Office of Environment, Health, Safety and Security
Operating Experience Level 3

OE-3: 2020-05 July 2020

# Unexpected Exposure to Electrical Energy

## PURPOSE

This Operating Experience Level 3 (OE-3) document provides information about the dangers related to the **unexpected** exposure to electrical energy at Department of Energy (DOE) sites. In addition, it discusses ways to avoid such events and the importance of applying the Seven Guiding Principles and Five Core Functions of DOE's Integrated Safety Management (ISM) System.

## BACKGROUND

The Department of Labor's Bureau of Labor Statistics (BLS) reported 417 fatalities due to direct exposure to electricity in the period from 2014 to 2018. The Occupational Safety and Health Administration (OSHA) states that many workers, in general, are unaware of the potential electrical hazards present in their work environment, which makes them more vulnerable to the danger of electrocution. OSHA identifies the following hazards as the most frequent causes of electrical injuries: contact with power lines, lack of ground-fault protection, path to ground missing or discontinuous, equipment not used in manner prescribed, and improper use of electrical extension cords.

Electrical hazards have long been an inherent danger in DOE operations. However, the Five Core Functions as defined in the DOE ISM policy (DOE P 450.4A, *Integrated Safety Management Policy*), along with site specific processes, provide the structure to protect workers when consistently implemented: 1) *Define the Scope of Work,* 2) *Analyze the Hazards,* 3) *Develop and Implement Hazard Controls,* 4) *Perform Work Within Controls,* and 5) *Provide Feedback and Improvement*. Understanding the sources of electrical power, verifying conductors are not energized, and following approved procedures and practices are essential before working on any electrical equipment.

OSHA Standard 29 CFR §1910.147, *The Control of Hazardous Energy (Lockout/Tagout)*, incorporated by reference in 10 CFR 851, *Worker Safety and Health Program*, requires organizations to develop an energy control program. An energy control program is required to consist of energy control procedures, employee training, and periodic inspections. In addition, 10 CFR 851 incorporates by reference the National Fire Protection Association (NFPA) Standard 70E (2015), which further expands upon requirements for control of hazardous electrical energy.

## REPORTING CRITERIA AND EVENT DESCRIPTIONS

From May 2019 through March 2020, there were 163 events related to electrical hazards at DOE facilities reported into the Occurrence Reporting and Processing System (ORPS) based on two reporting criteria. Criteria 2D (1) includes any unexpected or unintended personal contact with a hazardous energy source, and Criteria 2D (2) includes any failure to follow a prescribed hazardous energy control process that results in potential worker exposure to uncontrolled hazardous energy, or the discovery of an uncontrolled hazardous energy source.

Examples of potential unexpected exposures to electrical hazards include: making surface

penetrations that result in encounters with electrical conduits or circuits; discovering uncontrolled or exposed electrical wiring; discovering electrical circuits not documented in the "as-built" drawings; encountering unattended or unmarked open electrical control panel boxes; and the performance of electrical work by untrained/unqualified persons.

These examples, which illustrate different ways that workers may be unexpectedly exposed to electrical energy, highlight the importance of applying ISM Core Functions in planning work and developing procedures, and ensure that an electrically safe work condition is established prior to commencing work.

Selected excerpts from some of the reported ORPS electrical events are included below:

1) On May 3, 2019, an electrician noticed scorch marks and evidence of arcing on exposed flat wire exposed by the removal of the overlying carpet squares after a work order was created to address the impacts of a water leak in the building. The work order noted that two of the three electrical circuits associated with the flat wire were tripped by the initial water leak, but the immediate corrective actions failed to address the potential electrical hazard and require the electrical source be controlled via Lockout/Tagout (LOTO). As a result, the facility maintenance staff that removed the affected carpet squares were exposed to the electrical hazard. Upon noticing the evidence of arcing and the scorch marks, the electrician secured the circuits through a LOTO and notified their supervisor. (ORPS Report NA--LSO-LLNL-LLNL-2019-0021)

