

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

Supplemental Incident Investigation Report

Report Date: 9/29/2018

Incident Number: E20150801-01

Utility: SCE

Date and Time of the Incident: 8/1/2015, 9:36:00 AM

Location of the Incident: Near Desert Knoll Avenue & Valle Vista Rd.
Twentynine Palms, CA
County: San Bernardino

Summary of Incident:

This report supplements SED's electric incident investigation report for incident number E20150801-01. The scope of this supplemental report is to describe additional violations related to a missing nut that would have secured in place the insulator that supported the 12 kV conductor, which was hanging less than eight (8) feet above the ground and resulted in injuries to three individuals.

Fatality / Injury: There were 3 injuries reported.

Property Damage: None Reported

Utility Facilities involved: North Adobe, 12 kV Circuit

Witnesses:

	<i>Name</i>	<i>Title</i>	<i>Phone</i>
1	Koko Tomassian	SED Senior Utilities Engr	(213) 576-7099
2	Derek Fong	SED Senior Utilities Engr.	(213) 576-6850

Evidence:

<i>Source</i>	<i>Description</i>
1 SCE	SCE Data Request Response K.18-03-008 SED-SCE-001

2 SCE

SCE Data Request Response K.18-03-008
SED-SCE-002

3 SED

Crossarm and insulator analysis

Observations and Findings:

On August 1, 2015, three individuals were injured when they contacted an SCE 12 kV conductor. SED investigated the incident and issued an investigation report dated April 15, 2016, detailing SED's investigation findings. SED found SCE to be in violation of several General Order (GO) 95 rules and issued Citation E.18-02-001 ("Citation") on February 12, 2018. On March 14, 2018, SCE filed to appeal the Citation, initiating proceeding K.18-03-008. During the course of K.18-03-008, SED discovered additional violations that warrant the issuance of this supplemental investigation report. SED discovered SCE Notification No. 403983607, which substantially impacts the nature and circumstances of SED's investigation of this incident, the Citation, and the associated penalty amount.

On October 13, 2011, SCE generated Notification No. 403983607 following a detailed inspection of Pole number 43502S. A "Notification," also known as a work order, is a record that is generated whenever work needs to be performed; a Notification typically includes the date of issuance, a description of the work, the priority level of the work, and the required completion date. SCE records indicate that Notification No. 403983607 is for the repair of a damaged primary insulator on Pole number 43502S, which is the pole that supported the subject crossarm that broke in this incident. The notification's "Additional Description" field, provided in a screenshot of SCE's work management system, indicates the finding as a "missing nut on primary insulator pin."¹ SCE labeled this condition, which is a violation of GO 95, Rule 31.1, as a Priority Level 3 for correction and did not assign a corrective action date.² At the time of the incident, this notification was still pending, meaning that SCE had not corrected the problem.

A primary function of an insulator is to provide mechanical support for an overhead conductor. Insulators come in various forms depending on their intended use and design configuration: (1) pin insulators, (2) strain insulators, and (3) suspension insulators. The subject insulator in this incident was a "pin" type porcelain insulator. Pin insulators are commonly used on distribution circuits. A pin insulator consists of an insulator, typically made of glass or porcelain, that is mechanically supported by a pin, commonly a wooden or metal dowel with screw threads. The insulator is installed through a pinhole on a utility crossarm. Pinholes are typically pre-drilled at specific horizontal distances across a crossarm. To ensure that the pin is securely affixed within the pinhole, a nut is installed and tightened onto the threaded end of the pin opposite the insulator. Pin insulators commonly have a groove on the top of the insulator where a conductor can be seated. The conductor is then secured in the groove via a tie wire that is wrapped around the conductor and through the insulator. Because the insulator and the conductor rely on the insulator pin for mechanical support, the structural integrity of the pin is essential to the pin insulator functioning for its intended use.

¹ See screenshot of notification details for Notification No. 403983607 included in Appendix A.

² In October 2011, when the detailed inspection occurred, a Priority Level 3 was defined as an "acceptable safety and/or reliability risk" and did not require a specified timeframe for corrective action per GO 95, Rule 18.

