Operating Experience Summary

OES 2025-03 April 2025

Electrocution Hazard: A Near Fatal Reminder of Electrical Safety

Translating Investigations into Prevention & Learning

This Operating Experience Summary (OES) provides a concise and informative synopsis of a Department of Energy (DOE) accident investigation and, through the lens of Integrated Safety Management (ISM), converts the outcomes into actionable and practical steps that can help an organization prevent similar serious events from impacting our workforce and mission in the future.

Imagine This

A seasoned high-voltage electrician, with well over 20 years of experience, arrived at work on December 27, 2022, ready to perform a routine maintenance task. By that afternoon, they were fighting for their life after contacting an energized 12.47kV circuit inside a switchgear cubicle. This isn't a hypothetical scenario; it's the reality of an accident that occurred at the SLAC National Accelerator Laboratory on December 27, 2022.

Why This Matters to You

Electrical work (regardless of voltage) is inherently dangerous, and even experienced professionals can fall victim to hazards if procedures and good practices are not followed meticulously. This OES isn't about assigning blame; it's about identifying vulnerabilities in our safety systems and preventing similar incidents from occurring at your facility. Whether you're a manager, supervisor, or electrician, the lessons from this event at SLAC National Accelerator Laboratory are crucial for safeguarding your team.

The Incident

On December 27, 2022, a high-voltage electrician (HVE1) at SLAC made hand contact with an exposed, energized circuit part inside a 12.47 kV switchgear cubicle. Due to the severity of the electrical shock and the contraction of their muscles, they were unable to release. Fortunately, a nearby high-voltage electrician pulled HVE1 from the cubicle, interrupting the current and preventing a potentially fatal outcome, however, HVE1 sustained severe injuries to their hands and face.

On December 29, 2022, the Office of Science Deputy Director for Operations directed a DOE Accident Investigation Board (AIB) be assembled to identify the causes related to the accident (Investigation Report).

Key Takeaways: Identified Weaknesses in the Safety Net

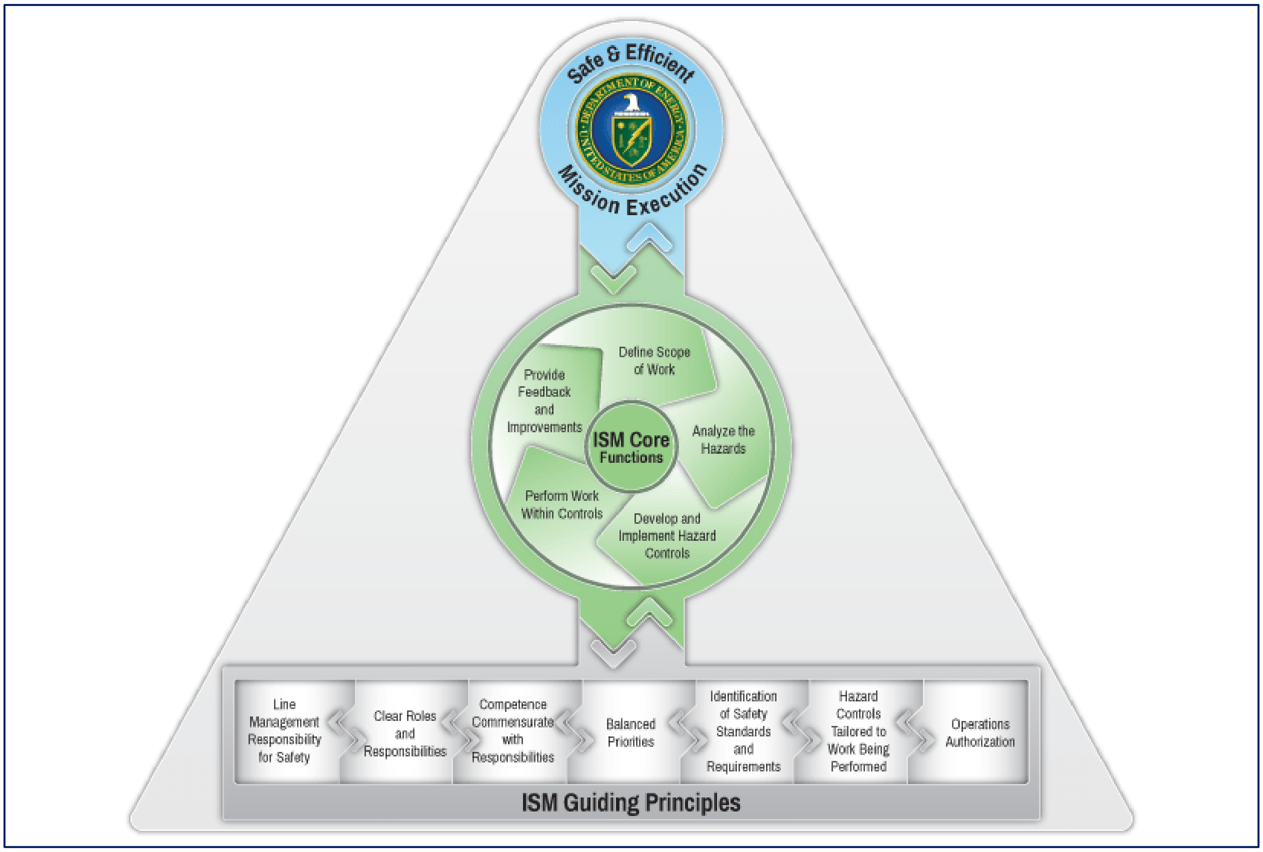
The AIB investigation uncovered significant weaknesses in the application of the Integrated Safety Management (ISM) system, highlighting areas where improvements are essential to prevent recurrence:

