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Exhibit Number	:	CA-10
Commissioner	:	Alice Reynolds
Admin Law Judge	:	John Larsen
Witness	:	H. Eng

PUBLIC ADVOCATES OFFICE
CALIFORNIA PUBLIC UTILITIES COMMISSION

Testimony on Prudence of Operations for Thomas Fire and Debris Flow Cost-Recovery Application

System Protection

San Francisco, California
June 6, 2024

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SYSTEM PROTECTION

I. INTRODUCTION

This testimony pertains to Southern California Edison Company's (SCE or Edison) application to recover costs associated with the December 2017 Thomas Fire and subsequent debris flows (Application 23-08-013).

This testimony presents the analysis of the Public Advocates Office at the California Public Utilities Commission (Cal Advocates) regarding SCE's system protection settings for the Castro circuit, and the prudence of SCE's practices and operations in the time period leading up to the Anlauf and Koenigstein ignitions.

This testimony relates to specifically to Exhibit SCE-02, SCE's testimony on the Anlauf and Koenigstein ignitions, and Exhibit SCE-03, SCE's testimony on prudence of operations.

II. SUMMARY OF FINDINGS

SCE should have been more prudent with respect to adjusting all recloser settings in fire risk zones on the Red Flag Warning days. On Red Flag Warning days, in addition to disabling the reclose function of the reclosers, SCE should have adjusted the phase and ground current settings to be more sensitive, which would have de-energized the lines more quickly during a fault, minimizing the risk of wildfire ignition.

RAR-1228 and RAR-179 are the recloser devices on the Castro Circuit that should have protected the circuit-segments where the Anlauf and Koenigstein ignitions (respectively) occurred. SCE changed the recloser settings of RAR-1228 and RAR-179 to be less sensitive.[1] This sensitivity reduction caused the overcurrent relays to trip later, at higher fault currents, and not de-energize the circuit segments in time to prevent ignition.

[1] SCE response to data request CalAdvocates-SCE-A2308013-22, questions 4d & 5d, March 27, 2024, and attached documents "Castro AR 1228 Calc Sheet 1_8_2014" and "Castro AR 179 Calc Sheet 6_19_2014".

III. BRIEF OVERVIEW OF AUTO RECLOSERS AND THEIR SETTINGS

Auto reclosers are protective devices that can operate automatically when a circuit experiences abnormally high currents. In the event of a fault or disturbance, such as a temporary short circuit or momentary overcurrent, the auto recloser acts as an automatic switch that opens and closes to isolate the fault and then to restore power supply quickly.

The auto recloser is composed of an overcurrent relay that automatically trips and recloses a preset number of times. Tripping shuts off power to the circuit-segment downstream of the auto recloser; reclosing restores the power to the line. The auto recloser improves the reliability of electric service due to its ability to restore power automatically after clearing temporary faults. It plays an important role in maintaining a reliable and uninterrupted power supply.

Reclosers can be programmed with a range of protective settings using the manufacturer's time-current characteristics curve (see Appendix A). The settings can be adjusted to trip for a specified overload (or fault condition) and fault duration, as defined by a time-current curve. This is accomplished through an overcurrent element of a relay, which I discuss in greater depth in the following section.

Further, the reclosing function of an auto recloser can be disabled, which prevents the device from reclosing even after a fault clears. This setting is often used during Red Flag Warning days.[2]

IV. OVERVIEW OF OVERCURRENT RELAY

The overcurrent relay is embedded in the auto recloser. The overcurrent relay protects power systems from excessive currents that can damage equipment and cause faults, which can lead to fire. When the high current exceeds a preset current value and a preset time interval, the recloser acts as a switch and deenergizes the downstream circuit segment to prevent equipment damage and reduce safety hazards.

