Docket	:	A.14-02-008
Exhibit Number	:	
Commissioner	:	Michel Peter Florio
Admin. Law Judge	:	Stephen C. Roscow
ORA Project Mgr.	:	Xian Ming Li
ORA Witnesses	:	Xian Ming Li

OFFICE OF RATEPAYER ADVOCATES
CALIFORNIA PUBLIC UTILITIES COMMISSION

Testimony on Revised Root Cause Evaluation In Pacific Gas and Electric Company Application for Compliance Review of Utility Owned Generation Operations, Electric Energy Resource Recovery Account Entries, Contract Administration, Economic Dispatch of Electric Resources, Utility Retained Generation Fuel Procurement, and Other Activities for the Period January 1 through December 31, 2013 (U39E)

San Francisco, California
September 28, 2016

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CHAPTER 1

TESTIMONY REGARDING REVISED ROOT CAUSE EVALUATION

(Witness: Xian Ming Li)

I. INTRODUCTION AND RECOMMENDATIONS

Pacific Gas and Electric Company ("PG&E") submitted its Energy Resource Recovery Account ("ERRA") Compliance Application for the period of January 1, 2013 through December 31, 2013 ("Record Period") on February 28, 2014. The proceeding addressed costs associated with activities that occurred during the 2013 Record Period, including an outage at Unit 2 of the utility-owned generation ("UOG") nuclear facility Diablo Canyon Power Plant ("DCPP") that occurred between July 10, 2013 and July 14, 2013. Based on its analysis, the Office of Ratepayer Advocates ("ORA") recommended a disallowance of $4,739,812.09 for the 2013 DCPP Unit 2 outage.[1] The proceeding was submitted for decision by the Commission following receipt of reply briefs on October 3, 2014.[2]

On April 6, 2016, PG&E filed a motion to set aside submission of this proceeding and reopen the record to allow for the submission of a revised Root Cause Evaluation ("Revised RCE") of the Unit 2 outage. On May 6, 2016, an Amended Scoping Memo and Ruling of the Assigned Commissioner ("Amended Scoping Memo") granted the motion. PG&E submitted testimony and the Revised RCE on June 20, 2016.

ORA's testimony addresses the reasonableness of PG&E's management of the Unit 2 outage at DCPP. It is based on ORA's analysis of information submitted by PG&E that includes, but is not limited to, PG&E's testimony and workpapers submitted with its application, responses to data requests, and ORA's August 15, 2016 site visit to DCPP.

ORA's review focused on whether PG&E provided clear and convincing evidence that it prudently operated its facilities in compliance with the reasonable manager

[1] ORA Opening Brief, p. 25.

[2] Amended Scoping Memo, p. 2.

standard as defined in Decision ("D.") 09-09-088.[3] ORA considered whether PG&E's actions comported with "what a reasonable manager of sufficient education, training, experience, and skills using the tools and knowledge at his or her disposal would do when faced with a need to make a decision and act."[4] Based on its review, ORA believes that PG&E did not act imprudently in its management of the July 10, 2013 Unit 2 DCPP forced outage. ORA previously recommended a $4.7 million disallowance but with this additional information and review, ORA no longer recommends a disallowance.

II. BACKGROUND

DCPP Unit 1 and Unit 2 each have three phases, or areas, of main bank transformers ("MBT") designated as phases "A" "B" and "C" for a total of six phases.[5, 6] Each phase has a dead end insulator where a 500-kilovolt ("kV") transmission line terminates and an associated lightning arrester ("LA") connected to the 500kV line.[7] DCPP experienced outages due to flashovers of LAs in 2013 and 2014.

A. July 10, 2013 Unit 2 A Phase event

On July 10, 2013, a transmission ("T-line") crew was conducting a hot wash of the Unit 2 A Phase dead-end insulator when an overspray of the wash water from the insulators was blown onto the A Phase LA.[8] This caused a flashover across the LA leading to a Unit 2 reactor trip, causing an outage that lasted until July 14, 2013.[9]

PG&E issued a RCE report in 2013 following the event, known as "RCE A," to determine the underlying causes. PG&E explains that "(a) root cause is the most basic reason(s) for a problem, the removal of which prevents, or minimizes the probability of recurrence of the problem. A contributing cause is a lower level cause that in and of itself

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[3] D.09-09-088, p. 37.

