CALIFORNIA PUBLIC UTILITIES COMMISSION
Safety and Enforcement Division
Electric Safety and Reliability Branch

Incident Investigation Report

Report Date: 11/9/2021

Investigator: James Miller

Incident Number: E20180118-01

Utility: Southern California Edison Company (SCE)

Date and Time of the Incident: 1/18/2018, 10:30 a.m.

Location of the Incident: Near Highway 395 and Highway 58
Kramer Junction, CA
County: San Bernardino

Summary of Incident:

[redacted], a journeyman lineman for Herman Weissker Incorporated (HWI), sustained fatal injuries while adjusting the rigging on a de-energized overhead 115 kV conductor near the intersection of Highways 395 and 58 in San Bernardino County. My investigation revealed that although the 115 kV conductor had been de-energized by SCE prior to start of work, the conductor had not been grounded properly and safely in accordance with the requirements of SCE's Overhead Grounding Manual. As a result, a nearby energized 220 kV circuit induced a current into the 115 kV conductor, indirectly energizing it, which led to Mr. [redacted] fatal injuries.

Fatality / Injury: There was 1 fatality reported

Property Damage: None

Utility Facilities involved: Kramer-Cool Water 115 kV Circuit

Witnesses:

	Name	*Title*	*Phone*
1.	James Miller	CPUC Investigator	(213) 266-4715
2.	Eric Coolidge	SCE Claims Investigator	(626) 302-6947
3.	[redacted]	Foreman	[redacted]
4.	[redacted]	Journeyman Lineman	[redacted]
5.	[redacted]	Union Representative	[redacted]
6.	[redacted]	SCE Construction Manager	[redacted]

Evidence:

Source	*Description*
1. SCE	315 Letter
2. SCE	Safety Event Report
3. SCE	Contractor Incident and Evaluation Report
4. HWI	Tailboards
5. SCE	Work Orders
6. SCE	Work Order Map-Model
7. CPUC	Interview Notes
8. CPUC	Scene Photographs
9. [redacted]	Scene Photographs
10. SCE	Data Request Responses
11. SCE	Kropp Employment History
12. Cal/OSHA	Incident Report

Observations and Findings:

In late 2017, SCE contracted HWI to work on the Kramer-Coolwater 115 kV circuit near the intersection of Highways 395 and 58 at Kramer Junction in San Bernardino County. The job included the replacement of a lattice steel tower with a new tubular steel pole and the relocation of three existing conductors from the old structure to the new one. The lattice steel tower supported three conductors of the Kramer-Coolwater circuit.

SCE determined that HWI was qualified to perform the scope of work safely based on HWI's previous safety record, history of successful completion of similar projects, and through correspondence with other utility companies who were satisfied with their work[1]. ISNetworld, SCE's third-party administrator for the project, also approved HWI for the project based on their Experience Modification Rate (EMR) of 77% as calculated by the Workers Compensation Insurance Rating Bureau of California.

SCE staff de-energized the Kramer-Coolwater circuit on January 12, 2018, at 6:20 AM so that HWI staff could proceed with the conductor relocation process. De-energization is an important safety precaution because contact with energized high-voltage conductors can present a safety hazard to workers. Although the Kramer-Coolwater circuit was successfully de-energized, the nearby Kramer LSP 220 kV circuit remained energized. The Kramer LSP circuit ran parallel to the Kramer-Coolwater circuit in this area, about 300 feet to the south. See Figure 1.

[1] HWI had previously completed sub-transmission (66-115 kV) work for SCE since becoming qualified for the work by SCE in June 2013. Previous to becoming approved, SCE had interviewed Riverside Public Utilities staff who had previously hired HWI for similar work and were satisfied with their performance.

