Event Analysis Report

Bakersfield Incident – Property Damage

EIR No.: EI200724B

Date of Event: July 24, 2020

Date Reported to the CPUC: July 24, 2020

Issue No(s).: 119511157

Report Rev: 01

[redacted]	[redacted]	2/5/2021
Leadership Approver	Signature	Date
[redacted]	[redacted]	1/28/2021
Incident Investigator	Signature	Date

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1. EXECUTIVE SUMMARY

On July 24, 2020 at approximately 1230 hours, a section of the underground primary cable failed in the Stockdale 2111 21kV Distribution Circuit between transformers T2142 and T2143 ("Cable Section #1") in Bakersfield, resulting in a power outage affecting 4,100 customers. The failed cable was part of the distribution service to a residential apartment complex. Damage to the electrical wiring and water pipes in the residential apartment complex was reported after the incident. Residents were evacuated and provided hotel accommodations as a safety precaution while the electrical system of the apartment complex was being inspected. By 1745 hours, the fault location had been isolated to a section of primary underground conductor between transformers T-2142 and T-2143 and the DCC successfully restored service to all 4,100 impacted customers.

On July 25, 2020 at 0820 hours, a 3-way primary switch on the same Stockdale 2111 21kV Distribution Circuit failed catastrophically and caught fire at the intersection of Ming Avenue and New Stine Road in Bakersfield, approximately 400 feet from the location of the previous incident. The switch failure was most likely related to the age of the switch, high fault currents through the switch due to July 24th failure of Cable Section #1, system protection devices that had been by-passed, and mechanical failure of the SCADA arm[1] of the subject 3-way primary switch. The July 25th incident damaged the cables adjacent to the switch in an underground enclosure, destroyed the enclosure lid, destroyed the SCADA device associated with the switch, and caused an oil spill from the switch that leaked to the adjacent underground enclosure. The incident affected a total of 1,600 customers. PG&E restored normal service to 1,600 customers at 1145 hours on July 26, 2020. The 3-way switch that failed was recovered and preserved as evidence. The switch was transferred to the PG&E's Applied Technology Services ("ATS") facility in San Ramon for further investigations.

PG&E reported the July 24th incident to the CPUC on July 24, 2020 at 2245 hours under the Property Damage criterion, triggering investigation by PG&E's Electric Incident Investigations ("EII") department. PG&E elected to investigate both the July 24th and 25th incidents together and reported both incidents in its 20-day report to the CPUC on August 21, 2020. PG&E is not

[1] The complete assembly of the SCADA motor/control systems that is used to remotely pull the arm to open or close the switch remotely via SCADA is herein referred to as the SCADA arm.

aware of any injuries or fatalities that occurred as a result of either incident. This report summarizes the findings of that investigation.

The investigation indicated the most likely apparent cause of the July 24th incident to be: [2]

- C1: Ineffective guidance and controls on repair-replacement decisions for underground distribution equipment experiencing repeated failures. This most likely resulted in the underground Cable Section #1 being repaired instead of replaced prior to July 24, 2020. Had the underground Cable Section #1 been replaced in accordance with current maintenance practices, it is unlikely the cable would have subsequently failed on July 24, 2020.

The investigation indicated the most likely apparent causes of the July 25th incident to be:

- C2: Insufficient verification of the post repair system configuration (after repairing an adjacent cable section) resulting in system protection fuses 10616 and 10614 being bypassed prior to the July 24th incident. This most likely resulted in a longer duration fault current during the failure of the Cable Section #1 on July 24, 2020 and contributed to excess stress on the 3-way primary switch that eventually failed on July 25, 2020. [3]
- CC1: The age of the failed 3-way primary switch was more than the average age of similar assets and most likely contributed to the failure of the switch on July 25, 2020. The average age of the PG&E 600 A vacuum-in-oil switches is 19 years. [4] The failed 3-way primary switch was manufactured in 1985 based on its nameplate information.
- CC2: In-service risk related to the SCADA arm failure, which is considered low and tolerable. This most likely resulted in the operation of the already-failed SCADA arm prior to the failure of the switch on July 25, 2020. It is possible that, the SCADA arm mechanism malfunction resulted in an incomplete opening of the 3-way switch contacts

[2] An apparent cause is defined as a determination based on the evaluator's judgment and experience. The emphasis of an apparent cause analysis is primarily to correct a particular event or problem without a special effort to identify the underlying system or process problems that may have contributed to the problem. [NERC (2019), "ERO Cause Code Assignment Process: An Event and Data Analysis Tool," Rev. 7, dated 02/2019]

[3] The failed three-way primary switch consisted of three sets of switches that were identified as 11003, 11004 and 11005, inside an oil-filled tank.

[4] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)," Rev. 1, dated 06/19/2020.

which put extra stress on the switch internal components and likely contributed to the switch failure.

The immediate corrective actions taken were:

For July 24, 2020 incident:

- PG&E isolated the fault and restored power to the customers.
- PG&E provided hotel accommodations to some of the residents impacted by the incident.
- PG&E isolated the smart meters servicing the apartment complex and secured electrical and plumbing contractors to inspect and repair affected electrical wiring and water lines on the customer side.
- PG&E isolated the damaged primary underground cable section and successfully restored service to all 4,100 impacted customers.
- PG&E replaced Cable Section #1 between transformers T2142 and T2143 (Cable Section #1) on 9/2/20.[5] The failed cable Section #1 was abandoned in place.[6]
- PG&E issued a "Safety Flash" to provide rapid awareness of the incident related to bypassed fuse and subsurface fused switches.7
- It should be noted that PG&E already has several controls in place in the form of programs and identified mitigation opportunities for distribution under-ground equipment. A cable replacement program is currently in place to mitigate the effect of aged underground cables.[8]

For July 25, 2020 incident:

- PG&E replaced the subject Switch (3-way primary switch), its associated SCADA device, and the damaged cables.
- PG&E used mobile generator units to supply temporary power to customers while the repairs were being performed.

[5] Electric Underground Tag Notification #: 119506517.
[6] Email from the PG&E field operations superintendent – Kern division, dated October 15, 2020.
[7] Safety Flash: Work Procedure Error: Replacing Blown Fuse in a Subsurface Fused Switch, Date Created: 8/24/2020, Author: Jim McCoy
[8] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, Table 14, Cable Replacement Program, Control ID: EDUG1_C29.

- PG&E is evaluating temperature sensors for the 200- and 600-Amp subsurface switches as a future technology for condition monitoring of the switches.[9] The incident 3-way switch was a 600-Amp subsurface switch.

Additional corrective actions and activities underway identified from the investigation which would prevent recurrence of this and similar incidents are summarized below in Table 1:

CA/ GA #	CA/GA Description
CA1	Reinforce PG&E requirements for the repair and replacement of distribution underground primary cables to Field Operations (PG&E document number 061324 - Guide for the Repair and Replacement of distribution Underground Primary Cable). [10]
CA2	Issue safety alert regarding work procedure error for replacing fuses and removing the fuse bypass after.
GA1	Consider implementation of additional inspection/maintenance techniques to better ensure in-service functionality of the SCADA motor/control assembly.
GA2	Reinforce PG&E procedure to perform an infrared safety inspection for all electric distribution personnel who enter energized manholes and vaults or who open energized subsurface enclosures and pad-mounted equipment with the intent to perform or coordinate work in accordance with the Utility procedure TD-2404P-01.