[4] D.09-09-088, p. 37; D.10-07-049, p. 13.

[5] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 33.

[6] See Attachment 8: PG&E Data Request Response ORA_039-Q01 for a map and images of the Unit 2 MBT, dead end insulators and LAs.

[7] *Id.*

[8] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 34.

[9] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 28.

would not result in the event or undesirable outcome."[10] RCE A adopted the following root cause ("RC") and contributing causes ("CC"):[11]

- RC: "Hot washing A Phase transmission line string insulators (500kV dead-insulators) with inadequate controls for oversight of supplemental personnel and risk analysis resulted in a conductive overspray, which induced an external arc around the lightning arrester insulation resulting in flashover."
- CC1: "Interface protocols between DCPP personnel and transmission and distribution facilities personnel were 'not fully implemented.'"[12]
- CC2: "Conflicting procedural guidance and less than adequate execution of AD7.DC6, On-line Maintenance Risk Management caused employees to categorize the hot wash activity as a non-trip risk."[13]
- CC3: The basis for hot wash as a preventative maintenance activity was not properly documented.[14]

B. February 2, 2014 Unit 2 B Phase event

On February 2, 2014, the Unit 2 500kV B Phase LA failed after an hour and a half of light rain, leading to a Unit 2 reactor trip.[15] PG&E conducted a RCE for the event in 2014, known as "RCE B." RCE B determined that the root cause of the event could not be conclusively identified and instead identified a presumptive or probable root cause ("PRC") which could have led to the failure of the LA: "An internal failure of one section of the lightning arrester in conjunction with external moisture resulted in full internal arc through, subsequently grounding the "B" phase main generator output resulting in a Unit differential trip of Unit 2."[16] The RCE could not positively identify the cause of the

[10] PG&E Testimony Regarding Revised Root Cause Evaluation, p. 1-6.
[11] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 54.
[12] PG&E Testimony Regarding Revised Root Cause Evaluation, p. 1-6 and Attachment A, p. 29.
[13] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 29.
[14] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 30.
[15] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 15.
[16] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 244.

internal failure and instead identified three potential causes ("PC"), discussed further in Section III.[17]

RCE B also included as a CC "a potential weakness in IEEE [Institute of Electrical and Electronics Engineers] industry standards for design and testing of lightning arrester since they do not address:

- Non-uniform contamination levels
- Rate of contamination build-up exceeding polymer absorption capacity
- Acceptable external to internal voltage gradient margins."[18]

As a corrective action following the 2014 event, PG&E replaced its polymer LAs with silicone greased LAs to address the PRC and requested that the IEEE standards committee revise its standards to address the CC.[19]

C. Re-review of RCE A

RCE B identified new information regarding lighting arrester properties and flashovers, leading to a re-review of RCE A in 2015.[20] Both LA flashovers involved identical ABB Inc. ("ABB")[21] polymer LA components under similar circumstances of external moisture following an extended period of dry weather.[22] PG&E's Corrective Action Review Board ("CARB") directed a re-review team to examine RCE A and RCE B. It also directed an engineering review of the 2013 RCE report to evaluate the RC and CC of the A Phase LA flashover and determine if corrective actions from the B Phase LA flashover were sufficient to correct the causes of the A Phase flashover.[23]

A Revised RCE was approved by PG&E's CARB on July 22, 2015 that "supersedes" RCE A.[24] For PG&E, when a RCE is superseded, it "has been revised and

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[17] *Id.*

[18] *Id.*

[19] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 24.

[20] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 3.

[21] ABB Inc. is the lightning (surge) arrester vendor.

[22] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 3.