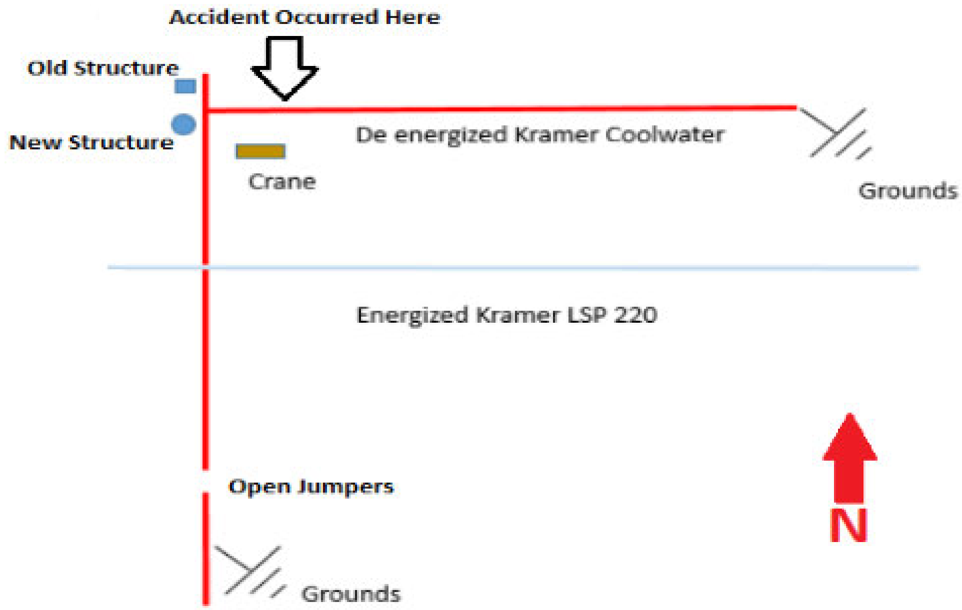

Figure 1: A bird's-eye diagram of the worksite. The Kramer-Coolwater circuit, in red, had been de-energized. The Kramer LSP circuit, in light blue, remained energized and ran parallel to the Kramer-Coolwater circuit.

In addition to de-energizing a transmission circuit, it is also critical to worker safety that the circuit also be grounded. This is necessary (in part) because of a phenomenon called "induction" in which de-energized conductors can inadvertently become energized due to the fluctuating magnetic field of energized conductors nearby. Grounding brings the de-energized conductors to the same electrical potential as the earth and creates low-resistance pathways for current to follow back to the ground. When working from an elevated work platform, it is also important to connect the body of the platform to the de-energized conductor by means of a bond, which is a conductive cable with one end clamped to the conductor and the other to the platform. This creates an equipotential zone in which workers can operate safely.

The devices used to ground a circuit included bonds, grounding rods, and grounding plates. A bond, as mentioned above, is a short conductor with clamps on both ends. Bonds are used to electrically connect conductors, bringing them to the same electrical potential. Bonds can also be used to electrically connect other types of equipment, for example a conductor to the body of a steel pole, or a conductor to an elevated work platform. Grounding rods and grounding plates are similar. A grounding rod is a long metal rod, usually about eight feet long. This is driven into the earth and connected to the grounded circuit with a bond. The rod provides a low-resistance path for electrical current to pass into the earth in case the conductor becomes energized. A grounding plate is like a grounding rod with a large metal plate on the end. The plate is buried in the earth and its large surface area creates an even better electrical connection with the earth than the grounding rod does. In the event that a worker is in contact with the grounded conductor that suddenly becomes energized, the vast majority of the electric current will pass through the grounding device rather than the worker, and the extent of the worker's injuries will be greatly reduced or possibly eliminated.

HWI journeyman linemen [redacted] and [redacted] installed the grounding devices, which included bonds and a grounding plate, for the project sometime between January 12 and January 18, 2018. Mr. [redacted] and Mr. [redacted] bonded the de-energized conductors together near the old lattice steel tower and grounded the circuit at only one point, an H-frame east of the work site. See Figure 2. They used a grounding plate to ground the conductors near the H-frame. The plate was bonded to the de-energized conductors of the Kramer-Coolwater circuit and buried approximately 10 feet deep in the soil next to the H-frame.