Table 1: Corrective actions (CA) and General actions (GA)[11] identified from the investigation

A nonconformance with the Utility procedure TD-2404P-01 [12] was identified during this investigation (PG&E procedural violation, see GA2 in **Table 1** for corrective action). No potential non-compliances were identified relating to this incident (no identified regulatory violations).

This report concludes PG&E's investigation into the Bakersfield incidents on July 24 and July 25, 2020. 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

[9] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, Page 23 of 74.
[10] 061324, "Guide for the Repair and Replacement of distribution Underground Primary Cable" Rev. 1, dated 7/1/2014
[11] Corrective Actions (CA) are linked to the cause of the incident. General Actions (GA) do not on their own mitigate the occurrence of a future incident. Examples of GA include evaluations to determine viability or potential effectiveness of a proposed corrective action and actions linked to additional findings.
[12] Working Near Underground Electric Distribution Cables and Field repair of Electric Distribution Cables and Field Repairs of Electric Distribution Line Equipment, Publication date: 05/15/2018, Rev:1.

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

The PG&E investigation team developed the following problem statements to guide and focus this investigation and causal analysis:

Problem Statement #1

> *On July 24, 2020 at approximately 1230 hours, a section of the primary distribution underground cable in Stockdale 2111 21kV Circuit between the T2142 and T2143 distribution transformers failed. As a result of the failure, Circuit Breaker 2111/2 opened automatically, resulting in a power outage affecting 4,100 customers. At the same time, the Bakersfield Fire Department ("BFD") reportedly received notification of a fire at [redacted] in Bakersfield ("Incident Location"). At 1235 hours, BFD reportedly arrived at the Incident Location and saw no signs of a fire. There were reports of damage to cable TV boxes and water main pipe at the [redacted] as a result of this incident.*[13]

Problem Statement #2

> *On July 25, 2020 at approximately 0820 hours, the 3-way primary switch failed catastrophically and caught on fire at the intersection of Ming Avenue and New Stine Road, 400 feet from Incident Location. The switch was at the Stockdale 2111 21kV Distribution Circuit and the resulting outage affected 1,600 customers.*

This incident was reported under the property damage criterion since damages sustained will exceed $50,000. The purpose of this report is to determine the underlying cause(s) of the

[13] ILIS report #: 20-0075695.1, Switching Log #: 20-75695.

failure(s) and identify any corrective or preventive actions that could prevent or mitigate future occurrence within the PG&E service territory.

3. EXTENT OF CONDITION

Underground Cables

PG&E experiences, on average, 1,000 cable system (cables, splices, elbows, and terminators) related failures per year in its underground distribution cable systems. Approximately 60% of these failures are cable failures; the remaining are splices, elbows, and other termination failures. The average age of all primary underground cables (excluding network) currently in service is 27 years.[14]

The cable section that failed on July 24, 2020 ("Cable Section #1") was installed in 1989 and is a 21 kV No. 2 Aluminum (cross-linked Polyethylene) XLP (XLPE) Cable in Conduit (CIC) type cable.[15] This cable is past the average age of such cables currently in service. Cable Section #1 is located between transformers T2142 and T2143 and serves as a redundant power source inside a loop distribution service and would not carry load in normal configuration.[16] During the building boom of the mid-1960s to late 1970s, the underground residential distribution (URD) design was used extensively in the urban and suburban neighborhoods. The primary cables installed in PG&E's local loop URD system were for the most part unjacketed CIC, with both High Molecular Weight Poly Ethylene (HMWPE) and XLPE insulation. The PG&E cable replacement strategy continue to focus on CIC cables. Failure rates of the XLPE cable in conduits are reported to be 0.9 failures per 100 miles.[17]

Underground Switches

The 3-way switch that failed on July 25, 2020 is considered a part of primary underground equipment switches known as 600 Amp vacuum in oil sectionalizing switches. The 600 Amp

[14] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 14 of 74.
[15] EDGIS database
[16] Cable Section #1 is normally open at T2143 and thereby would not normally carry load
[17] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 12 of 74.

subsurface switches are a younger asset compared to 200 Amp load break oil rotary (LBOR) switches; however, due to the higher number of operations, they typically experience more stress over their lifetime. Although the number of failures per year for LBOR and 600 Amp switches is relatively low in relation to their asset bases (less than 0.3% for both), there have been instances where these switches have failed catastrophically, and this represents a safety risk of injury to the public and employees.[18] There are programs to place temperature sensors on this type of switch for early warning before catastrophic failure. These switches are replaced mostly during emergency work, or when inspections detect problems such as oil leaking.

The average age of the 600 Amp switches is 19 years.[19] The incident switch was manufactured in 1985 and was nearing the end of its useful service life. It is reported that, on average, there are 25-30 failures of these types of switches per year, with a population of roughly 10,000 units. The catastrophic failures are usually the result of an issue with the internal switch components, and often lead to tank swelling/ruptures and oil spills. Typically, this type of switch fails when they are being operated.[20] Not all failures are catastrophic; highest risk is when the switches are being operated with an operator working next to the switch. The 600 Amp vacuum oil switches see high fault currents and are operated a lot more than 200 Amp switches. Inspections are visual and are mainly looking for oil leaks. Full inspections have a three-year cycle; one third of the switch population is inspected every year in addition to the yearly patrols and the map location is confirmed every year by patrols.[21]

4. SUMMARY OF THE ASSET STRATEGY

Underground Cables

The long-term distribution underground line asset goals which support PG&E's mission, vision, and strategic objectives include:

[18] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 18 of 74.
[19] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 18 of 74.
[20] Email and conversation with PG&E Electric Distribution Standards on December 11, 2020.
[21] Email and conversation with PG&E Electric Distribution Standards on December 11, 2020.

- Replace all remaining primary paper insulated lead covered (PILC) cables from the distribution system (non-Network).
- Replace all existing live-front transformers with dead-front, pad-mounted transformers.
- Replace all oil-filled switches with solid dielectric switches.
- Transition from dead-break elbow connections to load-break elbows in as many junctions, subsurface and pad-mounted transformers, and underground switches as possible.
- Leverage technological advances to develop condition-based replacement programs with appropriate replacement rates.