[23] *Id.*

[24] PG&E Testimony Regarding Revised Root Cause Evaluation, pp. 1-10.

the original conclusion and/or corrective actions have been changed making the new document the current document of record for cause and corrective actions."[25] The Revised RCE made the following changes regarding the 2013 A Phase flashover:

- Determined that the RC found in RCE A is no longer applicable and instead, adopted the PRC of RCE B for the 2013 A Phase flashover.[26]
- Determined that only one CC from RCE A is still valid: "Hot washing A Phase transmission line string insulators (500kV dead-end insulators) with inadequate risk analysis contributed to a lightning arrester failure."[27]
- Applied the CC in RCE B to the 2013 A Phase flashover.[28]
- Found that the corrective actions to RCE A and RCE B are complete.[29]

III. DISCUSSION

A. Revisions to RCE

The flashover of the B Phase LA, a component identical to the A Phase LA, under similar circumstances of external moisture, led to additional forensic analysis and technical review that provided additional evidence not present in RCE A.[30] As a result, PG&E reconsidered the 2013 event root cause. PG&E's Revised RCE determined that the A Phase LA had a "design inadequacy that challenged its reliability in DCPP's service environment. The design inadequacy would have made the arrester susceptible to the same failure under conditions of heavy mist or light rain as later proven after the second

[25] *Id.*

[26] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 4.

[27] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 5.

[28] PG&E Data Request Response ORA_037-Q08, p. 1.

[29] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 4.

[30] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 9.

failure."[31] PG&E's re-review found that the RC adopted in RCE A[32] is superseded by the PRC[33] found in RCE B.

Additionally, PG&E reconsidered the contributing causes. RCE A had included three CCs, two of which the re-review decided are no longer valid. They were removed in the Revised RCE and "determined not to be germane to the RCE" because they did not contribute to the event.[34] These two invalidated CCs are:[35]

- CC1: Failure to fully implement interface requirements for transmission and distribution personnel.
- CC3: The basis for hot wash as a preventative maintenance activity was not properly documented.

The Revised RCE retained one CC from RCE A: "Hot washing A Phase transmission line string insulators (500kV dead-end insulators) with inadequate risk analysis contributed to a lightning arrester failure." The hot wash was occurring during the LA failure and was the source of the water, making it a contributor to the event.[36] Additionally, "mis-categorizing the hot wash activity as a non-trip risk led to inadequate risk perception, evaluation, mitigation, and complacency."[37] If the hot washing had been characterized as a higher risk, additional oversight would have been implemented.[38] However, PG&E's re-review shows that even without this CC, the LA could have failed because of the underlying issues with reliability of polymer LAs in general at DCPP.[39]

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[31] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 25.

[32] "Hot washing A Phase transmission line string insulators (500kV dead-end insulators) with inadequate controls resulted in a conductive overspray, which induced an external arc around the lightning arrester insulation resulting in flashover."

[33] "An internal failure of one section of the lightning arrester in conjunction with external moisture resulted in full internal arc through, subsequently grounding the "B" phase main generator output resulting in a Unit differential trip of Unit 2."

[34] PG&E Data Request Response ORA_037-Q07, p. 1.

[35] PG&E Testimony Regarding Revised Root Cause Evaluation, p. 1-6 and Attachment A, p. 54;

[36] PG&E Data Request Response ORA_037-Q06, p. 1.

[37] PG&E Data Request Response ORA_037-Q06, p. 2.

[38] PG&E Data Request Response ORA_037-Q06, p. 1.

[39] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 24.

B. Review of Potential Causes for Probable Root Cause

In the Revised RCE, PG&E adopted a PRC of "(a)n internal failure of one section of the lightning arrester in conjunction with external moisture resulted in full internal arc through, subsequently grounding the "B" phase main generator output resulting in a Unit differential trip of Unit 2."[40] External moisture can be in the form of human initiated moisture, rain, fog, or dew.[41] In the case of the 2013 event, the external moisture was from overspray of the wash water from a hot wash.[42] However, the re-review was not able to positively identify the cause of the internal failure. Instead, it offers three probable causes of the internal failure, ranked from highest probability to lowest:[43]

- PC 1: "Asymmetric deposition of 'extra heavy' levels of contaminants on the surface of the lightning arrester resulting in uneven voltage gradients across the lightning arrester causing a current path internally which leads to a full internal arc through."
- PC 2: "Heavy contamination exceeded the external withstand capacity causing an external failure which subsequently initiated an internal failure."
- PC 3: "Assembly errors resulting in internal contamination initiating an internal failure."