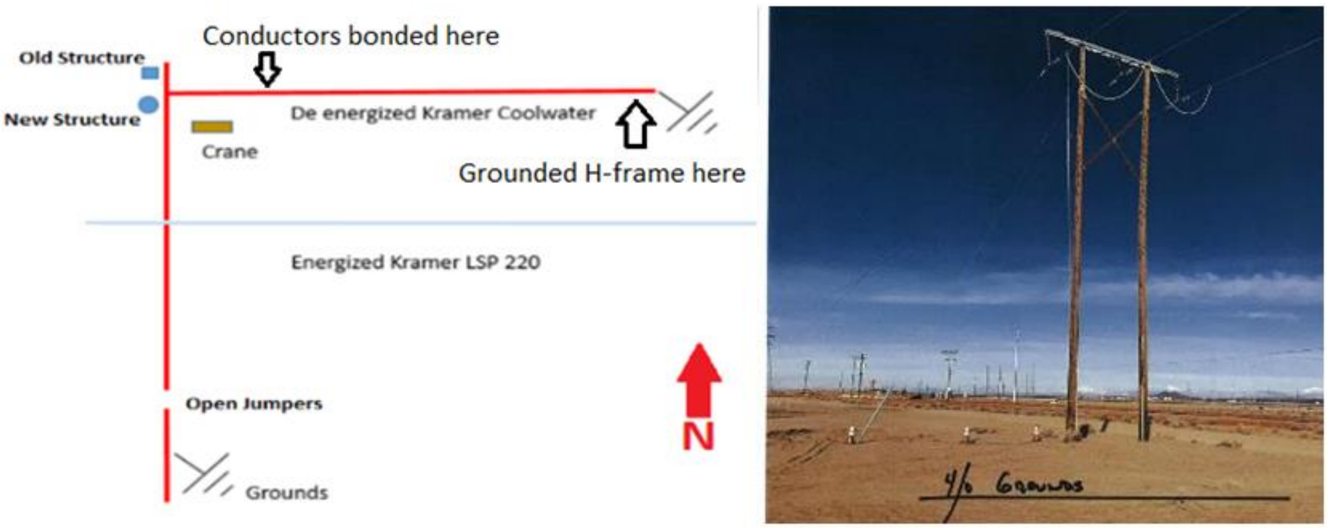

Figure 2: The grouded H-frame to the east of the incident location. The conductors were bonded and grounded here. This was the only point at which the conductors were grounded. This photograph was taken by [redacted] *about two hours after the incident occurred.*

On January 18, the day of the incident, the grounding devices were in place and HWI staff planned to begin moving the three de-energized conductors of the Kramer-Coolwater circuit from the old lattice steel structure to the new steel pole. See Figure 3. They performed a tailboard meeting that morning before work began. The crew discussed the work to be performed and potential hazards that may arise. The tailboard record did not reflect that the crew had discussed the induction hazard presented by the Kramer LSP during that meeting.

Figure 3: The scene of the incident on the day it occurred. The bucket truck was near the steel lattice tower. Although the conductors were bonded together here, none of the structures in this photograph were grounded.

HWI's process for moving the conductors involved both an elevated work platform and a crane. First, two linemen would ascend to the conductor in the elevated work platform. They would then create an equipotential zone by attaching a bond between the elevated work platform and the conductor. Next, they would attach rigging to the conductor that allowed the crane to securely manipulate the conductor. After the rigging was attached, they would remove the bond from the conductor. The crane could then move the conductor from the old structure to the new one, and the process would repeat until all three conductors had been relocated.

On the morning of January 18, 2018, HWI staff had successfully moved the first two conductors (top and middle) of the Kramer-Coolwater circuit from the old structure to the new one. The bond had protected the men in the elevated work platform during these two operations. Around 10:30 AM, HWI linemen [redacted] and [redacted] were working on the elevated work platform and had successfully attached the rigging to the third and final conductor to be moved. Mr. [redacted] removed the bond from the conductor, and for unknown reasons, he grabbed the conductor with his right hand and sustained his fatal injuries through electric shock. Mr. [redacted] should not have grabbed the conductor after removing the bond. It is likely that he was attempting to further adjust the rigging on the conductor and had forgotten that the bond had been removed. If the bond had been connected, it could have protected him from electrocution as it had while attaching the rigging to the first two conductors.

Mr. [redacted] was transported by ambulance to Barstow Medical Center, and then air-lifted to Loma Linda University Hospital. He never regained consciousness and died as a result of his injuries on Saturday, January 20, 2018. Mr. [redacted] was a qualified Journeyman Lineman who completed an eight-step, 8,000-hour electrical apprenticeship program in 2014 and worked as a Journeyman Lineman from that time until his death. Mr. [redacted]s fatal injury was primarily caused by electromagnetic induction from the nearby energized Kramer LSP circuit, which SCE confirmed as the cause of death in a February 14, 2018 letter.

SCE's Overhead Grounding Manual requires that worked conductors be grounded on both sides of the workspace while working from an elevated work platform or an induction hazard is present. My investigation revealed that the subject de-energized conductors were only grounded on one side of the workers, to the east.

There is some disagreement as to whether a grounding device was in place to the west of the worksite when the incident occurred, but both SCE and SED agree that no grounding device was connected to the western end of the conductors at that time. On February 7, 2018, while on site, I observed only one grounding device on the relevant part of the Kramer-Coolwater circuit; this device was the grounding plate on the H-frame to the east of the worksite. HWI and SCE staff confirmed during February 7, 2018 interviews that this was the only grounding device connected to the conductor when the incident occurred. SCE also stated in a November 27, 2019 letter that the relevant part of the circuit was only grounded at the H-frame. Later, after I pointed out that SCE's Overhead Grounding Manual requires grounding devices on both sides of a workspace when an induction hazard is present, HWI claimed in an October 12, 2020 letter that the lattice steel tower to the west of the worksite was indeed grounded with a grounding rod. SCE later stated in a December 16, 2021 letter that grounding bonds had been used to electrically connect the western end of the conductors to the lattice steel structure and the new steel pole, but that they were not in place at the time the incident occurred. SCE explained that these bonds had been removed from the conductors to facilitate their movement during the transfer process. SCE provided photographs taken after the incident occurred showing the bonds attached to the lattice structure and the new tubular steel pole. Regardless of whether these bonds were attached to the two structures on the day of the accident, they were not connected to the conductor being moved at the time the accident occurred.

