Operating Experience Summary

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Failure to Verify Voltage Results in Electrical Near Miss

1

There is a danger in using an underrated meter when testing high-voltage circuits: a phase-to-ground short can occur. It is essential to ensure that multimeters are correctly set up to perform the required measurement (voltage, current, resistance) and are rated correctly for the circuit to be tested.

On February 7, 2007, at the Nevada Test Site Underground Test Area, a construction wireman attempted to check an energized 2,400-volt circuit while troubleshooting a control panel for a submersible pump (Figure 1-1), and the multimeter he was using failed, burning portions of the test leads and emitting a puff of smoke. Investigators determined that the wireman did not verify the actual voltage inside the panel (480 volts) before he used his 1,000-volt-rated Fluke digital voltmeter. The wireman, who was wearing gloves and eye protection at the time of the near miss, was not injured. (ORPS Report NA--NVSO-NST-NTS-2007-0003, final report filed 03/22/2007)

Two wiremen were dispatched to start a submersible electric pump from the pump motor controller located at a groundwater test well. After several unsuccessful starts, the wiremen decided to troubleshoot the problem, although troubleshooting was not within the scope of the job. One of the wiremen assumed that the voltage inside the pump motor controller was 480 volts based on his experience working with other submersible pumps of typical voltage. When he touched the test leads of the 1,000-volt-rated voltmeter to the circuit to get a voltage reading, the meter immediately failed, and part of the test leads burned away (Figure 1-2). The wireman was not injured, but there was minor smoke damage to his gloves.

Figure 1-1. Pump motor controller and damaged meter on concrete pad (circled)

Figure 1-2. Closeup of the damaged multimeter

Investigators determined that the experienced wireman failed to verify the voltage range of the equipment before he used his multimeter to measure the voltage. The wireman's selection of PPE and measurement equipment was based on his incorrect assumption that the power for this submersible pump was 480 volts. However, the correct, 2,500-volt rating is stamped on the manufacturer's nameplate (Figure 1-3) fastened to the top front of the motor controller outer door. There is also a weathered label on the lower section of the door that states, "DANGER HIGH VOLTAGE KEEP OUT." This was an additional indication that there was high voltage inside the controller panel.

The wireman was accustomed to seeing labels on the panel fronts that indicated 480 volts, and investigators believe the markings on the motor controller were not obvious enough to ascertain the voltage inside the panel. As a corrective action, all similar equipment will be checked

Figure 1-3. Manufacturer's nameplate showing "2500" in the volts block (circled)

to verify voltage. Labels indicating the correct voltage will be installed so that they are visible and understandable. Also, a sign was placed at the entrance to the Nevada Test Site to remind workers to identify voltage hazards before performing work.

Investigators also determined that the good intentions of the wiremen to try and identify what might be wrong resulted in an unapproved change in the job scope when one of the wiremen accessed the energized equipment.

A similar event occurred at the Nevada Offsite Facilities, where a journeyman electrician received second-degree flash burns over 18 percent of his face and hands when his multimeter blew up. He connected a 1,000-volt-rated, Beckman Tech 310 digital multimeter to the primary side of an energized 4,160-volt transformer. The electrician was wearing sunglasses instead of safety glasses. A second electrician standing 6 feet away had his hair singed. Investigators learned that the electrician was only supposed to check the secondary side of the transformer and not the primary side, which was outside the scope of the work. (ORPS Report DP-NVOO--RSNO-OFFNTS-1991-0009)

These events underscore the importance of positive equipment verification to ensure that all hazards are correctly identified to protect the worker. Inattention to detail or performing work based on assumptions can result in unsafe conditions. It is also important to perform only the work that is within the scope of the assigned task. If conditions or situations change, stop work and seek additional direction to proceed safely. This is extremely important when working in or around energized electrical systems, where hazards need to be analyzed to determine safe approach distances for shock and arc flash protection and for selection of proper PPE.

