Event Analysis Report

Bakersfield - Media

EIR No.: EI181120A

Date of Event: November 20, 2018

Date Reported to the CPUC: November 21, 2018

CAP Issue No(s).: 115409386

Report Rev: 01

[redacted]	[redacted]	5/16/22
Leadership Approver	Signature	Date
[redacted]	[redacted]	5/16/22
Incident Investigator	Signature	Date

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1. EXECUTIVE SUMMARY

On November 20, 2018, at 1700 hours, PG&E's Distribution Control Center received SCADA notification and SmartMeter signals indicating an outage on the Bakersfield 1115 12kV Underground Circuit and affecting 860 customers. A PG&E restoration supervisor arrived at the northeast corner of 20th and Eye Street ("Incident Location") at 1745 hours and observed Bakersfield Fire Department and three news agencies on site. The PG&E restoration supervisor immediately checked in with the fire captain, who stated there was the sound of an explosion and a fire near PG&E Vault 39. The lid to Vault 39 was laying on the ground adjacent to the vault. The fire was extinguished prior to the PG&E restoration supervisor's arrival, so he proceeded to make the scene safe by placing cones around the perimeter of Vault 39 while waiting for the PG&E troubleman. When the troubleman arrived, he observed oil in Vault 39 on Switch 5059/5061/5062, on the surrounding transformers in the vault, and on the sidewalk. He also observed a damaged vehicle parked near the vault. Switch 5059/5061/5062 was retained as evidence.

The incident was reported in a timely manner to the CPUC on November 21, 2018, at 1300 hours under the Media criterion, initiating an investigation by the Electric Incident Investigations ("EII") team. This report reviews the findings of that investigation.

PG&E performed an event analysis which included field observations, system protection analysis, failure analysis, and patrol and inspection record review. The failed switch was evaluated by PG&E's Applied Technology Sciences ("ATS") team. The findings of the evaluation showed damaged internal Vacuum Interrupters ("VI"). The specific cause of the failure was not identified due to the damage from the initial failure and subsequent fire.[1]

A causal factor tree analysis was performed, and no corrective actions were identified as a result of the investigation. No potential non-compliances or non-conformances were identified as a result of this investigation.

[1] Attachment 01_ATS_Bakersfield Underground Switch Inspection Report.pdf, page 7

This report concludes PG&E's investigation into this incident. Unless otherwise noted herein, where there are conflicts between this report and previous PG&E reports related to this incident, this report shall take precedence. If additional information becomes available with the potential to affect the conclusions of this investigation, PG&E reserves the right to re-open this investigation. All times, customer counts, and measurements in this report are approximate.

2. PROBLEM STATEMENT

On November 20, 2018, at 1700 hours, PG&E's Distribution Control Center received a SCADA notification and SmartMeter signals indicating an outage on the Bakersfield 1115 12kV Circuit. Upon arrival at the Incident Location, a PG&E restoration supervisor observed the Bakersfield Fire Department and three news agencies on-site. The PG&E employee also observed the lid to Vault 39 was detached and laying on the ground, oil in the vault, on the surrounding transformers in the vault, oil on the sidewalk, and remnants of an extinguished fire.

This event was reported to the CPUC under the Media criterion, triggering the investigation by the EII group. This report summarizes the findings of the investigation.

3. EXTENT OF CONDITION

As part of this investigation, PG&E conducted a search of ILIS records for outages involving failed underground switches. From 2018 to 2022 there were 10,336 outages due to failed underground equipment or involving underground equipment, 246 outages (2%) specifically related to failed underground switches.[2]

A search of the EIR database from 2018-2022 shows a total of 349 EIRs, with three EIRs referencing failed or damaged underground switches, representing less than 1% of all EIRs in this timeframe.

A search of the CAP database shows two instances, including this incident, of subsurface 600A switch failures from 2018 to present.

