Operating Experience Summary

U.S. Department of Energy
Office of Health, Safety and Security
OE Summary 2006-14
December 8, 2006

Inside This Issue

Wearing Arc Flash Clothing Can Save Your Life

1

On October 20, 2006, at the Wood River Refinery near St. Louis, Missouri, a significant arc-flash event occurred in an electrical substation while electricians were conducting phase testing on an energized 4.16-kV circuit breaker cubicle. No one was injured because workers were wearing the proper electrical PPE at the time of the incident.

The Wood River Refinery, which is operated by ConocoPhillips, had replaced one of two electrical feeders to their substations during a recent turnaround (refinery outage). Both feeders were energized; but, to prevent a major fault from occurring, they could not be electrically tied together until proper phasing had been verified. Electricians were following a phase-testing procedure that involved inserting two voltmeter probes into holes to make contact with energized "stabs" inside the holes (Figure 1-1) for each phase. The stabs were connected to the 4.16-kV busses located in the back of the circuit breaker cubicle inside the switchgear.

This switchgear has a grounded steel shutter that covers the holes when the circuit breaker is not installed in the cubicle. The shutter can be opened to expose the energized stabs for phase testing. However, the grounded edge of the steel shutter remains very close to the opening where the voltmeter probes are inserted.

Investigators suspect that the metal edge of the voltmeter probe touched the metal edge of the shutter as the electrician inserted the probe. As the probe tip moved closer to the energized stab, an initial arc jumped to the probe. When the electrician saw

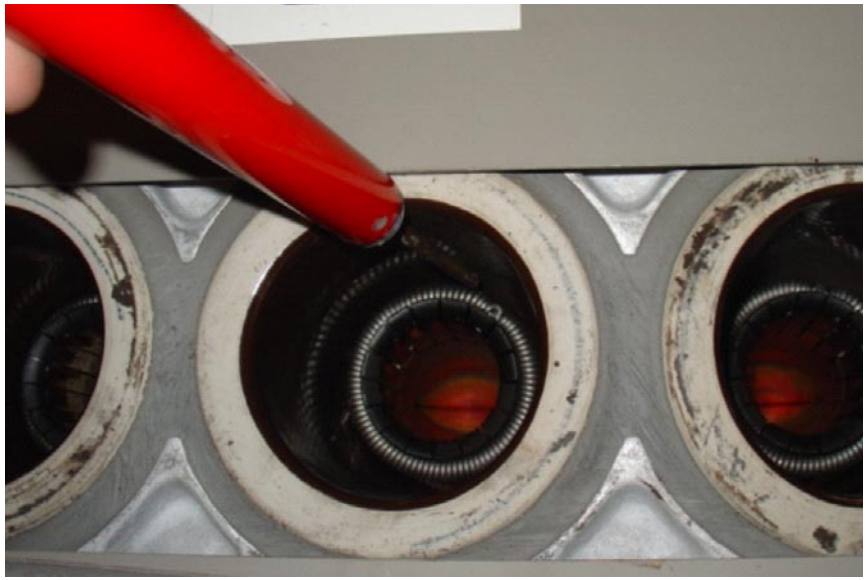

Figure 1-1. Holes where the energized stabs are located and metal shutter

and heard the arc, he immediately started to leave. As the probe was withdrawn from the hole, the arc grew in length, forming conductive gases that produced a phase-to-phase fault. Investigators believe that within 2 to 3 seconds of the initial arc, ionized air provided a conductive path between electrical phases, resulting in the arc blast.

The electrician's PPE prevented him from being injured when the arc flash occurred. Figure 1-2 shows the condition of the 65-calorie flash hood after it was exposed to the tremendous heat energy of the arc flash; the inside of the hood looked like new. For comparison purposes, Figure 1-3 shows a new flash hood similar to the one worn by the electrician.