The fact that the nut was missing, as identified in Notification No. 403983607, prevented the pin from providing sufficient mechanical support to the insulator as intended. The nut installed on the insulator pin is supposed to tightly secure the insulator pin – and the associated insulator and conductor – to the crossarm. When the nut is missing, neither the pin nor the insulator is securely affixed to the crossarm and the pin cannot provide mechanical support to the insulator and conductor as intended. Additionally, the lack of a nut enables the unsecured insulator pin to move around in the pinhole of the crossarm, creating additional stresses on the crossarm. These additional stresses are not accounted for in the crossarm’s design, as the condition of an unsecured insulator and pin does not comport with proper construction and installation. Included in Appendix A to this report is a brief explanation of the stresses imposed by an unsecured pin insulator (i.e. missing the nut securing the pin to the crossarm) moving around in a crossarm pinhole. Appendix B of this report includes photos of the damage that can result when the neutral plane of the crossarm is subjected to tensile forces.

SED concludes that SCE’s mis-prioritization of the need to repair the missing nut and the resulting lack of corrective action led to the incident that caused harm to the public. Having an unsecured pin insulator moving around in a crossarm pinhole presents an extremely hazardous and dangerous condition. An unsecured insulator pin can allow the insulator assembly to fall off the crossarm. Additionally, movement of the insulator pin within the pinhole, unrestricted by the securing nut, subjects the crossarm to damaging tensile stresses that can result in a crossarm failure. In this case, the crossarm failed and broke, causing the insulator to detach from the crossarm and become suspended at a height well below the minimum above ground vertical clearance that is required by GO 95.

SCE categorized the hazardous and dangerous condition of the missing nut as Priority Level 3, meaning that the condition was deemed “an acceptable safety and/or reliability risk”. At the time SCE labeled the missing nut as Priority Level 3, GO 95, Rule 18-A defined Priority Level 3 as an “acceptable safety and/or reliability risk,” and did not specify a maximum corrective action timeframe. GO 95, Rule 18-A defined Priority Level 1 as an “immediate safety and/or reliability risk with high probability for significant impact,” and required immediate corrective action, while Priority Level 2 was defined as a “variable (non-immediate high to low) safety and/or reliability risk” and required corrective action between 0-59 months, with the time period for correction to be determined at the time of identification. The fact that SCE did not assign a corrective action date for the missing nut indicates that SCE planned to correct the condition as “opportunity maintenance” when other work that SCE considers to be higher priority is performed on the pole.

At the time of the detailed inspection in 2011 that found the nut to be missing,³ GO 95 Rule 18-A, Resolution of Safety Hazards And General Order 95 Violations stated in part:

Each company (including utilities and CIPs) is responsible for taking appropriate corrective action to remedy safety hazards and GO 95 violations posed by their facility... For purposes of this rule, “safety hazard” means a condition that poses a significant threat to life or property... All companies shall establish an auditable

³ The Commission has modified GO 95 Rule 18-A several times subsequently. However, in this instance, the provisions in effect at the time of the inspection finding the nut to be missing would be applicable.

maintenance program for their facilities and lines. Further, all companies must include a timeline for corrective actions to be taken following the identification of a safety hazard or violation of General Orders 95 or 128 on the companies' facilities. The auditable maintenance program should be developed and implemented based on the following principles.

(1) *Priorities shall be assigned based on the specifics of the safety hazard or violation as related to direct impact and the probability for impact on safety or reliability using the following factors:*

- * Type of facility or equipment;*
- * Location;*
- * Accessibility;*
- * Climate;*
- * Direct or potential impact on operations, customers, electrical company workers, communications workers, and the general public;*
- * Whether the safety hazard or violation is located in an Extreme or Very High Fire Threat zone.*

(2) *There will be three priority levels, as follows:*

a) *Level 1:*

- Immediate safety and/or reliability risk with high probability for significant impact.*
- Take action immediately, either by fully repairing the condition, or by temporarily repairing and reclassifying the condition to a lower priority.*

b) *Level 2:*

- Variable (non-immediate high to low) safety and/or reliability risk.*
- Take action to correct within specified time period (fully repair, or by temporarily repairing and reclassifying the condition to a lower priority).*
- Time period for correction to be determined at the point of identification by a qualified company representative:*
- Overhead: 0-59 months*
- Where communications company actions result in electric utility GO violations, the electric utility's remedial action will be to transmit a single documented notice of identified violations to the communications company for compliance.*

c) *Level 3:*

- Acceptable safety and/or reliability risk.*

- *Take action (re-inspect, re-evaluate, or repair) at or before the next detailed inspection.*
- d) *Exceptions (Levels 2 and 3 only) – Correction times may be extended under reasonable circumstances, such as:*
- *Third party refusal*
 - *Customer issue*
 - *No access*
 - *Permits required*
 - *System emergencies (e.g. fires, severe weather conditions)*