[2] ILIS Data Query

The incident switch was manufactured by Trayer in 2000 and is a 600A vacuum in oil sectionalizing switch that was installed in 2001. As of August 2020, PG&E had roughly 10,000 of these switches throughout the service territory with 25-30 cumulative failures, representing a small failure rate (~0.3%). The average age of the 600A switches in the system is 19 years. [3]

PG&E began installing the 600A subsurface switches in 1964 as Northern California experienced high population growth. The oil temperature in these switches is being actively monitored due to the high number of operations they typically experience over their lifetime. The number of failures per year for 600A switches is relatively low, less than .3%, but there have been instances where these switches have failed catastrophically, representing a safety risk to the public and employees. These failures are the primary driver behind the strategy to install Temperature Alarm Devices on load break oil rotary ("LBOR") switches, 600A switches, and subsurface transformers. PG&E has established a replacement plan for the 200A LBOR switches and intends to expand the replacement plan to include 600A subsurface switches in the future. There is currently a transition from oil-filled switches to solid dielectric switches.[4] PG&E is currently installing temperature sensors on subsurface equipment installed prior to 1978 and has so far completed 8,000 installations.[5]

4. EVENT SUMMARY

Please refer to the 20-Day Report submitted to the CPUC on December 20, 2018.

4.1. Event Timeline

November 20, 2018

- 1700 hours – PG&E's Distribution Control Center received notification of an outage on the Bakersfield 1115 12kV Circuit
- 1745 hours – PG&E restoration supervisor arrived at Incident Location

[3] Event Analysis Report EI200724B, Submitted to the CPUC February 2021
[4] Asset Management Plan, TD-8106, page 29
[5] Internal interview, Asset Strategy, 4/12/22

- 1830 hours – Bakersfield Fire Department released the Incident Location
- 1915 hours – Switching performed and 750 customers restored
- 2140 hours – Additional 90 customers restored

November 22, 2018

- 0750 hours – Replace of switch completed, remaining 20 customers restored

5. HISTORY

5.1. GO 165 Patrols and Inspections

The GO 165 patrols and inspections are visually performed inspections. An infrared gun is also used to determine temperature differentials at all connections.

5.1.1 GO 165 Patrols

- August 18, 2018 – no abnormal conditions identified
- May 5, 2016 – no abnormal conditions identified
- April 16, 2013 – no abnormal conditions identified

5.1.2 GO 165 Inspections

- June 16, 2017 – no abnormal conditions identified
- April 7, 2014 – no abnormal conditions identified

5.2. Manhole Inspections

Manhole and vault inspections include checking for unsecured covers or missing bolts, damaged vaults, vaults not of sufficient strength for location, broken or damaged sump pumps, and broken, deteriorated or corroded ladders.[6]

- October 5, 2018 - no abnormal conditions identified
- July 8, 2017 - no abnormal conditions identified
- September 3, 2016 - no abnormal conditions identified
- September 5, 2015 - no abnormal conditions identified
- October 13, 2014 - no abnormal conditions identified

5.3. Installation/Testing

- Incident Switch was installed in 2001.[7]
- Consistent with industry practice, PG&E does not perform testing on in-service subsurface switches. PG&E does perform visual inspections to identify issues.

5.4. Outage History

A search of ILIS historical records show that in the 10-year period between November 20, 2008, and November 20, 2018, only one other unplanned outage occurred involving Switch 5059/5061/5062. This outage occurred on August 12, 2018, due to an adjacent transformer in Vault 39 blowing a center phase fuse which required Switch 5059 and 5061 to be operated.[8]

[6] TD-2305M-JA03 Job Aid Underground Inspection (Rev3 Jan 2020) (002).pdf, pages 28-31
[7] Internal Email, April 18, 2022
[8] ILIS Record 18-0069075

6. OBSERVATIONS & EVENT ANALYSIS

Analysis for this event included field observations, patrol and inspection analysis, system protection analysis, and failure analysis. These analyses are consistent with findings from interviews, physical evidence and additional data collected during the investigation.