Choosing and wearing proper PPE are critical to preventing injuries from an electrical arc flash. Arc flash clothing is made from materials that have an Arc Thermal Performance Value

Figure 1-2. Damaged flash hood

Figure 1-3. New flash hood

(ATPV), which is defined as the amount of heat energy (calories/cm^2) the fabric will absorb or deflect. Although this PPE is flame-resistant (FR), it is not designed for firefighting; rather, it is designed to reduce the risk of serious injury for certain levels of heat energy. The heat flux of 1.2 cal/cm^2 is considered the amount of heat required to produce the onset of a second-degree burn to unprotected skin. For example, holding your finger over the flame of a match for 1 second produces approximately 1 cal/cm^2 of incident energy. NFPA 70E, *Standard for Electrical Safety in the Workplace,* requires PPE used for arc flash protection to be marked with the arc rating in cal/cm^2. Arc-flash protective suits and FR clothing are manufactured in the following ATPVs: 6 cal, 11 cal, 15 cal, 25 cal, 40 cal, 50 cal, 65 cal, and 100 cal.

NFPA 70E also has identified tasks performed on electrical equipment and assigned a Hazard/Risk Category classification. The categories range from 0 to 4, with the highest number being the highest risk. The minimum hazard rating for an arc blast has a burn exposure of 4 cal/cm^2, which is an NFPA 70E Category 1 hazard rating. Table 1-1 shows the hazard/risk category and associated PPE rating.

Choosing the right PPE is only one part of the process. The following steps for preventing arc flash injuries should also be performed.

- Perform a flash hazard analysis to determine the flash protection boundary and necessary PPE.

- Perform an arc flash study to calculate the incident energy to which a worker could be exposed.
- Mark equipment to warn qualified workers of potential electrical arc flash hazards.
- Train and qualify workers who will work on or near energized electrical systems.

Since 2004, there have been six events in which electrical arcs have occurred while personnel knowingly worked on energized equipment. The most recent occurred at Brookhaven National Laboratory on April 14, 2006, where an electrical engineer was injured by an arc flash while closing a fused-disconnect switch in an electrical panel at the Relativistic Heavy Ion Collider. The electrical engineer was not wearing appropriate clothing or the PPE required for this operation and received first- and second-degree burns to his face and body. A Type B accident investigation was conducted, and one of the deficiencies noted was the failure to implement NFPA 70E. Arc flash calculations for the building where the incident occurred were not completed; therefore, PPE requirements based on arc flash calculations were not posted on the electrical panel. (ORPS Report SC--BHSO-BNL-AGS-2006-0002; OES 2006-13)

Table 1-1. Typical Protective Clothing Systems

Hazard/Risk Category	Clothing Description	ATPV Cal/cm²
0	Non-melting, flammable materials with fabric weight ≥ 4.5 oz/yd²	n/a
1	FR shirt and FR pants or FR coverall	4
2	Cotton underwear, FR shirt, and FR pants	8
3	Cotton underwear plus FR shirt and FR pants and FR coverall, or cotton underwear plus two FR coveralls	25
4	Cotton underwear, FR shirt, FR pants, and multilayer flash suit	40

The event at the Wood River Refinery underscores the importance of wearing PPE that is appropriately rated for the work being performed. Looking at the burn damage to the arc flash hood and its face shield, one can only imagine the injuries that the electrician might have sustained if it had not been worn. Electrical safety program administrators and electrical maintenance organizations should ensure that NFPA 70E has been implemented for arc flash protection.

KEYWORDS: *Personal protective equipment, PPE, arc flash, electrical safety, energized equipment*

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

Verify Part Numbers, Especially for Safety-Significant Systems

2

A recent event at the Savannah River Site Tritium Facility highlights the importance of double-checking requisitions for safety-significant components if a particular manufacturing material is desired.

On August 2, 2006, the facility was undergoing a preliminary visit for an operational readiness review when DOE's tritium safety specialist, who was one of the assessors, asked the project manager what material was used to seat the ½-inch valves coming in contact with tritium. Beta emitters such as tritium tend to degrade many polymers; therefore, the Department recommends that valves in tritium service (examples are shown in Figure 2-1) be manufactured of more radiation-resistant materials such as Vespel® or certain metal alloys.