2) On May 9, 2019, an Electrical Safety Officer (ESO) was performing a periodic inspection of a construction job site when he discovered an exposed hazardous electrical component in an unattended, open service panel. The electrician who had been working on the panels earlier in the day, had opened the panel to investigate safety interlock relays. The electrician was not planning to work in the panel or cross the restricted approach boundary for the energized terminal block, so he did not perform a LOTO on the panel. Due to an error in judgement, the panel was subsequently left open and unattended by the electrician, while he left the work location to attend training. This action violated NFPA 70E-2018 which requires that an attendant remain in the area as long as there is a potential for employees to be exposed to the electrical hazards. This requirement was also stipulated in the Safe Work permit under which the electrician was performing work. After discovering the open panel, the ESO verified the energized state on the terminal block, closed the panel to prevent access to the energized component, and reported the condition to management. (ORPS Report EE-GO--NREL-NREL-2019-0005)

3) On May 29, 2019, a worker pulled a project rack filled with computer servers away from the wall, plugged in the rack power cord, connected some network cables, and updated the servers. The worker did not notice exposed power cord wires from equipment that was removed six months earlier, nor that the project rack power also energized the exposed wires. After completing the server update, the worker removed the network cables from the server, rolled them up, and tossed them on the top of an equipment case where the exposed power cord wires were laying. The weight of the rolled network cables pushed down on the energized wires to short circuit against the case, leaving a small burn mark, and tripping the electrical circuit. The worker never came into contact with the energized wires. The staff immediately shut off power to the project rack system and notified management. The Environmental Safety and Health coordinator and Safety Subject Matter Experts walked down the lab to ensure the equipment was in a safe condition and a lockout device was placed on the cord plug. (ORPS Report NA--SS-SNL-5000-2019-0001)

4) On July 11, 2019, a maintenance crew conducting a safe-to-work check upon returning to work on a leak detector, discovered 120 volts of alternating current (VAC) not previously discovered during that morning's safe-to-work check. Earlier that morning, the maintenance crew held a pre-job meeting to troubleshoot a failed leak detector. The maintenance crew locked out the leak detection system, placed the system in a safe configuration, and exited. In the afternoon, the maintenance crew returned to work and continued troubleshooting. While performing another safe-to-work check following the reinstallation of the

lockout, 120 VAC was discovered on one of the terminals of the leak detector. This discovery contradicted findings from that morning's safe-to-work check. The team stopped work by placing the cover on the leak detector unit. (ORPS Report EM-RP--WRPS-200LWP-2019-0004)

5) On November 6, 2019, while conducting an excavation, a 2 inch PVC conduit containing three live 120 VAC circuits was struck. The impact resulted in the circuits tripping the associated breakers and some loss of power. The line was identified as the portal line and was locked and tagged out at the panelboard. The area around the line break was then excavated using soft digging methods to expose and assess the damage to the conduit. The electrical lines were repaired the next day. (ORPS Report NA--SS-SNL-8000-2019-0015)

6) On January 20, 2020, demolition and disposal (D&D) activities were being performed in the Radioactive Liquid Waste Treatment Facility Tank Room in preparations for a tank removal. The room's electrical conduits were flagged every three feet, red for energized conduit and green for air gapped conduit. During the demolition of a piece of conduit marked with a green flag, a worker's saw came in contact with a 480-volt energized conductor. Although the conduit being cut was green flagged, visual verification of the air gap was not performed prior to the workers commencing work. Personnel observed sparks, a pop, and then the facility immediately lost all power. Work was stopped and the building was evacuated. (ORPS Report NE-ID--BEA-MFC-2020-0002)

