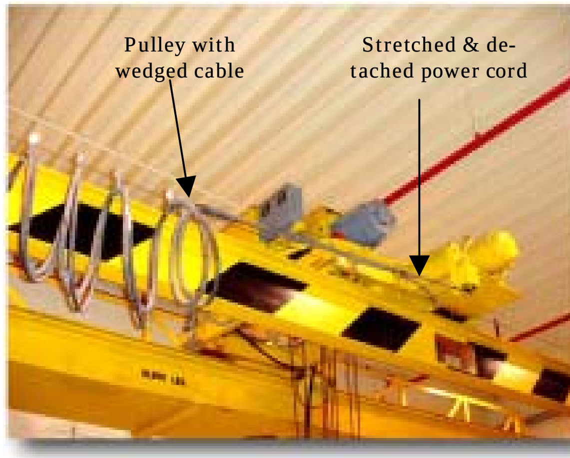

Figure 3.3. View of bridge crane showing pulleys, support cable, and power

This event illustrates the need for procedure compliance and demonstrates the adverse consequences of selecting improper replacement parts. Maintenance personnel and their supervisors did not recognize that the installation of pulleys represented a modification to the original equipment and did not know that an ETA was required. Although this event did not result in injuries or major equipment damage, it could have caused an electrical fire or compromised safety if the resultant power outage had shutdown any safety-related equipment.

GOOD PRACTICES

- STOP WORK and consult with management when identical or “like-for-like” replacement parts are not obtainable.
- Perform an engineering evaluation before installing replacement parts that are not identical to the original equipment.
- Contact the original equipment manufacturer if there are questions regarding replacement parts.
- Recognize and follow the appropriate procedures.

KEYWORDS: *Replacement parts, equipment modifications, engineering evaluations, cable support rings*

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

4. WORKER PUNCTURES ARM WITH KNIFE

On July 17, 2003, at the Rocky Flats Environmental Technology Site, a decontamination and decommissioning worker was removing tape from manlift tires when the knife he was using slipped and punctured his left forearm. A surgeon repaired a nicked artery and tendon in the worker's arm and released him that evening. (ORPS Report RFO--KHLL-SOLIDWST-2003-0018)

Because a puncture injury would introduce radioactive contamination into the worker's bloodstream more rapidly than would ingestion or inhalation, local occupational health department staff immediately performed a wound count and found it was positive. They performed a saline flush during the course of treatment and successfully decontaminated the wound. They also issued a bioassay kit to the worker to determine whether he received an exposure.

The worker used a knife similar in size and shape to a paring knife as a cutting tool. The knife is kept in the area to remove tape from heavy equipment tires and to cut tape in gloveboxes. Although the knife was an appropriate tool for removing tape, the worker should not have pulled the knife with one hand and the tape with the other. The worker did not suffer a permanent injury, and has since returned to work. However, there are a number of examples both within DOE and in private industry in which workers were more severely injured.

In November 2002, at the Oak Ridge East Tennessee Technology Park, a maintenance mechanic was using a linoleum knife to score lightweight aluminum insulation wrap. The mechanic placed an aluminum straightedge (see Figure 4-1) on the wrap to score a straight line. The straight edge started to move as he began moving the knife, so he knelt on the end of the straightedge and pulled the knife along it toward his body. The weight of his knee caused the straightedge to lift up on the opposite end. The straightedge knocked the knife handle as it moved down the wrap, changing its path of motion. The sudden change of motion caused the mechanic to pull the knife across his left thumb and cut through his leather glove. The mechanic's thumb required nine stitches.

Following an investigation, facility management revised the procedure for cutting aluminum wrap to specify the both the appropriate tools to be used and a safer cutting method. For example, an L-shaped aluminum straightedge, fabricated in-house, can be used to guide the knife while scoring the wrap (see Figure 4-2). Kevlar® gloves, shown below, help to prevent injuries as well. The use of scissors or snips should also be considered for cuts that do not create rough edges. (DOE Lessons Learned Identifier Y-2002-OR-BJCETTP-1201)

Two older events with rather severe injuries from utility knives, both involving electricians attempting to strip wires, were also reported to ORPS. On November 10, 1997, at Sandia National Laboratory, an electrician cut his arm while stripping 750MCM wire (a 1-inch-diameter cable) when the utility knife he was using slipped and cut his forearm. The wound

Figure 4-1. Scoring a straight line on aluminum wrap with a simple straightedge

was approximately 10 inches long and an inch deep. Between 150 and 200 stitches and 25 staples were required to close the wound in the electrician's arm. (ORPS Report ALO-KO-SNL-NMFAC-1997-0017)

On January 24, 1996, at Argonne National Laboratory–West, an electrician was stripping

Figure 4-2. Scoring the aluminum wrap with a safer straightedge

insulation from large conductors using a utility knife. The knife slipped, cutting a deep gash about 8 inches long on the inside of the electrician's left forearm. The worker was transported to the local hospital for treatment, where he remained overnight. (ORPS Report CH-AA-ANLW-TREAT-1996-0001)

These occurrences illustrate the hazards posed by improper use of knives. Utility knives serve many useful functions, but they also can cut deeply into hands, fingers, or other unprotected parts of the body. Drawing a knife toward the body should be avoided, but in situations where it is unavoidable, extreme care should be exercised to prevent injury (e.g., standing to the side). In the event at Rocky Flats, the mechanic could have scored the aluminum wrap horizontally and avoided the risk of injury.

USING KNIVES SAFELY

- Sharp knives are safer than dull ones because less force is needed to do the job.
- Point the knife away from yourself or anyone else while cutting.
- Don't use a knife as a substitute for a more appropriate tool (e.g., wire stripper, screwdriver, shears).
- Use all possible means to prevent the knife from slipping while it is cutting.
- Avoid cutting with one hand and grasping the object with the other.
- Wear protective equipment while cutting.
- Pay close attention when using knives.
- Keep the cutting path clear of other objects, including your other hand.
- When cutting thick objects, make several passes with the knife, increasing downward pressure with each pass.
- Close or sheathe the knife immediately after use.

KEYWORDS: *Knife, puncture, injury, radiation exposure*

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