An examination of procurement records and subsequent discussions with the vendor revealed that due to several mixups with vendors and product numbers, the valves that had been ordered and installed in 2001 were composed of a polychlorotrifluoroethylene (PCTFE) stem tip and a Teflon®-coated stainless steel bellows gasket, instead of the desired Vespel stem tip and silver-coated stainless steel (SS) bellows gasket. PCTFE stem tips and Teflon-coated bellows gasket are more vulnerable to beta-particle degradation than those procurement personnel believed they had ordered.

In 2001, when the valves were ordered for the Savannah River Tritium Extraction Facility, the purchase requisition specified product numbers that identifed the valves as being Vespel stem tip with a silver-coated SS bellows gasket. However, Swagelok, the valve manufacturer, changed the product numbers sometime that year as well. The vendor contacted Savannah River procurement personnel to inform them of the change and to recommend a replacement. The purchase requisition was amended to indicate the replacement part numbers, but neither the vendor nor procurement personnel recognized that the part numbers were incorrect.

In 1994, DOE published a Technical Notice entitled *Guidelines for Valves in Tritium Service* which was also excerpted in the July 1994 issue of *Fusion Technology*. The Technical Notice provided more details on the nature of tritium valve degradation and included recommendations for differing valve design applications and operational practices. Recommendations to avoid using inappropriate valve stem or seat material included

Figure 2-1. Valves used in tritium service

spot disassembly of selected valves as part of acceptance testing or ordering the parts disassembled to verify material compatibility and design, followed by assembly onsite. Other recommendations for valves in tritium service are based upon operational lessons learned and on design advice from DOE HDBK-1129-99, *Tritium Handling and Safe Storage.*

A tritium release on April 2, 1991, at the Lawrence Livermore National Laboratory, was caused by tritium degradation of the elastomer seat-sealing surface of a tritium isolation valve. Seat-sealing failure resulted in pressurizing the fittings downstream of the valve and an accumulation of tritiated water in a section of the fittings. (ORPS Report DP-OAK--LLNL-LLNL-1991-1002)

Another tritium leak occurred at Sandia Livermore, when a Teflon seat in a pressure regulator valve on a deuterium/tritium bottle cracked after exposure to the 800-psi gas mixture. Operations personnel did not realize that the pressure regulator contained Teflon; therefore, they took no special precautions. (ORPS Report DP-ALO-KO-SNL-TRL-1992-0002)

These events illustrate the importance of verifying the composition of purchased safety-significant equipment, especially when the possibility exists for premature failures because of material incompatibility. In such cases, requisition paperwork should instruct inspection personnel to inspect every item received to be sure it complies with purchase specifications.

KEYWORDS: *Tritium, valve, safety-significant, release, procurement, receipt and inspection, quality assurance*

ISM CORE FUNCTION: *Provide Feedback and Improvement*

Winter Safety 3

Winter weather has arrived and will soon test the sites' pre-snow and freeze protection planning. The *Operating Experience Summary* publishes a winter article every year as a reminder of the dangers from the effect of freezing weather on both indoor and outdoor operations. Despite the reminders, however, winter-related events continue to occur, often because of lack of communication, planning, and workers' situational awareness.

Lack of Planning and Communication

On December 5, 2006, Los Alamos National Laboratory reported that two weeks of below-and near-freezing temperatures caused five cases of significant equipment damage and flooding when HVAC coils froze. (ORPS Report NA--LASO-LANL-MATWAREHS-2006-0009)

Subsequent reviews revealed various deficiencies, ranging from lack of freeze protection plans to incomplete freeze protection plans. In one case, freeze protection inadequacies had been identified, but the corrective actions implemented proved to be ineffective. Management ordered a walkdown of all facilities after flooding occurred in some buildings and others had no heat, which required sending personnel home. Widespread reviews of procedures and freeze protection plans are currently underway.