ORA sought clarification from PG&E on the applicability of PC 3 to the Revised RCE since there was no evidence provided to show that the Unit 2 A Phase LA that failed in 2013 had an assembly nonconformance. PG&E stated that PC 3 was incorrectly applied to the Revised RCE and therefore ORA does not address it in this testimony.[44]

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[40] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 4.

[41] PG&E Data Request Response ORA_037-Q02, p. 1.

[42] PG&E Data Request Response ORA_037-Q07, p. 1.

[43] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 4.

[44] PG&E Data Request Response ORA_039-Q03, p. 2.

1. PC1: Asymmetric Deposition of Extra Heavy Levels of Contaminants

DCPP is located near the ocean and based on measured contamination concentrations, it is "classified in the heavy to very heavy contamination area."[45] The LAs in the Unit 2 transformer yard are exposed to salt, dirt and hydrocarbons from proximity to the ocean, construction and a diesel generator.[46] Due to the position of the diesel generator exhaust and wind tunnel in the area, the external contamination is more likely to be concentrated when deposited on the Unit 2 LAs.[47] The west side of the LAs also has a greater concentration of contaminants because the wind tunnel deposits the contamination unevenly.[48] PG&E contracted MPR Associates Inc. ("MPR") to conduct an independent review for RCE B and their research into the "non-uniform deposition of heavy contamination shows this condition to be conducive to heavy surface arcing, tracking, and early flashover."[49]

PG&E was not aware of the issues with asymmetric depositions of contaminants on polymer LAs before it began its review for RCE B.[50] Before PG&E used polymer LAs at DCPP, it had used silicone greased porcelain LAs[51] but had not observed any asymmetric pattern of contamination.[52] PG&E re-greased the LAs during every refueling outage[53] but silicone grease encapsulates the contaminants to prevent the build-up of conductive materials so the asymmetric pattern of contamination was not visible[54] and did not impact the voltage gradient across the porcelain LAs.[55] The Unit 2 LAs were

[45] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 96.

[46] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 231.

[47] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 225.

[48] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 231. August 15, 2016 ORA site visit to DCPP.

[49] PG&E Data Request Response ORA_038-Q01 Attachment 01, p. 7-2.

[50] August 15, 2016 ORA site visit to DCPP.

[51] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, pp. 16-17.

[52] August 15, 2016 ORA site visit to DCPP.

[53] Every 18 months.

[54] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, pp. 94-95.

[55] August 15, 2016 ORA site visit to DCPP.

switched from silicone greased porcelain to polymer in 2011.[56] At that time, PG&E made the decision to switch from porcelain to polymer LAs due to personnel safety concerns; polymer "is a soft rubber compound and cannot fracture like porcelain or become a damaging projectile during a failure."[57]

After the switch to polymer LAs in 2011, PG&E decided to hand clean the LAs during refueling outages.[58] PG&E had one such opportunity to observe asymmetric contamination between installation of the polymer LAs and the July 2013 event and that was during the February 2013 refueling outage.[59] However, there was no guidance to look for asymmetric contamination as the manufacturer and IEEE industry standards are silent with respect to non-uniform contamination levels.[60, 61]

2. PC2: Heavy Contamination Exceeded the External Withstand Capacity

The ABB handbook "identifies that heavy external pollution, such as salt contamination, on LAs is known to change the external voltage distribution. External voltage differences could induce an external failure eventually leading to an internal failure of the LA."[62] Additionally, lack of periodic rainfall allows the buildup of contamination. This, in turn, increases the potential for external voltage redistribution leading to an external arc or internal voltage redistribution leading to partial discharge.[63]

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[56] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 104.

