Russell City Energy Center Incident Investigation

SAFETY AND ENFORCEMENT DIVISION

ELECTRIC SAFETY AND RELIABILITY BRANCH

October 12, 2022

Report Date:	October 12, 2022
Investigators:	James Cheng, Stephen Lee, Chris Lee
Incident Number:	RC20210528-2
Utility:	Russell City Energy Company LLC
Date and Time of the Incident:	5/27/2021 @ 23:47 Hours
Location of the Incident:	3862 Depot Road, Hayward, CA 94545, Alameda County

California Public Utilities Commission

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Executive Summary

Summary of Incident

On May 27, 2021, around 23:47 hours, the Russell City Energy Center (RCEC)experienced a mechanical failure of the steam turbine generator. This Failure resulted in an explosion that threw dozens of metal pieces off the project site and resulted in a fire requiring mutual response by the Hayward, Alameda County, and Fremont Fire Departments. The explosion severely damaged the steam turbine generator. In addition to the immediate public health and safety threat, this incident resulted in a loss of 600 megawatts (MW). Two Firefighters suffered minor smoke related respiratory problems (coughing) after extinguishing the fire. No other significant injuries or deaths were reported. Upon request, RCEC retained an Environmental Consultant, Jensen-Hughes to complete a toxic substance release evaluation. Jensen-Hughes did not discover any unusual toxic substances or that any toxic substances were released.

Root Cause Analysis by Structural Integrity Associates

Structural Integrity Associates (SIA) was retained by RCEC to perform a Root Cause Analysis (RCA). SIA's RCA was released on November 24, 2021. The RCA concluded that there was one cause of the incident, "The systems' inability to detect and drain excess water under pressure and at high temperature within the reheater system is the root cause of the STG drivetrain event [at RCEC].[1]

Joint State Agency Investigative Team (JAIT)

The California Public Utilities Commission's (CPUC) Safety Enforcement Division (SED) and the California Energy Commission (CEC) established a Joint State Agency Investigation Team (JAIT). The JAIT was comprised of engineers from SED's Electric Safety and Reliability Branch (ESRB) as well as engineers from the CEC. The CEC has jurisdiction and permitting authority for thermal power plants 50 MW and greater in California. This jurisdiction includes infrastructure associated with these thermal plants and is intended to ensure that proposed thermal power plants are designed, constructed, and operated in a manner that protects public health and safety, promotes general welfare, and preserves environmental quality.

The CPUC's Safety and Enforcement Division ensures that regulated electric, gas, and telecommunications services are delivered in a safe and reliable manner. In particular, ESRB

[1] Investigative Report Calpine Russell City Steam Turbine/Generator Event, Structural Integrity Associates, Page 4.

enforces CPUC rules, Public Utilities Code and General Orders (GOs) to ensure that power plants and utility companies run a safe and reliable electric system.

The JAIT reviewed the RCA and concluded that an inspection of the power plant, review of associated documents and training records was necessary. The JAIT reached this decision because SIA's RCA was limited in the scope, both in its analysis and restoration recommendations. From February 7th – 9th, 2022, the JAIT conducted an onsite investigation at RCEC. The investigation focused on the power train involved in the incident, as well as facility operations, maintenance, and management practices.

Three Causal Factors Identified by JAIT

As a result of the investigation, the JAIT determined that there were three categories of causal factors in the incident. The categories are:

1. Deficiencies in control room operator interface and training;
2. Deficiencies in maintenance for critical valves and equipment; and
3. Inadequate protection from water induction.

This report elaborates on SED's six (6) Findings, three (3) Recommendations, and five (5) Observations that require corrective actions.[2]

Conclusion

Over the course of the investigation, the JAIT worked closely with both RCEC and the Russell City Energy Company, LLC (RCEC, LLC) to ensure that each of the Findings, Recommendations and Observations were appropriately resolved. Upon the JAIT's site visit to the facility in May 2022, the JAIT concluded that all corrective actions had been completed.

The outstanding and collaborative nature of working with both the CEC and City of Hayward has provided SED with the resources to complete a more in-depth investigation, including access to the outstanding experience and expertise of the CEC Engineering staff, the City of Hayward's Administrative staff and the input from first responders. The depth of this collaboration has also opened additional avenues for both agencies to work together to provide effective regulatory oversight and resolve contemporary issues facing the electric energy sector of California.

[2] In this context, "Findings" are possible violations of General Order 167-B Operating Standards. Findings become violations if not cleared up by a corrective action. "Recommendations" are improvements and Industry Best Practices not mandated by any regulation. Finally, "Observations" are issues that need follow-up or are issues of concern.

I. Incident Investigation

Summary of Incident and Investigation

On May 27, 2021, at approximately 23:47 hours the Russell City Energy Center (RCEC) had a serious incident involving the steam turbine and its associated generator (STG) which resulted in a fire and explosion. The fire started because of an "overspeed event". Lube oil continued to fuel the fire which then ignited the hydrogen used to cool the generator. Twenty minutes after the Hayward Fire Department (HFD) arrived on scene, the location of additional hydrogen storage was established and secured, and the lube oil pumps were shut down. With this accomplished, the HFD extinguished the fire at approximately 03:00 hours the following morning. The Alameda County Fire Department and the Fremont Fire Department also responded and provided back-up.

No injuries to RCEC personnel were reported. Fire suppression water carried lube oil into the site's storm water retention pond. This pond discharges into the canal west of RCEC. The discharge was contained, and no waterways were impacted. RCEC returned to service on August 10, 2021, at 21:00 hours with the combustion turbines operating in simple cycle. Simple cycle is also referred to as one-by-one (1X1) operation where the exhaust heat is not captured for the Steam Turbine (STG). Current production available is 350 megawatts. The anticipated date for replacement of the ST Gen-Set and full operation is June 1, 2022.

Fatalities / Injuries

No fatalities or injuries to plant personnel were reported.

Property Damage

The incident severely damaged the Steam Turbine and Generator Set (ST Gen-Set). Debris and parts were expelled (liberated) from the facility and sent into adjacent properties up to a quarter mile away. Most notably the Public Utility Water Treatment Facility and the Hayward Housing Navigation Center on Depot Road were damaged by debris.

Utility Facilities Involved

The Mainstream Turbine and Generator (ST Gen-Set) and auxiliary equipment.

Investigation Participants

	Name	Title	Phone
1.	[redacted]	[redacted] Manager	[redacted]
2.	[redacted]	[redacted] Manager	
3.	[redacted]	[redacted] Director [redacted]	[redacted]
4.	Jim Cheng	SED Lead Utilities Engineer	(916) 928-9839

5.	Chris Lee	SED Utilities Engineer	(415) 703-1323
6.	Stephen Lee	SED Utilities Engineer	(916) 661-2353
7.	Geoff Lesh	CEC Lead Engineer	(916) 651-9859
8.	Tim Smith	CEC Engineer	(916) 651-9851
9.	Brett Fooks	CEC Engineer	(916) 654-5593

Documents Reviewed

A comprehensive list of all documents reviewed over the course of this investigation is included in Appendix B at the end of this report.

Chronology of the Incident Investigation

This section provides a chronology of the investigative activities undertaken by the CPUC and CEC in response to the May 27th incident.

June 7, 2021

After the May 27th incident, the managers of RCEC (Plant Management) requested to delay the physical investigation of RCEC by a week to allow for a complete safety evaluation, provide scaffolding and secure oil slick walkways. On June 7, 2021, an engineer from the Electric Safety and Reliability Branch (ESRB) of CPUC's Safety and Enforcement Division (SED) and two engineers from the CEC were onsite to investigate the incident. Plant Management also limited access to RCEC due to COVID protocols. Safety orientations were held outdoors, and the control room was in lock down making interviews with control room staff difficult.

During the initial tour of RCEC there was evidence of an oil fed fire by the residual oil and the black charring of surfaces. All fire suppression devices had discharged. Large holes in the turbine casing provided evidence that parts from the steam turbine had exited [redacted].

The Steam Turbine Generator is divided into four major parts: the High Pressure (HP) Section, Intermediate Pressure (IP) Section, Low Pressure (LP) Section and the Generator. Each section is connected by large solid steel shafts. This is illustrated in Figure 1. The steel shafts are supported by bearings which have high pressure oil (lube oil) injected into them. The lube oil and lube oil pumps allow the shafts to rotate and prevent the Turbine from stopping due to surface rubbing and wear called "bearing seizure".