6.1. Field Observations

On November 20, 2018, at 1745 hours, a PG&E restoration supervisor arrived at the Incident Location and observed the Bakersfield Fire Department and three news agencies on site. Upon checking in with the fire captain, it was explained that they had heard an explosion and arrived to find a small fire near Vault 39. The fire was extinguished prior to the restoration supervisor's arrival on site. The restoration supervisor made the scene safe with cones around the perimeter of the vault until a PG&E troubleman arrived. Upon arrival, the PG&E troubleman observed oil in Vault 39 on Switch SW 5059/5061/5062, on the surrounding transformers in Vault 39, and on the sidewalk. A private vehicle parked near Vault 39 also sustained damage from the fire.

Figure 1: Fire in Vault 39, 20th and Eye Street, Bakersfield, 11/20/2018. Source: Media

Figure 2: Vault 39 lid and damaged vehicle, 20th and Eye Street, Bakersfield, 11/20/2018. Source: PG&E

6.2. Patrol and Inspection Analysis

The GO 165 inspections and patrols of the 600A subsurface switches are an external review of the equipment. The visual inspections and patrols include looking for visual issues and non-conformances. This includes the enclosure, tank, bushings, conductor, connection points, cable, bare conductors, signage, marking, clearance, validation of any existing EC tags, mapping discrepancies, oil level and oil leaks.[9] Because the VIs are internal components, it is not possible to inspect them. Bushings on these types of switches are under the elbows and are inspected.[10] In reference to this incident, the external portion of the L1 bushing was cracked as visible in Figure 4. Bushings T2 and R3 had internal cracks visible in Figure 5.[11] There were no abnormal conditions identified in the last two cycles of patrols and inspections.

6.3. System Protection Analysis

The system protection scheme was analyzed as part of this investigation, and it was determined the scheme worked as designed. Circuit Breaker 1115/2 saw the three-phase fault and isolated the failed switch by design at 1700.[12][13]

6.4. Failure Analysis

PG&E's Applied Technology Sciences ("ATS") conducted an external visual inspection and teardown for internal inspection of the failed switch to help determine if there were any issues with the switch. The inspection determined that four of the nine internal VI ceramic bodies were cracked and both internal and external portions of bushings were cracked. Because the switch was examined after a catastrophic failure, it's possible that much of the damage was a result of the failure, and not the cause of the failure. The cracked bodies of the VIs allowed oil to enter

[9] Internal Email, April 22, Field Compliance
[10] Internal Email, April 14, 2022, Electric Compliance
[11] Attachment 01_ATS_Bakersfield Underground Switch Inspection Report.pdf, page 6
[12] ILIS Report 18-0101611
[13] Internal Email, April 20, 2022, Electric Distribution Planning

the vacuum envelope. Oil in the vacuum envelope does not have sufficient insulating properties to prevent the arc from extinguishing, resulting in the VI's catastrophic failure. The cause of the cracked VIs was not identified due to the damage from the initial failure and subsequent fire.[14] The CPUC was present for the teardown and inspection of the switch.

The age of the switch can also affect performance though it is likely not a contributing factor to this incident. The vacuum envelope is constructed with moving and fixed seals that allow for movement of the electrical contact. These seals can degrade over time resulting in loss of vacuum in the envelope. Depending on the equipment design (i.e., oil-filled or air), the failure of the vacuum will result in oil or air leaking into the envelope. At some point, the vacuum can be degraded to the point that it does not have sufficient insulating properties to allow for reliable operation. This failure mode is age-dependent and does not depend on the number of operations.[15] The average age of the 600A switches in the PG&E system is 19 years.[16] The incident switch was installed in October 2001 and, at the time of failure, was 17 years old. As a result, EII concluded that age is likely not a contributing factor to the equipment failure.

The following photos are from the ATS teardown and inspection.

[14] Attachment 01_ATS_Bakersfield Underground Switch Inspection Report.pdf
[15] Internal Email, Electric Engineering, 2/11/22
[16] Asset Management Plan, TD-8106, page 29

Figure 3: Fire damage evident on tank; burned oil, soot. Switch handles appear to be intact and in the closed position, grounding ring intact and connected to tank.