KEYWORDS: *Near miss, meter, multimeter, electrical safety, hazardous energy control, voltage*

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

Aerosol Can Explodes Inside a Hot Truck and Damages Windshield

2

On March 20, 2007, at Sandia National Laboratory New Mexico Site, a 2½-oz. aerosol can overheated and exploded inside a maintenance truck, resulting in a broken windshield (Figure 2-1). The event was reported as a near miss because workers could have been in the vehicle at the time of the incident. (ORPS Report NA--SS-SNL-NMFAC-2007-0003)

Two days before the event occurred, an electrical fire protection craftsperson left a can of "Smoke Check," which is a flammable aerosol for testing smoke detectors, on the dash near the windshield of the truck. The can was a spare that he carried in his back pocket when he was out testing smoke detectors.

Figure 2-1. Hole in windshield of maintenance truck

He intended to put the can in a side compartment on the truck, but instead put it on the dash while he drove back to the Maintenance Office. The can rolled behind a box of tissues, where it was no longer visible, and the craftsperson forgot about it.

On the day of the incident, an electrical craftsperson drove the truck to work in a building where there was an electrical outage. The craftsperson parked the truck facing south, and left it there from about noon to 2:00 P.M. When the craftsperson returned to the truck, the can had already exploded. Figure 2-2 shows the 6-inch by 6-inch hole in the windshield from inside the truck.

Because there were no signs of any type of ignition, investigators believe the aerosol can overpressurized from solar heating. To test this theory, industrial hygiene personnel measured the temperature at the base of the dash on a south-facing truck when the ambient air temperature was 70°F and determined that the temperature in that area of the truck was 160°F.

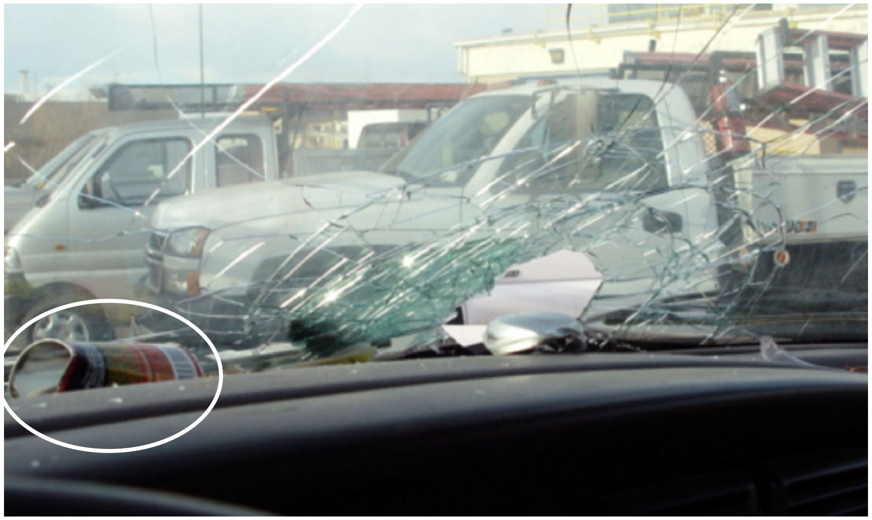

Figure 2-2. Shattered windshield and aerosol can (circled)

Aerosol cans are supposed to be stored in the side compartments of the truck along with the hood used for testing smoke detectors. The industrial hygiene staff found that temperatures in the truck side compartments were within 5 degrees of ambient temperature.

A similar event occurred in May 2001 at the Hanford River Protection Project when an aerosol can exploded and blew out the back window of a government vehicle (Figure 2-3). Investigators learned that maintenance workers had stored several aerosol cans behind a seat inside the vehicle. Ambient temperatures in the area had reached 101°F. The explosion propelled the ruptured can through the window to the ground outside, where it was found by electricians. Investigators also found three other ruptured cans inside the vehicle. (ORPS Report EM-RP--CHG-TANKFARM-2001-0039; Lessons Learned 2001-RPP-HNF-SN-01-05)

In August, 2003, the Safety and Industrial Hygiene Department at ALCOA's operations in Rockdale, Texas, issued a Safetygram that cited two incidents in which aerosol cans exploded inside closed vehicles on hot summer days. The Safetygram cautioned against keeping items such as WD-40®, Fix-A-Flat®, hair spray, or deodorant in a vehicle in hot weather.