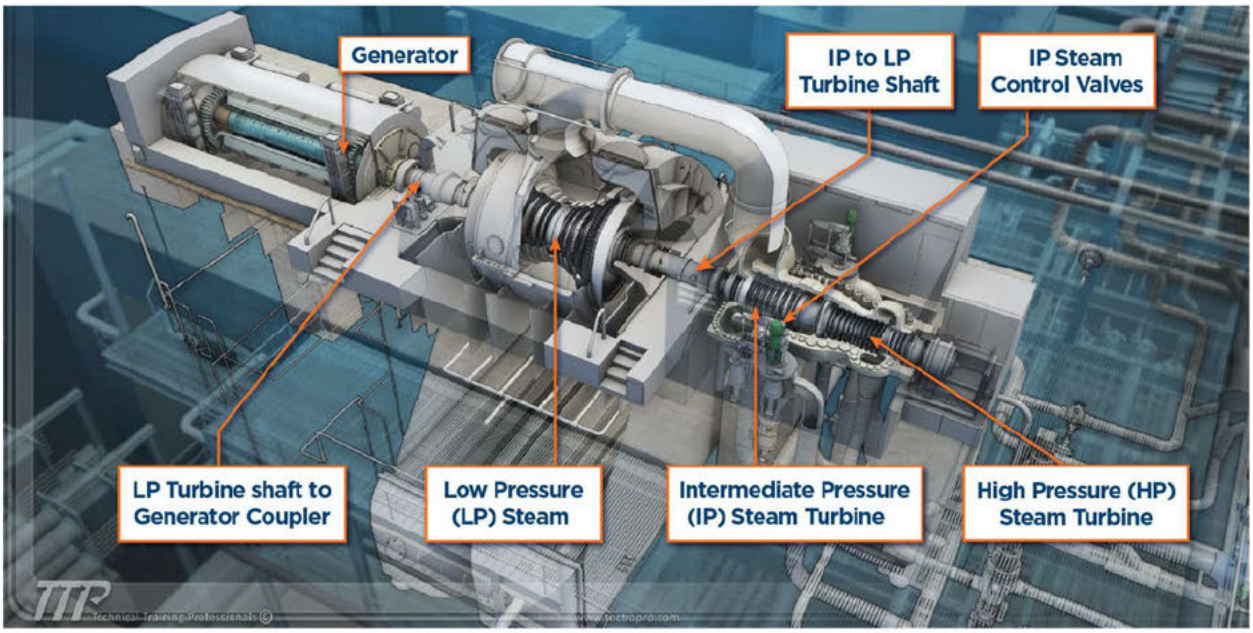

Figure 1: General Electric [redacted] Steam Turbine Generator Graphic.[3]

Figure 2. Aerial view of RCEC.

The investigation began with a tour of the damaged Steam Turbine Generator (STG). Starting at [redacted] direction. An aerial view (AV) is provided for orientation.

[3] Figure 1: Technical Training Professionals.

Figure 3: Google Aerial View (AV) to help in orientation. This picture is the Steam Turbine upper deck before the incident and shows the path engineers took during the tour.

[redacted], SED Staff observed extensive damage to the "Front Standard". This is the control point for the STG and provides rotational speed indicators, axial thrust indicators and lube oil pressure monitoring. Staff observed that the damage was significant with the speed indicator being completely smashed, bearings had completely ceased, and sheared bolts and missing hardware were evident.

Figure 4. The "Front Standard" with the housing and top casings removed.

Figure 5. Damage was evident to the speed indicator and the bearings were seized.

The Combined Hot Reheat Control (CHRH) valve provides steam to the intermediate pressure section of the STG. This is the valve that Structural Integrity Associates (SIA) determined had failed due to thermal seizure and allowed water to enter the STG. It is this water which caused the "water impingement event" (event). This event preceded the STG overspeed.

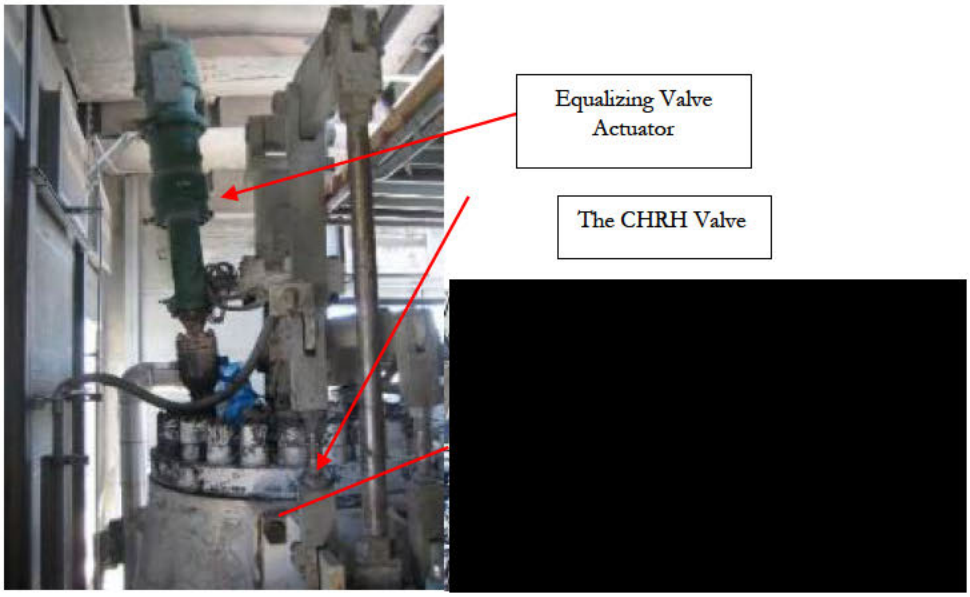

Figure 6. Turbine Steam Combined Hot Reheat Stop and Control Valve [redacted].

The STG shaft [redacted] the intermediate pressure (IP) section and at the connection point to the low-pressure (LP) section. The connecting section was [redacted].

Figure 7. The Turbine shaft that connects the High-Pressure and Intermediate Turbine to the Low Pressure (LP) Section [redacted]. All upper bearing housings [redacted].

The connecting section of the IP & LP sections [redacted]. The metal casings of the IP & LP sections [redacted].

Figure 8. The IP - LP turbine shaft [redacted]. This was lowered to the ground after the incident.

The LP exit point that connects to turbine to the generator [redacted]. The drive shaft connecting the LP section to the generator [redacted].

Figure 9. LP Turbine housing and Output shaft.

There is clear evidence of the connecting end of the generator shaft [redacted].

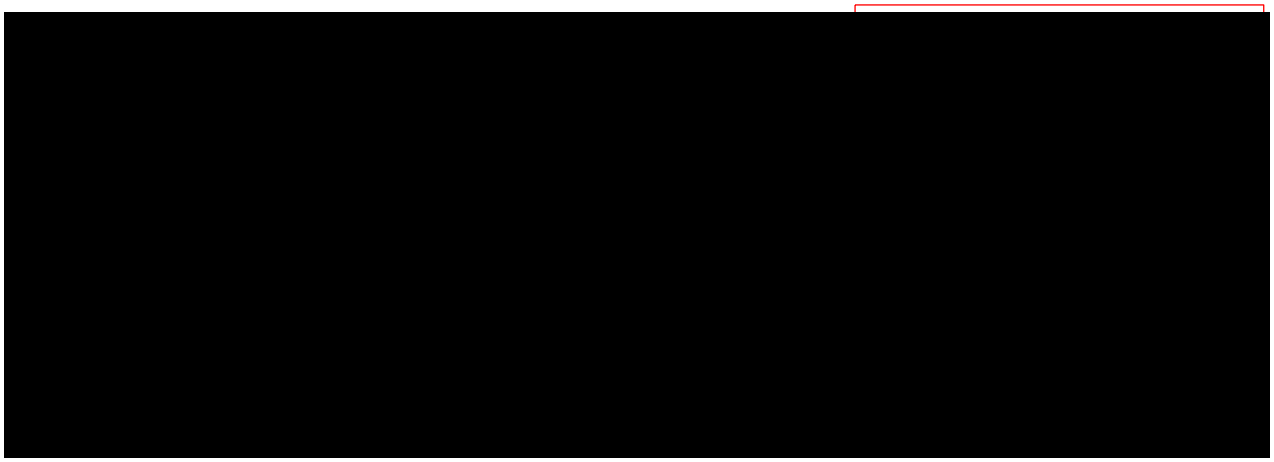

Figure 10. The Generator Input shaft and the Generator coupling .

The turbine to generator connection shaft .

Figure 11. This is the Generator Input Shaft. .

the STG where the commutator or electrical connection to the generator is

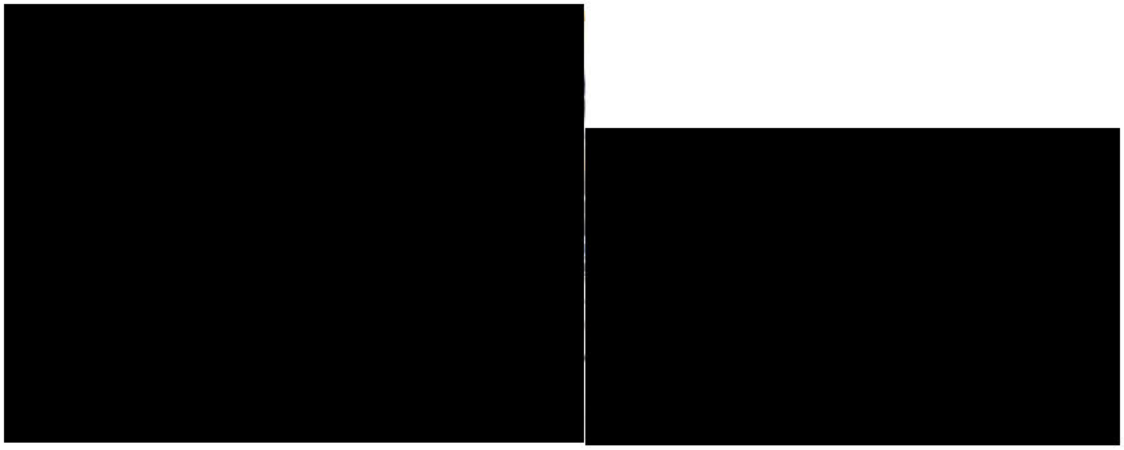

Figure 12. This end is the Generator Commutator and Exciter.