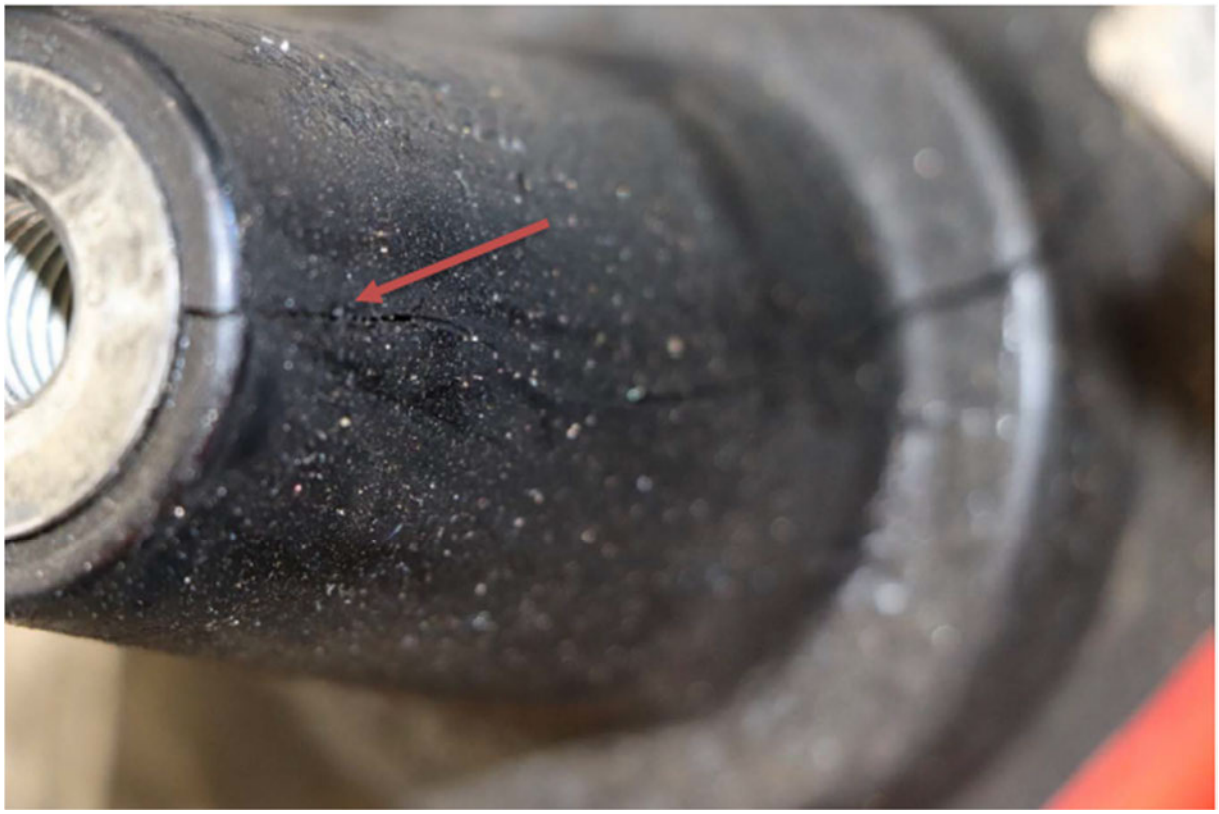


Figure 4: Cracked L1 bushing

Figure 5: Cracked T2 bushing

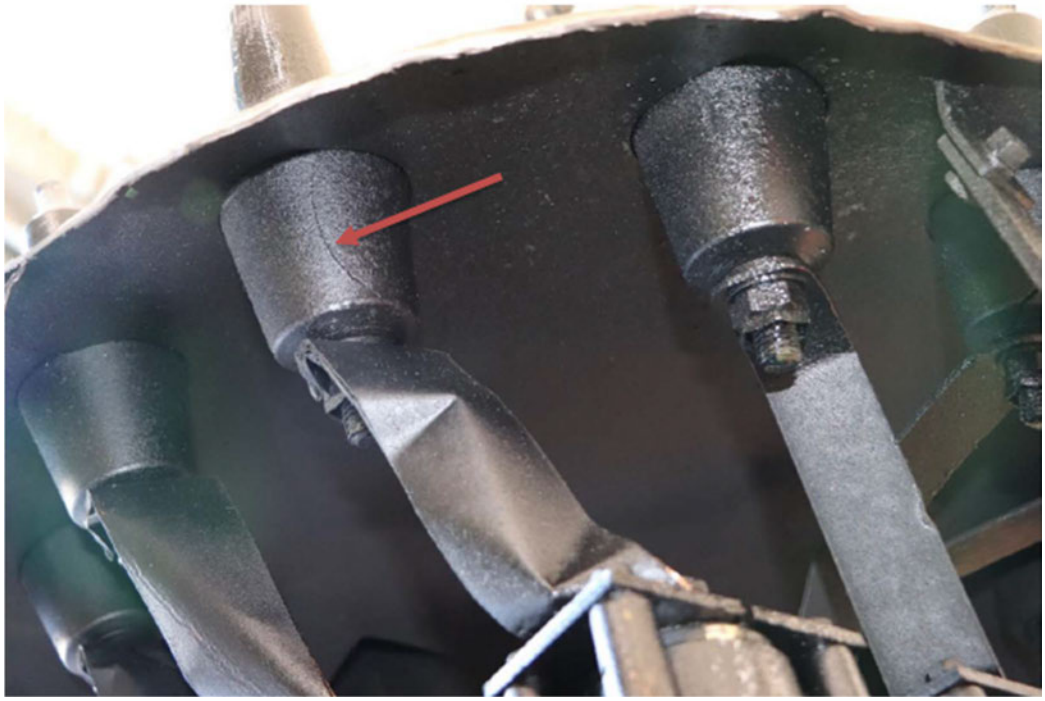