Although the long-term goals listed above do not have a specific target date for completion, there are on-going efforts on several different capital investment programs to achieve these goals. The distribution line underground asset family objectives were developed to optimize the asset life cycle by maintaining and improving the asset condition and adequately mitigating risks. These objectives have been established to align investment in the asset family with its asset management strategy, reduce risks, and ultimately realize PG&E's corporate mission and vision.[22]

Underground Switches

The early models of underground switches installed at PG&E were part of the legacy underground distribution systems built with PILC cables. Transfer ground rocker arm main (TGRAM) and transfer ground rocker arm loop (TGRAL) switches and conduit switches were all installed to interconnect, sectionalize, and to transfer load between circuits. D&W switches and ES-55 fused disconnects provided fuse protection for local loops. The great majority of these devices were installed in vaults or manholes, predominately in densely populated cities and older downtown areas. A significant number of these underground switches have been replaced as part of PILC cable replacement projects. Over 800 TGRAM and TGRAL switches were replaced on a dedicated program that began in 2010 and was completed in 2016.[23]

From the 1960s through the mid-1990s, Northern California experienced high population growth. Many new neighborhoods and cities were built during this era. The PG&E distribution

[22] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 22 of 74.
[23] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 18 of 74.

system expanded significantly to meet this demand and, starting in the mid-1960s, suburban neighborhood beautification efforts gave rise to the URD design, which included local loops. These started to become interconnected in the late 1960s through 200 amps load break oil rotary (LBOR) switches. A few years later, the 600 Amp vacuum in oil, sectionalizing switches (the 3-way switch) became the mainline switches of preference to interconnect and transfer load between circuits.[24]

5. EVENTS SUMMARY

Please refer to the 20-day report, submitted to the CPUC on August 20, 2020, for summary description of the events. A summary and/or history of relevant events is included in Table 2 based on the existing records.

With reference to Figure 1, the sequence of relevant events leading to the July 24 and July 25 incidents are:

For July 24, 2020 incident:

1. Cable section between transformers T2142 and T2143 (Cable Section #1) was out of service since 2018. The problem was described as: "Bad single phase of 21KV #2 AL primary cable between transformers T2143 and T2144, needs repair. Long run around building. Cable was a loop and already found to be bad between transformers T2143 and T2142 which is a shorter straight run and probably easier to repair."[25]
2. The cable section between transformers T2142 and T2143 (Cable Section #1) is normally open at T2143 and was used for redundancy – it normally does not carry load.
3. On July 22, 2020, the section between transformers T2143 and T2144 (adjacent to Cable Section #1) failed.[26]
4. Cable section between transformers T2143 and T2144 as well as Cable Section #1 (which was out of service since 2018) were repaired after the outage on July 22, 2020 and they were both put back in service.[27]

[24] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020, page 18 of 74.
[25] Electric underground Tag Notification #: 119488324.
[26] ILIS No. 20-0074659.
[27] Electric Underground Tag notification #: 119488324.

5. Both 10616 and 10614 fuses were bypassed sometime after July 22, 2020 and before July 24, 2020.
6. The cable section between transformers T2142 and T2143 (Cable Section #1) failed on July 24, 2020 and caused the 2111/2 breaker to operate due to both fuses 10616 and 10614 fuses being bypassed at the time, resulting in loss of the entire feeder, damage to the secondary customer side, and added stress on the 3-way primary switch.[28]

For July 25, 2020 incident:

1. In addition to the abnormal fuses and stresses on the 3-way switch, the SCADA operating mechanism of the 3-way switch malfunctioned and did not pull all the way open after the event on July 24, 2020 during fault isolation and customer restoration process, further adding stress on the subject switch.[29]
2. The responding troubleman reported hearing noise from the switch on July 24, 2020 when he checked the switch at the direction of the Distribution Control Center (DCC) during the restoration process. The responding troubleman "disconnected the SCADA device and the handle went all the way back to immediately closed". The troubleman visually inspected the switch, operated it, opened and closed it to make sure it closed, and the switch was put back in service.[30] The 3-way switch in question is 600 vacuum-in-oil type. Partial opening of the contacts, therefore, will normally occur inside the vacuum bottle, which normally may not be as problematic for the switch as partial opening inside the oil.
3. The age of the subject 3-way switch was more than the average age of similar assets and most likely contributed to the failure of the switch on July 25, 2020. The average age of the PG&E 600 A vacuum-in-oil switches is 19 years.[31] The subject 3-way primary switch was manufactured in 1985 based on its nameplate information.
4. On July 25, 2020, the subject 3-way switch failed catastrophically.

The customer restorations included the following activities:

[28] See the 20-day report.
[29] ILIS 20-0075695.
[30] Interview with PG&E Troubleman.
[31] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)," Rev. 1, dated 06/19/2020.

For July 24, 2020 incident:

1. PG&E area Restoration Supervisor observed burn marks on customer facilities such as water pipes and communication boxes; PG&E Meter Department removed the meter glass from the socket and insulated the meters to remove hazard from public.
2. After being contacted by the Restoration Supervisor, PG&E area Superintendent for Kern Division secured electrical and plumbing contractors to inspect and repair affected electrical wiring and plumbing on the customer side.
3. PG&E Area Superintendent secured hotel accommodations to some of the residents impacted by the incident.
4. DCC attempted to isolate the fault by operating the SCADA operating mechanism of the 3-way switch when it failed to pull all the way.[32]
5. DCC directed the responding troubleman to investigate the 3-way Switch. The troubleman reported hearing noise from the switch and "disconnected the SCADA device and the handle went all the way back to immediately closed". The troubleman visually inspected the switch, operated it, opened and closed it to make sure it was closed, and the switch was put back in service.[33]
6. DCC completed necessary switching, restoring 4,030 customers by 1700 hours.
7. By 1745 hours, the fault location had been isolated to a section of primary underground conductor between transformers T-2142 and T-2143 and the DCC successfully restored service to all 4,100 impacted customers.
8. These restoration actions ended the outage at 1745 hours on July 24, 2020.

For July 25, 2020 incident:

1. At 1955 hours, the PG&E Repair Crew arrived at the Incident Switch and replaced the Switch, its associated SCADA device, and the damaged cables.
2. PG&E used mobile generator units to supply temporary power to customers while the repairs were being performed.
3. The restoration actions ended the outage at 1145 hours on July 26, 2020.

[32] ILIS 20-0075695.
[33] Interview with PG&E Troubleman.

The meteorology data from PG&E station SR-58, 7 miles south-east of the Incident Location, recorded mean temperature of 85 ºF and wind gust of 15 miles per hour on July 24, 2020, and mean temperature of 86 ºF and wind gust of 18 miles per hour on July 25, 2020 at the time of the incident, respectively. No lightning strikes were reported on either incident day.

Date & Time	Event Description	Reference documents	Comments
September 21, 2016 **at 1510 hours**	Outage due to failure of the underground primary conductor between transformers T2142 and T2143. Opened tag to repair the section	ILIS # 16-0066354; Electric Underground Notification # 111977227	Reported fuse 10614 open. 66 customers affected.
September 23, 2016 **at 1000 hours**	Repaired the cable section towards switch 6525 and re-energized	Electric Underground Notification # 111977227; Switching Log # 16-66795	Primary conductor between and T2142 and T2143 repaired and placed back in service.
July 3, 2018 **at 1444 hours**	Outage due to failure of the underground primary conductor between transformers T2142 and T2143. Fuse 10614 operated.	ILIS # 18-0056773; Electric Underground Notification # 114751599	NEED FOLLOW-UP TESTING TO DETERMINE WHERE CABLE NG AND REPAIR/REPLACE ERR#294425
July 3, 2018 **at 1816 hours**	Repair Cancelled. "No Good" cable at T2142. THIS WILL HAVE TO BE WORKED UNDER C.O.E. PROGRAM.PIN 294425.	Electric Underground Notification # 114751599, C.O.E data PIN # 294425	Cable section remained out of service. "NG CABLE BETWEEN TRANSFORMERS T2142 & 6525. CREW NEEDS TO REPORT ON AND TEST."
April 9, 2019 **at 1025 hours**	SW 11003, 11005 comm failed. Tcom & DLT found No Good 5802 controller. FLISR impacted.	CE Notification # 116985080	Not clear whether the controller issue or comm issue.
April 9, 2019 **at 1027 hours**	Found and repaired loose connector. Switches left in service.	CE notification # 116985080	Loose connector was repaired, and the device returned to service.
July 22, 2020 **at 1125 hours**	Bad single phase of 21 kV #2 AL primary cable between transformers T2143 and T2144 that failed and resulted in opening a fuse and loss of 66 customers. Cable was a loop and was already found to be bad	ILIS # 20-0074659; Electric Underground Notification # 119488324; OIS # 969835.	Fuse 10616 blown. Trouble-man tested and re-fused 10616. Found bad cable from T2143 to T2144. Isolated and re-energized. One

