Subject/Title of Occurrence

IR2 Electrical Arc Flash Injury Incident

Description of Occurrence

Management Summary:

On Tuesday December 27th, 2022, an electrician from SLAC National Accelerator Laboratory's High Voltage (HV) group within the Facilities and Operations (F&O) Division sustained injuries requiring hospitalization when an arc flash occurred while performing Zero Voltage Verification (ZVV) on 12.47 kV switchgear. The injured electrician was part of a crew preparing multiple substations and downstream electrical equipment for planned preventative maintenance. The crew was working under an approved electrical work plan (EWP). The crew was in the process of deenergizing and locking out substation B626 in accordance with the EWP. The energy isolation plan for substation B626 requires three breakers to be opened, racked out, and LOTO lock and tag applied. These steps were performed without incident.

The energy isolation plan also requires 12 kV ZVV to be performed on B626 switchgear 12 kV bus. For reasons that are not yet understood the electrician attempted to perform ZVV on the upstream side rather than the downstream side of the B626 main breaker. The upstream 12 kV feeder connected to the main breaker was outside of the energy isolation boundary and was energized. The arc flash and injury occurred when attempting to perform this ZVV. In addition, the injured worker was not wearing the required shock hazard and arc flash hazard PPE at the time of the incident.

Other members of the work team present at the scene heard the arc flash and immediately came to the aid of the injured electrician and contacted both 911 and SLAC Emergency Response. No other workers were injured in this event.

Incident Description:

On Tuesday December 27th, 2022, three electricians from SLAC National Accelerator Laboratory's High Voltage (HV) group within the Facilities and Operations (F&O) Division were preparing electrical substations B522 and B626 for outages needed to support Preventative Maintenance (PM) work that is required every 5 years. The work plans included an Electrical Work Plan (EWP) with HV Switching Orders (SOs) and Lock Out Tag Out (LOTO) Energy Isolation Plans (EIPs) for (1) installation of a generator to support building and equipment impacted by the outage, and (2) performing LOTO and Zero Voltage Verification (ZVV) prior to releasing the substations to subcontractors, who would perform the PM tasks. During EWP development, the Maintenance and Operations Support Group Leader performed a regional field walk of the job site to write the initial plan, then walked the job with electricians who planned to do the work and subcontractors. The Maintenance and Operations Support Group Leader walked the job sites again with the subcontractor after the job was awarded. The Maintenance and Operations Support Engineer also walked the job to verify breakers and Switching Order portions of the EWP. Once the EWP final draft was ready, the High Voltage Supervisor reviewed the EWP, verified that the drawings and switching diagrams were available, then authorized electricians to perform the work, including walk of the job location. Workers then walked the job and communicated any concerns or changes needed. The High Voltage Supervisor then confirmed with workers that they completed their job walk and felt comfortable with the work plan. Next, the EWP was signed off as complete by the Maintenance and Operations Support Group Leader and the Maintenance and Operations Support Engineer involved in job planning and with authorization from the high and low voltage shop supervisors and released to proceed from the building and substation building managers. Workers assigned to perform the tasks in the EWP signed the EWP to acknowledge that they understood the plan and would adhere to steps and hazard controls. Once the EWP was fully authorized, released, and acknowledged, the work was scheduled.

Starting the morning of Tuesday, December 27th, all three electricians attended a tailgate at 6:00 AM with High Voltage group personnel where the EWP for B626 and B522 was discussed; the assigned workers confirmed that

they understood the plan and steps and felt comfortable doing the work. At 6:30AM the electricians attended a broader Facilities and Operations (F&O) tailgate to coordinate work between facilities group for the day ahead. In accordance with the EWP for the generator installation, the electricians began work by visiting B726 and B522 substations, which contained electrical feeder equipment upstream from the planned PM work. At B726 and B522, the electricians visually checked that related breakers were open or racked out and then applied LOTO locks in preparation for ZVV, energy isolation and other preparation work planned for later in the day. In accordance with SLAC minimum requirements for entry into a substation building by electrical workers, the electricians were outfitted in NFPA Arc Flash Category 2 attire, including arc-rated long pants and long sleeve shirt, leather boots, hard hat, and safety glasses. Arc Flash Category 2 PPE have a minimum arc rating of 8 cal/cm^2.

Continuing with the steps in their EWP, the electricians then proceeded to the B626 substation where the first ZVV of the day was planned. The lead authorized worker, Worker A, lead the other two electricians through a discussion of the work planned in B626, including a review of the EWP and single-line electrical diagrams. The EWP and SO planned for the B626 substation included application of a Group LOTO on Breaker #342 and then ZVV on 3 breakers downstream from Breaker #342. Breaker #342 was open, racked out and locked out to de-energize substation B626 and the downstream equipment, but the feeder to breaker #342 from master substation breaker #75 was still energized.