- **Scope of Work:** Inadequate planning failed to account for all aspects of the work, leading to a work package that could not be safely executed.
- **Hazard Analysis:** The Electrical Work Plan (EWP) did not adequately identify the hazards associated with the work.
- **Hazard Controls:** The EWP did not fully identify appropriate controls for the work scope hazards, and those identified did not align with SLAC's Employee Safety & Health manual.
- **Work Performance:** Multiple deviations from the approved work plan and its established controls occurred without stopping to question the discrepant work steps or hazards identified during the performance of work.
- **Feedback/Improvement:** There was no effective means for identifying and reporting unsafe work practices nor an incentive to improve.

Integrated Safety Management (ISM) System

In this OES, we will observe the event through the lens of the ISM framework to identify potential areas that can be strengthened in our work processes across the Department. How can we more effectively use the structured and consistent set of ISM tools in the work planning and control cycle to incorporate critical requirements such as [10 CFR 851 *(Worker Safety and Health Program)*]() and to safely plan and execute our complex and high-risk mission work?

DOE has implemented the ISM Policy (DOE P 450.4A, Chg1) to integrate safety into management and work practices at all levels in the planning and execution of work. This policy sets expectations for a systematic approach to work planning and control for the DOE complex for the protection of workers, the public and the environment. All organizations develop, maintain, and implement ISM systems into their operations and work practices based upon the ISM Guiding Principles and Core Functions shown in the DOE ISM pictogram:



Guiding Principles (GPs)

The guiding principles, shown above, are the foundational framework for developing and implementing an effective ISM System.

Core Functions

Core functions build on the guiding principles, providing the necessary structure for any work activity that could potentially affect workers (as well as the public and environment) and are applied as a continuous cycle with the degree of rigor appropriate to address the type of work activity and hazards involved.

The DOE G 450.4-1C, *Integrated Safety Management System Guide* provides valuable additional information, including helpful terminology and narrative that describes the relationship between ISM principles, functions, operational work, and performance results

NOTE: DOE **requirements** for implementing an ISM System are contained in DOE O 450.2, *Integrated Safety Management* (for federal organizations) and DOE Acquisition Regulation (DEAR) clause 48 CFR 970.5223-1, *Integration of Environment, Safety, and Health into Work Planning and Execution* (for DOE contractors).