Date & Time	Event Description	Reference documents	Comments
	between transformers T2143 and T2142, which is a shorter straight run and probably easier to repair.		transformer off. Called the crew for repair.
July 23, 2020 **at 0416 hours**	Completed repairs. Also performed repairs on the underground primary conductor between switches T2142 and T2143.	Electric Underground Notification # 119488324; ILIS # 20-0074659.2; OIS 969835; Switching log # 20-74659	Both cable sections repaired. Cable section between transformers T2143 and T2142 was already out of service since 2018.
July 24, 2020 **at 1401 hours**	Circuit breaker event due to bad cable between transformers T2142 and T2143. Trouble-man reported "UG CONDUCTOR THAT WAS JUST FIXED WENT BAD AGAIN." Cable between transformers T2142 and T2143 was isolated and remained isolated.	ILIS # 20-0075695.1; OIS # 971316; Personnel Interview	During the restoration, it was found that the 3-way switch was not open although the SCADA signal showed open. The switch was found to be partially closed and was "buzzing". It was found that the fuse bypass switches 10614 BP and 10616 BP were closed.
July 25, 2020 **at 0821 hours**	Underground 3-way switch exploded causing damage to all cables in enclosure containing sw11005 / 11004 / 1103 and destroyed box lid, oil appears to have leaked into switch enclosure to the east as well. Scada equipment was also destroyed as a result.	ILIS # 20-0075956	
July 26, 2020 **at 1147 hours**	Replaced the underground 3-way switch and damaged cables	Electric Underground Notification # 119507002	

Table 2: Summary and/or history of all events since 2016 on Stockdale 2111 21kV Distribution Circuit based on the existing records.

Figure 1: Electrical distribution map showing the relevant cable sections and equipment.

6. MAINTENACE HISTORY

Inspections of the underground cables include visual inspections and InfraRed (IR) imaging.[34] No records of IR images are found related to the failed cable sections on July 22 and July 24, 2020. This means that the IR test results did not display an excessive temperature differential at the time of the inspections. Only if higher temperatures are detected would the Compliance Inspector (CI) provide pictures and an IR datasheet as evidence.[35]

Inspections of underground switches are visual and mainly look for oil leaks as an indication of degradation. Full inspections have a three-year cycle; one third of the population of the switch

[34] EDPM Manual, Overview Section, page 12 of 20, Electronic file page 136.
[35] EDPM Manual, Underground Infrared Assessment, Electronic file pages 227 - 236 and 252.

population is inspected every year in addition to the yearly patrols and the map location is confirmed every year by patrols.[36] The last reported inspection of the failed 3-way switch was performed on June 28, 2019 with no abnormal conditions identified.[37] The prior inspection and last two patrols of the failed 3-way switch, prior to 2019 were performed in 2014, 2016, and 2017 are shown in Table 3.

Completion Date	Closure Date	Notification No	Order	Description
06/19/2014	08/14/2014	107443502 /108196097	42023108 /42140925	BFE_UG Inspections_Distribution_Infrared / ENCL_COUL_INSP - 5001 MING AVE *LOC1 Note: Cancelled as splice box was never installed.[38]
05/13/2016	07/31/2016	110765305	42538901	BFD-UGLinePatrols
05/11/2017	09/03/2017	112091904	42850000	BFE_UG Inspections_Distribution_Infrared
06/28/2019	12/22/2019	115383046	43568349	BFD-UGLinePatrols

Table 3: Inspection records of the failed 3-way switch.

7. OBSERVATIONS & EVENT ANALYSIS

Analysis for this event included Site Inspections, System Protection Analysis, Evidence Examination/Failure Analysis, and Internal Guidance Analysis. Additionally, publicly available information and interviews of PG&E personnel were considered. These observations are consistent with findings from the interviews, physical evidence and digitally recorded data of the events.

Additionally, with respect to the failure of the 3-way switch on July 25, it should be noted that the SCADA operating mechanism of the switch malfunctioned and did not pull all the way open after the event on July 24, 2020 during fault isolation and customer restoration process. Prior to the switch failure and during the response to the failure of the adjacent cable section on July 24, 2020, the troubleman assisting with restorations reported hearing noise from the 3-way switch

[36] EDPM Manual, Underground Infrared Assessment, Electronic file pages 227 - 236 and 252.
[37] Electrical Maintenance Patrol/Inspection Daily log, June 28, 2019.
[38] Electric Underground Tag notification #: 108196097.

when he checked the switch at the direction of the Distribution Control Center. The responding troubleman “disconnected the SCADA device and the handle went all the way back to immediately closed”. He visually inspected the switch, operated it, opened and closed it to make sure it closed, and the switch was put back in service after finding no external problem. The switch failed the next day.

7.1. Site Inspections

Observations made after the event, including field inspections performed by the Investigations team and others found:

- Field observation confirmed the location of the repaired underground cables after the incident on July 22, 2020 at [redacted]. A Google map view of the general area of the incidents between July 22 to July 25, 2020 is shown in Figure 2. Figure 3 to Figure 6 show selected pictures taken at the site of the failed cables during the site inspection on August 4, 2020.
- Damage on the low-voltage customer side was observed after the incident on July 24, 2020 at the water pipes and communication boxes. Figure 7 shows some high-temperature damage on the low voltage side after the incident on July 24, 2020.
- The failed 3-way switch was in an underground vault at the corner of the Ming Avenue and New Stine Road. This switch failed catastrophically on July 25, 2020 and caused a fire at the underground vault (see Figure 8). Figure 9 shows the 3-way switch location during the site inspection on August 4, 2020.

7.2. System Protection Analysis

Digitally recorded protection data from the Stockdale 2111/2 feeder was downloaded and reviewed. The earliest recorded event was August 2, 2020, with seven (7) events recorded on August 4, 2020, and three (3) events recorded on August 5, 2020. None of the recorded events were from the date of the incidents between July 22 to July 25, 2020. Furthermore, the recorded events were unrelated to the incident that is subject of this investigation. Therefore, breaker relay protection data for the events in question was not recovered. The SCADA data is shown in Figure 2. The plotted data shows the total feeder current of Stockdale 2011/2 feeder from July 23, 2020 until July 25, 2020 noon time.