[redacted] shows the extreme force applied upon it.

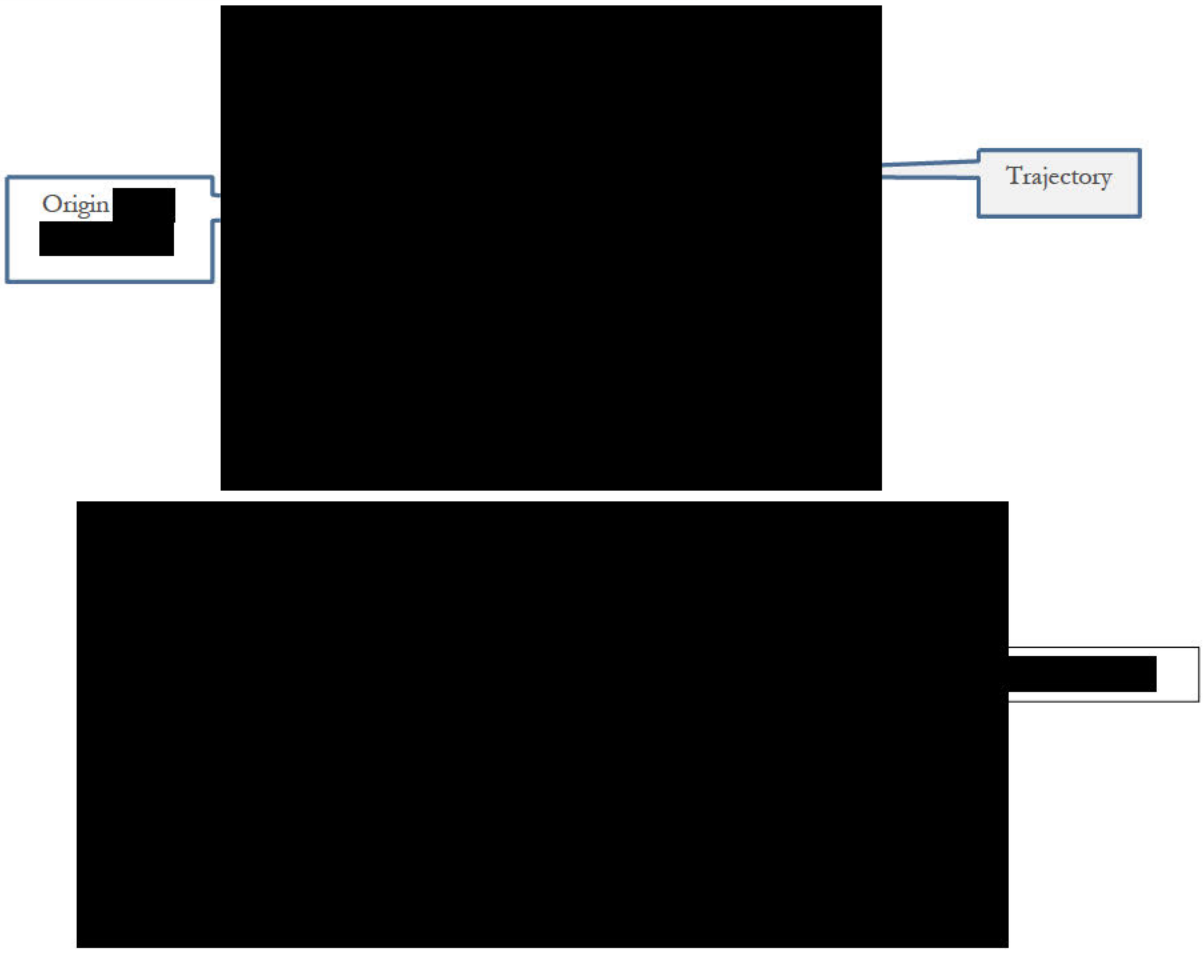

Figure 13. The [redacted] was found next to [redacted] after striking the [redacted].

When the rotation of the turbine blades exceeds design limits, they become disconnected from the shaft (liberated) and cause extensive damage. The design limit for this turbine is approximately 4,100 revolutions per minute (RPM). [redacted]. The liberation of turbine blades [redacted] up to a quarter mile into the surrounding community.

Figure 14. Left: Southeast LP Turbine Casing [redacted]. Right: North facing LP Turbine casing [redacted].

A facility for assisting unhoused individuals, the "Housing Navigation Center" had a 12-pound turbine root pierce their roof and land in a food preparation area. Fortunately, there were no fatalities or significant collateral damage. The facility was unoccupied at the time of the incident due to COVID.

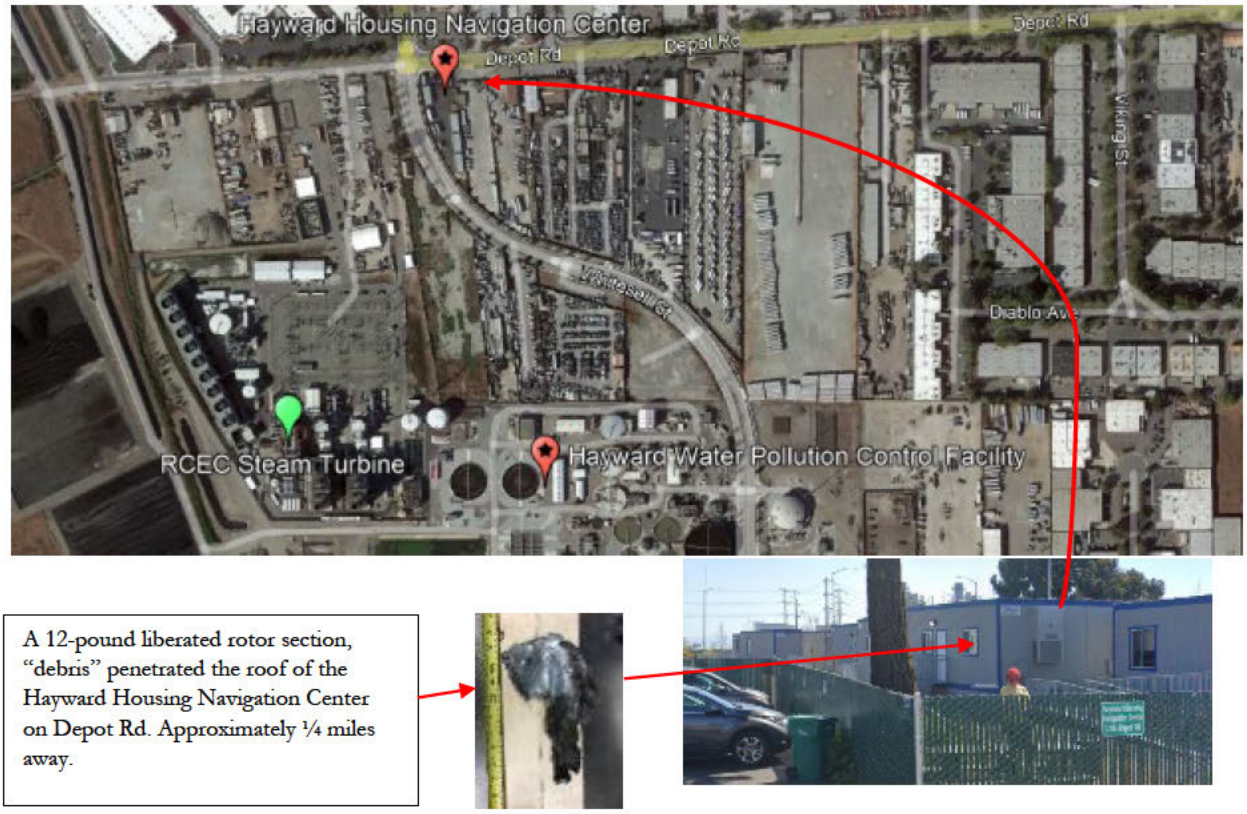

Figure 15. Debris was scattered in the adjacent Hayward Waste Pollution Control Facility and as far as a quarter of a mile away at the Hayward Housing Navigation Center.[4]

Lube oil supply lines were severed, and the pumps continued to supply oil during the initial incident response by firefighting agencies. This continued supply of oil hampered fire suppression efforts. The lube oil pumps were not shut down until the fire department requested it twenty minutes into the fire fight. Two fire fighters suffered smoke related injuries: bloody noses, difficulty breathing and coughing. They were placed on home medical leave for two days after the incident.[5] RCEC, LLC hired Jensen-Hughes to investigate possible toxic fume releases from the fire and none were noted.

[4] Hayward Housing Navigation Center | City of Hayward - Official website (hayward-ca.gov).