A missing insulator nut is an immediate safety and/or reliability risk that leaves open a hazardous and dangerous condition, as it allows movement of the insulator pin, unrestricted by the absence of a securing nut. This movement could allow the insulator to fall off the crossarm, for example, in windy conditions not abnormal to the area.⁴ Also, movement of the insulator pin within the pinhole, unrestricted by the securing nut, subjects the neutral plane of the crossarm to damaging tensile stress that can result in a crossarm failure. Because of these effects, it is incorrect to categorize the missing nut as an “acceptable safety and/or reliability risk.” Either type of failure could cause the energized 12 kV conductor to be easily accessible to the public, as happened in this incident.

SED concludes that the hazardous and dangerous condition created by the missing nut was an “immediate safety and/or reliability risk with high probability for significant impact” and that accordingly it should have been classified as a Priority Level 1 violation that requires immediate corrective action. SCE mis-prioritized this safety hazard as an “acceptable safety and/or reliability risk.” Therefore, SCE is in violation of GO 95, Rule 18-A for failing to correctly prioritize and immediately correct the violation of the missing nut.

GO 95, Rule 31.1, Design, Construction, and Maintenance, states in part:

Electrical supply and communication systems shall be designed, constructed, and maintained for their intended use, regard being given to the conditions under which they are to be operated, to enable the furnishing of safe, proper, and adequate service.

As explained above, insulator pins are intended to provide mechanical support to the insulator, and by extension the attached conductor. As such, insulator pins should be designed, installed, and maintained properly to provide sufficient mechanical support. SCE’s failure to properly maintain the subject pin insulator and make sure that it is secured to the crossarm contributed to the failure of the crossarm on SCE Pole No. 43502S. This resulted in a 12 kV overhead conductor supported on the crossarm to fall down and become suspended to less than 8 feet

⁴ A missing nut can cause the insulator to fall off the crossarm. For example, winds can cause uplift or vertical vibrations on the conductor that can pull the insulator out of the pinhole. Additionally, if the crossarm is split, then wind loading on the conductor can cause the insulator to be pulled off the crossarm (or slide off the crossarm).

above the ground, an unsafe condition. Therefore, SCE is in violation of GO 95, Rule 31.1, for failing to properly maintain and secure the pin insulator on the subject crossarm.

California Public Utilities Code (Pub. Util. Code) Section (§) 451, states in part:

Every public utility shall furnish and maintain such adequate, efficient, just, and reasonable service, instrumentalities, equipment, and facilities, including telephone facilities, as defined in Section 54.1 of the Civil Code, as are necessary to promote the safety, health, comfort, and convenience of its patrons, employees, and the public.

On October 13, 2011, SCE personnel identified that the nut securing the insulator (that supported the 12 kV conductor with insufficient above ground clearance) to the crossarm was missing. SCE failed to recognize the severity and hazard of this violation. Consequently, SCE labeled this hazardous and dangerous condition as “Priority Level 3” and allowed the unsafe condition to remain uncorrected for several years. As such, SCE is in violation of Pub. Util. Code § 451 for failing to take appropriate action to maintain or repair the subject pin insulator as necessary to prevent injury to the public.

Preliminary Statement of Pertinent General Order, Public Utilities Code Requirements, and/or Federal Requirements:

<i>General Order or Statute</i>	<i>GO Rule or Section</i>
1 GO 95	18-A
2 GO 95	31.1
3 Pub. Util. Code	§ 451

Conclusion:

SED’s investigation described in this Supplemental Incident Investigation Report found that SCE is in violation of the following rules and statute:

1. GO 95, Rule 18-A, for failing to prioritize accurately and immediately correct the hazardous and dangerous condition identified by Notification No. 403983607, from October 13, 2011 to August 2, 2015.
2. GO 95, Rule 31.1, for failing to ensure that the pin insulator was properly secured to enable the furnishing of safe service, from October 13, 2011 to August 2, 2015.
3. Pub. Util. Code § 451, for failing to take appropriate action to maintain or repair the subject pin insulator as necessary to promote public safety, from October 13, 2011 to August 2, 2015.