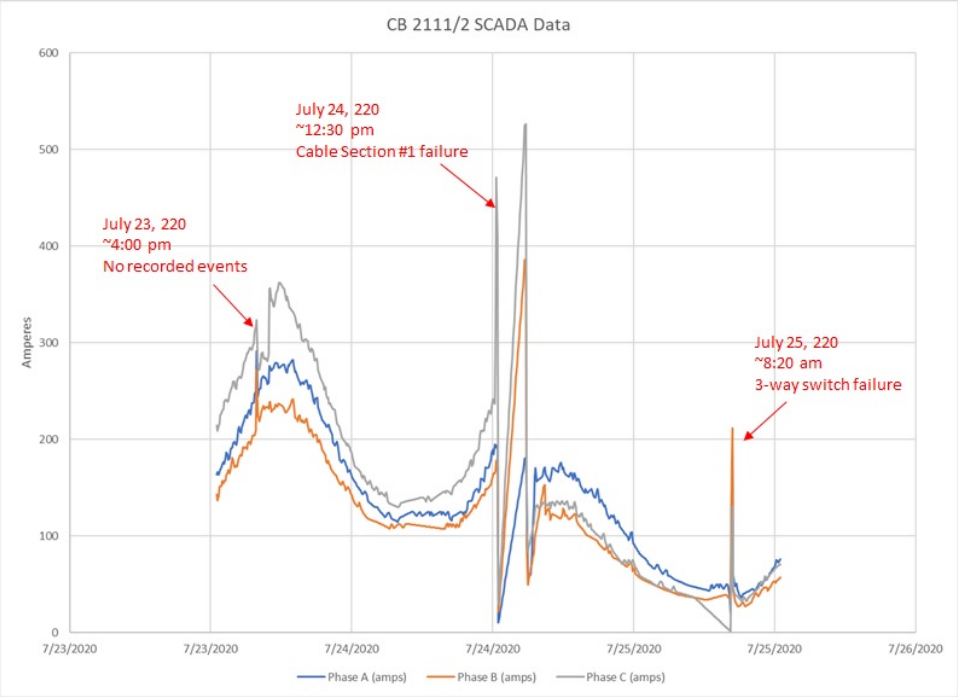

Figure 2: SCADA data of Stockdale 2011/2 feeder currents.

7.3. Failure Analysis

The failed Cable Section #1 between the transformers T4122 and T4123 (Cable Section #1) was not recovered from the underground section due to the potential risk of breakage during removal; therefore, this cable section was not available for failure analysis.[39]

The 3-way switch that failed was recovered and preserved as evidence. The switch was transferred to the PG&E's Applied Technology Services ("ATS") facility in San Ramon for further investigations. ATS evidence inspection revealed damaged vacuum interrupters inside the failed switch. The specific cause failure was not identified "due to the damage from the initial failure and subsequent fire."[40] The PG&E's ATS report detailing the results of the failure analysis of the switch is included in Attachment 9.

[39] Email from the PG&E field operations superintendent – Kern division, dated October 15, 2020.
[40] Applied Technology Services report #: 006.6-20.15

7.4. Control Center Analysis

Distribution Control Center (DCC) reports were obtained for the three events on July 22, July 24 and July 25, 2020, as well as all other relevant events. These reports detail the sequence of the events and reported activities and generally offer no opinions or findings regarding the apparent causes. Detailed sequence of events and the reference documents are listed in Table 2. Some of the observations recorded in the DCC reports include finding the fuse bypasses being closed and finding the SCADA arm partially closed during the restorations on July 24, 2020.[41] Furthermore, the switching log for the repairs after the incident on July 24, 2020, with respect to the incident switch, reported that the switch was manually closed and operated a couple of times and described as "operated a couple of times and switch is ok for service".[42]

7.5. Internal Guidance Analysis

The Electric Distribution Preventive Maintenance manual (EDPM) and Distribution Underground Asset Management Plan (Excluding Network Systems)[43] were the internal guidance documents used in this investigation. Inspections of the underground cables including visual inspections and InfraRed (IR) imaging are required by EDPM.[44] Some of the inspection and repair history of failed Cable Section #1 is shown in Table 2. This cable section had failed on July 3, 2018 and had been out of service until its repair on July 22, 2020.

PG&E document number 061324, dated 07-01-2014, provides guidance for the repair and replacement of distribution underground primary cables. Table 3 of this document provides a decision matrix to repair or replace underground primary cables after failure. For the loop or radial 200-Amp CIC cable sections between equipment and/or vault, the decision matrix states replacement of all phases between devices if there are 2 or more failures within the same protection zone. Furthermore, if the failed cable sections are left out of service for more than six months, the cables must be replaced. The subject underground Cable Section #1 was repaired on July 22, 2020 before it failed on July 24, 2020. This cable section had already failed twice in 2016 and 2018 and was out of service since 2018. According to the PG&E guide, the cable

[41] ILIS report, Event Log 20-0075695.1.
[42] Switching Log Number 20-75695, Order #51.
[43] Electric Plan TD-8106, "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1, dated 06/19/2020.
[44] EDPM Manual, Overview Section, page 12 of 20, Electronic file page 136.

should have been replaced instead of being repaired. Had the underground Cable Section #1 been replaced in accordance with current maintenance practices, it is unlikely the cable would have subsequently failed on July 24, 2020.

The Utility procedure TD-2404P-01 [45] requires that "All electric distribution personnel who enter energized manholes and vaults or who open energized subsurface enclosures and pad-mounted equipment with the intent to perform or coordinate work MUST first PERFORM an infrared safety inspection." There has been no report of infrared measurements before the inspection of the 3-way switch and the SCADA arm on July 24, one day before its failure. This investigation determined that this was a non-conformance with the said procedure. However, it is unlikely that infrared measurements would have detected a failure within the oil-filled tank of the incident 3-way switch.

7.6. Collected Evidence

PG&E collected and stored the following evidence at [redacted] – Figure 10 (referenced to photos taken during site visit).

- Evidence tag 1046 – UG 3-way switch
- Evidence tag 1047 – SCADA stand
- Evidence tag 1048 – 1100 cable
- Evidence tag 1049 – 3 wire 1/0 cable

The failed switch was taken into the evidence locker in PG&E's Bakersfield facility and was photographed during the August 4, 2020 site inspection (Figure 9). The evidence was later transferred to the PG&E's ATS facility in San Ramon, California for further examination (Figure 11).

[45] Working Near Underground Electric Distribution Cables and Field repair of Electric Distribution Cables and Field Repairs of Electric Distribution Line Equipment, Publication date: 05/15/2018, Rev:1.

Figure 3: A Google map view of the general area of the incidents.

Figure 4: Repair site between transformers T2143 and T2144 on the southeast driveway of the [redacted]. The area was repaired on or after July 22 and before July 24, 2020. Photo taken on August 4, 2020.