Work Location and Activity

The work activity planned for Monday, December 27, 2022, involved electrical preventive maintenance (PM) actions scheduled to be performed on two substations and their downstream loads. For ease of understanding, these substations will be referred to as SS-A and SS-B. Both substations SS-A and SS-B house 12.47 kV switchgear and are located inside Building 626 and Building 522 respectively. SS-A and SS-B are both fed from breaker 75 (BRK75) which is located in a separate area of SLAC at the Main Substation; however, SS-A is also fed from a separate, energized source.

The PM work was to be conducted in two phases. Phase 1 was scheduled to isolate power to SS-A (but not SS-B) to allow for maintenance in the area before connecting temporary generators. Phase 2 consisted of fully isolating both SS-A and SS-B and performing the remaining PMs on the 12.47 kV breakers and downstream equipment.

At 0600, the HV electricians group met to discuss the day's work assignment. The HV Supervisor assigned this particular Electrical Work Plan (EWP) to HVE1 and HVE2 with two other High Voltage electricians (HVE3 and HVE4) assisting. This EWP utilized a switching order (SWO1) which provided sequencing of operations (e.g., Notify, Verify, Open, Close, Install, Remove, etc.) for specific equipment including various switches and breakers.

HVE1 began executing the EWP up to where it directed the performance of the first switching action referenced in SWO1. This switching action was to verify that a breaker (BRK360) was open, racked out, and physically locked. Though unexpected, when HVE1 and HVE2 arrived at the location where BRK360 was housed, they found it had already been racked out due to unrelated work (change in field conditions). Regardless, HVE1 continued with applying their lock to the rack-out mechanism of BRK360, and with the help of HVE2, began applying grounds to the back of BRK360. This particular action was not directed by SWO1.

Once HVE1 and HVE2 finished applying grounds to BRK360, they moved on to subsequent steps directed by SWO1, eventually arriving at Building 626 where SS-A was located. They opened BRK342 (the event breaker), which de-energized the bus and all downstream loads. Observing the building lights go out, they inaccurately concluded the SS-A switchgear was fully de-energized. At the same time, HVE3 and HVE4, who were located in Building 522 where SS-B is housed, noticed their own lights go out for a few seconds and come back on. Not expecting this, HVE4 contacted HVE1 over the radio to inquire about it but was told the automatic transfer switch controlling the lights was a normal operation to be expected. HVE4 asked HVE1 and HVE2 to meet them at Building 522 after they had completed their work in Building 626 to further discuss this matter.

HVE1 and HVE2 then proceeded to rack out BRK342 and apply a lock to its associated racking mechanism. At this point, HVE2 noticed the BRK342 arc flash label applied to the front of the switchgear listed two separate sources supplying power (see **Figure 1**). HVE2 voiced their concerns to HVE1, who was at the back of the switchgear, stating that the label indicated BRK75 was one of the two power sources supplying BRK342. However, HVE1 did not acknowledge or respond to HVE2. No clarification or follow up discussions were held on this issue between HVE1 and HVE2.

Figure 1

HVE1 then proceeded to perform what they considered to be a Zero Voltage Verification (ZVV) on a 120V service receptacle located inside Building 626, and without any power indicated, confirmed the receptacle was de-energized. At this point, HVE1 and HVE2 both concluded the SS-A switchgear was now fully isolated and de-energized. This conclusion would nearly be fatally incorrect, as BRK75 was still supplying power to BRK342.

HVE1 then proceeded to open the disconnect for the SS-A battery bank, isolating all control power to the switchgear and disabling all meters, relays, and indicating lights located on the front of the switchgear including BRK342. Though done to prevent battery bank discharge, this disconnect step was NOT directed in either SWO1 or the EWP. Additionally, by doing so, this action eliminated any visual cues to others in the area that power was still being supplied to the line side of BRK342 from BRK75.