After considering SCE’s failure to properly maintain and secure the pin insulator to the crossarm, SCE’s mis-prioritization of the missing nut as a Priority Level 3, SCE’s failure to correct immediately the hazardous and dangerous situation, the impact these actions had on the failure of the subject crossarm, and the ensuing harm to the public caused by this incident, SED

concludes that these violations, combined with the violations described in the original E20150801-01 investigation report, warrant the issuance of a citation to SCE for the maximum allowable penalty amount of \$8,000,000.

Appendix A

Increased Crossarm Internal Tensile Stress and Damage Due to a Missing Insulator Nut

Overview: On August 1, 2015, SED Staff visited the incident site and photographed the crossarm on SCE Pole number 43502S. Both ends of the crossarm – the “North End” which points north and the “South End” which points south – were sheared. Two pieces of wood had broken off from the South End and fallen to the ground. Eight photos of the crossarm taken on August 1, 2015 are shown in Figures A-1 to A-8.



Figure A-1: The crossarm on SCE pole number 43502S. Source: SED

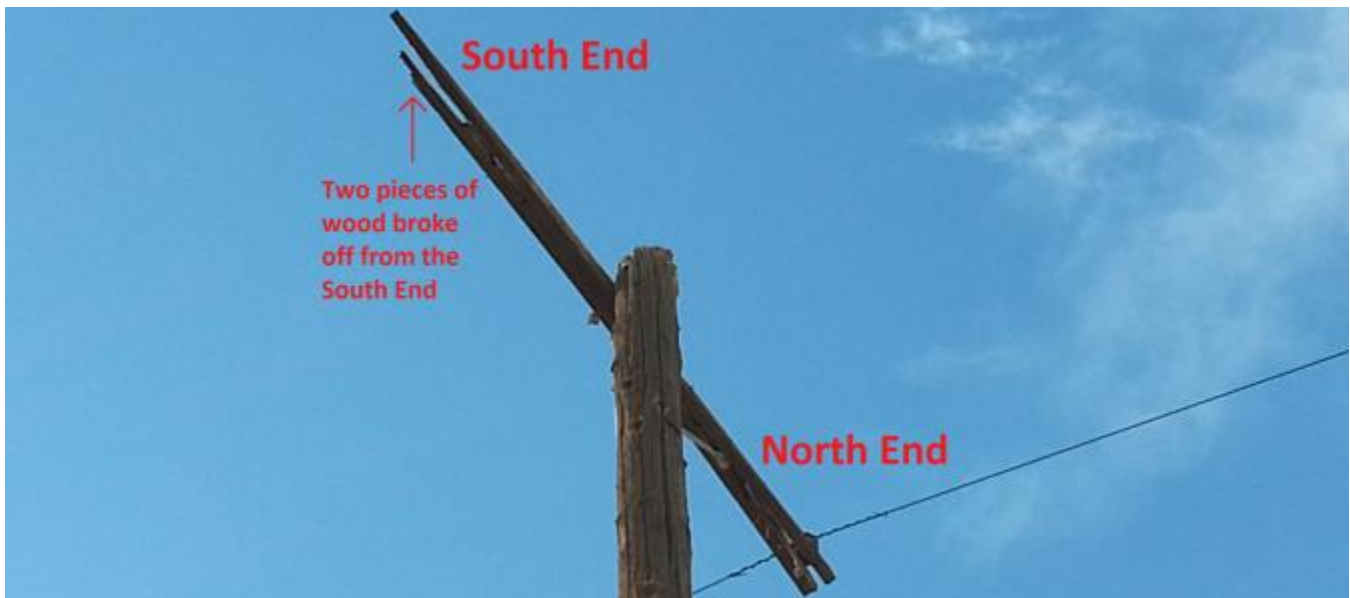


Figure A-2: The crossarm on SCE pole number 43502S. Source: SED



Figure A-3: "South End – Broken Piece 1" (photo 1/4) is the larger of the two pieces that broke off from the South End.



Figure A-4: "South End – Broken Piece 1" (photo 2/4) showing where the insulator would have been installed. Source: SED



Figure A-5: "South End – Broken Piece 1" (photo 3/4). The "Anti-split" throughbolt did not support insulators. Source: SED



Figure A-6: "South End – Broken Piece 1" (photo 4/4) showing where the insulator & pin would have been installed. Source: SED.



Figure A-7: "South End – Broken Piece 2" is the smaller of the two pieces that broke off from the South End. Source: SED



Figure A-8: The photo shows the insulator nut on the "North End" insulator. Source: SED.