Notably, SLAC policy requires the use of 100 cal/cm^2 arc rated suits for high voltage electrical substation work even though the actual arc flash energies are much lower. No work is performed on equipment with arc flash incident energy above 40 cal/cm^2 (NFPA Category 4). Arc flash incident energies for SLAC electrical equipment are NFPA Category 4 or lower. Normal work attire for facilities electrical workers is NFPA Category 2 attire described above for substation access.

Worker A was the lead authorized worker and designated to perform the electrical work in B626. However, for reasons not yet understood Worker A did not change into the 100 cal/cm^2 suit, but rather remained in the NFPA Category 2 attire as the work commenced. Worker A was additionally wearing a raincoat, as rainstorms persisted throughout the day. The raincoat may have been arc-rated or FR-rated, but this information could not be confirmed. The three electricians approached the switchgear cubicles in B626. Worker B proceeded to the other side of the cubicle, and Worker C stayed in the vicinity of Worker A.

For reasons not yet understood, Worker A approached the line side enclosure of Breaker #342 (the energized feeder from master substation breaker #75) rather than the load side of Breaker #342 (the deenergized and locked out switchgear bus work) for ZVV. Worker A proceeded to open the cubicle door (where the energized feeder was terminated) and was lifting the boot off of a test point when Worker C heard the arc flash occur. Worker C grabbed Worker A and pull them both away from the cubicle. Worker B immediately called 911. Simultaneously, subcontractors and additional employees outside B626 heard the arc flash, made additional calls to SLAC Emergency Response, 911, and proceeded to the SLAC front gate to escort emergency responders to the scene.

SLAC EMTs arrived within approximately five minutes and fire trucks and ambulance arrived shortly thereafter. Worker A was treated by EMTs on the scene and taken to the hospital for emergency medical care. SLAC Security secured the scene. Notifications to line management, SLAC Management, Environmental Safety and Health personnel and the SLAC Site Office were promptly initiated. As of the submission of this notification report, Worker A was still being treated in the hospital. No other personnel were injured in this event.

A DOE independent root cause analysis investigation was initiated by the SLAC Site Office to elucidate root causes and Judgements of Need to prevent recurrence. Updates to the preliminary information contained in this initial notification report will be included in the final DOE investigation report. A summary of the final DOE investigation report analysis, Judgements of Need and any lessons learned will be provided in the final ORPS report for this event. The Issues and Corrective Actions derived from the JONs from the investigation will be managed via the SLAC Issues and Improvements Management System (SIIMS).

Initial Issues/Causes Identified

1. A 100 cal/cm^2 suit was not in use during the arc flash event though it is required by SLAC policy for high voltage electrical work in substations.
2. Zero Voltage Verification work was attempted on an energized breaker rather than the de-energized breakers downstream.
3. Early fact-finding efforts incidentally discovered outdated or incorrect electrical drawings in the SLAC SEDA document management database, indicating gaps in configuration management.

Immediate Actions Taken

1. All high voltage electrical work was immediately stopped, and a process delineated to allow division management approval for exceptions related to incident investigation and emergency work.
2. All Winter Break work was re-reviewed, and all work related to Control of Hazardous Energy stopped.
3. An enhanced rigor work review process was drafted to permit review and restart of stopped work on a case-by-case basis.
4. Mental health resources for employees were provided by Human Resources to all Associate Laboratory Directors and Division Directors.

Preliminary Lessons Learned (if available)

1.
2.

Notifications

Name	Date	Time	Organization	Notification Type
Carole Fried	122722	0929	SLAC ESH Director	☐ DOE HQ OC ☒ Other
Nancy Mate	122722	0942	SSO	☐ DOE HQ OC ☒ Other

ORPS Reporting Criteria

Reporting Criteria: 2(D)1 Hazardous Energy, 2(A)3 Personnel Safety and Health
Report Level: ☒ **High** ☐ **Low** ☐ **Informational**
Will SLAC Submit Report to ORPS Database? ☒ **Yes** ☐ **No**
If No, SSO Concurrence Obtained From (Name, Date):
Subcontractors Involved? ☐ **Yes** ☒ **No**

Division/Project: Facilities and Operations/EPD
System/Building/Equipment: **IR2/**B626 Substation/Breaker #342
Plant Area: B626 Substation
Discovery Date: 122722 **Time:** 0924
Categorized Date: 122722 **Time:** 1000
Categorized by Facility Manager/Designee: ☒ Marc Clay ☒ Cindy Patty
Duty Officer: ☐ Greg Johnson ☐ Ralph Kerwin ☒ Lance Lougee ☐ Simon Ovrahim