The overcurrent relay operates in an inverse tripping characteristic, meaning that the higher the fault current, the faster (shorter) the tripping time. Conversely, the lower

[2] Exhibit SCE-03 at 56-58.

the fault current, the longer it takes for the overcurrent relay to trip. Increasing the electric current and duration setting (that is, making it less sensitive) causes the relay to trip at a higher fault current and/or longer duration.[3]

The fault current setting of the overcurrent relay is dependent on the short-circuit current (SCC) of an electric system. The SCC is the highest electric current that can exist in a particular system. It is much higher than the full load current of a system (that is, the maximum current the equipment in a system can draw). The SCC is the traveling current along the unintended path with no or very low resistance. This unintended path could be two lines slapping together (phase-to-phase fault) or a line falling to the ground (phase-to-ground fault).

According to Ohm's Law, voltage (V) is equal to current (C) multiplied by resistance (R) or V = C*R, or C=V/R. When R approaches zero and V stays constant, C will increase to a much higher value. The SCC, depending on the total impedance of the system, can be a few or many orders of magnitude higher than the full load current. Thus, the current setting of the relay must be set much higher than the normal (or full load) operating current of the system**.**

V. ANLAUF IGNITION

A. SCE changed the settings on RAR 1228 in 2014.

On January 8, 2014, SCE changed the protection settings on recloser RAR 1228. The new settings were less protective**.**[4] SCE increased the amperage of current that would cause the recloser to trip (that is, to shut off the circuit-segment).

Table 1 shows how SCE changed the recloser settings on RAR 1228 on January 8, 2014.[5]

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[3] *See* Appendix A for further detail.

[4] SCE response to data request CalAdvocates-SCE-A.23=08-013-22 question 4d, attachment "Castro AR 1228 Calc Sheet 1_8_2014".

[5] SCE response to data request CalAdvocates-SCE-A2308013-22, question 4d, March 27, 2024, and attached documents "Castro AR 1228 Calc Sheet 1_8_2014".

Table 1 RAR 1228 Fault Current Settings		
	Phase	**Ground**
Old Setting (prior to January 8, 2014)	100 A	15.8 A
New Setting (after January 8, 2014)	200 A	100 A

The new settings have higher fault current for phase-to-phase and ground faults. These new settings indicate that the fault current must be higher than the previous settings for the recloser to trip. SCE's 2014 change of settings meant that the overcurrent relay embedded in the recloser would trip at a higher electrical current than it would have with the previous setting.

B. Impact of RAR 1228 Setting Change

On December 4, 2017, at 18:17:02.064, RAR 1228 recorded a phase-to-phase fault (886 amps on phase A and 908 amps on phase B), as shown in Table 2 below. However, the recloser did not trip. The magnitude and duration of the fault current did not meet the preset value of the relay's time-current characteristics curve for the recloser to trip. Therefore, the fault self-cleared, and the circuit segment remained energized. The recloser may have failed to trip because the fault current setting had been changed to a less sensitive setting of 200 amps phase fault current on January 8, 2014. The recloser detected fault currents but failed to trip because the settings in effect in December 2017 were not sensitive enough to trip at those fault current values.

At 18:40:56.129 on December 4, 2017, another phase-to-phase fault occurred (see Table 2 below). This time, the fault currents were higher, at 1565 amps and 1593 amps on the two phases.[6] Again, recloser RAR 1228 did not trip. The circuit segment remained energized.[7]

[6] Exhibit SCE-02, Appendix A, pages A1 and A2.

[7] Exhibit SCE-02, Appendix A, pages A1 and A2.

Approximately half a second later, at 18:40:56.658, a third phase-to-phase fault occurred (see Table 2 below). The fault currents were 1468 amps and 1488 amps on the two phases.[8] The recloser finally tripped and deenergized the circuit segment.[9]

If SCE had retained the original (pre-2014) recloser settings (with a minimum-to-trip value of 100 amps for phase faults), RAR 1228 could probably have tripped at the first phase-to-phase fault at 18:17:02.064, because the new setting is twice the original fault current setting (100 amps to 200 amps).

Had the recloser tripped at the first phase-to-phase fault on December 4, 2017, the recloser would have rapidly shut off power to Anlauf Canyon at 18:17. This would have reduced the amount of energy released by the fault at 18:17 (as well as preventing any subsequent faults). Had the recloser tripped at that time, the number of sparks produced by the fault could have been reduced and possibly prevented ignition.