Figure 6: Cracked R2 bushing

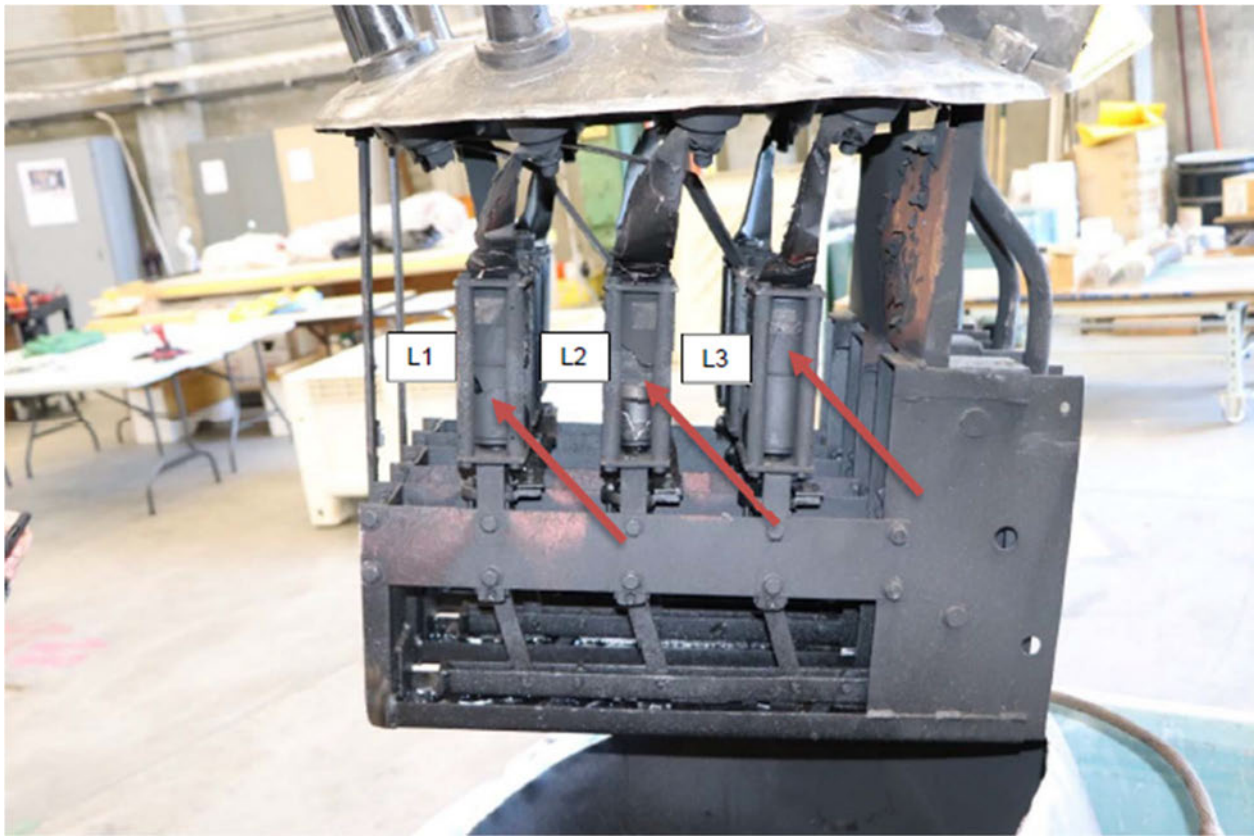


Figure 7: Internal mechanism, fire damage, cracked vacuum interrupters (VIs)