7) On February 7, 2020, while performing zero energy verification with a voltmeter prior to reconnecting the conductors into a replaced actuator in Room 70A of Technical Area 50, Building 1, an electrician (E1) discovered two conductors energized at 120 volts. The day before, E1 and another electrician (E2) locked and tagged out circuit 4 in the electrical panel under a simple LOTO. At that time, E2 performed the zero-voltage verification at the actuator and detected no energy. E1 and E2 then placed the conductors in an electrically safe condition. However, when E1 performed a second zero voltage verification prior to reconnecting the conductors into the replaced actuator, E1 detected the two energized conductors and paused work. A subsequent electrical inspection found a second isolation point that fed the actuator that was not identified during the work planning phase and was not locked or tagged out during the work. (ORPS Report NA--LASO-LANL-TA55-2020-0006)

8) On March 16, 2020, a Mine Safety and Health Administration (MSHA) inspector was exposed to an electrical safety hazard during a required quarterly facility inspection. The MSHA Inspector opened the cover of a 208-volt safety disconnect switch exposing bare conductor terminations. The Inspector did not have the proper Personal Protective Equipment, (PPE) for exposure to this hazard. After the inspector opened the cover, he proceeded to test for the presence of voltage using a hot stick electrical verification tester. Facility Operations personnel locked the switch cover pending an investigation. (ORPS Report EM-CBFO--NWP-WIPP-2020-0007)

Although the events mentioned above resulted in no injuries, these occurrences serve as a reminder to ensure an electrically safe work condition is established and that proper LOTO procedures are in place before work begins on or near electrical energy. These events serve to illustrate the value of adhering to the ISM Five Core Functions to prevent incidents through proper work planning and analysis. For example, developing and implementing appropriate hazard controls, as exhibited in event 7, can significantly reduce or even avoid the potential for worker exposure to hazardous electrical energy.

## Work Planning and Performance

Safety-related work practices, procedures, and planning must be applied before work on or near exposed electrical energy. The equipment involved in the work task must be in an electrically safe work condition consistent with NFPA 70E Article 120. DOE workers with the potential to be exposed to an electrical hazard must be trained on the electrical hazards in their work environment and must be aware of the risks associated with working in and around electrical wiring and equipment. Workers must be qualified when working within the shock and arc flash boundaries.

If unexpected situations arise during work performance, work should stop in order to conduct analyses to ensure that the new situation does not present any additional unanalyzed hazards that could lead to exposure to hazardous electrical energy or reduce the effectiveness of exposure controls. Additional information on electrical safety work practices and training, can be found in NFPA 70E (2015), Article 110, *General Requirements for Electrical Safety-Related Work Practices*.

Activity-level work planning should be guided by, and implement attributes associated with the first three, ISM Core Functions, Define *the Scope of Work, Analyze the Hazards,* and *Develop and Implement Hazard Controls*. Another important attribute, associated with ISM Core Function, *Perform Work within Controls*, states "Work control processes during the performance of work include continuous identification of hazards, stopping work to re-evaluate hazards and controls, and work packages in the field." This attribute is particularly applicable when encountering unexpected electrical energy. (See description of these attributes in DOE G 450.4-1C, *Integrated Safety Management System Guide.*)

Other sources with guidelines for helping to plan DOE electrical work include:

- OSHA, *Controlling Electrical Hazards (3075): "*only qualified electricians with formal Lock-out/Tag-out (LOTO) training, as well as current LOTO certification should work with electrical circuits."
- DOE-HDBK-1211-2014, *Activity-Level Work Planning and Control Implementation*, states that "effective hazard analysis should include thorough work screening and planning, identifying and implementing hazard controls, developing instructions, and specifying worker qualifications to perform the work within controls."
- DOE-HDBK-1092-2013, Electrical Safety (which is under revision), Section 2.10.2 on Work Planning lists 15 steps on electrical work planning including "Consideration for 'What can go wrong'."
- DOE Order 422.1, *Conduct of Operations*, emphasizes the "implementation of hazard controls in work planning and execution process" to integrate safety into work planning.

## RECOMMENDATIONS

1. **Comply with Regulations**. Specifically, comply with 10 CFR 851, *Worker Safety and Health Program*, which incorporates by reference OSHA's *Control of Hazardous Energy* Regulation (10 CFR 1910.147) and NFPA 70E-2015. (Core Function 4).