C. Timeline of Anlauf Ignition

The Anlauf Ignition occurred in Anlauf Canyon on the evening of December 4, 2017.[10] SCE has provided fault current data which captured the electrical events on RAR 1228 in connection with the Anlauf ignition.[11]

Table 2 below shows the electrical events recorded on recloser RAR 1228 around the time of the Anlauf ignition.[12] RAR 1228, also called the Anlauf Canyon Remote Automatic Recloser, was located at the bottom of Anlauf Canyon. It was the nearest protective device upstream of the Anlauf ignition location.[13, 14]

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[8] Exhibit SCE-02, Appendix A, p. A1.

[9] Exhibit SCE-02, Appendix A, pp. A1 and A2.

[10] Exhibit SCE-02 at 1.

[11] Exhibit SCE-02, Appendix A, pp. A1 & A2.

[12] Exhibit SCE-02, Appendix A, pp. A1 & A2.

[13] Exhibit SCE-02, Appendix A at A1. Footnote 1 states that “the Anlauf Canyon Remote Automatic Recloser (RAR 1228) was closest to the events in Anlauf Canyon.”

[14] Exhibit SCE-03 at 13.

Table 2 RAR 1228 Electrical Events & Current Readings on 12/4/2017						
Time	**Fault Type**	**Current in Amps**				**Recloser Tripped?**
		A Phase	**B Phase**	**C Phase**	**Ground**	
18:17:02.064	A-B Phase	886 A	908 A	27 A	2 A	No
18:40:56.129	A-B Phase	1565 A	1593 A	31 A	0 A	No
18:40:56.658	A-B Phase	1468 A	1488 A	20 A	0 A	Yes

Table 1 shows that the RAR-1228 recorded three phase-to-phase faults that began at 18:17:02.064 on December 4, 2017.[15] The circuit segment did not trip until 18:40:56.658. These events indicate that the fault current was neither high enough nor lasted long enough for the relay to trip on either the first or second phase-to-phase fault.[16] In other words, the relay settings were not sensitive enough to trigger the tripping operation. Thus, the circuit segment remained energized until the fault current lasted long enough for the relay to trip, which occurred at 18:40:56.658.

VI. KOENIGSTEIN IGNITION

A. Electrical Event Records for December 4, 2017

The Koenigstein Ignition occurred at approximately 19:27 on December 4, 2017.[17] SCE has provided fault current data which captured the electrical events on the RAR 179 in connection with the Koenigstein ignition.[18]

Table 3 summarizes the electrical events and the current readings for phases A, B, and C, and the Ground, on December 4, 2017 for recloser RAR 179.[19] Phase C is one of the three energized phases of the Castro circuit.

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[15] Table 2 data is drawn from Exhibit SCE-02, Appendix A, pp. A1 & A2.

[16] Cal Advocates does not have the fault duration information with respect to the relay's time-current curve.

[17] Exhibit SCE-02 at 4.

[18] Exhibit SCE-02, Appendix A, p. A1.

[19] Exhibit SCE-02, Appendix A, pp. A2 & A3.

Table 3 RAR 179 Electrical Events & Current Readings on 12/4/2017						
Time	**Fault Type**	**A Phase**	**B Phase**	**C Phase**	**Ground**	**Recloser Trip?**
19:27:03.816	A-C Phase	924 A	84 A	858 A	4 A	No
19:27:05.736	C Phase to Ground	30 A	61 A	611 A	626 A	No
19:27:06.356	C Phase to Ground	29 A	61 A	611 A	658 A	No
19:27:08.118	C Phase to Ground	32 A	57 A	609 A	618 A	Yes

Table 3 shows that four faults occurred over a period of about 4.3 seconds. After the initial phase-to-phase fault, the C-phase conductor separated and hit the ground in about 2 seconds. This produced a phase-to-ground fault that lasted approximately 2.5 seconds before the recloser tripped.