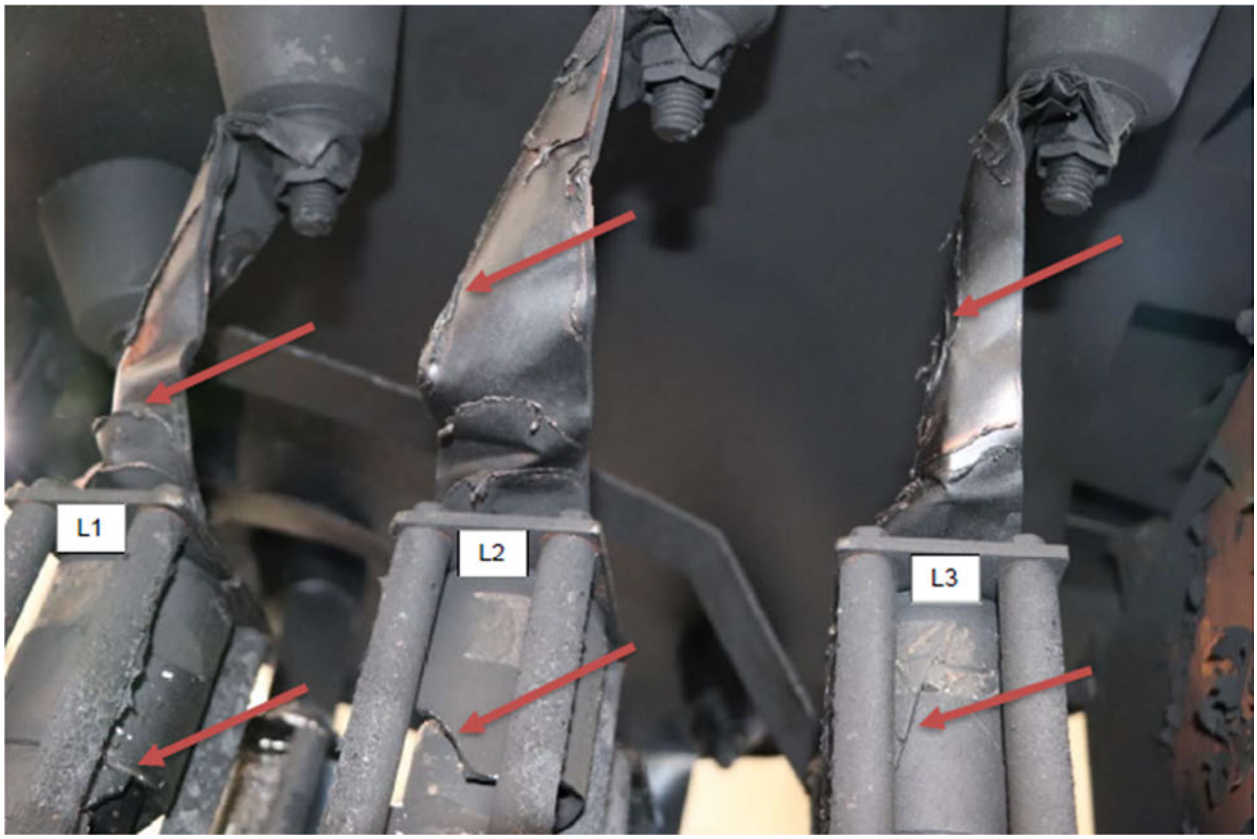