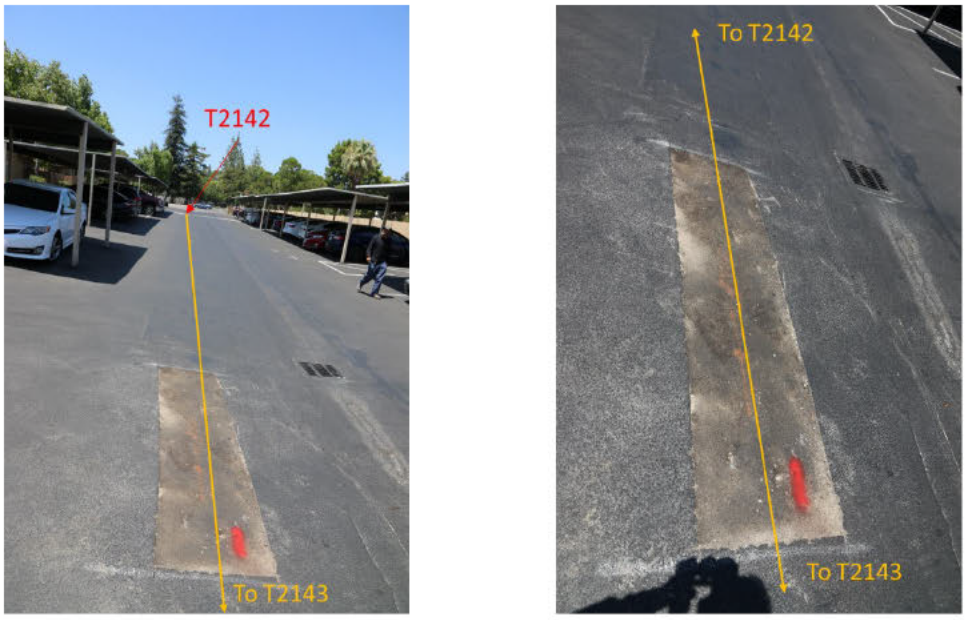

Figure 5: Repair site between transformers T2142 and 6525/T2143 (Cable Section #1) on the southeast driveway of [redacted]. Photo taken on August 4, 2020.

Figure 6: T2142 transformer location. Photo taken on August 4, 2020.

Figure 7: The primary cable toward switch 6525 at the transformer T2142 is lifted and tagged out. Photo taken on August 4, 2020.

Figure 8: Damaged equipment on the customer side. Photo taken on August 4, 2020.

Figure 9: Fire at the underground vault housing the 3-way switch. Photo taken on July 25, 2020.

Figure 10: Location of the 3-way switches – the switch failed catastrophically on July 25, 2020. Photo taken on August 4, 2020.

Figure 11: The failed 3-way switch (11003, 11004, 11005) kept in evidence locker. Photo taken on August 4, 2020.

Figure 12: The failed 3-way switch in PG&E's Applied Technology Services Facility in San Ramon, CA. Photo taken on October 7, 2020.

Figure 13: Nameplate of the failed 3-way switch.

8. CAUSE & CONTRIBUTING CAUSES

The causal analysis was performed in a structured sequence of steps. The method used involves repeatedly asking why the event or pre-condition existed and provides evidence to support the "why" in order to identify the underlying causes. Figure 12 and Figure 13 shows the causal evaluation charts developed for the July 24 and July 25 incident, respectively. Based on this evaluation, the identified apparent causes of the subject incidents are as follows:

Incident #1 (July 24, 2020):

- **C1. Guidelines and controls on repair-replacement decisions for equipment experiencing repeated failures were ineffective**. Cable Section #1 had failed previously in 2016 and in 2018 and there was an existing repair tag on that section recommending replacement under the Critical Operating Equipment (C.O.E.) program since 2018. The cable section was ultimately repaired (not replaced) on July 22, 2020; although, PG&E's guidelines of underground cable failures required repairing the first failure but replacing the cable after a subsequent failure on the same conductor. although the 2018 failure had recommended replacement, the repair crew had the option to replace the cable (perhaps not realizing that the cable had experienced prior failures). Had the cable been replaced on July 22, 2020 instead of being repaired, it is highly likely that the July 24, 2020 failure could have been avoided.

Incident #2 (July 25, 2020):

- **C2. Insufficient verification post repair system configuration** resulted in fuses 10616 and 10614 to remain bypassed after their replacement following the failure of the Cable Section #2 on July 22, 2020. This likely caused a longer duration fault current during the failure of the Cable Section #1 on July 24, 2020, as well as excess stress on the 3-way primary switch that eventually failed on July 25, 2020.[46] In addition to having a longer duration fault, the fault extent resulting from bypassed fuses prompted the Distribution Control Center to attempt to remotely open the 3-way primary switch via the SCADA

[46] The failed three-way primary switch consisted of three sets of switches that were identified as 11003, 11004 and 11005, inside an oil-filled tank.

operating mechanism which unbeknownst to them, had already failed; thereby likely adding additional stress onto the switch and its ultimate catastrophic failure.

The subject fuses were replaced after the failure of a cable section adjacent to the Cable Section #1 on July 22, 2020, and part of the fuse replacement procedure is to bypass the fuse during the replacement. The clearance and associated switching log for the repairs on July 22, 2020 however do not provide details regarding this step, and verification of whether fuses have been activated as part of the restoration process; it is left to the field crew to complete these tasks and perform the necessary verification.[47] It was discovered after the failure of the Cable Section #1 that both fuses immediately upstream of the cable section were still bypassed, indicating the post repair field verification process was not sufficient.

- **CC1: The age of the failed 3-way primary switch was more than the average age of similar assets.** The age and wear of the switch most likely contributed to the failure of the switch on July 25, 2020. The average age of the PG&E 600 A vacuum-in-oil switches is 19 years.[48] The failed 3-way primary switch was manufactured in 1985 based on its nameplate information.

- **CC2. Ineffective maintenance and inspection of the 3-way primary switch resulted in operation of the already-failed SCADA arm**. Ineffective maintenance and inspections in identifying the failed SCADA arm resulted in the operation of the already-failed SCADA arm prior to the failure of the switch. The SCADA arm malfunction resulted in an incomplete opening of the 3-way switch contacts which put extra stress on the switch internal components and likely contributed to the switch failure. Additionally, the switch was inspected as part of the emergency response to the July 24 failure of Cable Section #1. The Failed SCADA arm was identified, and noise was heard from the subject switch. The switch was manually operated a few times, visually inspected and was placed back in service. Had the 3-way switch been tagged as no-good and taken out of service for further diagnostics after reported noise from the device on July 24, 2020, the switch would not have failed the next day.

[47] Switching Log Number: 20-74659.
[48] Electric Plan TD-8106, “Distribution Line Underground Asset Management Plan (Excluding Network System)” Rev. 1, dated 06/19/2020.

This report concludes PG&E's investigation into the Bakersfield incidents occurring on July 24 and July 25, 2020. 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.