Damage Assessment: SED's investigation and photos revealed the following:

- Figures A-1 and A-2 above show that the crossarm was sheared along a Vertical Shearing Plane. Shearing is a failure mechanism that results in cracks and splits. The Vertical Shearing Plane is defined as a plane between and parallel to the front and back faces of the crossarm. The Vertical Shearing Plane is the red plane depicted in Figures A-9 and A-10 below.
- Figure A-2 shows that pieces of the South End broke and fell to the ground.
- Figures A-3 through A-7 show that the Vertical Shearing Plane on the South End was incomplete due to the presence of an "Anti-split" throughbolt. The throughbolt caused a portion of the Vertical Shearing Plane to fold over into a Horizontal Shearing Plane. The Horizontal Shearing Plane is defined as a plane between and parallel to the top and bottom faces of the crossarm. The Horizontal Shearing Plane is the blue plane depicted in Figures A-9 and A-10. The reason the throughbolt created a Horizontal Shearing Plane is that shearing planes are typically parallel to bolt or screw holes, as holes (particularly those subject to tensile stress) create areas of stress concentration.
- Figure A-8 shows that the North End insulator, which did not fall off the crossarm during the incident, had an intact insulator nut.

Crossarm with Shearing Planes

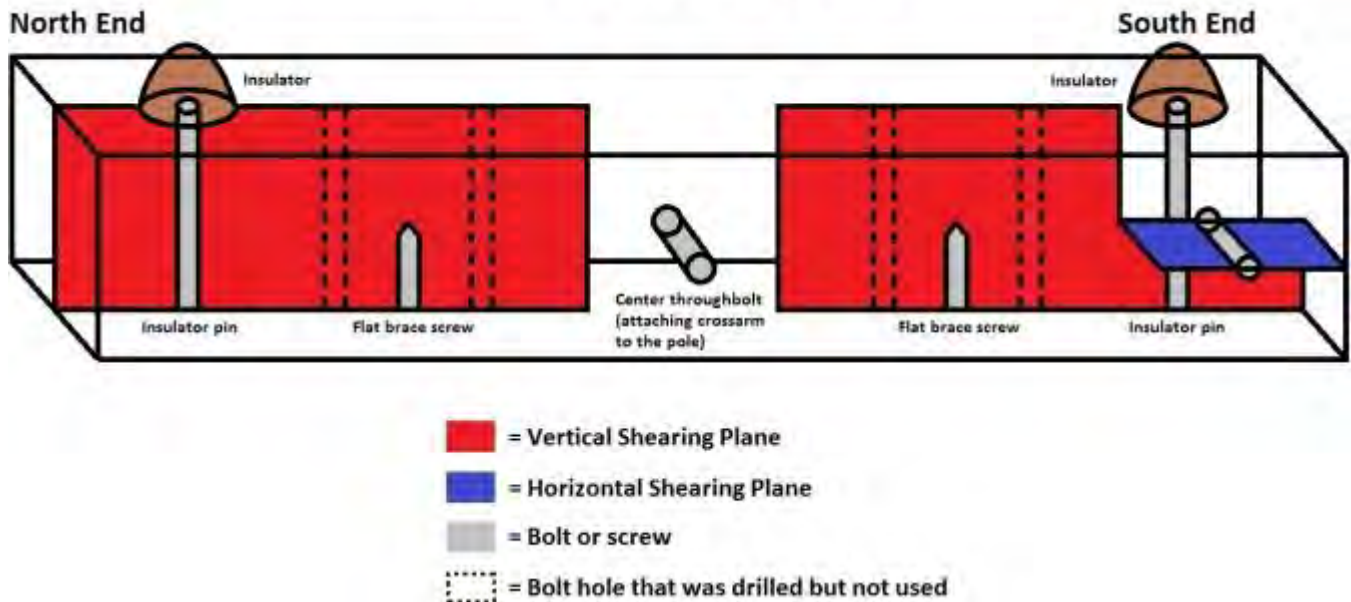


Figure A-9: A depiction of the crossarm showing the Vertical Shearing Plane and the Horizontal Shearing Plane. The figure also shows the vertically-oriented bolts/screws and the horizontally-oriented bolt that contributed to the shearing pattern. Note: Not shown are three pre-drilled horizontally-oriented bolt holes that did not contribute to either shearing plane. Source: SED



Figure A-10: "South End – Broken Piece 1" showing part of the Vertical Shearing Plane and part of the Horizontal Shearing Plane. It is clear from this figure that the "Anti-split" throughbolt caused the Horizontal Shearing Plane. Source: SED

Damage Causes: On July 27, 2018, during preparations related to K.18-03-008, SED found SCE Notification No. 403983607, which indicated that an insulator supported on pole number 43502S had a nut missing from its pin (see Figure A-11). Subsequently, SED Staff reviewed its earlier photographs, taken on August 1, 2015, of the insulator that fell to the ground, which demonstrated that the insulator pin was missing the nut (see Figure A-12).