[5] Telephone Interview with Hayward Fire Chief Garrett Contreras, July 13, 2021

Figure 16. Severed lube oil lines

Lube oil was then carried by the fire suppression water into the drainage ditch and retention pond. An estimated 4,000 gallons of lube oil was released. Fortunately, the wind helped retain the oil booms and oil slick from exiting RCEC's Retention Pond. RCEC, LLC hired Environmental Logistics (EL), to survey the stormwater retention pond and the channel that feeds out to the San Francisco Bay. EL's biologist confirmed that no lube oil had made it offsite.

Figure 17. The storm water runoff canal and oil absorbing socks in use.

Figure 18. The water retention pond and the oil retention booms in service.

June 17, 2021

Two ESRB engineers visited the site to do another follow-up incident investigation.

Figure 19. The steam turbine upper casing and rotor [redacted].

Figure 20. [redacted] rotor.

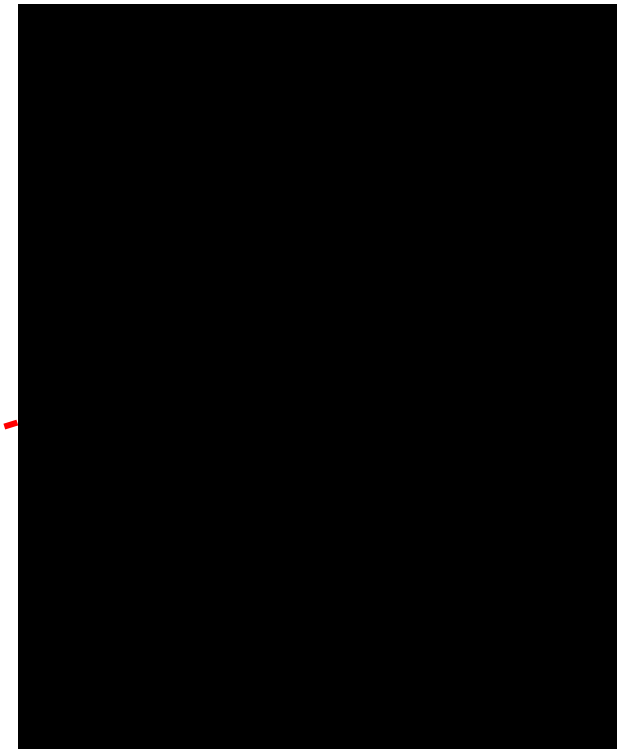

Figure 21. Close-up of the rotor [redacted]

August 3, 2021

The JAIT established coordination with City of Hayward and met onsite with the Hayward Fire Chief to discuss the incident and future coordination efforts. During this visit the JAIT also toured the Hayward Housing Navigation Center facility.

Figure 22. Navigation Center food preparation area.

Figure 23. Navigation Center roof hole caused by debris.

Figure 24. Left: Blade root as found in the Navigation Center.

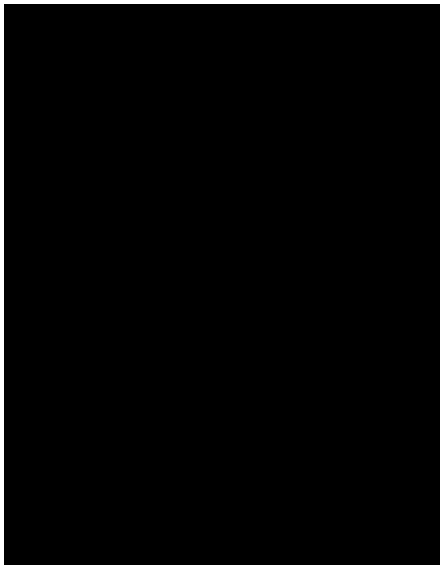

Figure 25. [redacted] IP section of the STG.

August 5, 2021

CPUC – SED Lead Engineer, Jim Cheng provided an overview of the CPUC's 2019 RCEC Audit Report. The attendees[6] also discussed the corrective actions identified, implementation, a forthcoming site inspection and the process and timeline for the RCA.

[6] Attendees included both CEC and SED engineers, the Hayward County Fire Department (the local Certified Unified Program Agency (CUPA)), and City of Hayward's City Manager's Office (COH).

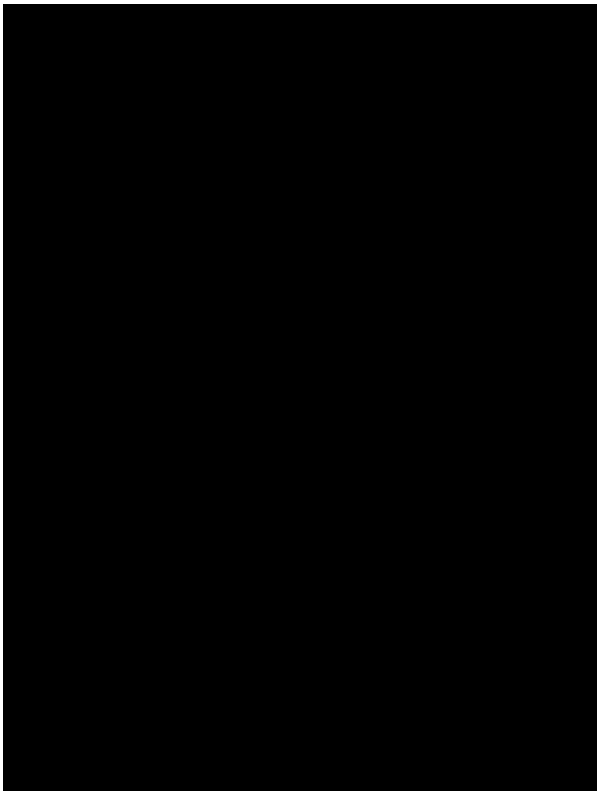

Figure 26. STG removed.

Figure 27. Capped main steam lines.

Figure 28. Emergency steam exhaust ports.

August 10, 2021

RCEC returned to operations in simple cycle mode (combustion turbines only) producing 300 megawatts.

August 16, 2021

CPUC – SED Lead Engineer, Jim Cheng provided a PowerPoint presentation on the CPUC's General Order (GO) 167-B and the 2019 RCEC Audit Report. Attendees present included CEC Chair David Hochschild; former STEP Lead Commissioner Karen Douglas; Hayward Mayor, Barbara Halliday; Hayward City Manager, Kelly McAdoo; Hayward Fire Chief, Garrett Contreras; CEC Compliance Monitoring and Enforcement Office Manager, Elizabeth Huber; CEC Engineering Office Manager, Geoff Lesh; CEC Engineers, Brett Fooks and Tim Smith; [redacted] Manager, [redacted], [redacted] Vice President [redacted]; and [redacted] Director [redacted], [redacted] The attendees also toured the explosion and fire site.

Figure 29. Combined Hot Reheat (CHRH) valve was open for inspection and analysis. A forensic analysis by Structural Integrity Associates indicate this valve played a key role [redacted].

August 19, 2021

CEC Commissioner Andrew McAllister and Patricia Monahan attended a tour of the RCEC facility and the Hayward Housing Navigation Center.

August 27, 2021

CEC Vice Chair Siva Gunda, and former CPUC President Marybel Batjer attended a tour of the RCEC facility and the Hayward Housing Navigation Center.

October 19, 2021

The CEC inspection team performed a compliance inspection of RCEC to review whether RCEC was in conformance with the Conditions of Certification.

November 30, 2021

Structural Integrity Associates (SIA) presented their Root Cause Analysis (RCA) Report and recommended corrective actions to CEC, SED CUPA and COH staff. The presentation included a question-and-answer period as well as an onsite inspection. Engineers from SED and the CEC came away from the RCA Presentation unsatisfied with the analysis. The RCA was limited in the scope. Both the CPUC and CEC concluded that further investigation to identify the fuller set of causal factors in the incident was needed.

December 21, 2021

The CEC and SED responded to SIA's RCA by forming the Joint agency Investigation Team (JAIT), consisting of three engineers from the CEC and three engineers from SED. CEC staff decided to hire an expert consultant to gain a better understanding of the incident. The two engineers, from West Peak Energy then joined the JAIT.

January 3, 2022

CEC and SED leadership and staff, CUPA and COH staff received another and more in-depth briefing from Structural Integrity Associates on the Root Cause Analysis Report. The JAIT also conducted a site tour and inspection to see the restoration progress being made.

February 7 – 9, 2022

The JAIT performed a comprehensive onsite investigation of the explosion and fire site.

The JAIT focused its site inspections not only on the power train involved in the incident that is comprised of the steam turbine and electrical generator and associated heat recovery steam generator, but also examined facility operations, maintenance, and management practices that may have contributed to the causation of this incident.

Figure 30. Lower half of the steam turbine in place.

Figure 31. The Cold Reheat Valve that allowed the accumulated water to enter the Steam turbine.

March 21, 2022

The JAIT provided a list of corrective actions and a required compliance timeline to RCEC Management.

RCEC retained SIA who performed the Root Cause Analysis (RCA). The RCA was released to the CPUC and CEC on November 24, 2021. SIA was established in 1983 and acts as an Industry Consultant specializing in the Root Cause Analysis of system failures. Although SIA's RCA provided an overview of the event, equipment involved and outcome of the incident, it failed to include electrical failures and, most importantly, human factors.