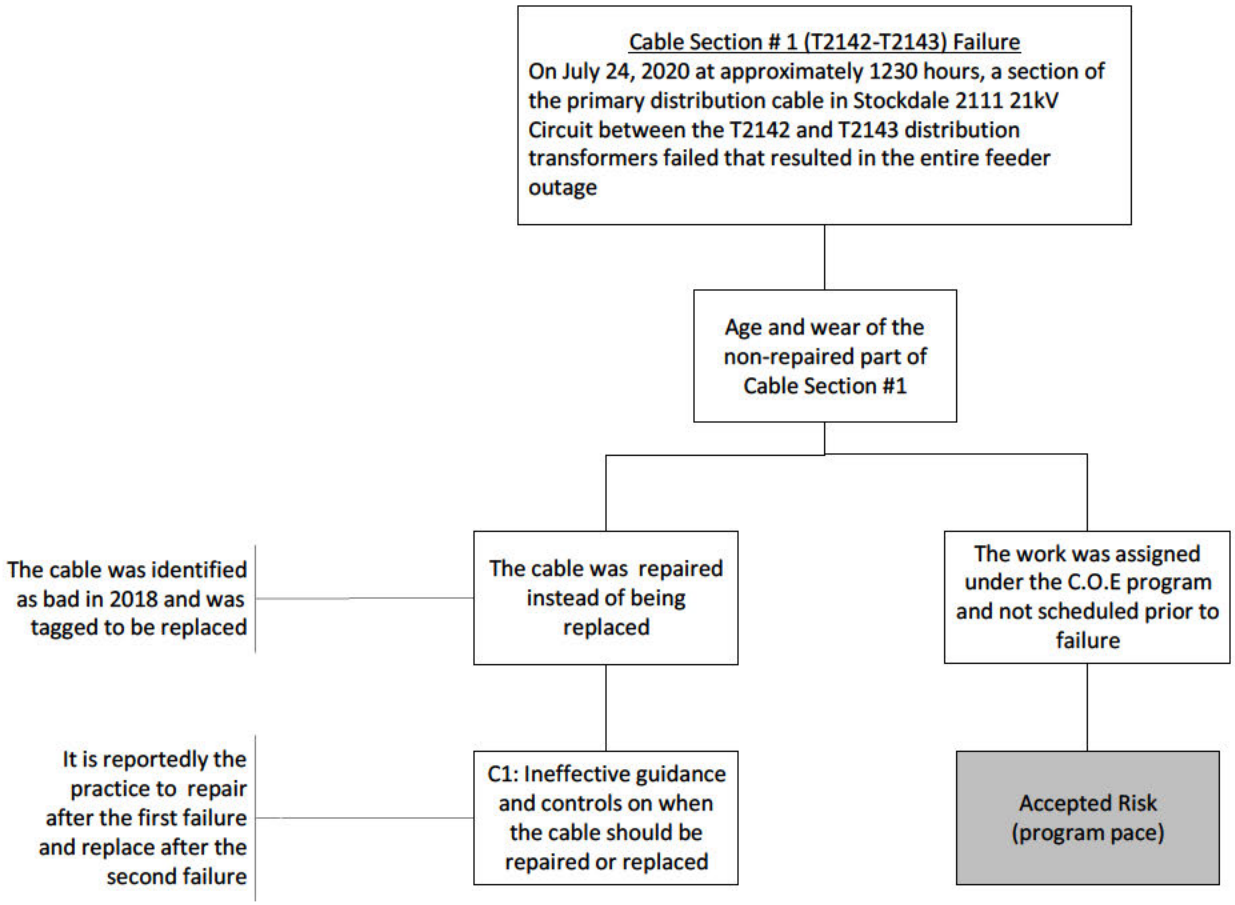

Figure 14: Causal evaluation chart - Incident #1 (July 24, 2020)

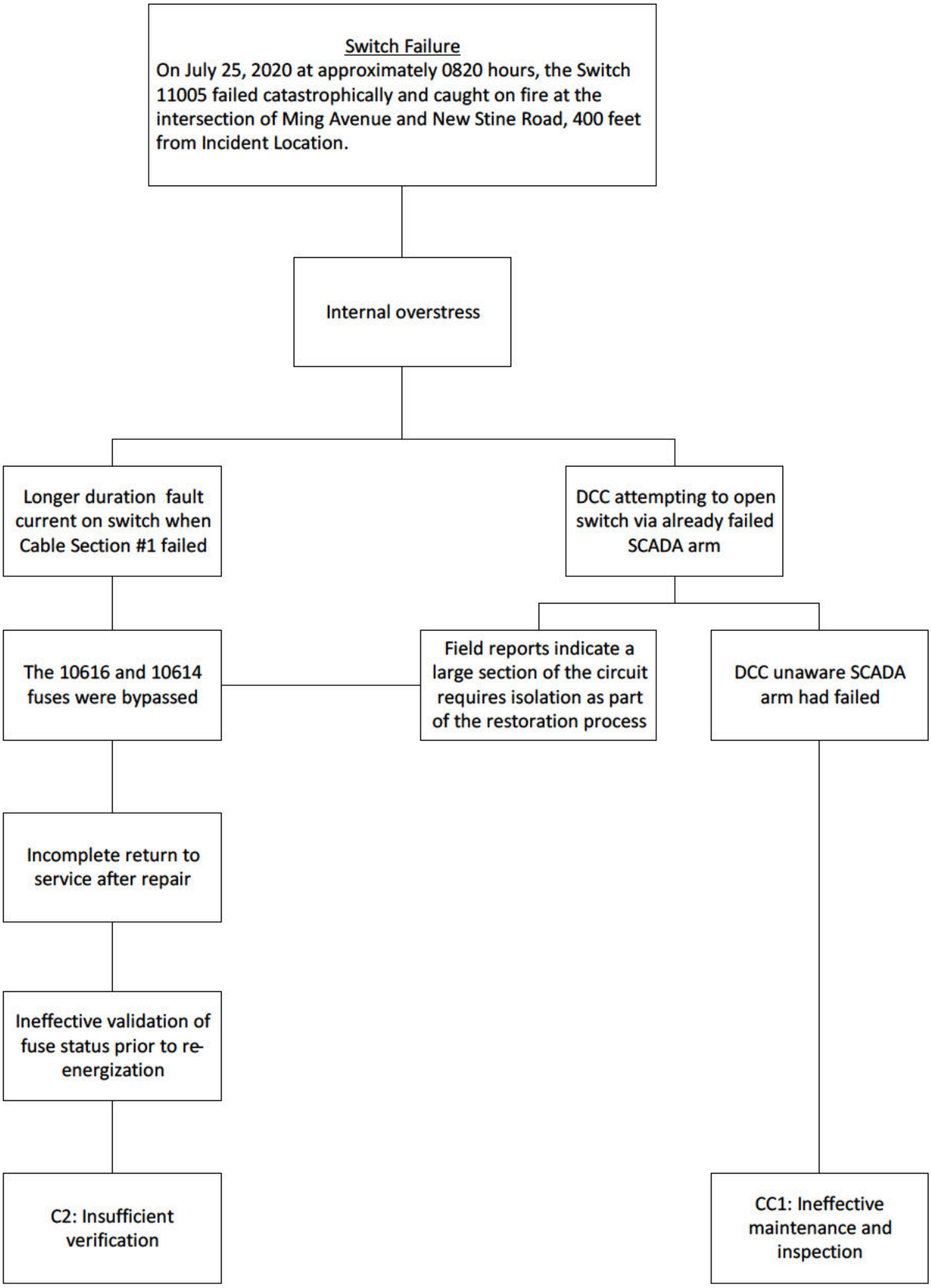

Figure 15: Causal evaluation chart - Incident #2 (July 25, 2020)

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

The immediate corrective actions taken were:

For July 24, 2020 incident:

- PG&E isolated the fault and restored power to the customers.
- PG&E provided hotel accommodations to some of the residents impacted by the incident.
- PG&E isolated the smart meters servicing the apartment complex and secured electrical and plumbing contractors to inspect and repair affected electrical wiring and water lines on the customer side.
- PG&E isolated the damaged primary underground cable section and successfully restored service to all 4,100 impacted customers.
- PG&E replaced Cable Section #1 between transformers T2142 and T2143.[49]

For July 25, 2020 incident:

- PG&E replaced the subject Switch, its associated SCADA device, and the damaged cables.
- PG&E used mobile generator units to supply temporary power to customers while the repairs were being performed.