RAR 179 tripped after the last of the four recorded faults at 19:27:08. At this time, RAR 179 recorded a ground fault current of 618 amps. However, the recloser measures and records relay data at intervals, not continuously. Therefore, the recloser may not have taken a measurement when the fault current reached its peak value. Since the recloser tripped in 1.083 seconds, SCE estimated that the ground fault current was 1050 amps.[20] If the fault current were only 618 amps, the relay would have taken 1.82 seconds to trip.[21]

B. Analysis of Event Records

Table 3 shows that a phase-to-phase fault occurred at 19:27:03 but RAR 179 did not trip because of the relatively low fault currents of 924 and 858 amps (on phases A and C, respectively). Although these phase fault currents were higher than the recloser's phase current setting of 280 amps, tripping would still depend on the fault current setting.

[20] Meeting with SCE subject-matter experts on May 20, 2024.

[21] Exhibit SCE-02, Appendix A, pp. A2 & A3.

For the recloser to trip, the fault current must have the current value and duration that align with the time-current curve for the overcurrent relay.

Next, a C-phase to ground fault occurred at 19:27:05 due to the separation of the C-phase conductor. One end of the C-phase conductor fell on the ground, which caused the Koenigstein ignition.[22, 23] The ground fault current had readings of 626 amps at 19:27:05.736 and 658 amps at 19:27:06.356. Still, RAR 179 did not trip.[24] Although these fault currents exceeded the recloser's ground fault setting of 120 amps, they did not last long enough to meet the time and current combination that would cause the recloser to trip (pursuant to the time-current curve for the overcurrent relay). Consequently, the separated conductor on the ground remained energized, releasing electrical energy and igniting a fire.

RAR 179 did not trip during the first phase-to-phase fault or the two subsequent phase-to-ground faults. RAR 179 finally tripped at 19:27:08 and deenergized the circuit segment.[25]

The broken conductor remained energized until 4.3 seconds after the first phase-to-phase fault (from 19:27:03.816 to 19:27:08.118)[26] and ignited a fire.[27, 28]

C. SCE changed the settings on RAR 179 in 2014.

Table 4 below shows that SCE changed the settings of RAR 179 to a less sensitive ground current setting of 165 amps on January 8, 2014. SCE then changed the recloser to a more

[22] Exhibit SCE-02 at 66.

[23] Koenigstein Fire Agency Report at 5 (Exhibit SCE-02, Appendix C, p. C5).

[24] Exhibit SCE-02, Appendix A, pp. A2 and A3.

[25] Exhibit SCE-02, Appendix A, pp. A3.

[26] Exhibit SCE-02, Appendix A, pp. A2 and A3.

[27] Koenigstein Fire Agency Report at 5 (Exhibit SCE-02, Appendix C, p. C5).

[28] Exhibit SCE-02 at 68.

sensitive ground current setting of 120 amps on May 19, 2014, but it was still less sensitive than the original setting of 100 amps prior to January 8, 2014.[29]

Table 4 **RAR 179 Settings**		
	Phase	**Ground**
Original Setting prior to January 8, 2014	280 A	100 A
Setting Change on January 8, 2014	280 A	165 A
Setting Change on May 19, 2014	280 A	120 A

D. Impact of RAR 179 Setting Change

It is likely that SCE's change to a less sensitive ground fault current setting delayed the tripping action of the overcurrent relay when phase-to-ground faults occurred on December 4, 2017. Had SCE retained the more sensitive pre-2014 settings, the overcurrent relay might have been able to trip the circuit at the initial phase-to-ground fault at 19:27:05.

If the ground fault current setting had remained unchanged at 100 amps, the event timeline suggests that RAR 179 could have tripped (if the fault lasted long enough) at the first and second phase-to-ground faults at 19:27.05 and 19:27.06. If RAR 179 had tripped sooner, the number of sparks caused by the faults would have been reduced.