The RCA concluded with a singular cause of the incident: "The systems' inability to detect and drain excess water under pressure and at high temperature within the reheater system is the root cause of the Steam Turbine Generator drivetrain event at Russell City Energy Center."[7] And put forth four "Restoration Recommendations":[8]

1. Implementation of controls logic to utilize existing Heat Recovery Steam Generator (HRSG) reheated system drains to discharge water from the HRSG harps when offline.
2. Implementation of controls logic to utilize existing HRSG reheated system drains to alleviate undesirable pressure within the HRSG reheater system when offline.
3. Re-configure the Cold Reheat (CRH) stop valve to close based on its actuator torque value.
4. Convert the Hot Reheat (HRH) stop / check valve from manually operated to electrically actuated including the implementation of controls logic to positively isolate the offline HRH piping and HRSG RH.

Recommendations 1 and 2 utilize existing hardware to prevent unintended levels of water and pressure within an offline HRSG without requiring operator intervention, thereby reducing the risk of a water accumulation that could lead to an induction event.

Recommendation 3 reduces the risk of the CRH piping supplying steam to an offline HRSG which can result in the accumulation of water and pressure.

Recommendation 4 reduces the risk of a water induction event from occurring with the addition of valve actuators and controls logic that do not require operator interaction.

[7] Structural Integrity Associates, Root Cause Analysis pg. 4

[8] Structural Integrity Associates, Report No. 2100930.401 October 18, 2021, Pg. 2-3

Figure 32. Logic of RCA corrections and how they will be implemented.[9]

May 18 – 20, 2022

The JAIT performed a two-day on-site inspection to review the progress made by RCEC Staff and to clear outstanding Corrective Actions.

The JAIT noted that several issues remained unresolved. At the conclusion of the on-site inspection, the JAIT requested the following additional documentation and proof of compliance:

- Proof of Low-Pressure Auxiliary Steam Block & Control Valve of the Heat Recovery Steam Generator installation.
- Improvements to the "Water Induction Procedures" to enhance the stepwise processes and correct grammatical errors that could create a lack of clarity and non-conformance (GO 167-B Operating Standard 7).
- Proof of completion for he "Alarm Prioritization" work.
- Proof of compliance to all ASME TDP-1 standards and updated spreadsheet annotations.
- A copy of RCEC's - CUPA response and attachments sent to the City of Hayward.

[9] Structural Integrity Associates Power Point Presentation November 30, 2021.

- Inclusion of "water off" instructions to the ONPO and Emergency Shutdown Procedures.
- Photos of the new Intermediate Pressure (IP) and Low Pressure (LP) turbine blades.
- Photos of the IP-LP rotor in lower casing.
- Photos of all newly painted ammonia tank surfaces.
- Photos of the ferric-sulfide tank and valving.

The following photos are from the May 2022 visit.

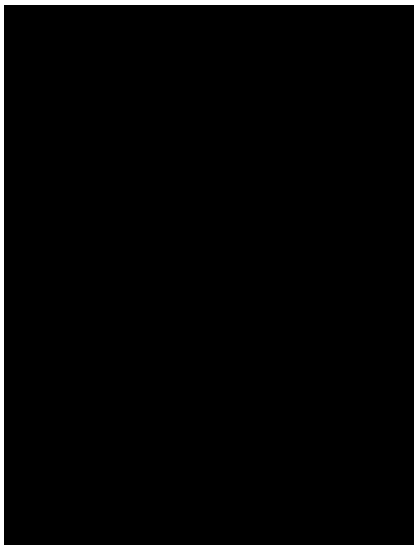

Figure 33. Missing LP Block Valves.

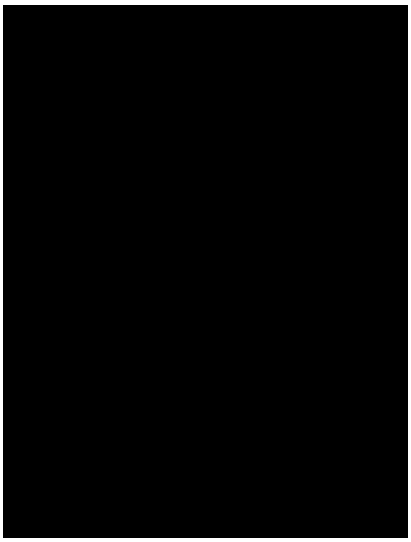

Figure 35. Newly install IP Block Valves.

Figure 34. New Cold Reheat Control Valve.

Figure 36. New motor actuated Steam Intercept Valve. Time for this valve to close has been reduced from [redacted] mins to [redacted] mins.

Figure 37. New Generator in place.

Figure 38. New advanced non-sparking dual clip commutator.

Findings and Corrective Actions

Joint Agency Review of Root Cause Analysis

The SED and CEC Engineering Teams reviewed SIA's RCA and found the RCA to be limited in its analysis and recommendations. Both teams observed many shortcomings with the report. For example, the report did not include a cause map or logic tree and failed to provide any analysis of human interaction, provision of preventative maintenance, inclusion of auxiliary equipment or a detailed investigation of the malfunctioning valves, gear boxes or actuators. The JAIT determined that the RCA had inadequately covered the following areas: offline steam piping isolation, control room operator interface and training, and maintenance.

Because of these shortcomings, the JAIT developed a list of Corrective Actions RCEC needed to resolve to resume combined cycle operations by June 1, 2022. This comprehensive list of Corrective Actions along with the expected date of completion can be found in Appendix C. These corrective actions contain a mix of operations and maintenance changes, improvements to operator notification systems to improve situational awareness, and upgrades to hardware and control system integration.

The JAIT also conducted a site investigation to fill in the areas where the RCA was lacking or fell short in addressing specific questions. The JAIT conducted the site investigation of RCEC from February 7 through February 9, 2022.

SED's Findings, Recommendations, and Observations

SED's analysis of the events leading up to the incident and the incident itself, as well as document reviews and on-site visits and audits resulted in the following findings, recommendations, and observations.

Findings

This section details ESRB's Findings or possible violations of General Order 167-B Operating Standards that ESRB engineers observed in relation to the May 27th incident. Findings do not trigger a Notice of Violation (NOV) unless power plant management or the generating asset owner refuse to comply by generating a corrective action. In short, findings become violations if not cleared up by a corrective action. SED issues NOVs in cases of negligence or violations of safety and general orders.

FINDING 1

GO 167-B Operating Standard 28: Equipment and System, states:

"H. Steam Turbine

2. Detailed Guidelines

In developing its plans, procedures, and training programs to comply with the Operating Standards, the GAOs should consider the following issues.

> *27. Water induction potential is minimized. If no formal water induction equipment is in-place or is unavailable, there is a total plant procedure indicating operating practices of other components to affect a water induction minimization program. There are several ways that water induction can occur. Operations personnel are aware of these causes in order to be able to react to and minimize water induction. Appropriate action is taken upon the detection of water induction to prevent damage." (emphasis added)"*

Finding 1: RCEC lacked adequate training of staff for a water induction event.

SIA's RCA states, "The systems' inability to detect and drain excess water under pressure and at high temperature within the reheater system is the root cause of the STG drivetrain event at Russell City Energy Center."[10] Of the 5,391 transient alarms (insignificant alarms that display such as motor not "on"), 39 non-transient alarms (alarms that display an unusual condition) occurred later in the 1x1 block 2 (one combustion turbine "Unit 2" and one steam turbine) operation and after SIA forensically determined that water had accumulated in HRSG 1. Thirteen of these non-transient alarms occurred during operation [redacted] hours prior to the trip. [redacted] [11] Therefore Personnel should have been appropriately trained to respond to or differentiate the "transient" and "non-transient" alarms that flooded the control system prior to the incident. RCEC was unable to provide SED with evidence of a specific procedure or training program addressing water induction to mitigate or reduce the risk.

RCEC was exempt from having a Water Induction Procedure at the time of commissioning. RCEC was commissioned in 2007 and ASME TDP-1 Standards became mandatory in 2013. RCEC has since established a specific Water Induction (Prevention) Procedure as well as several revamped Training Procedures. ESRB engineers did not issue a Notice of Violation (NOV) because RCEC was exempt and only by continuing to operate without ASME TDP-1 Standards would be a violation of this standard. ESRB cleared this Finding on May 30, 2022.

FINDING 2

GO 167-B Operating Standard 13: Routine Inspections, states:

"A. In the case of data monitored automatically, plant control systems act to warn personnel via the alarms or other appropriate notices evident to personnel. Personnel

[10] Structural integrity Associates Root cause Analysis, page 4, paragraph 4.

[11] Root Cause Analysis, Structural Integrity Associates, page 37, paragraph 1.

take appropriate action in response to alarms or notices. Data is filed in accordance with plant procedures."(emphasis added)

Finding 2: The alarm system did not appropriately notify Plant Personnel of the pending water induction event.