Figure 2-3. Blown out rear window from aerosol can

The Department of Geosciences at San Francisco State University states that the air temperature inside a closed vehicle can reach 120°F when the outside temperature is only 70°F. The National Highway Traffic Safety Administration also states that temperatures in a closed vehicle can climb from 78°F to 125°F in about 8 minutes. When the liquefied gas propellant used in aerosols is heated, vapor is produced that can quickly pressurize the can. A temperature rise to only 86°F can double the pressure inside the aerosol can.

Preventing Heat-Related Aerosol Can Explosions

- Read and heed warning labels and precautionary statements on all aerosol cans.
- Do not store aerosol cans inside vehicle cabins, especially on dashboards or near windows.
- Store aerosol cans inside industrial coolers.
- Inspect vehicles for the presence of pressurized containers and remove them from the vehicle.
- Park vehicles in shaded areas if possible.

These incidents underscore the importance of properly storing aerosol cans. The heat generated inside a closed vehicle parked in direct sunlight may be enough to increase the pressure inside the can to the point that it ruptures explosively. Workers should always read and understand the warning labels on aerosol cans and ensure cans are handled, stored, and disposed of properly.

KEYWORDS: *Aerosol can, explode, rupture, near miss, overheat, pressurized, vehicle, sun*

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

PPE and Engineered Controls Can Prevent Welding Exposure to Hexavalent Chromium

3

Welding is the main activity of concern for worker exposures to hexavalent chromium at DOE facilities. In the past 2 years, six events involving potential exposures above permissible levels for hexavalent chromium have occurred at DOE sites. Three of these events happened in the past 5 months, including the two recent events described below.

On February 15, 2007, while hard-surfacing the end of a drill bit, a subcontractor welder at the Hanford Groundwater Protection Project was exposed to hexavalent chromium at a level that exceeded the OSHA Permissible Exposure Limit (PEL). Results from a lapel sampler he wore indicated an exposure level of 65.5 micrograms per cubic meter (μg/m^3). The welder received a medical evaluation and returned to work with no restrictions. (ORPS Report EM-RL--PHMC-GPP-2007-0001)

Investigators learned that, although the job was conducted outside in a light breeze, the welder did not wear any respiratory protection or use any engineered controls (i.e., local exhaust ventilation) during the 3 hours it took to complete the welding job.

On January 5, 2007, while stick-welding a stainless steel support to a carbon steel plate, an ironworker at the Hanford site was exposed to levels of hexavalent chromium greater than the OSHA PEL. The ironworker's sampler measured 53μg/m^3 in the immediate jobsite area. The protection factor of the worker's half-face respirator reduced the exposure to 5.3 μg/m^3. (ORPS Report EM-RP--BNRP-RPPWTP-2007-0001)

Investigators learned that the ironworker used approximately 5 pounds of 309 series welding rod, which contains up to 25 percent chromium. They also learned that the ironworker was not monitored during the last 30 to 60 minutes that he was welding because he forgot to put his sampler back on after removing it during a break. Investigators also learned that a local exhaust system was not used during this welding job.

These events underscore the importance of using local exhaust ventilation (Figure 3-1), wearing adequate respiratory protection, and monitoring breathing space with a sampler.

On February 28, 2006, OSHA lowered the PEL from 52 μg/m^3 of air as an 8-hour, time-weighted average to 5 μg/m^3 because of a determination that the risk for lung cancer in workers exposed to hexavalent chromium increases at levels below the original OSHA PEL. Studies of workers in the chromate production, plating, and pigment industries consistently have shown increased rates of lung cancer. In addition, repeated and prolonged exposure to hexavalent chromium can damage the mucous membranes of the nasal passages and result in ulcers.

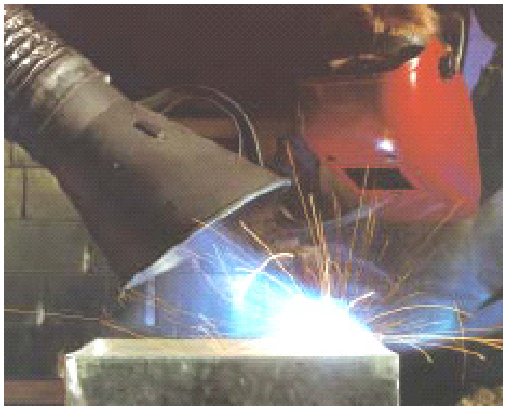

Figure 3-1. Using local exhaust ventilation at the workpiece

Of all the occupational exposures to hexavalent chromium, stainless steel welding presents the greatest risk. The intense heat of the welding arc vaporizes the base metal, the filler material, and the electrode coating, which condenses into tiny particles called fumes. The base metal may contain chromium in amounts up to 30 percent, along with the filler material. Without adequate controls, these fumes can be inhaled, resulting in exposures several times above legal limits.