[57] PG&E Data Request Response ORA_039-Q02, pp. 2-3. PG&E determined that returning to porcelain lightning arresters following the 2014 event would be safe "due to the low probability of lightning arrester failure combined with the use of venting ports that limit the lightning arrester internal pressure to prevent a lightning arrester rupture if a failure were to occur."

[58] August 15, 2016 ORA site visit to DCPP.

[59] August 15, 2016 ORA site visit to DCPP.

[60] August 15, 2016 ORA site visit to DCPP. PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 15.

[61] As part of its corrective actions, PG&E has returned to silicone grease porcelain LAs and even though the correction to IEEE standards regarding polymer LAs does not apply, PG&E has requested the IEEE standards committee revise its standard to address non-uniform contamination levels to inform the industry.

[62] PG&E Testimony Regarding Revised Root Cause Evaluation, Attachment A, p. 225.

[63] *Id.*

PG&E states that, "(c)ontinuous years of operation with internal partial discharge could lead to an internal failure of a LA."[64]

PG&E was aware of the high contamination around DCPP and considered the performance of polymer LAs in such an environment before switching from silicon greased LAs. ABB "specifically stipulated to PG&E/DCPP that the polymer lightning arrester meets the IEEE and IEC standards for 'Heavy Pollution'."[65] Additionally, "(b)ased on an international academic consensus, and domestic manufacturer consensus, MPR believes that polymer insulator material is the best HV (high voltage) insulator material in high contamination environments."[66] Based on this information, ORA does not believe that PG&E acted imprudently in selecting and maintaining its polymer LAs.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on ORA's review of PG&E's testimony and workpapers submitted with its application, responses to data requests, and ORA's August 15, 2016 site visit to DCPP, ORA determines that PG&E did not act imprudently in the July 10, 2014 Unit 2 DCPP forced outage. ORA previously recommended a $4.7 million disallowance but with this additional information and review, ORA no longer recommends a disallowance.

[64] *Id.*

[65] PG&E Data Request Response ORA_037-Q09, p. 1.

[66] PG&E Data Request Response ORA_038-Q01 Attachment 01, p. 5-4.

LIST OF ATTACHMENTS FOR CHAPTER 1

#	Attachment	Description
1	ATTACHMENT 1	Statement of Qualifications
2	ATTACHMENT 2	PG&E Data Request Response ORA_037-Q02
3	ATTACHMENT 3	PG&E Data Request Response ORA_037-Q06
4	ATTACHMENT 4	PG&E Data Request Response ORA_037-Q07
5	ATTACHMENT 5	PG&E Data Request Response ORA_037-Q08
6	ATTACHMENT 6	PG&E Data Request Response ORA_037-Q09
7	ATTACHMENT 7	PG&E Data Request Response ORA_038-Q01 Attachment 01
8	ATTACHMENT 8	PG&E Data Request Response ORA_039-Q01 and selected attachments
9	ATTACHMENT 9	PG&E Data Request Response ORA_039-Q02
10	ATTACHMENT 10	PG&E Data Request Response ORA_039-Q03

ATTACHMENT 1

Statement of Qualifications

QUALIFICATIONS AND PREPARED TESTIMONY
OF
XIAN MING LI

Q.1 Please state your name and business address.

A.1 My name is Xian Ming (Cindy) Li. My business address is 505 Van Ness Avenue, San Francisco, CA 94102.

Q.2 By whom are you employed and in what capacity?

A.2 I am employed by the California Public Utilities Commission as a Public Utilities Regulatory Analyst in the Electricity Planning and Policy Branch of the Office of Ratepayer Advocates (ORA).

Q.3 Briefly state your educational background and experience.

A.3 I hold a Master of Science degree in Agricultural Resource Economics from the University of California Davis, and a Bachelor of Arts degree in Economics from University of California Berkeley. I joined the Electricity Pricing and Customer Programs Branch in October of 2012 and joined the Electricity Planning and Policy Branch in April 2016.

Q.4 What is the scope of your responsibility in this proceeding?

A.4 I was responsible for preparing ORA's testimony.

Q.5 Does this complete your testimony at this time?

A.5 Yes, it does.