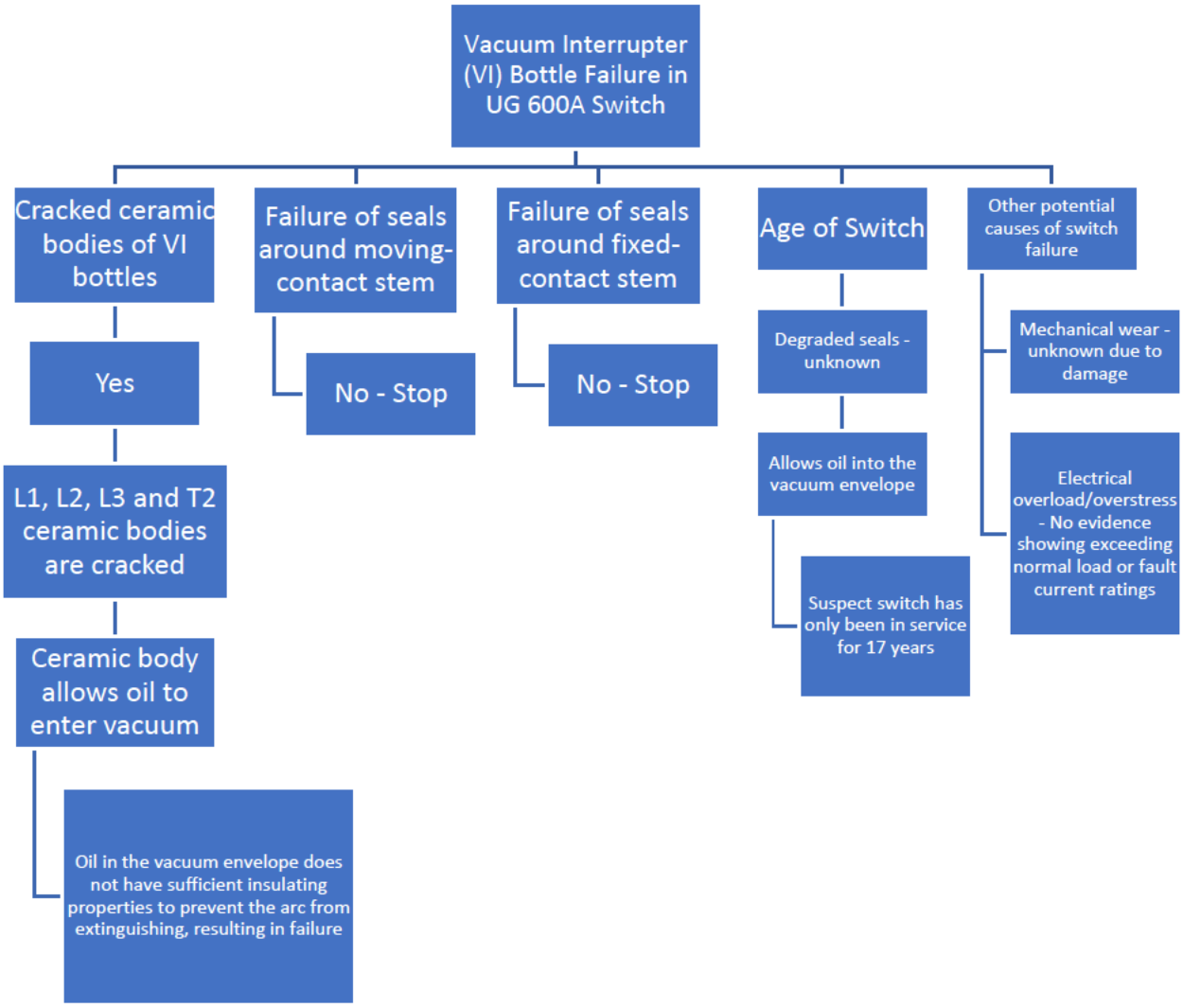