The [redacted] controller registered 5,391 alarms during a four-day period prior to the incident. Thirty-nine (39) of these alarms were raised after the accumulation of water in the reheat system was present. Thirteen (13) of the alarms occurred during transient operation and indicated the presence of water. Page 11 of the RCA, "*Review of* [redacted] *alarm logs also indicated alarms were present indicating the presence of water detection in the RH Bowl feeding the IP steam turbine based on bowl thermocouple temperature spreads."*[12] RCEC responded that 3,578 of the prior alarms were appropriate since HSRG 1 was out of service and on "turning gear".[13] RCEC Plant Management insisted no action was required. ESRB engineers insisted that the turning gear system alarms must be either differentiated in or removed from the [redacted] control notification system. This differentiation would have allowed the 13 significant alarms and reheat bowl alarms to prompt an appropriate response from the Control Room Operator.

In response to ESRB's concerns, RCEC has since established alarm prioritization, mapping and coding. This included visual color coding on their annunciator. ESRB engineers did not issue a Notice of Violation (NOV) because only continued operation in this manner would be a violation of this standard. ESRB cleared this Finding on May 30, 2022.

FINDING 3

GO 167-B Operating Standard 13: Routine Inspections, states:

"Routine inspections by plant personnel ensure that all areas and critical parameters of plant operations are continually monitored, equipment is operating normally, and that routine maintenance is being performed. Results of data collection and monitoring of parameters during routine inspections are utilized to identify and resolve problems, to improve plant operations, and to identify the need for maintenance. All personnel are trained in the routine inspections procedures relevant to their responsibilities."

Finding 3: Plant Personnel failed to inspect and utilize proper lubrication for the Limitorque actuator.

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[12] There is also a footnote indicating that the [redacted] alarm indirectly indicated the presence of water, based on differential temperatures within the ST approximately [redacted] prior to the trip command. The [redacted] time [redacted] corresponds approximately to [redacted] as the [redacted] clock is approximately [redacted] off in synchronization to site local time.

[13] SIA Root Cause Analysis: Page 36 Sec. 5.10

The HRSG #1 CRH stop valve contributed to the STG failure and utilizes a gear box and Limitorque MX20A actuator. The Original Equipment Manufacturer (OEM) manual, *Maintenance of the Actuator* Section 6 –states, "clean and lubricate the valve stem regularly to avoid torque build-up and wear due to silting and corrosion" and Section 6.1 – *Lubrication* further specifies that for lubrication, "MX actuators are oil-filled, as standard, using Mobil SHC 632. Exxon Teresstic SHP 320 may be used as a direct substitute." When ESRB engineers requested clarification as to which lubrication was used for the Limitorque actuator components, RCEC indicated it uses Mobilith SHC 100. ESRB engineers could only find a limited number of inspection work orders. Continued failure to periodically inspect and utilize proper lubrication for the Limitorque actuator is a violation of this standard.

RCEC has since established a preventative maintenance (PM) program for the gear box and established corrected lubrication requirements. ESRB engineers did not issue an NOV because it was never determined if the lubrication was at fault for the failure. Additionally, the OEM manual did not provide a time interval for the PM. ESRB cleared this Finding on May 20, 2022.

FINDING 4

GO 167-B Operating Standard 28: Equipment and Systems, states:

"H. Steam Turbine

2. Detailed Guidelines

In developing its plans, procedures, and training programs to comply with the Operating Standards, the GAOs should consider the following issues.

I. Monitoring Critical Operating Parameters Gland Seal System

2. Detailed Guidelines

In developing its plans, procedures, and training programs to comply with the Operating Standards, the GAOs should consider the following issues.

c. Temperature control by attemperation and spray water control valves are in good working condition.) Any orifices for either continuous drain lines or spray nozzles are monitored for operation impacts due to excessive wear." (emphasis added)

Finding 4: RCEC does not provide annual preventative maintenance for the attemperators and other system critical valves.

RCEC was unable to identify or provide SED with any attemperator maintenance records. Industry *"Best Practices"* indicate that all Power Plant attemperators should be inspected annually and records must be retained on any preventative maintenance (PM) or repairs. Continued operation without an annual PM and record keeping is a violation of this standard.

No PM was required by the original equipment manufacturer (OEM). RCEC has since established an annual PM program for the attemperators and other critical steam system valves. ESRB cleared this Finding on May 20, 2022.

FINDING 5

GO 167-B, Operating Standard 8: Plant Status and Configuration, states:

"Station activities are effectively managed so plant status and configuration are maintained to support safe, reliable and efficient operation.

B. Configuration Control

4. Lessons learned from user feedback, maintenance history, and operating experience are used to improve configuration control processes." (emphasis added)

NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, – 5.4.6.1 Turbine Lubricating Oil Fires, states:

"A critical aspect of responding to turbine lubricating oil fires is minimizing the size and duration of the oil spill. The need for lubrication to protect a turbine-generator's bearings and shaft should be balanced against fire damage from allowing the oil leak to continue. The following steps can be useful in minimizing fire damage and should be considered during preplanning and training for emergency conditions:

1) Tripping the turbine." (emphasis added)

Finding 5: RCEC does not allow for Operator Intervention (best judgment) is shutting down system components during an emergency situation.

The lube oil system remained on for twenty minutes after the Steam Turbine came to a full stop. To minimize the size and duration of the oil spill, Plant Operators should be trained and given the authority to shut off lube oil pumps and water supply pumps under these conditions. Not doing so exacerbated the release of oil and spread of the fire. Continued operation without such Operator Intervention is a violation of these standards.

RCEC has added water shutoff procedures to the On Normal Operations Procedures (ONOP) and Emergency Operations Procedures (EOP). ESRB engineers cleared this Finding on May 30, 2022.

FINDING 6

GO 167-B Operating Standard 8: Plant Status and Configuration, states:

'Station activities are effectively managed so plant status and configuration are maintained to support safe, reliable, and efficient operation.

B. Configuration Control

Lessons learned from user feedback, maintenance history, and operating experience are used to improve configuration control processes."

GO 167-B Operating Standard 4: Problem Resolution and Continuing Improvement, states:

"The GAO values and fosters an environment of continuous improvement and timely and effective problem resolution."

A. Self-Assessment

Self-assessment activities are used to compare actual performance to management's expectations, and to identify and correct areas needing improvement. While self-assessments, by definition, are driven from within, they may be used to measure internal performance to external criteria, such as CAISO, EPA or OSHA. Self-assessment is both a discreet activity and a continuous process that may include such activities as:

1. Dedicated teams, with a specific chartered objective to assess certain program(s) or element(s).

2. Management monitoring of on-going performance through performance metrics or problem resolution process monitoring.

3. Discreet event investigations."

Finding 6: RCEC failed to complete an in-depth analysis of the Combined Hot Reheat Steam Valve #2 (CHRH).

SIA identified the CHRH as having suffered deformation (bending) and thermal seizure, thus allowing water and steam to enter and cause the overspeed event to occur. This conclusion was arrived at by visually inspecting the valve stem. This visual inspection ignores other possible causes for valve seizure such as water hammer or vapor lock. Results from a formal metallurgical investigation can be more precise and facilitate industry wide improvements. SED agrees with RCEC that all metals are subject to thermal and physical distortion, but some alloys are more resistant to this than others i.e., turbine blades. It also needs to determine if the valve stem is compliant with all OEM specifications. Therefore, citing GO 167-B, Section 11.3[14], SED insists that

[14] GO 167-B. 11.3 Tests and Technical Evaluations. Upon SED's request, a Generating Asset Owner shall conduct a test or technical evaluation of a Generating Asset (or shall contract with an auditor, consultant, or other expert, mutually selected by SED and the Generating Asset Owner, to conduct the test or technical evaluation) so as to provide information reasonably necessary for determining compliance with the Standards enforced by this General Order. The Generating Asset Owner will pay all costs and liabilities resulting from such tests or technical evaluations, except for SED's own staff expenses. If a test or technical evaluation may reasonably result in the reduced or suspended generation from a Generating Asset, the Generating Asset Owner shall notify CAISO as soon as the Generating Asset Owner becomes aware of the test or technical evaluation. To the extent feasible, Commission staff shall schedule such tests or evaluations to minimize generation disruptions and shall, as appropriate, coordinate its activities with CAISO.

a metallurgical analysis be carried out by the many options available such as microscopy, spectrometry or hardness testing of the valve stem. The results of this test should then be sent to the OEM (GE) to determine if there is an alloy that will be better suited in both thermal stability or resistance to bending. SED shall be copied on all test results, correspondence, and evaluations.

RCEC LLC's consultant, Structural Integrity Associates (SIA) completed the Materials Analysis and it was cleared May 16, 2022. The CPUC has no jurisdiction over SIA therefore, no enforcement action was recommended or taken.

Recommendations

This section details the four Recommendations that RCEC and/or RCEC, LLC should implement to align with industry best practices. The Recommendations are not mandated by any Public Utilities Code or General Order. They are suggested "Improvements" and "Industry Best Practices" provided to improve the plant's overall performance and compliance.

Recommendation 1

RCECshould improve their Hazardous Materials Emergency Business Plan with a more inclusive analyses of other potential equipment, instrumentation failure, and human error of other inclusive hazards (ammonia, oil fed fires...). RCEC should also provide an additional analysis of hazards having potential impact of the surrounding community (offsite) of RCEC. The analysis should include in the analysis how identified scenarios shall be addressed, and what consequences would likely be developed.