2. **Develop and Implement a Hazardous Electrical Energy Control Program**. Energized electrical equipment equal to or greater than 50 volts (AC and DC) must be in an electrically safe work condition before an employee performs work. See NFPA 70E Article 130 for additional information. (Core Functions 2 and 3).

3. **Identify and Label All Hazardous Electrical Energy Sources.** Job safety planning and pre-job briefings must be conducted before work on, or near, exposed electrical energy. For example:
   - Follow site permitting procedures before conducting any work. (Core Functions 1 and 4).
   - Carefully evaluate the subterranean environment prior to excavation, construction, or demolition projects; mark the location of all existing underground utility lines; and de-energize the lines to protect workers from exposure to electrical energy. (Core Functions 2 and 3).
   - Review "as-built" drawings before starting work to penetrate a surface, and stop work if indicators of unexpected electrical energy are observed, such as sparks, the smell of electrical burning, or the presence of electrical insulation debris on drill bits or other tools. The appropriate supervisor should be notified and the organization's applicable reporting procedures should be followed. (Core Functions 2, 3, 4 and 5).

4. **Control Exposure to Electrical Hazards.** While working on and around electrical equipment and wiring, a hazard assessment must be conducted to identify the existing and potential workplace hazards, as well as the control methods in accordance with the hierarchy of controls prescribed by 10 CFR §851.22. PPE is the least effective control method because it does not eliminate the hazard, is subject to human error, and may introduce additional hazards. Workers must be trained on the proper use of PPE and

must use safe work practices when working on or near electrical energy, even when PPE is donned or doffed.

5. **Confirm Zero Energy.** Always remember to use an appropriate meter to check for power, i.e., Test Before Touch. (Core Functions 4 and 5).

Electrical hazards are inherent in many of the work activities performed by DOE. These hazards cannot always be eliminated, but by applying the Seven Guiding Principles and Five Core Functions of ISM into DOE's work activities, the risks associated with these hazards can be safely managed.

## REFERENCES


ORPS Report NA--LSO-LLNL-LLNL-2019-0021. *Building 551W Uncontrolled Hazardous Energy Discovery*

ORPS Report EE-GO--NREL-NREL-2019-0005. *Uncontrolled Hazardous Electrical Energy Source Discovered in the Science and Technology Facility*

ORPS Report NA--SS-SNL-5000-2019-0001. *Discovery of Unexpected Electrical Energy*

ORPS Report EM-RP--WRPS-200LWP-2019-0004. *Hazardous Energy Discovered During Second Safe-To-Work Check of Basin 43 Leak Detector*

ORPS Report NA--SS-SNL-8000-2019-0015. *Excavation Uncovers Electrical Conduit*

ORPS Report ORPS Report NE-ID--BEA-MFC-2020-0002. *480 Volt Welding Circuit Conduit Cut during D&D Operations*

ORPS Report NA--LASO-LANL-TA55-2020-0006. *Worker Discovers 120-Volt Energized Conductors during Zero Voltage Verification*

ORPS Report EM-CBFO--NWP-WIPP-2020-0007. *Inspector Opens Electrical Panel without Required PPE*

10 CFR 851, *Worker Safety and Health Program*

DOE P 450.4A, *Integrated Safety Management Policy*

DOE-HDBK-1211-2014 (DOE Handbook), *Activity-Level Work Planning and Control Implementation*

DOE-HDBK-1092-2013 (DOE Handbook), *Electrical Safety*

DOE Order 422.1, *Conduct of Operations*

Occupational Safety and Health Administration (OSHA), *Controlling Electrical Hazards (3075)*

DOE G 450.4-1C, *Integrated Safety Management System Guide*

NFPA 70E 2015, Article 110, *General Requirements for Electrical Safety-Related Work Practices*


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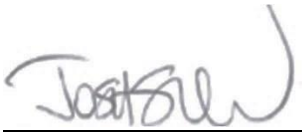
This OE-3 document requires no follow-up report or written response.



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