Additional corrective actions and activities underway identified from the investigation which would prevent recurrence of this and similar incidents are summarized below in Table 4:

[49] Completed on 9/2/20. Electric Underground tag No. 119506517. The failed cable section was abandoned in place per email from the PG&E field operations superintendent – Kern division, dated October 15, 2020.

Cause(s)	CA/ GA #	CA/GA Description	Action Owner	Due Date
C1: Ineffective guidance and controls on repair-replacement decisions NERC Code: A4B1C01 – Mgt Guidance not well defined / understood	CA1	*Administrative Control* Reinforce PG&E requirements for the repair and replacement of distribution underground primary cables to Field Operations (PG&E document number 061324 - Guide for the Repair and Replacement of distribution Underground Primary Cable). Deliverable: Decide on the best course of action to effectively reinforce the PG&E requirement. Identified action(s) will be agreed upon by affected LOBs, and a new corrective action assigned for implementation. CAP: 120469865	[redacted]	4/30/2021
C2: Insufficient verification of the post repair system configuration (fuses left bypassed) NERC Code: A3B1 – Skill Based Error	CA2	*Administrative Control* Issue safety alert regarding work procedure error for replacing fuses and removing the fuse bypass after. Deliverable: Safety Flash CAP: N/A	[redacted]	Issued on August 24, 2020
CC2: in service risk related to the SCADA-arm failure considered low and tolerable NERC Code: A2B3C02 – Inspection / Testing LTA	GA1	*Administrative Control* Consider implementation of additional inspection/maintenance techniques to better ensure in-service functionality of the SCADA motor/control assembly. Deliverable: Documentation of decision and rationale in CAP CAP: 120470380	[redacted]	6/1/2022

Cause(s)	CA/ GA #	CA/GA Description	Action Owner	Due Date
N/A [50]	GA2	*Administrative Control* Reinforce PG&E procedure to perform an infrared safety inspection for all electric distribution personnel who enter energized manholes and vaults or who open energized subsurface enclosures and pad-mounted equipment with the intent to perform or coordinate work in accordance with the Utility procedure TD-2404P-01 Deliverable: Decide on the best course of action to effectively reinforce the PG&E requirement. Identified action(s) will be agreed upon by affected LOBs, and a new corrective action assigned for implementation. CAP: 120469958	[redacted]	4/30/2021

Table 4: Corrective actions for causes and contributing causes

10. POTENTIAL NON-CONFORMANCES AND NON-COMPLIANCES

A non-conformance with the Utility procedure TD-2404P-01 was identified during this investigation (PG&E procedural violation). The Utility procedure TD-2404P-01 [51] requires that "All electric distribution personnel who enter energized manholes and vaults or who open energized subsurface enclosures and pad-mounted equipment with the intent to perform or coordinate work MUST first PERFORM an infrared safety inspection." There has been no report of infrared measurements before the inspection of the 3-way switch and the SCADA arm on July 24, one day before its failure. Although this is a non-conformance with the said procedure, it is unlikely that infrared measurements would have detected a failure within the oil-filled tank of the incident 3-way switch.

[50] The general action GA2 is defined as the response to an identified non-conformance that did not directly contribute to the cause of this incident.
[51] Working Near Underground Electric Distribution Cables and Field repair of Electric Distribution Cables and Field Repairs of Electric Distribution Line Equipment, Publication date: 05/15/2018, Rev:1.

Regulation	Requirements	Reason for Potential Non-Conformance
Utility procedure TD-2404P-01	All electric distribution personnel who enter energized manholes and vaults or who open energized subsurface enclosures and pad-mounted equipment with the intent to perform or coordinate work MUST first PERFORM an infrared safety inspection.	• There has been no report of infrared measurements before the inspection of the 3-way switch and the SCADA arm on July 24, one day before its failure

Table 5: Summary of potential non-conformances

It should be noted that the PG&E distribution switching procedure (TD-2908P-01) requires NOT to operate the switch if any parts of the switch are suspected to be deteriorated or deformed (e.g., evidenced by excessive noise from the switch). A noise was heard from the subject switch when the switch was inspected as part of the emergency response to the cable failure that occurred on July 24, 2020. The switch was manually operated a few times, visually inspected and was placed back in service and it failed the next day. The noise may be interpreted as evidence of "deterioration", supported by the switch failure the next day. However, no specific threshold of noise can be defined that would be an indication of "deterioration" and such determination is left to the inspector's judgement. Therefore, placing the switch back in service after hearing noise is not considered a non-conformance.

No potential non-compliances are found as a result of this investigation.

11. REFERENCES

Internal Documents:

- Weather Data
- Electric Distribution Preventive Maintenance Manual (EDPM), Electric Plan TD-8106 "Distribution Line Underground Asset Management Plan (Excluding Network System)" Rev. 1,
- 061324, "Guide for the Repair and Replacement of distribution Underground Primary Cable" Rev. 1
- Email from the PG&E field operations superintendent – Kern division, dated October 15, 2020.
- EDGIS database

- Email and conversation with PG&E Electric Distribution Standards on December 11, 2020.

External Documents: N/A

Reports: N/A

12. ATTACHMENTS

Attachment 01_ILIS_20-0074659_CONF.pdf

Attachment 02_ILIS 16-0066354_CONF.pdf

Attachment 03_ILIS 18-0056773_CONF.pdf

Attachment 04_EU notification_111977227_CONF.pdf

Attachment 05_EU notification_114751599_CONF.pdf

Attachment 06_Switching Log_16-66795_CONF.pdf

Attachment 07_C.O.E data PIN_294425_CONF.pdf

Attachment 08_CE notification_116985080_CONF.pdf

Attachment 09_ATS evidence examination report_CONF.pdf

Attachment 10_ Safety Flash_EO Troublemen Work Procedure Error_Subsurface Fused Switch_CONF.pdf

13. PREVIOUSLY COMPLETED REPORTS AND DATA REQUESTS

20-Day Report

Attachment 1: EI200724B 20-day report, submitted to the CPUC August 20, 2020

Attachment 1.1: 2016 GO165 patrol records

Attachment 1.2: 2019 GO165 patrol records

Attachment 1.3: 2014 GO165 inspection records

Attachment 1.4: 2017 GO165 inspection records

Attachment 1.5: EC notification_119506305

Attachment 1.6: EC notification_119506517

Attachment 1.7: EC notification_119507002

Attachment 1.8: ILIS_20-0075695

Attachment 1.9: ILIS_20-0075956

Attachment 1.10: Bakersfield Fire Report

Attachment 1.11: PG&E Safety Flash

Data Request

DR2009032 – Bakersfield – Property Damage.pdf Data Request, submitted to the CPUC in portions on November 5, 2020, November 20, 2020, and December 2, 2020.