At around 0815, HVE1, HVE2, HVE3 and HVE4 went to their maintenance shop for a morning break. After finishing, HVE1, HVE2, and HVE3 returned to Building 626 where SS-A and BRK342 were located. Upon arriving, HVE2 engaged with several subcontractors to discuss various aspects of the PM activities.

Meanwhile, HVE1 asked HVE3 for assistance inside Building 626 and both workers proceeded to the backside of BRK342. Once there, HVE3 observed the door to the BRK342 cubicle was already unlatched and cracked open, and like the others, believed the switchgear to be de-energized. HVE3 then proceeded to stage a grounding hook on the wall just behind the switchgear.

While HV-3 was staging the grounding hook, HVE1 came in-between them and the cubicle, fully opened the door, reached into the switchgear, and lifted an insulation boot off the top of phase "A" surge arrestor (see **Figure 2**), exposing a bolted connection energized to ground. However, since they removed the insulation boot with their left hand while holding on to the grounded cubicle enclosure with their right hand, electricity flowed across their upper chest from the phase "A" connection to the cubicle enclosure.

Figure 2

HVE3 noticed HVE1 reach in, lift the insulation boot, and immediately go into a tight contraction, being unable to release. With no rescue equipment pre-staged or available nearby, and no time to get help, HVE3 grabbed HVE1's raincoat tail and forcefully yanked HVE1 out of the energized cubicle. This action interrupted the shock current and HVE1 fell unconscious to the floor with serious injuries to their hands and face.

The Event as seen through the Eyes of the ISM system

During their investigation, the AIB noted weaknesses in all five ISM core functions, contributing to HVE1 reaching into the energized switchgear. Though human performance issues were also at play during the event, the goal of this OES is to build organizational resilience and increase the level of awareness of the organizational performance deficiencies leading up to the accident.

The following provides a synopsis of those weaknesses in Core Functional areas which are fully identified in the SLAC Accident Investigation Report that can be found at the *DOE Accident Prevention and Investigation Program Website*.

CF-1: Define the Scope of Work

The Bottom Line: The planning process failed to account for all necessary aspects of the work scope to produce a work package that could be safely executed.

Supporting Facts

- ✓ A field walkdown to verify the EWP was inadequate and failed to identify several inaccuracies and discrepancies. These would have triggered additional reviews or revisions prior to EWP approval.
- ✓ The outage planning process did not assign sufficient resources and time to accommodate the increased work scope.
- ✓ The number of available workers to complete the work scope was extremely limited due to the holiday period, requiring a staggered outage plan (Phase 1 and 2).
- ✓ The development of a modified outage plan released some of the work while the switchgear at SS-A was partially energized.

CF-2: Analyze the Hazards

The Bottom Line: The Electrical Work Plan (EWP) did not identify the hazards associated with the work.

Supporting Facts

- ✓ The work planning review and approval process failed to identify that the work package contained steps for the HVEs to perform that introduced hazards to the work rather than mitigate them.
- ✓ The EWP did not document an arc flash risk or shock assessment, including arc flash boundaries and required Personal Protective Equipment (PPE) commensurate to the risk associated with the work.
- ✓ A blanket policy requiring high level energy arc flash suits for all high voltage work regardless of the labeled incident energy led to infrequent verification and field-checking of labels.
- ✓ A neglect for shock and arc flash boundaries led to HVE's wearing PPE that offered little protection.

CF-3: Develop and Implement Hazard Controls

The Bottom Line: The EWP did not fully identify appropriate controls for the work scope hazards, and those that were identified did not align with SLACs Employee Safety & Health manual.

Supporting Facts

- ✓ No arc flash boundaries were identified.
- ✓ The EWP did not identify specific controls for the shock hazard for individuals performing the work:
  - The limited approach boundary was not listed.
  - The restricted approach boundary was not listed.
  - The PPE required to enter the restricted approach boundary was not specified.