Electromagnetic induction is a phenomenon whereby an alternating electric current in one conductor can cause an electric current to also flow in another nearby parallel conductor, even if that parallel conductor is not otherwise energized. The degree to which induction occurs, i.e., the magnitude of the current induced in the second conductor, is proportional to the distance the two conductors run parallel to each other. SCE considers an induction hazard to exist wherever transmission lines run parallel for over 600 feet or when the de-energized conductors are located within transmission/sub-transmission corridors. The Kramer-Coolwater and Kramer LSP transmission circuits run parallel for over 700 feet through a transmission corridor that included the worksite.

SCE requires special grounding schemes when an induction hazard is present. SCE's Overhead Grounding Manual dictates that the conductors must be grounded at a minimum of two places to ensure safety: one set of grounds shall be placed on either side of the worksite and an additional bond should connect the conductor to the elevated work platform while the work is being performed[2]. See Figure 4 for a diagram of how a work site should be grounded in this situation, and the Appendix for a detailed explanation of why a minimum of two sets of grounding devices are necessary to mitigate the electrocution hazard presented by induction.

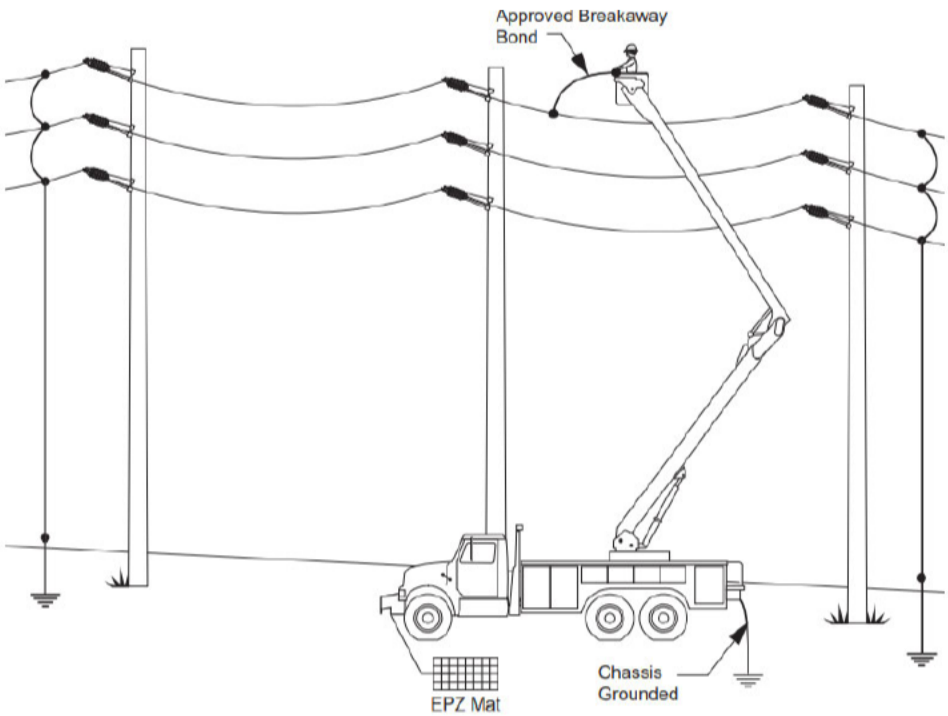

Figure 4: A figure from SCE's Overhead Grounding Manual showing how conductors should be grounded when linemen are working on a transmission circuit from a bucket truck when an induction hazard is present. SCE's Overhead grounding manual requires grounding devices be installed on both sides of the worksite.

HWI's grounding plan contained only two of the three elements required by SCE's Overhead Grounding Manual. The circuit was grounded to the east of the worksite, and the workers used a bond between the elevated work platform and the conductor, but a second grounding device was not connected to the conductors west of the worksite as shown in Figure 5. If a second grounding device had been connected to conductors west of the workspace, the extent of Mr. [redacted]'s injuries could have been greatly reduced or eliminated. SCE explained the importance of grounding on both sides of workers when and induction hazard is present in a December 16, 2021 letter in response to an SED inquiry regarding the incident:

> *The grounding on both sides of the worker helps ensure that a ground is between any source of energization and the worker. During a fault, voltage is higher on the source side of the ground than the opposite side, so grounds on both sides help ensure one ground is always on the source side. Also, it can provide redundancy in the event any grounding hardware fails during an inadvertent energization.*

[2] See SCE's Overhead Grounding Manual, Section 4.10.3.