E. Impact of Phase Fault Setting

If SCE had adjusted the phase fault current setting on RAR 179 to a lower value than 280 amps, the recloser could have tripped and deenergized the circuit segment at the first phase-to-phase fault at 19:27:03.816. With a phase current setting of 280 amps, the

[29] SCE response to data request and CalAdvocates-SCE-A2308013-05, question 13, November 30, 2023, file "013_Castro AR 179 OD43.pdf"; SCE response to data request CalAdvocates-SCE-A2308013-22, questions 4d & 5d, March 27, 2024, and attached documents "Castro AR 1228 Calc Sheet 1_8_2014" and "Castro AR 179 Calc Sheet 6_19_2014".

recloser did not trip,[30] which caused an ignition leading to a fire. However, had SCE selected a more sensitive phase current setting, the recloser could have tripped at the phase-to-phase fault. This could have prevented the subsequent phase-to-ground faults.

VII. SCE DID NOT ADEQUATELY CONSIDER WILDFIRE RISK WHEN ADJUSTING RECLOSER SETTINGS.

RAR 179 and RAR 1228 were in a high fire-risk area, as determined by the Commission, Cal Fire, and SCE.[31, 32] SCE's decision to adjust these reclosers' fault current settings to be less sensitive increased the likelihood that faults would not cause the protective devices to trip. This, in turn, increased ignition risk.

The question remains if SCE considered the need for shorter tripping times and lower fault current settings due to wildfire risks in 2014, when SCE selected less sensitive recloser settings.

SCE disabled both reclosers' (RAR 1228 and RAR 179) automatic reclose function prior to the Thomas Fire on December 4, 2017.[33] However, automatic reclosing can only occur if the recloser trips in the first place. Even though the reclose function was disabled, SCE's 2014 changes to the time-current curves left the system at greater ignition risk.

SCE should have conducted a more detailed review of the recloser settings, considering if the circuit segments downstream of the reclosers are in a high fire-risk

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[30] A setting of 280 amps is known as the pickup current. However, a combination of current and duration is required to trigger the overcurrent relay. The pickup current of 280 amps alone would not meet the duration criteria for the recloser to immediately trip. See Appendix A for further details.

As discussed in the previous section, the phase fault currents at 19:27:03 (924 and 858 amps) exceeded the recloser's pickup current setting, but did not attain the requisite combination of time and duration, as determined by the time-current curve for the overcurrent relay.

[31] Exhibit SCE-03 at 8-9 (footnote 4): "Pursuant to the interim Fire Threat Map adopted by the Commission in D.09-08-029 and D.12-01-032, the areas near the Anlauf and Koenigstein ignitions were designated as Very High (as designated on the Cal Fire map)."

[32] Exhibit SCE-03 at 8-9: "The areas near the Anlauf and Koenigstein ignitions were both designated by SCE as HFRAs."

[33] Exhibit SCE-03 at 57-58; SCE response to data request CalAdvocates-SCE-A2308013-12A, question 11c, February 14, 2024.

area. Prior to changing the auto recloser settings, SCE should have performed a reliability assessment of all the Castro circuit segments in the high fire-risk areas, using the following metrics:

- Number of outages and the outage duration caused by wire-down events,
- Number of reclosers,
- Type of recloser,
- Settings of reclosers,
- Number of phase-to-phase faults (sustained and momentary),
- Duration of the phase-to-phase faults,
- Number of ground faults,
- Duration of ground faults,
- Phase-to-phase fault current reading and duration of fault current *without* recloser tripping operations,
- Phase-to-phase fault current and duration of fault current *with* recloser tripping operations,
- Ground fault current reading and duration of fault current recorded *without* recloser tripping operations,
- Ground fault current reading and duration of fault current recorded *with* recloser tripping operations,
- Duration of ground-fault related outages, and
- Number and location of ignition events.

