DOCKETED	
Docket Number:	01-AFC-07C
Project Title:	01-AFC-7C Russell City Energy Company
TN #:	241966
Document Title:	Root Cause Analysis - Restoration Recommendations
Description:	N/A
Filer:	Deric Wittenborn
Organization:	Ellison Schneider Harris & Donlan LLP
Submitter Role:	Applicant
Submission Date:	2/25/2022 11:05:17 AM
Docketed Date:	2/25/2022

dtragesser@structint.com
11515 Vanstory Drive, Suite 125, Huntersville, NC 28078 | 704-949-8060

October 18, 2021
REPORT NO. 2100930.401
REVISION: 0
PROJECT NO. 2100930.00

Jessica Grossman
Calpine Corporation
Walnut Creek, CA

Subject: Calpine Russell City Energy Center Restoration Recommendations

Reference: Proposal No. 2100930.R0

Dear Jessica,

This letter report documents the independent development of restoration recommendations for the Russell City Energy Center (RCEC) as a result of the steam turbine and generator (STG) event that occurred in May of this year. Structural Integrity Associates, Inc. (SI) performed a root cause analysis for this event under project number 2100556.00. This report documents the recommendations developed supporting the restoration of RCEC to combined cycle operation.

Background

The Russell City Energy Center steam turbine and generator (STG) experienced a mechanical failure as a result of an overspeed event late in the evening on May 27, 2021. After modifications were performed to utilize the STG condenser without the STG, both gas turbine blocks have operated since the event in a simple cycle configuration while restoration activities have commenced.

Under project 2100556.00, Calpine contracted with Structural Integrity Associates, Inc. (SI) to perform an independent investigation with a focus on determining the root cause of the event. SI performed an initial onsite investigation from May 30th to June 4th second onsite investigation occurred on July 26th after the steam turbine and main steam system valves were exposed. SI's investigation was documented under project 2100556.401 within the investigation report.

For the purposes of this assessment, the root cause summary from 2100556.401 is provided:

Prior to the event on May 27th, the out-of-service HRSG #1 reheat system maintained elevated pressure levels and condensed excessive quantities of high temperature water within its harps. The reheat systems were not equipped by design to reliably detect the presence of water in all circumstances. Additionally, the distributed control system was not configured to mitigate the presence of excessive water under near operating pressure and elevated temperatures within an out-of-service HRSG. The systems' inability to detect and mitigate the presence of 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.

Development of Restoration Recommendations

A detailed review of the operation data from the event and the operating time period of approximately 5 days prior to the event was performed. Historical data including block operation and HRSG RH conditions (pressure, CRH flow, and SV position) were also considered as far back as plant commissioning in 2013. The conditions that led to the event as well as factors that contributed to the magnitude of the event were reviewed against combined cycle and conventional steam industry knowledge and best practices.

From this review, a list of potential actions was created. Each restoration recommendation was then evaluated against the following criteria:

- Prevents Cause - Undetected / unmitigated excess water under pressure and at high temperature within an offline HRSG RH
- Prevents Symptom - Water induction and overspeed event
- Detection / Monitoring - Detecting undesirable conditions related to the cause, at a point where mitigation can occur
- Alarm / trending - Provide operations awareness of undesirable conditions related to the cause
- Automated Mitigation - Remove the cause without operator intervention

Summary of Recommendations

Based on the down select of potential actions, SI's restoration recommendations are as follows:

1. Implementation of controls logic to utilize existing HRSG reheated system drains to discharge water from the HRSG harps when offline.
    - Actuate existing drains to discharge accumulated water from HRSG RH
    - Utilize existing RH drain sensors where possible, may require the addition of water detection sensors

2. Implementation of controls logic to utilize existing HRSG reheated system drains to alleviate undesirable pressure within the HRSG reheater system when offline.
   - Actuate existing drains to discharge unintended pressure from HRSG RH
   - Prevents the pressurization of an offline HRSG as well as the reducing the risk of water accumulation
   - Utilize existing RH pressure transducers
3. Re-configure the CRH stop valve to close based on its actuator torque value
   - CRH piping is under pressure returning steam to the HRSG when the STG is in operation and is a significant source of steam and pressure to the HRSG RH
   - Configuring the CRH SV to "torque to close" reduces the risk of steam leakage into the HRSG RH by actuating the valve to positively seat the valve disk against the valve seat
   - This configuration is also more likely to detect and alarm if the valve fails to reach the fully closed position
4. Convert the 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.
   - The HRH stop / check valve prevents reverse flow into an offline HRSG. However, for a plant that operates in cyclic and peaking duty, a manually operated configuration is not a practical means of routinely isolating an offline HRSG.
   - Utilization of the existing valves with the addition of actuators and controls logic
   - Automation of the valve prevents a water event from occurring as a result of equalization of HRSG pressure when operating in a 1x1 configuration

Items 1 and 2 utilize existing hardware to prevent unintended levels of water and pressure within an offline HRSG without requiring operator intervention, therefore, reducing the risk of a water accumulation that could lead to an induction event. Item 3 reduces the risk of the CRH piping supplying steam to an offline HRSG which can result in the accumulation of water and pressure. Finally, item 4 reduced the risk of a water induction event form occurring with the addition of valve actuators and controls logic again not requiring operator interaction.

These restoration activities reduce RCEC's risk of creating the conditions that could result in a significant water induction event without requiring operator interaction. Additionally, the risk of a water induction event from an offline HRSG is reduce by the automatic isolation of that HRSG.

SI will continue to support Calpine and the Russell City Energy Center as needed through its restoration activities and remains available Calpine as a trusted independent engineering vendor.

Very truly yours,

Dan Tragesser | Associate
Structural Integrity Associates, Inc.®
Powered by Talent and Technology

Reviewer:

David King | Associate

Structural Integrity Associates, Inc.®

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cc: Rosemary Antonopoulos, Calpine Corporation
David King, Structural Integrity Associates