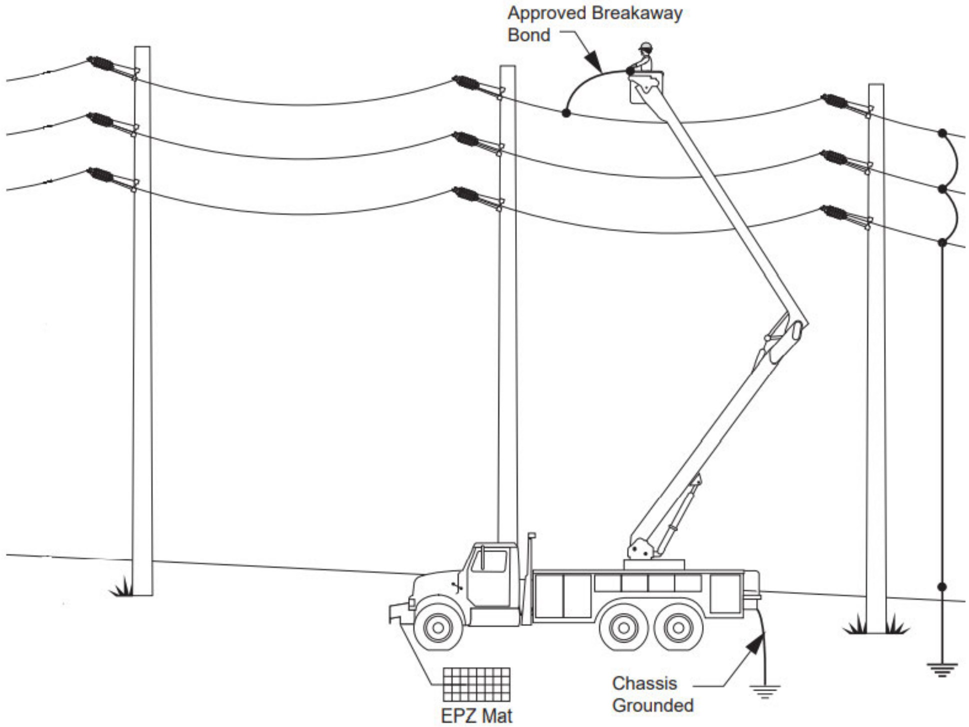

Figure 5: A simplified diagram of HWI's grounding scheme at the worksite. Compared SCE's grounding diagram above in Figure 4, HWI's scheme left out the grounding device to the left of the elevated work platform. The bond connecting the platform to the conductor had also been detached by HWI staff at the time the incident occurred.

SCE's Contractor Safety Management Standard Version 6, which was the applicable standard at the time of the incident, contains instructions for contractor field monitoring and other practices to ensure that SCE's contractors perform their work safely. Some requirements of the standard were not met for this project.

SCE's Contractor Safety Management Standard, Version 6, Section 3.2, Contractor Orientation for Tier 1 Contractors, states in part:

> *Within 15 Calendar days after receipt of notice to proceed or in advance of the Tier 1 Contractor's start of work (whichever is sooner), the Edison Representative or delegate shall ensure a Contractor Orientation is performed in collaboration with the Contractor by ensuring the development/review of the following:*
>
> *a. The Hazard Assessment (Appendix D)*
> *b. The Project/Site-Specific EHS [Environmental Health and Safety] Plan*
> *c. The Handbook for Contractors Checklist (Contained in the EHS Handbook for Contractors)*
>
> *These documents shall be reviewed with the Contractor Representative, signed by the Edison Representative and Contractor Representative prior to the start of work, and archived in project records using Appendix E: Contractor Orientation Review.*

The Contractor Safety Management Standard (CSMS) requires that an SCE representative perform a contractor orientation by reviewing three documents prepared by the contractor. These documents are The Hazard Assessment, The Project/Site-Specific EHS Plan, and The Handbook for Contractors Checklist. Once the contractor has completed the documents and submitted them to the SCE representative, he or she must review the documents and archive them along with the Contractor Orientation Review.

General Order (GO) 95, Rule 31.1, Design, Construction and Maintenance, states in part:

> *For all particulars not specified in these rules, design, construction, and maintenance should be done in accordance with accepted good practice for the given local conditions known at the time by those responsible for the design, construction, or maintenance of communication or supply lines and equipment.*
>
> …
>
> *All work performed on public streets and highways shall be done in such a manner that the operations of other utilities and the convenience of the public will be interfered with as little as possible and no conditions unusually dangerous to workmen, pedestrians or others shall be established at any time.*

GO 95, Rule 31.1 requires utility companies to conduct construction activities in accordance with accepted good practice and to do so in a way that is not unusually dangerous to workmen. The CSMS and its requirements, being official SCE policy, is one such accepted good practice.