As weather conditions change, routine tasks must be reevaluated and changes communicated to workers. In 2006, at Idaho National Laboratory, six events involving cut power cords occurred within a 5-week period in January and February. All of the events occurred while workers were clearing snow during especially heavy snowfall, as illustrated by the following four events.

On February 13, 2006, a worker removing ice and snow damaged an energized 100-volt power line. The worker was using hand tools to perform the task in compliance with management directives. The power line had been identified during the walkdown and was thought to be completely protected and obscured by angle irons and trailer hitches; however, this was not the case. The primary lesson learned in this event was the need for improved communication and very specific instructions. Everyone involved in snow-removal operations must verify all assumptions, have a questioning attitude, and communicate precise information. (ORPS Report EM-ID--CWI-RWMC-2006-0004)

On January 11, 2006, a worker removing snow with a Bobcat Skidsteer impacted a 240-volt lighting panel and damaged it. The Bobcat operator had been pressed into service because there were not enough snow blowers to perform the task and he did not receive a pre-job briefing about hazards he might encounter when removing snow near buildings. (ORPS Report EM-ID--BBWI-AMWTF-2006-0002)

On January 4, 2006, a temporary laborer snagged a 480-volt power cable with the rear blade of a snow-removal tractor. The cable had supplied temporary power to a heater in a temporary diesel generator trailer and was not visible because it was under a foot of snow. The laborer stopped and removed the cord from the blade. Luckily, the laborer did not receive a shock when he removed the cord. Several corrective actions were put in place as a result of this event. The power cable was relocated so it was 2 to 3 feet above ground and placed along a fence to protect it. In addition, orange stanchions were placed to provide temporary markers, other vulnerable buried cords were identified, and the Job Safety Analysis was revised to include actions laborers should take when impacting electrical wiring or cables, such as not handling the damaged wires. (ORPS Report NE-ID--BEA-ATR-2006-0001)

On January 3, 2006, the auger blades on a snow blower became entangled with a 480-volt temporary power cord running between a building and a temporary trailer. The unprotected, unmarked cord was buried under 2 feet of blowing, drifting snow. An effective snow-removal plan was not in place to identify potential problems. (ORPS Report EM-ID--BBWI-AMWTF-2006-0001)

Warm Clothing and PPE

Workers should be aware that insulated outdoor PPE may present hazards when worn indoors, as shown by the following example.

On February 10, 2005, at the Oak Ridge K-25 site, a chemical operator stood too close to a 480-volt heater, inadvertently melting her Tyvek coveralls in the rear mid-section. Because of the cold weather, the employee was also wearing Carhartt full coveralls under the PPE, limiting her ability to feel the heat until the damage had been done. Pre-work planning must balance the dangers of multiple hazards when assigning PPE; in this case, radiological protection that can inhibit a worker's ability to feel and react to a non-radiological hazard. (ORPS Report EM-ORO--BJC-K25GENLAN-2005-0002)

Injuries

Despite past experience and warnings to exercise caution when walking outside in inclement weather, more than 18 workers incurred reportable injuries from slips and falls on icy surfaces in the past two winters.

On January 19, 2006, at Los Alamos National Laboratory, an operator walked down the external stairs of a control room and slipped on black ice at the bottom of the stairway. The fall resulted in torn ligaments in his shoulder that required surgery. The area had inadvertently been watered to control dust during asphalt operations in accordance with the Laboratory's air quality permit. However, the possibility of freeze dangers had not been considered. (ORPS Report NA--LASO-LANL-PHYSTECH-2006-0001)

On March 16, 2005, at Los Alamos National Laboratory, two employees arriving at work slipped on black ice; one of them fell and broke her arm. Both employees were wearing appropriate winter footwear. The Laboratory had reopened that morning for business after being closed for 2 days because of snow and wintry conditions. While the Laboratory was closed, snow removal crews had worked continuously, but slipping dangers remained, especially for those whose arrival preceded any melting of the ice. (ORPS Report NA--LASO-LANL-PHYSTECH-2005-0001)