RCEC enhanced their Hazardous Materials Emergency Business Plan to include additional scenarios. This enhancement is not required but the deficiency came to light as a result of the incident. This Recommendation was cleared by ESRB engineers on May 20, 2022.

Recommendation 2

RCEC should consolidate the time and date stamps for both the [redacted] and Ovation digital control system to avoid confusion.

This Recommendation is not required per GO 167-B however RCEC resolved this concern, and it was cleared by ESRB engineers on May 20, 2022.

Recommendation 3

RCEC should reevaluate and improve the controls that could trip the STG prior to motoring of the generator.

This Recommendation is not required in GO 167-B, however RCEC resolved this concern, and it was cleared by ESRB engineers on May 20, 2022.

Recommendation 4

RCEC should develop procedures for the implementation of the SIA restoration recommendations.

This Recommendation is not required per GO 167-B, however RCEC has since developed these procedures and the issue was resolved on May 20, 2022.

Observations

This section details the five (5) observations made over the course of the investigation. These observations led to the performance recommendations below and similar to the recommendations section above, are not mandated and not required by any standard or regulation SED is required to enforce. Observations are issues that were agreed upon by all parties involved as follow-ups and reassurances for further completion of a process or corrective action.

Observation 1

RCEC will develop a document of "lessons learned" from the incident and share this document with all Calpine Combined Cycle Power Plants fleetwide.

This Observation is not required per GO 167-B, however RCEC has undertaken this task and the issue was resolved on May 30, 2022.

Observation 2

RCEC LLC will implement all appropriate corrective actions to its other combine cycle generating assets fleetwide with written confirmation provided to the JAIT.

This Observation is not required per GO 167-B, however RCEC, LLC has undertaken this task and the issue was resolved on May 30, 2022.

Observation 3

RCEC will be made compliant with current ASME TDP-1 Water Induction Prevention Standards.

RCEC was commissioned in 2007 and therefore exempt from compliance with 2013 ASME TDP-1 Water Induction Prevention Standards. Since the incident RCEC has now become compliant with current ASME TDP-1 Water Induction Prevention Standards, therefore as of May 30, 2022, this Observation has been resolved.

Observation 4

RCEC will request that Nooter-Eriksen (HRSG Original Equipment Manufacturer (OEM)) and General Electric (STG OEM) fully review the RCEC water induction incident and provide any observations, findings, or analysis to the company.

This Observation was resolved on May 20, 2022.

Observation 5

RCEC and RCEC, LLC will review all documents and OEM recommendations along with SIA's Corrective Actions.

This Observation was resolved on May 20, 2022.

Conclusion

On May 27th RCEC and RCEC, LLC released all final documents requested and these were reviewed by the CPUC's ESRB engineers. On May 30, 2022, ESRB engineers concluded that all corrective actions had been completed.

Appendix A: Glossary of terms

ACRONYM/ABBREVIATION	DEFINITION
AV	Aerial View
CAISO	California Independent System Operator
CEC	California Energy Commission
CPUC	California Public Utilities Commission
CRH	Cold Reheat
CRHV	Combined Reheat Valve
CT	Combustion Turbine
CUPA	Certified Unified Program Agency
EPA	Environmental Protection Agency
ESRB	Electric Safety and Reliability Branch
GAO	Generator Asset Owner
GE	General Electric
GO	General Order
HAZOP	Hazard and Operability Analysis
HRH	Hot Reheat
HRSG	Heat Recovery Steam Generator
IP	Intermediate Pressure
JAIT	Joint Agency Investigation Team
LP	Low Pressure
NFPA	National Fire Protection Agency
NOV	Notice of Violation

OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
RCA	Root Cause Analysis
RCEC	Russell City Energy Center
RH	Reheater
SIA	Structural Integrity Associates
ST Gen-Set	Steam Turbine and its Generator
STG	Steam Turbine Generator
SV	Stop Valve
TC	Thermocouple

Appendix B: Documents reviewed

1.	Operator Logbooks from May 25, 2021, through May 30, 2021
2.	Steam Turbine (ST) OEM Manuals for Lube Oil Bearing Seals
3.	Lube Oil Analysis Past Three (3) Years
4.	Work Orders for all ST Bearing Seals Past Three (3) Years
5.	Failure and Root Cause Analysis of Failure and Fire (When available)
6.	Digital Control System (DCS) Logs from 05/26/2021 at 00:01 hrs. to 05/28/2021 at 24:00 hrs.
7.	DCS Instrument Calibration Records; most recent.
8.	Overspeed Trip Tests; past three (3) years.
9.	Plant Operators Training Records; past two (2) years.
10.	Plant Organization Chart.
11.	OSHA 300 Reports; past five (5) years.
12.	Current Air Permits.
13.	RATA Testing; past five (5) Years.
14.	Shutdown Checklist.
15.	Steam Turbine rotational speed records of any type from 05/26/2021: 00:01 hrs. through 05/27/2021: 24:00 hrs.
16.	Work Orders for all DCS Alarms from 05/25/2021: 00:01 hrs. through 05/27/2021: 21:47 hrs.
17.	Steam Turbine rotational speed records of any type from 05/26/2021: 00:01 hrs. through 05/28/2021: 24:00 hrs.
18.	Steam Turbine P&ID's with all current and intended modifications to the steam system.
19.	Operator Training Procedures

20.	Operator Training Curriculum
21.	Operator Qualifications
22.	Operator Job Description
23.	Calpine Technical Training Information
24.	Completed Responses to the attached "Russell City Operator Questionnaire"
25.	An unredacted copy of the full and final Root Cause Analysis of the incident
26.	An unredacted copy of the full and final Root Cause Analysis of the incident
27.	The Department of Toxic Substance Control hazardous waste compliance report approved by the Certified Unified Program Agency (CUPA) involved and corrective actions taken this year for all hazardous materials (Hazmat) accumulation storage areas (seven violations were indicated), fire suppression water clean-up, and other Hazmat waste at the Russell City Energy Center (RCEC).
28.	All RCEC Hazmat Manifests for the current year.
29.	Any photo evidence to substantiate EPA compliance.
30.	The Department of Toxic Substance Control hazardous waste compliance approved by the Certified Unified Program Agency (CUPA) involved and corrective actions taken this year (2021) for all hazardous materials (Hazmat) accumulation storage areas.
31.	Any photo evidence to substantiate EPA compliance.
32.	OEM Manuals for the HRSG Cold Reheat Stop Valve (CRHSV#1)
33.	All recent Preventative Maintenance Work Orders for the CRHSV#1prior to the overspeed event.
34.	OEM Gear/Actuator Installation, Operating and Maintenance Instructions for the HRSG Cold Reheat Stop Valve (CRHSV#1).

35.	Any post event Toxic Substance and Human Exposure evaluations performed
36.	All attachments to and appendices and referenced photos in the RCA.
37.	Power plant reconfiguration/startup checklist (starting in 1X1 mode, for changing from 2X1 operation to 1X1 operation, or from 1X1 to 2X1 operation)
38.	Item 2 above, (completed) for the final configuration change prior to the incident
39.	Shut down checklist (completed) for the incident
40.	All manuals, presentations, and other documents regarding operator/employee trainings in effect at the time of the incident.
41.	Training status of personnel performing the startup/operation/shutdown leading to the incident
42.	"Additional operating data" referenced on pg. 14 of the RCA
43.	Extended operating data of startups and shutdowns of HRSG#1 and HRSG#2 (extending 2 hours or more after startups, and beginning 2 hours or more before shutdowns)
44.	A simplified schematic representation (similar to the figures shown in the presentation on November 30, 2021) of reheat loop/IP turbine including piping, drains, valves, sensors with labels as used in the RCA
45.	The presentation that was given on November 30, 2021.
46.	Glossary of acronyms used in RCA
47.	All earlier versions of RCA, or any portion thereof, including but not limited to the first version of the RCA summary.
48.	Prior risk assessment done for the 1x1 operation configuration (e.g. FMEA, fault-tree, or other).
49.	Report of evaluation and test results of the valve (HRSG #1 CRH stop valve); Please provide the maintenance records for the last two years for HRSG #1 and HRSG #2 CRH stop valves.