The CSMS's Standard Statement states, in part:

> *The purpose of this standard is to establish SCE safety-related requirements for SCE personnel conducting company business with Contractors and Subcontractors. This standard sets the expectation that all stakeholders ensure tasks/activities with potential for serious injuries and fatalities are properly identified and mitigated.*

Violation 1

The Hazard Assessment form, found in Appendix D of the CSMS, is a list of possible hazards associated with construction work. Beside each hazard listed is a checkbox which the contractor must check if that hazard will be present at the worksite. To the right of each checkbox is a small area in which the contractor can input control measures that could be taken to mitigate the hazard. The Hazard Assessment form also instructs the contractor to develop and submit a Project/Site-Specific EHS Plan that addresses the hazards identified in The Hazard Assessment.

The Project/Site-Specific EHS Plan must address the hazards identified in The Hazard Assessment, but it does not require that the contractor provide detailed safety plans, such as where to place grounding devices.

The CSMS requires a Tier 1 contractor to submit The Hazard Assessment and The Project/Site-Specific EHS Plan to SCE prior to the start of work. My investigation revealed that HWI completed and submitted The Hazard Assessment form to SCE but did not develop or submit The Project/Site-Specific EHS Plan. The CSMS does not require The Project/Site-Specific EHS plan to include detailed grounding plans, but it does require it to address the hazards identified in the Hazard Assessment, such as the hazard of inadvertent energization. By including such hazard mitigation measures in the EHS plan, and based on SCE's policy that requires contactors to follow its own grounding practices, SCE's representative may have discussed with the contractor the proper grounding practice to use in this specific project. Implementing the proper grounding procedure may have prevented or reduced the extent of Mr. [redacted]s injury. SCE is in violation of GO 95, Rule 31.1, for allowing work to proceed without receiving The Project/Site-Specific EHS Plan from HWI and thereby failing to ensure that the construction and maintenance of its facilities were performed safely and in accordance with the accepted good practices of SCE's Contractor Safety Management Standard.

Violation 2

The CSMS also requires the contractor to complete and submit to SCE The Handbook for Contractors Checklist. The Handbook for Contractors Checklist, found in SCE's EHS Handbook for Contractors, is a checklist of the items covered by the handbook. The purpose of the checklist is to provide an outline of requirements contained in the handbook that the SCE representative is to review with the contractor representative prior to the start of work. By signing this document, the contractor representative affirms that he or she understands the items contained in the checklist and will ensure compliance with the requirements contained in the handbook. Among other requirements, the EHS Handbook for Contractors states that the contractor must abide by SCE's safety standards, and that the contractor's procedures must not conflict with SCE's. The checklist must be signed and dated by both the contractor's and SCE's representative.

The 2016 SCE Handbook for Contractors (in effect at the time of the Kramer Junction Project) contains the following expectation for contractors:

Section 8.1 General Health and Safety Requirements:

> *Contractor shall ensure its work procedures do not conflict with the health and safety requirements of SCE policies, standards or programs.*

SCE's Handbook for Contractors requires contractors to ensure that their work procedures do not conflict with SCE's. HWI's Accident Prevention Manual, in section 120, *Grounding,* does not conform to the practices of SCE's Overhead Grounding Manual. As mentioned earlier in the report, SCE's manual requires a set of grounds on both sides of the worksite when and induction hazard is present. HWI's manual makes no mention of induction and only prescribes a set of grounds on each side of a worksite when splicing a conductor together. If HWI had thoroughly completed The Handbook for Contractors Checklist, which reaffirms that the contractor will comply with SCE standards, then HWI and SCE staff would have discovered that HWI's procedures were not in compliance with SCE's and work on the project would have been delayed until they were rectified. SCE stated in a December 16, 2021 letter that if it was discovered that a contractor's grounding methods were in conflict with SCE's standards, work would be halted until their practices could be revised. From the letter:

> *SCE requires that all transmission/sub-transmission contractors to meet or exceed the provisions of SCE's grounding manual. In the event a contract crew is identified as not meeting SCE's minimum grounding standards, all work requiring grounding would be stopped until appropriate grounding has safely been established.*

On October 6, 2020, SCE's Construction Project Manager and Representative for this project stated to me that he never received the missing documents from HWI and that he did not complete the Contractor Orientation Review. SCE also confirmed this in an October 12, 2020 letter. SCE explained that Mr. [redacted] failed to request the documents from HWI because he was not aware that they were required. SCE stated that Mr. [redacted] had received training on the requirements of SCE's 2017 Contractor Safety Management Standard in February 2017 but that he had not retained all that he had learned.