Figure 8: Cracked vacuum interrupters, evidence of arcing and melted parts on connections inside the tank

7. CAUSE & CONTRIBUTING CAUSES

A Causal Factor Tree was performed as part of this investigation and concluded that cracked ceramic VIs inside the underground switch allowed oil into the vacuum envelope. The cause of failure for the VIs was unable to be determined.


Vacuum Interrupter (VI) Bottle Failure in UG 600A Switch
Cracked ceramic bodies of VI bottles
Yes
L1, L2, L3 and T2 ceramic bodies are cracked
Ceramic body allows oil to enter vacuum
Oil in the vacuum envelope does not have sufficient insulating properties to prevent the arc from extinguishing, resulting in failure
Failure of seals around moving-contact stem
No - Stop
Failure of seals around fixed-contact stem
No - Stop
Age of Switch
Degraded seals - unknown
Allows oil into the vacuum envelope
Suspect switch has only been in service for 17 years
Other potential causes of switch failure
Mechanical wear - unknown due to damage
Electrical overload/overstress - No evidence showing exceeding normal load or fault current ratings

8. CORRECTIVE/GENERAL ACTIONS (CA/GA) SUMMARY

No corrective actions other than the initial switch replacement were identified as a result of this investigation.

9. POTENTIAL NON-CONFORMANCES AND NON-COMPLIANCES

No potential non-conformances and non-compliances were identified as a result of this investigation.

10. REFERENCES

- ILIS Data Query
- Event Analysis Report EI200724B
- Attachment 01_ATS_Bakersfield Underground Switch Inspection Report.pdf
- Internal Emails
- Asset Management Plan TD-8106
- Data Request DR191101
- Electric Transmission Preventative Maintenance Manual

11. ATTACHMENTS

Attachment 01_ATS_Bakersfield Underground Switch Inspection Report.pdf

12. PREVIOUSLY COMPLETED REPORTS AND DATA REQUESTS

20-Day Report

EI181120A - Bakersfield Media - 20 Day Report.pdf, submitted to the CPUC December 20, 2018

Attachment 1 -2016 UG Patrol.pdf

Attachment 2 - 2017 UG Inspect.pdf

Attachment 3 - 2017 UG Manhole Insp.pdf

Attachment 4 - 2018 UG Manhole insp.pdf

Attachment 5 - 2018 UG Patrol.pdf

Attachment 6 - EC Notification 115403085.pdf

Attachment 7 - ILIS 18-0101611.pdf

Attachment 8 - Photos.pdf

Data Request

DR191101 - Bakersfield.pdf, Data Request submitted to the CPUC January 10, 2019

Attachment 1 - Question 1 - One Line Diagram.pdf

Attachment 2 - Question 2 - Bakersfield 1115.xlsx

Attachment 3 - Question 5 - ILIS Report.pdf

Attachment 4 - Question 7 - TD 2908P-01.pdf

Attachment 5 - Question 8 - Failed UG 600 Amp Switches 2014-2018 Rev1.xlsx

Attachment 6 - PDIF for Failed UG 600 Amp Switches 2014-2018_2019.02.12.xlsx

Attachment 7 - Question 9 - EC 115016211.pdf

DR1902121 - Bakersfield.pdf, Data Request submitted to the CPUC February 12, 2019

DR1902131 - Bakersfield.pdf, Data Request submitted to the CPUC February 13, 2019

Attachment 1 - Question 2 - Claims.pdf

Attachment 2 - Question 4 - PPSOT-GUID-000004328.pdf

Attachment 3 - Question 4 - PPSOT-GUID-000013785.pdf

Attachment 4 - Question 4 - ISG and Elastimold Solid Dielectric Switches.pdf

Attachment 5 - Question 4 - Elastimold and G W Vault Switches.pdf