50.	Manufacturer's HRSG #1 CRH stop valve specs and assembly drawings.
51.	Report of investigation and test results of the IP-stop valve (IV#2 & RSV #2)
52.	IP-stop valve (IV#2 & RSV #2) manufacturer's specs and assembly drawings.
53.	The assessment report that determined the viability of reusing or repairing the HP/IP turbine post incident.
54.	SIA and RCEC LLC operator interviews for the personnel on site during the incident, including any transcripts, notes, or other recordings, including audio or video, of the interviews.
55.	The borescope inspection report of the horizontal HRH pipe sections of the CRVs and the inlet of the CRVs.
56.	A clarification of the statement in Section 5.11 of the RCA, "STG line breakers opening prior to the closure of IV #2 and RSV #2 based on delay logic within the protection system ."
57.	Any other reports generated by SIA concerning the facility or the incident, including but not limited to the recommendations made by SIA or any report regarding recommendations.
58.	Contracts between RCEC LLC and SIA relevant to the RCA, including but not limited to the second contract for recommendations.
59.	All documents and information regarding the facility's alarm design and/or protocols, including documents and information regarding the alarm priority levels.
60.	Agreements with PG&E (including power purchase agreements) that govern operation of the facility.
61.	Any communications from or with PG&E (written or emailed) regarding this facility, including notes from calls or oral communications with PG&E, on May 27, 2021 or during the 10 days prior and after May 27, 2021.
62.	A list of all documents SIA reviewed during preparation of the RCA and recommendation report.
63.	All CAL-OSHA 300 reports for the current year (2021)

64.	An Analysis or Testing of the Toxins released (airborne or otherwise) from the Incident
65.	Evaluation of the Health and Physical Impact of the Toxins Released
66.	Proof of Notification of all exposed or affected people and personnel
67.	P&ID Symbol Legend sheet
68.	P&ID [redacted]
69.	P&ID's [redacted]
70.	P&ID [redacted]
71.	P&ID [redacted]
72.	P&ID [redacted]
73.	P&ID [redacted]
74.	P&ID [redacted]
75.	All post incident reports or debriefs from all operators that who were onsite during the incident.
76.	Nooter-Eriksen HRSG drawings showing sectionals and side views with all drains and sizes.
77.	OEM cold start procedure from Bechtel or others.
78.	Operating procedures for total plant shutdown.
79.	Operating history for changing from 2x1 to 1x1 operation for the past 3 years.
80.	OEM recommendations operations changes from 2x1 to 1x1 operation.
81.	Schematic of HRSG drainage valves on the steam pendant.
82.	All DCS Alarms from 05/22/2021; 00:01 hrs. through 05/28/2021; 24:00 hrs.
83.	Staff Interviews
84.	Superseded by DR-RC20220802-17

85.	Logic Scope for SIA Corrective Action Recommendations
86.	Logic for Generator Lockout Protective Relays
87.	Larger and Clearer Graphs of graph 5.2 & 5.10 from the SIA RCA
88.	Unit Trip criteria for Vibration Parameters (i.e. graph 5-2)
89.	List of Procedural Changes as a result of all Corrective Actions
90.	Daily Rounds Sheets from 05/22/21: 00:01 through 05/28/22: 23:59
91.	DCS Logs for a similar change in operation, 2X1 to HRSG 2: 1X1 Operation
92.	Russell Energy Center Steam Turbine Generator (STG) Generator Protection Relay 86 (A&B) device alarm and trip history for the May 27, 2021, incident. There are two redundant devices, a [redacted] and [redacted]. Therefore, information from both devices should be included.
93.	Bechtel logic drawings and instrumentation calibration history for the [redacted] and [redacted] previously noted showing how these devices were designed to work and what options were selected when they were installed.
94.	Provide photographs or material inventory logs of the type of oil/grease used as lubrication for the CRH stop valve actuator assembly.
95.	Ovation vs. Relay Protection Time Stamp – Confidential and Proprietary
96.	Calpine-Joint Agency Verification Dates_03182022
97.	Confidential RCEC Response 3.16.2022
98.	Operational Alarm Classification
99.	NERC Reference Document
100.	HRH Valve Inspection
101.	HRH Valve Dimensional Checks
102.	HRH Pictures
103.	HRH Valve Report (Parts 1&2)

104.	Steam Turbine rotational speed records of any type from 05/26/2021: 00:01 hrs. through 05/28/2021: 24:00 hrs.
105.	Steam Turbine P&ID's with all current and intended modifications to the steam system.
106.	RCEC LLC Technical Training Information
107.	Completed Responses to the "Russell City Operator Questionnaire"
108.	An unredacted copy of the full and final Root Cause Analysis of the incident
109.	All RCEC Hazmat Manifests for the past 5 years.
110.	The Department of Toxic Substance Control hazardous waste compliance approved by the Certified Unified Program Agency (CUPA) involved and corrective actions taken this year (2021) for all hazardous materials (Hazmat) accumulation storage areas.
111.	Any photo evidence to substantiate EPA compliance.
112.	OEM Manuals for the HRSG Cold Reheat Stop Valve (CRHSV#1)
113.	All recent Preventative Maintenance Work Orders for the CRHSV#1prior to the overspeed event.
114.	OEM Gear/Actuator Installation, Operating and Maintenance Instructions for the HRSG Cold Reheat Stop Valve (CRHSV#1).
115.	Any post event Toxic Substance and Human Exposure evaluations performed
116.	All attachments to and appendices and referenced photos in the RCA.
117.	Power plant reconfiguration/startup checklist (starting in 1X1 mode, for changing from 2X1 operation to 1X1 operation, or from 1X1 to 2X1 operation)
118.	All final configuration change prior to the incident
119.	Shut down checklist (completed) for the incident

120.	All manuals, presentations, and other documents regarding operator/employee trainings in effect at the time of the incident.
121.	Training status of personnel performing the startup/operation/shutdown leading to the incident
122.	"Additional operating data" referenced on pg. 14 of the RCA
123.	Extended operating data of startups and shutdowns of HRSG#1 and HRSG#2 (extending 2 hours or more after startups, and beginning 2 hours or more before shutdowns)
124.	A simplified schematic representation (similar to the figures shown in the presentation on November 30, 2021) of reheat loop/IP turbine including piping, drains, valves, sensors with labels as used in the RCA
125.	The presentation that was given on November 30, 2021.
126.	Glossary of acronyms used in RCA
127.	All earlier versions of RCA, or any portion thereof, including but not limited to the first version of the RCA summary.
128.	Prior risk assessment done for the 1x1 operation configuration (e.g. FMEA, fault-tree, or other).
129.	Report of evaluation and test results of the valve (HRSG #1 CRH stop valve); Please provide the maintenance records for the last two years for HRSG #1 and HRSG #2 CRH stop valves.
130.	An Analysis or Testing of the Toxins released (airborne or otherwise) from the Incident
131.	Evaluation of the Health and Physical Impact of the Toxins Released
132.	Proof of Notification of all exposed or affected people and personnel
133.	All post incident reports or debriefs from all operators that who were onsite during the incident.
134.	Nooter-Eriksen HRSG drawings showing sectionals and side views with all drains and sizes.
135.	OEM cold start procedure from Bechtel or others.

136.	Operating procedures for total plant shutdown.
137.	Operating history for changing from 2x1 to 1x1 operation for the past 3 years.
138.	OEM recommendations operations changes from 2x1 to 1x1 operation.
139.	Schematic of HRSG drainage valves on the steam pendant.
140.	ALL DCS Alarms from 05/22/2021; 00:01 hrs. through 05/28/2021; 24:00 hrs.
141.	Logic Scope for SIA Corrective Action Recommendations
142.	Logic for Generator Lockout Protective Relays
143.	Larger and Clearer Graphs of graph 5.2 & 5.10 from the SIA RCA
144.	Unit Trip criteria for Vibration Parameters (i.e. graph 5-2)
145.	List of Procedural Changes as a result of all Corrective Actions
146.	Daily Rounds Sheets from 05/22/21: 00:01 through 05/28/22: 23:59
147.	DCS Logs for a similar change in operation, 2X1 to HRSG 2: 1X1 Operation
148.	Russell Energy Center Steam Turbine Generator (STG) Generator Protection Relay 86 (A&B) device alarm and trip history for the May 27, 2021, incident. There are two redundant devices, a [redacted] and [redacted]. Therefore, information from both devices should be included.
149.	Bechtel logic drawings and instrumentation calibration history for the [redacted] and [redacted] previously noted showing how these devices were designed to work and what options were selected when they were installed.
150.	Photographs or material inventory logs of the type of oil/grease used as lubrication for the CRH stop valve actuator assembly.
151.	Reconcile and provide the comparison or time difference between the RCEC Generator Protection 86 differential [redacted] clock and the RCEC Ovation DCS system at 5/27/21 that corresponds to the event log at that time.

152.	Calibration settings for the RCEC Generator Protection 86 differential [redacted].
153.	Intermediate Pressure (IP) Turbine Blade inspection report and any additional photos photographs of the of the IP turbine blades.
154.	Confirmation that HRSG #2's cold reheat valve, gearbox, and actuator have been disassembled and inspected to ensure full functioning and sealing. Please provide inspection report of the same.
155.	Report on the valve assembly and testing for all main steam and reheat valves.
156.	Copy of the test report of the generator breaker and generator protection relays/trip mechanism tested prior to startup.
157.	Water Induction Procedures
158.	All documents present to the Joint Agency Investigation Team on May 18,2022.
159.	Corrected Water Induction procedure
160.	Photos of all water induction high priority alarms with appropriate color coding. For example, but not limited to: HRSG Re-pressurization, HP ERV, HP By-pass, HP NRV, HI-HI Drum Level, HRSG HRH Re-pressurization...
161.	Updated TDP-1 verification spreadsheet.
162.	RCEC's - CUPA response and attachments sent to the City of Hayward
163.	Inclusion of "water off" instructions as added to the ONPO or Emergency Shutdown Procedures
164.	Photos of the installed LP Reheat Block valves.
165.	Photos of the Intermediate Pressure (IP) an Low Pressure (LP) turbine blades.
166.	Photos of the IP-LP rotor in lower casing.
167.	Photos of all newly painted surfaces.
168.	Photos of the ferric-sulfide tank and valving.