My investigation revealed that HWI did not complete or submit the checklist to SCE. As mentioned above, by signing this document, the contractor representative affirms that he or she understands the items contained in the checklist and will ensure compliance with the requirements contained in SCE's EHS Handbook for Contractors. Among other requirements, the EHS Handbook for Contractors states that the contractor must abide by SCE's safety standards, and that the contractor's procedures must not conflict with SCE's procedures. If HWI had completed the checklist, it would have had to confirm it modified its grounding procedures in order to comply with SCE's. Instead, HWI's grounding procedures and practices were out of compliance. SCE is in violation of GO 95, Rule 31.1, for allowing work to proceed without completion of The Handbook for Contractors Checklist and thereby failing to ensure that construction and maintenance of its facilities were performed safely and in accordance with the accepted good practices of SCE’s Contractor Safety Management Standard.

Violation 3

SCE’s CSMS further requires that representatives from both companies sign a filled out Contractor Orientation Review (found in Appendix E of the CSMS) after The Hazard Assessment, The Site-Specific EHS Plan, and The Handbook for Contractors Checklist have been completed by the contractor and received by SCE’s representative. The purpose of The Contractor Orientation Review is to provide a checklist that binds the documents reviewed during the contractor orientation and to ensure mutual understanding between SCE and the Contractor regarding what is required to safely perform work at SCE. The checklist includes boxes to be checked for each of the three documents above, The Hazard Assessment, The Project/Site-Specific EHS Plan, and The Handbook for Contractors Checklist. The three boxes must be checked to verify that the documents have been received, and then representatives from both companies must sign and date it. The SCE representative must then file The Hazard Assessment, The Project/Site-Specific EHS Plan, The Handbook for Contractors Checklist, and The Contractor Orientation Review before the project begins.

HWI completed The Hazard Assessment form prior to the start of work but did not complete or submit to SCE The Project/Site-Specific EHS Plan or The Handbook for Contractors Checklist. Through oversight, SCE allowed work to begin anyway.

My investigation revealed that SCE allowed work to proceed without completion of The Contractor Orientation Review. Completion of the review would have revealed that The Site-Specific EHS Plan and The Handbook for Contractors Checklist had not been completed, and SCE could have prevented HWI from commencing with the construction project until those documents were completed by HWI and reviewed by SCE, which could have made SCE and HWI aware that HWI’s grounding procedure should be modified to comply with SCE’s grounding procedure. Modifying HWI’s procedure to comply with SCE’s procedure is required in order for SCE to comply with its own policy, and would have provided a safer work environment that could have prevented or reduced the extent of Mr. [redacted]’s injury. SCE is in violation of GO 95, Rule 31.1, for failing complete The Contractor Orientation Review and thereby failing to ensure that construction and maintenance of its facilities were performed safely and in accordance with the accepted good practices of SCE’s Contractor Safety Management Standard.

Cal/OSHA also investigated this incident and cited HWI for three violations of their Title 8 Regulations. These included:

1. One violation of §2940.1, Voltage Determination and Energized Equipment or Systems, part (a), for failing to ensure that the electrical conductor involved in this incident was treated as energized until proven to be de-energized.

2. One violation of §2941, Work on or in Proximity to Overhead High Voltage Lines, part (i)(1)(D), for failing to properly ground the conductor or electrically insulate its workers.

3. One violation of §5006.1, Mobile Crane and Tower Crane-Operator Qualifications and Certification, part (a), for allowing Mr. [redacted] to operate the elevated work platform without a valid certificate of competency.

Preliminary Statement of Pertinent General Order, Public Utilities Code

Requirements, and/or Federal Requirements:

	General Order	*GO Rule*	*Violation*
1	GO 95	Rule 31.1	Yes

Conclusion:

My investigation revealed that SCE is in violation of GO 95, Rule 31.1, for failing to satisfy the requirements of its Contractor Safety Management Standard and its Handbook for Contractors, both accepted good practices. SCE violated Rule 31.1 a total of three times:

1. SCE's Contractor Safety Management standard forbids Tier 1 contractors from beginning work on a project without first submitting The Project/Site-Specific EHS Plan to SCE for its review. SCE allowed work to begin on the project without receiving this document from HWI. If HWI had completed the Project/Site-Specific EHS Plan, SCE's review of the plan and discussion of it with HWI's representative could have revealed that the hazards associated with the work had not been properly mitigated.

2. SCE's Contractor Safety Management standard forbids Tier 1 contractors from beginning work on a project without first submitting The Handbook for Contractors Checklist to SCE. SCE allowed work to begin on the project without receiving this document from HWI. Completion of the Handbook for Contractors Checklist would have revealed that HWI's grounding techniques were not in compliance with SCE's. Work on the project could have been postponed until this discrepancy between standards could be rectified.