On February 25, 2005, at Brookhaven National Laboratory, an employee was injured after being assigned to hand-shovel snow off walkways. Because of the snow's depth, he was unable to see a curb. He slipped off the edge of the curb, fell, and fractured an ankle. (ORPS Report SC-CH-BH-BNL-PE-2005-0001)

On January 17, 2005, a Hanford maintenance engineer slipped and fell on snow-covered ice while inspecting a septic drain field, fracturing his right leg. Investigators later determined that the surface where the engineer fell had not been designed or maintained to provide safe access under all anticipated weather conditions. (ORPS Report EM-RP--BNRP-RPPWTP-2005-0001)

On January 7, 2005, a Kansas City Plant Security Police Officer fell on an icy roof. He received a mild concussion and sprained his shoulder. Proper footwear (i.e., ice cleats) would have provided safer footing and might have prevented the fall. (ORPS Report NA--KCSO-AS-KCP-2005-0003)

Had sand, gravel, or salt been applied to icy areas, the injuries that resulted in each of these events may not have occurred.

Winter Driving

Whether you drive a government-owned vehicle or your own, taking some common-sense precautions *before the first snowflake falls* will help ensure that you arrive safely.

- Check brake fluid and ensure that the brakes provide even, balanced braking.
- Change or fill antifreeze, fill windshield wiper fluid, replace wiper blades.
- Ensure that the battery is fully charged, that tires have proper tread and inflation, and that oil is not low and is the proper viscosity for winter.
- Pack an emergency kit containing a blanket, cell phone, extra clothes, emergency flares, snacks, water, kitty litter/ sand, and other such items that could ensure your safety and comfort in the event of an accident or breakdown.

Drive in snow and ice only if necessary, and clean the snow off your car's headlights, tail lights, and all windows before you begin driving. *Don't drive looking through a porthole!*

More winter safety tips for driving, work, and home can be found at the websites of the American Automobile Association (AAA) (www.aaa.com), the National Safety Council (www.nsc.org), the Federal Emergency Management Agency (FEMA) (www.fema.gov), and the American Red Cross (www.redcross.org). Useful information can also be found in *Winter Storms: The Deceptive Killers*, a joint publication of the Red Cross, FEMA, and the National Oceanic and Atmospheric Administration.

Deer-Vehicle Collisions

Deer-vehicle collisions tend to increase during the winter months, a time when operations at DOE sites across the country start well before dawn and end well after dusk, which is exactly the time when deer are on the move.

Figure 3-1 shows the aftermath of an accident that occurred near Pittsburgh, Pennsylvania, on the first day of hunting season in 2006. A deer leaped through the front window of a pickup truck, killing the driver, and the truck veered off the road, hit a tree, and ran into an outdoor swimming pool.

Figure 3-1. Pickup runs into outdoor pool after a deer jumps through windshield

Although human population has spread and limited wildlife habitat, deer continue to follow seasonal patterns for mating and traditional paths to food and watering places. Instinct takes precedence over man's intrusion, but deer are no match for a moving vehicle. Because these animals are so compact, they can cause significant vehicle damage—on average, $2,000 per insurance claim.

The AAA advises "Don't veer for deer" because, despite the fact that no one wants to see animals injured or killed, hitting one straight on may be a safer option than swerving and hitting another motorist or light pole or going into a ditch and rolling the car over.

On February 8, 2002, near the Idaho National Laboratory, a government pickup collided with a moose that suddenly entered the roadway about 40 feet ahead. Despite the driver's attempt to avoid it, the moose hit the truck's front and rolled the cab, causing more than $4,000 in damage. Although the truck was totaled, both occupants wore seat belts and were unharmed.
(ORPS Report DP-ID--BBWI-SMC-2002-0003)

Space Heaters

Very little can be added to a discussion about space heaters that has not been addressed in OE Summary 2004-20 or in articles published in the media. When buying a new space heater, be sure to buy one with an independent testing laboratory sticker and a tip-over shut-off switch. In addition, keep flammable materials, such as drapes, at least 3 feet away from the heater and turn the heater off when leaving the room.