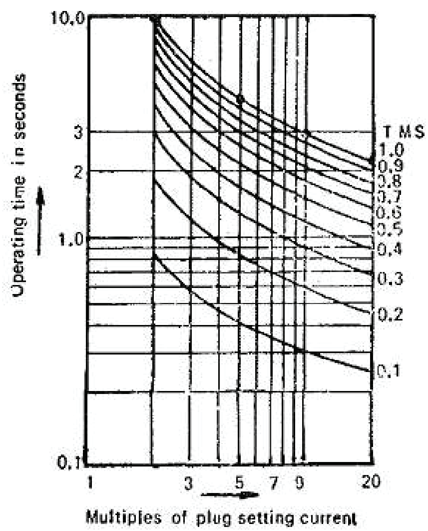
SCE has not presented evidence that it performed this depth of analysis to prudently address both reliability and wildfire risk, when determining the appropriate recloser settings on the Castro circuit. SCE could have done such an analysis either when adjusting recloser settings in January and May 2014 or at any later point. To mitigate risk on circuits that traverse fire risk areas, SCE only disabled the reclose function of the reclosers and did not adjust the recloser settings to be more sensitive for a faster trip.

Appendix A

Overcurrent Relay Current-Time Curve

The figure below shows typical Inverse Definite Minimum Time (IDMT) characteristics with different times multiplier settings on an overcurrent relay.[34]

The time-current characteristic is conveniently plotted on a log-log scale. Figure (4.7) shows the IDMT characteristics with different time multiplier settings (TMS).



To interpret this figure:

- The Y-axis on the left is the tripping time (in seconds) of the overcurrent relay.
- The Y-axis on the right is the TMS (time multiplier settings). SCE can adjust these settings.
- The X-axis is the magnitude of the electric current.
- The current settings aligned with 2 (between the 1 and 3) on the X-axis is called the pickup current. The recloser will record the current reading once the pickup current is met or exceeded.

Each curve in the figure is a possible time-current curve. Any point along the IDMT curve indicates the magnitude of current and the corresponding time in which the

[34] EEEGUIDE.COM, Online Electrical and Electronics Study, Overcurrent Relay Characteristics.

relay will trip. The curves are downward sloped: the higher the current, the shorter the tripping time; the lower the current, the longer the tripping time.

When a utility adjusts recloser settings:

- The 10 IDMT curves can be set lower or higher by adjusting the TMS value (from 0.1 to 1.0) on the right Y-axis.
- The lower the TMS value, the higher the sensitivity.
- The higher the TMS value, the less the sensitivity.
- The relay will not trip when the current is less than 2 on the X-axis (that is, the pickup current value).

VIII. WITNESS QUALIFICATIONS – HERMAN ENG

My name is Herman Eng. My business address is 320 4th St, Los Angeles, California. I am employed by the Public Advocates Office as a Senior Utilities Engineer (Specialist) in the Safety Branch.

I earned a BS in Electrical Engineering from the University of California, Los Angeles, and a MS in Electrical Engineering from California State University, Los Angeles. I am a Professional Engineer in Electrical Engineering in the State of California, and my license number is 12233.

I joined the Public Advocates Office in January 2023. In this role, I have worked on Wildfire Mitigation Plans and reviewed General Order 95 petitions by SCE.

I previously worked in the Los Angeles Department of Water and Power (LADWP) as an electrical engineer and a Power Engineering Manager for over 35 years. I have extensive experience in the areas of Claims and Investigation, System Protection, Distribution System Reliability and Distribution Planning.

I served as a forensic engineer for more than five years. I investigated and performed root cause analysis on power outages. I have represented the LADWP as an expert witness and teamed with city attorneys and third-party engineering consultants on defense strategy. I testified in court and provided depositions to defend against claims and high-profile lawsuits pertaining to power outages.

I was a System Protection Engineer for over three years. I was responsible for testing, commissioning, and troubleshooting protective relays from the 4.8 kV circuits to the 500 kV circuits in the distribution, transmission, and generation systems.

I spearheaded LADWP's Distribution Reliability Group in 2007, leading a team of electrical engineers. My project team improved LADWP's reliability performance significantly. We assessed the reliability performance of the distribution system, identified and initiated capital and maintenance projects targeting weak areas, and replaced overhead and underground infrastructure in the appropriate areas for optimum reliability performance.

I supervised a team of electrical engineers in Distribution Planning. We performed load forecasts, prepared load-related feeder plans, and performed load studies to assess the need to install new Distributing Stations.

This completes my statement of qualifications.