Notification	403983607	E1 REPAIR DAMAGE PRI INSLTR POLE
Notific. Status	OSNO OST5	REAP
<div style="display: flex; justify-content: space-between;"> General Data Address Location Scheduling overview Maintenance plan Tasks </div>		
Reference object		
Functional loc.	OM-43502S	POLE-DISTRIBUTION 43502S LOCATION
Equipment	201052164	POLE-DISTRIBUTION 43502S
Subject		
Coding	EZ-ELEV 0010	Distribution Primary
Description	REPAIR DAMAGE PRI INSLTR POLE	
<div style="border: 1px solid black; padding: 5px;"> <p>10/13/2011 14:41:45 FTPIWUSER (FTPIWUSER)</p> <p>Switching Concept: Reconnecting Poles</p> <p>Additional Description: 43502S MISSING NUT ON PRIMARY INSULATOR PIN.</p> <p>Crew Size: 1</p> <p>Estimated Man hours: 1.00</p> <p>Work Request Type: D</p> </div>		
Start/End Dates		
Required Start	10/13/2011 12:52:11	Priority Priority 3
Required End	00:00:00	<input type="checkbox"/> Breakdown
Responsibilities		
Planner group	284 / 1200	Yucca Valley S/C
Main WorkCtr	21884 / 1200	Yucca Valley Default W C
Person respons.		
Reported by	REDACTED	Notif. date 10/13/2011 12:52:11
Rem		
Object part	ED-POLE 003E	Insulator

Figure A-11: SCE Notification No. 403983607 screenshot from SCE's work management system, supplementing the notification "Description" column from SCE's notification records, to repair a damaged primary insulator on pole number 43502S, with the "Additional Description" indicating the issue was a missing nut on the primary insulator pin.



Figure A-12: Two views of the insulator that had been supported on the South End of the failed crossarm of pole number 43502S showing no nut attached to threaded portion of the insulator pin. Source: SED (left) and SCE (right)

Based on the facts and evidence available, SED concludes that the shearing damage in the crossarm was caused, in part, by cyclic loading (see Figures A-13 and A-14) of both the North End insulator pin, which did not fall off the crossarm in the incident, and the South End insulator pin, which *did* fall off the crossarm in the incident. The cyclic loading resulted in tensile stress and shearing of the crossarm along both the Vertical Shearing Plane and the Horizontal Shearing Plane. Additionally, SED concludes that the bending damage at the South End of the crossarm (resulting in South End – Broken Piece 1 and South End – Broken Piece 2 breaking off and falling to the ground) was due to the crossarm becoming weakened as a result of shearing along the Vertical Shearing Plane, making the crossarm susceptible to bending failure due to wind loading. It is likely that visible shearing of the South End along the Vertical Shearing Plane prompted utility personnel at some time prior to the incident to install the “Anti-split” throughbolt (see Figures A-3 through A-6). This conclusion is based on the fact that the South End of the crossarm exhibited a partial Vertical Shearing Plane despite having the “Anti-split” throughbolt, indicating that it was already sheared prior to the “Anti-split” throughbolt’s installation. Additionally, the Vertical Shearing Plane passes along the bottom of the “Anti-split” throughbolt, meaning that the shearing would have been visible to utility personnel standing on the ground. Finally, the installation of “Anti-split” throughbolts at the time of construction is not a known utility practice.

Prior to the incident, the front and back halves of the crossarm had a severe crack and perhaps even a complete split between them (Figure A-15). Because of this, the crossarm can be considered as two separate crossarms: a front crossarm and a back crossarm. One would imagine that a crossarm that is split between its front and back faces would separate completely. However, this crack or split did not occur over the entire length of the crossarm for two reasons: (1) the crossarm was supported on the pole via a throughbolt located at the center of the crossarm (“Center Throughbolt” as shown in Figure A-9), which prevented shearing in the vicinity of the center of the crossarm; and (2) the crossarm also had an “Anti-split” throughbolt installed at the South End of the crossarm which partially held together the front and back halves of the crossarm. See Figures A-9 and A-10 above.