The most effective way to reduce potential exposures is to use both PPE and engineered controls. The Washington State Department of Labor and Industries and the Building Trades Labor-Management Organization of Washington State produced an 11-minute video that clearly demonstrates how the magnitude of welding fume exposures, both inside and outside the welding hood, change with different combinations of respiratory protection and local exhaust ventilation. The video shows these changes in real time. As previously stated, the PEL for hexavalent chromium is 0.005 mg/m^3 (5 $\mu g/m^3$); the scales used in the video range from zero to 200 mg/m^3.

Additional information on the safety concerns associated with exposure to hexavalent chromium can be found at the following sources.

- OSHA Safety and Health Topic on Hexavalent Chromium http://www.osha.gov/SLTC/hexavalentchromium
- NIOSH Safety and Health Topic on Hexavalent Chromium http://www.cdc.gov/niosh/topics/hexchrom/
- ES&H Safety Bulletin 2006-01: Hexavalent Chromium (UPDATE)

The use of engineered controls (local exhaust ventilation) and appropriate PPE (respiratory protection) can protect welders from exposure to hexavalent chromium and other metals such as beryllium, iron oxide, and manganese. Local exhaust ventilation should be used for all indoor welding and cutting. If stainless steel welding is performed in an enclosed space where local ventilation is impractical, approved air line respirators should be worn.

How To Reduce Exposure to Welding Emissions

- Use local exhaust ventilation and fume-extraction welding guns to keep the breathing zone clear of particles and fumes.
- Ensure that exhaust-capture nozzles are properly placed and are not too far from the workpiece, which would allow fumes to remain in the breathing zone.
- Wear a helmet and position your head to minimize exposure to fumes in the breathing zone.
- Wear appropriate respiratory protection.
- Use special care when welding in a confined space, and provide additional ventilation/exhaust as necessary.
- Sample and monitor the breathing-air zone for concentration of contaminants.
- Read the MSDS for electrodes, and heed any warnings on the electrode container (e.g., electrodes containing chromium and manganese).
- Select materials that minimize chromium.

For stainless steel welding and cutting outside, approved respirators should be used; and, again, using an air line respirator rather than an air-purifying fume respirator will provide the best level of protection.

KEYWORDS: *Welding, hexavalent chromium, exposure, occupational safety, respirator, ventilation, engineered controls*

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

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Commonly Used Acronyms and Initialisms

Agencies/Organizations	
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CPSC	Consumer Product Safety Commission
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
INPO	Institute for Nuclear Power Operations
NIOSH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
SELLS	Society for Effective Lessons Learned Sharing

Units of Measure	
AC	alternating current
DC	direct current
mg	milligram (1/1000th of a gram)
kg	kilogram (1000 grams)
psi (a)(d)(g)	pounds per square inch (absolute) (differential) (gauge)
RAD	Radiation Absorbed Dose
REM	Roentgen Equivalent Man
TWA	Time Weighted Average
v/kv	volt/kilovolt

Job Titles/Positions	
RCT	Radiological Control Technician

Authorization Basis/Documents	
JHA	Job Hazards Analysis
JSA	Job Safety Analysis
NOV	Notice of Violation
SAR	Safety Analysis Report
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question

Regulations/Acts	
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
DD&D	Decontamination, Decommissioning, and Dismantlement
RCRA	Resource Conservation and Recovery Act
TSCA	Toxic Substances Control Act

Miscellaneous	
ALARA	As low as reasonably achievable
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
ISM	Integrated Safety Management
MSDS	Material Safety Data Sheet
ORPS	Occurrence Reporting and Processing System
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
SME	Subject Matter Expert