CF-4: Perform Work Within Controls

The Bottom Line: Multiple deviations from the approved work plan and its established controls occurred without stopping to question the discrepant work steps or hazards identified during the performance of work.

Supporting Facts

- ✓ Zero Voltage Verifications were performed out of order, two of which were performed in a location different than what was indicated on applicable procedures.
- ✓ The SS-A battery disconnect was opened, eliminating potential visual cues as to power status of the switchgear. This action was never directed in any work steps.
- ✓ Multiple 12.47 kV breakers were opened in SS-A that were not listed in the switching order.
- ✓ Even though a "Test Before Touch" is a highly encouraged action, none was performed after returning to an unattended jobsite. This alone would have detected the presence of a separate power source energizing BRK342 rear cubicle allowing workers another opportunity to fully realize actual system configuration.

CF-5: Provide Feedback and Continuous Improvement

The Bottom Line: There was no effective means for identifying and reporting unsafe work practices nor an incentive to improve.

Supporting Facts

- ✓ The most recent Control of Hazardous Energy (CoHE) program self-assessment was performed in September of 2021. However, the identified issues were not recorded for corrective action assignment and tracking.
- ✓ The Electrical Safety Officer was in a fully remote work status and did not conduct field audits of electrical safety and CoHE practices.
- ✓ The Electrical Safety Committee, which had previously served as an important mechanism for providing input and feedback to Management on work practices and program assessments, ceased meeting in 2010.
- ✓ No formal process had been used to capture Electrical Work Plan field changes so those could be incorporated into future work plans (e.g., document control).

- ✓ Critical communication efforts initiated by HVE2 regarding the information listed on the BRK342 arc flash label, and the indications that SS-B was still energized as brought up by HVE4, were ignored.

Take the Next Steps: Implementing the ISM Lessons

The ISM System and associated work planning and control processes are designed to mitigate the risks present in DOE operations and prevent adverse impacts to our people and our mission. The near-fatal incident at SLAC serves as a powerful reminder of the ever-present hazards of electrical work and the importance of a robust and effectively implemented ISM system. These processes are particularly important when multiple organizations are involved in trying to execute the work. The question remains, “What can we learn from this experience that can be applied across the DOE complex or even our own specific work?”.

Many of the event takeaways reinforce the importance of understanding that the ISM System is only as good as those who are implementing it. Many of us are familiar with the reality that any core function can continue to evolve during the execution of work from planning to “wrench turning.” With that in mind, consider asking the following questions prior to commencing work:

- Does our planning process produce work packages that can be safely executed?
- Have we involved qualified and competent personnel to help identify all risks associated with the work?
- Are all team members willing to stop and question discrepant work steps and/or newly identified hazards that come up while performing work?
- Do we have effective means for identifying unsafe work practices and are we empowering workers to report potential hazards without fear of reprisal?

In Closing

The goal of this Operating Experience Summary was to tell the story of a tragic accident to help prevent one like it from happening again. Working on high voltage systems is inherently dangerous.

This OES was developed to provoke those who read it, to ask themselves and their co-workers, “Could this happen to us?”, and if so, prompt change. Regardless of if you’re a senior manager, work planner, supervisor, or craftsman, consider asking “Is the organization that I’m a part of, including myself, doing everything reasonably possible to help ensure my “work family” goes home today?”. In doing so, we pay tribute to those who no longer can work with us, and honor those with whom we still do.

Think About This: As you read this OES, don't ask "How did they let that happen?". Instead, ask "Could this happen to us?" and, more importantly, "How will we prevent it from happening to us?".

Don't let this incident fade into memory. Use it as a catalyst for change, to reinforce your commitment to safety, and to ensure that everyone on your team goes home safe each day.

OES Article author: Jason Brustad, EHSS Office of ES&H Reporting and Analysis

For further information or questions about this OES, please contact Rizwan Shah, Accident Prevention and Investigation Program Manager, at (202) 586-4371 or by email at Rizwan.Shah@hq.doe.gov.