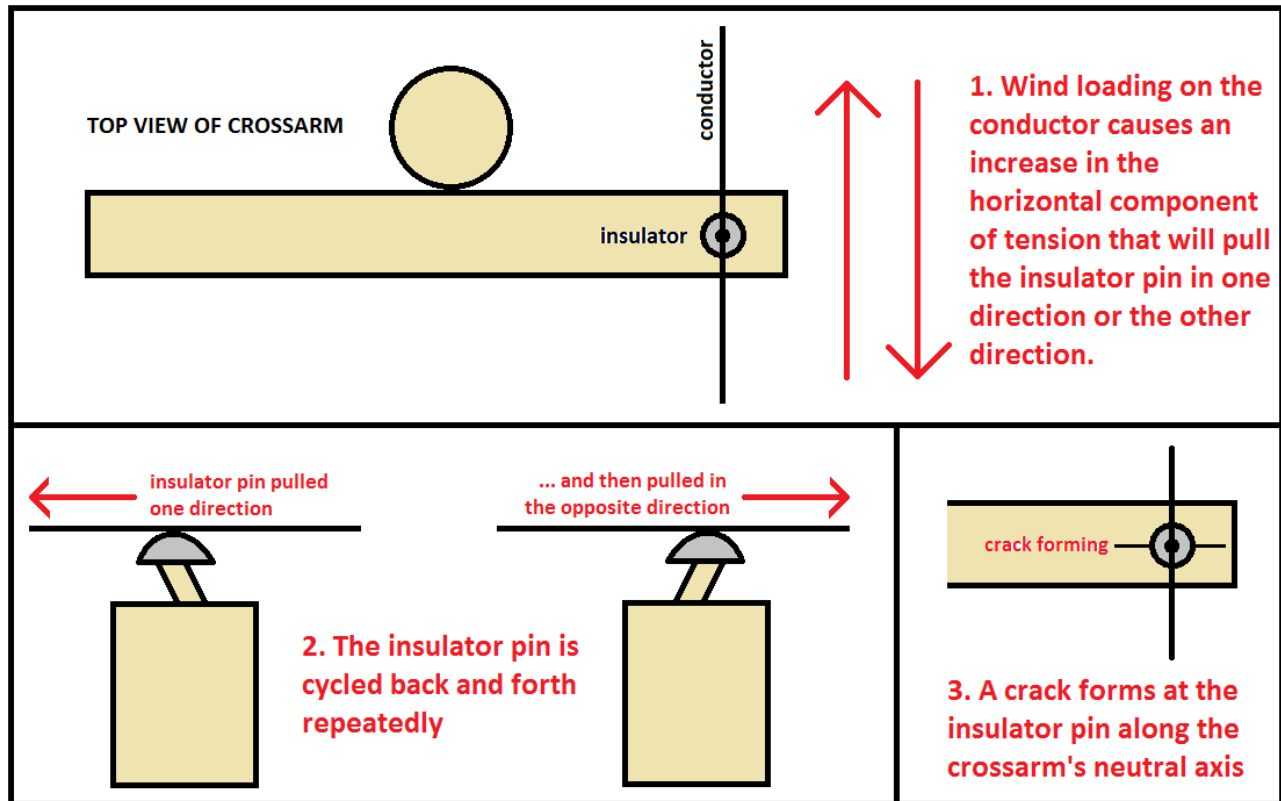


Figure A-13: Tensile stress along the neutral plane of the crossarm due to an insulator pin cycling back and forth imposing cyclic loading conditions unaccounted for in the original design.



Figure A-14: A log splitting technique that utilizes the tensile stresses produced from moving a wedge back and forth (i.e. cyclic loading) to split a log along a shear plane without needing other tools or equipment.