3. SCE's Contractor Safety Management standard forbids Tier 1 contractors from beginning work on a project without first completing and filing The Contractor Orientation Review. SCE allowed work to begin on the project without receiving this document from HWI. Completion of The Contractor Orientation Review by SCE's representative would have revealed that the two documents above had also not been received, and could have caused work on the project to be postponed until they were completed. Completion of The Project/Site-Specific EHS Plan and The Handbook for Contractors Checklist, as explained above, could have revealed issues with HWI's worker safety practices and would have revealed that HWI's grounding technique did not meet or exceed SCE's standards.

Appendix

An Explanation of Induced Current and SCE's Method of Grounding when a

Hazard is Present

Induced current is the phenomenon by which a conductor which is not directly connected to a voltage source can become energized by other nearby energized conductors. This is the same principal by which transformers operate.

Electricity is the flow of electrons or other charged particles inside of a conductor. When a charged particle is in motion, a magnetic field is produced that radiates in all directions. The magnitude of this magnetic field is proportional to the total flow of charged particles, also known as electrical current. This field permeates all space, but it becomes weaker the farther from the conductor it is measured.

Just as an electric current creates a magnetic field, a changing magnetic field can also create an electric current. In alternating current (AC) systems in the United States, the flow of current reverses 60 times per second, and the magnetic field the current produces also grows and shrinks at the same rate. Unlike in direct current (DC) systems, the magnetic field created by an AC conductor is always changing.

When an energized AC conductor is close enough to a de-energized conductor, the changing magnetic field it produces will *induce* a voltage and current into that otherwise de-energized conductor. If the second conductor is not grounded, the result will be a current that passes from one side of the conductor to the other and back again with each cycle. If the conductor is grounded on only one end, the result will be similar; current will pass from the ungrounded end of the conductor to the other, and into the earth. The reverse happens when the cycle completes and the current changes direction. If the conductor is grounded on both ends, current will flow from the earth at one end, through the conductor, and back into the earth on the other end, changing direction each cycle. This property of induced current necessitates different grounding schemes than grid-energized conductors. See Figure 6.

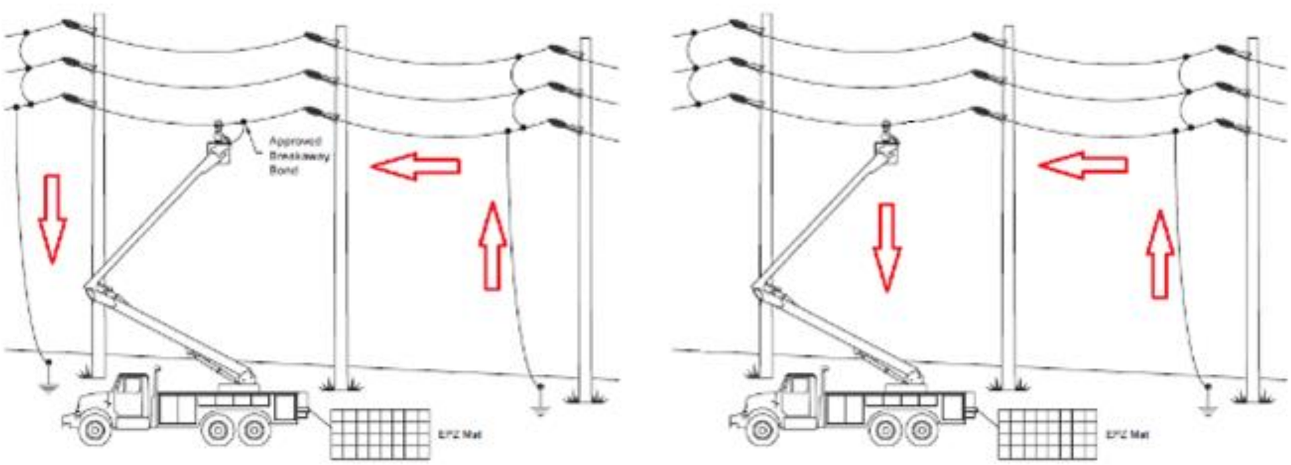

Figure 6: The figure above shows the path the induced current will take in two different grounding situations. On the left is diagram of a properly grounded worksite, and on the right is an improperly grounded one similar to how the worksite at Kramer Junction was grounded. The red arrows indicate the path the current takes.

In the properly grounded figure on the left, the current flows from the earth, up to the conductors, across and past the worker, and back down into the earth on the other side. If the worker were to touch the conductor in this situation, only a miniscule amount of current would pass through him. This is because the worker has a far higher electrical resistance than either set of grounds.

In the improperly grounded figure on the right, only one set of grounds is present. In this situation, the current flows from the earth, up to the conductors, across, through the worker, and into the ground by way of the bucket truck. The worker has a high electrical resistance, but the current still passes through him because there is no other path for it to take.