At DOE facilities, the site fire department may conduct periodic inspections to ensure that heaters used in personal or office spaces meet safety criteria.

Protecting Workers in Cold Environments

There is no doubt that work must go on despite the weather; however, the key is to provide safety guidelines to protect workers. OSHA has published tips to protect workers in cold environments. (See www.osha.gov.) The textbox below has some cold weather safety tips from OSHA, FEMA, and the American Red Cross.

Protect Yourself: Outdoor Winter Work

- Be aware of wind chill, the combination of temperature and wind velocity that causes rapid heat loss.*
- Wear layers made of fabrics such as polypropylene that wick moisture away from the body; avoid cotton, which holds in moisture.
- Wear proper footwear with treaded soles. Kick or "shuffle" off the packed snow when entering a building to prevent slipping.
- Protect your head and extremities that are susceptible to frostbite. An exposed head can lose up to 40 per cent of a body's heat. Cover your mouth to protect your lungs.
- If you wear a hard hat, add a compatible winter liner.
- Work in the warmest part of the day; take frequent short breaks in a warm shelter.
- Avoid fatigue — you need energy to keep warm.
- Perform strenuous work cautiously, because cold puts additional strain on the heart.
- Use the buddy system.
- Stay hydrated: Drink warm sweet beverages and avoid alcohol and caffeine.
- Eat warm high-calorie foods such as pasta and high-energy foods such as nuts or dried fruit.
- Know the symptoms of hypothermia: shivering, inability to perform complex motor functions, and confusion. Handle the person carefully; get help immediately. The cold heart is extremely vulnerable at this point, so warm the body's core before the extremities to avoid driving cold blood toward the heart.

* Wind chill is explained at the National Weather Service Website www.nws.noaa.gov

Past Operating Experience Summary Issues

OE Summaries 2002-22, 2003-23, 2004-19, 2004-20, 2004-24, and 2005-15 provide additional freeze protection, slip-fall, and winterization guidance based on occurrences reported to ORPS. Issue 2004-19 also includes an example of the cold weather checklist provided in DOE G 433.1-1, Section 4.18, "Seasonal/ Severe Weather and Adverse Environmental Conditions Maintenance."

These events demonstrate the importance of planning ahead when freezing weather is forecast, reminding employees of walkway hazards, having a freeze protection plan in place, and ensuring that outside workers are adequately protected. Use of lessons learned from previous years and various sources should include "what-if" scenarios.

KEYWORDS: *Freeze protection, snow, ice, space heater, slips, falls, winterization, deer*

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

The Office of Health, Safety and Security (HSS), Office of Analysis publishes the Operating Experience Summary to promote safety throughout the Department of Energy complex by encouraging the exchange of lessons-learned information among DOE facilities.

To issue the Summary in a timely manner, HSS 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 Ray Blowitski, (301) 903-9878, or e-mail address Ray.Blowitski@hq.doe.gov, so we may issue a correction. If you have difficulty accessing the Summary on the Web (URL http://www.eh.doe.gov/paa), please contact the Information Center, (800) 473-4375, for assistance. We would like to hear from you regarding how we can make our products better and more useful. Please forward any comments to Ray.Blowitski@hq.doe.gov.

The process for receiving e-mail notification when a new edition of the OE Summary is published is simple and fast. New subscribers can sign up at the Document Notification Service web page: http://www.eh.doe.gov/dns/ehdns.html. If you have any questions or problems signing up for the e-mail notification, please contact Ray Blowitski by telephone at (301) 903-9878 or by e-mail at Ray.Blowitski@hq.doe.gov.

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

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