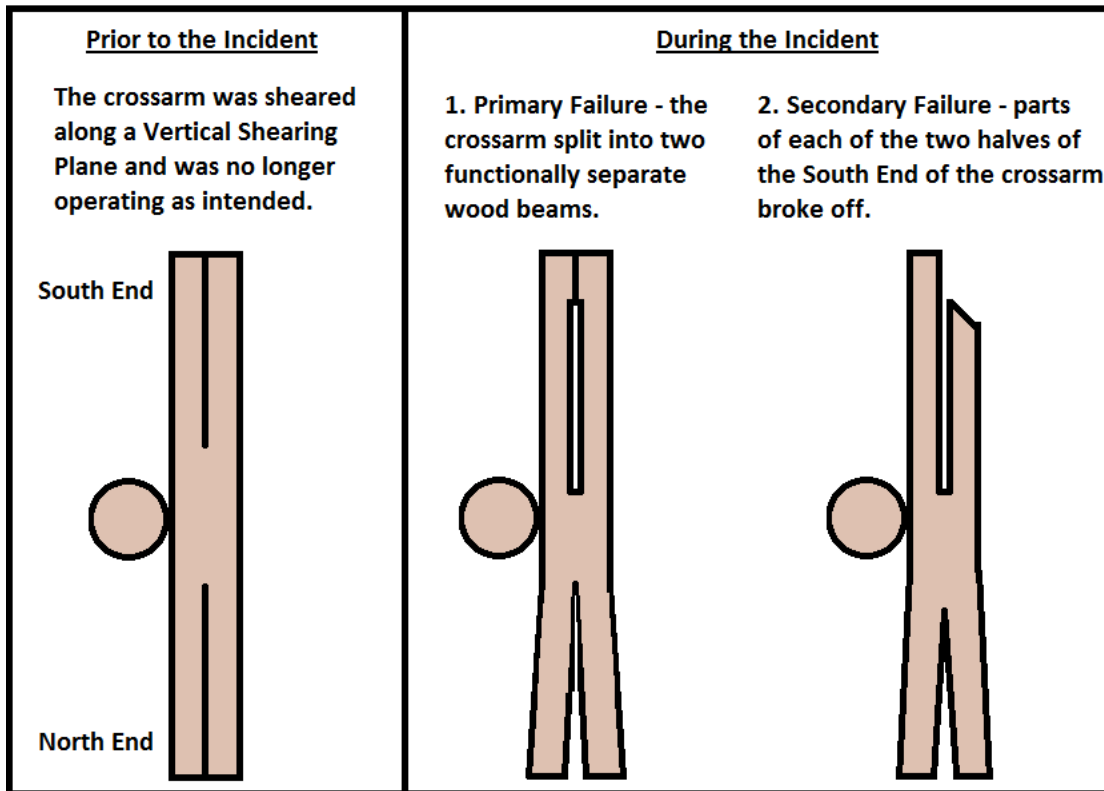


Figure A-15: The condition of the crossarm prior to the incident and during the incident.

Based on the facts and evidence available, SED concludes that the following events occurred during the incident:

- 1) During the wind event that began on July 29, 2015, wind loading caused a bending moment on the South End of the split crossarm.
- 2) The front and back parts of the South End of the crossarm – being much weaker than the original, single crossarm – both broke at the South End, and the two broken pieces fell toward the ground (see Figure A-15).
- 3) Because the nut was missing, the insulator pin pulled out of the crossarm pinhole. The resultant effect was the insulator pin, insulator, and conductor all became suspended less than 8 feet above the ground, creating an extremely hazardous and dangerous condition.
- 4) The first victim struck the conductor (which had insufficient clearance), and the impact caused the conductor to break and fall onto the ground.

Appendix B

Examples of Crossarm Damage Caused by Tensile Forces

Below are several photographs from other SED investigations that depict other crossarms that have failed along their neutral axis. The failed crossarms all typically crack, split, and fail along a neutral plane (either vertical or horizontal) and often through the centerline of pinholes.

1. Specimen 1



Figure B-1: The front face of Specimen 1.



Figure B-2: The front face of Specimen 1 – right side close-up.



Figure B-3: The top face of Specimen 1 – left side close-up.

2. Specimen 2



Figure B-4: The top face of Specimen 2.



Figure B-5: The top face of Specimen 2 – left side close-up



Figure B-6: The top face of Specimen 2 – right side close-up

3. Specimen 3



Figure B-7: The front face (supporting the HIGH VOLTAGE sign) of Specimen 3.



Figure B-8: The front face of Specimen 3 – right side close-up.

4. Specimen 4



Figure B-9: The front face of Specimen 4 – left side close-up.

5. Specimen 5



Figure B-10: The top face (the face supporting the three insulators) of Specimen 5.



Figure B-11: The top face of Specimen 5 – right side close-up.

6. Specimen 6



Figure B-12: The top face of Specimen 6 – right side close-up.