		Sequence of Events	Observations
11/8/2021	10:17	GT2 Start Command	
	10:31	GT2 FSNL	
	11:12	Main Steam reached Steam Turbine startup conditions [redacted]	**Ramp rate is too high. In less than one hour, the HRSG reached steam turbine operating conditions. It should have taken 3.5 hours.**
	13:21	GT2 Synch - MW setting adjusted from 25 to 16	
	13:24	GT2 - Temp Matching Mode Enabled	
	13:30	CRH condensate drain valve set in Auto mode	
	14:27	GT2 - Temp Matching Mode Disabled	**Deviation from startup procedure. Not documented in log book or in the startup procedure record. Plant leadership wanted to lower emissions.**
	14:27	GT2 - MW setpoint increased to 90MW	
	14:31	SCR in service	
	14:56	GT2 - Reaches 90MW	**Operators questioned plant leadership about running the GT at 90MW and it was decided by plant leadership to leave it at 90MW.**
	15:33	STG reset but would not start	**Communications failure in the Toshiba DCS, troubleshooting began**
11/9/2021	15:33	Troubleshooting efforts into loss of DCS communication with field sensors and devices	
11/10/2021	All Day	Troubleshooting continued, working to get Profibus operating	**GT2 - operation remained at 90MW**
		Profibus operation restored, DCS communications working	
	13:02	GT2 - MW setpoing decreased from 90MW to 45MW	**Operator began lowering the GT to minimize heat input to the HRSG**
	13:06	GT2 - MW setpoint decreased from 45MW to 15MW	**Operator lowered the GT to its minimum load to minimize heat input to the HRSG**
	13:06	STG reset and auto start initiated	
	13:06	Main Steam (1,035F @ 1,369psi)	**Design is** [redacted]
	13:06	STG - Cold-Cold Start Condition & Slow startup	
	13:06	STG - 2:1 Flow Control in Service	

Figure 9, Timeline of event (Part 1 of 2)

		Sequence of Events	Observations
11/10/2021	13:08	GT2 - MW setpoint increased from 15MW to 90MW	**Operator was instructed by the Operations Manager to raise the MW back up to get into DLN emissions mode**
	13:40	GT2 - MW setpoint decreased from 90MW to 50MW	**Unclear why the changes in GT MW setpoint**
	14:40	GT2 - MW setpoint increased from 50MW to 90MW	**Unclear why the changes in GT MW setpoint**
	14:50	GT2 - MW setpoint increased from 90MW to 110MW	**Unclear why the changes in GT MW setpoint**
	14:58	Main Steam (1,042F @ 1,500psi)	**Design is** [redacted]
	15:25	STG - HP Turbine Exhaust Temp High Alarm	[redacted]
	15:27	STG - Alarms Acknowledged (this includes the HP Turbine Exhaust Temp High Alarm)	**Acknowledgement only, no actions taken by anyone**
	15:29	STG - FSNL	
	15:29	STG - 41E Excitation Breaker Failed to Close	**Troubleshooting began**
	17:20	STG - HP Turbine Exhaust Temp >1120F	**Max range of the thermocouple is 1120F**
	17:29	STG - HP Inner Casing Upper Metal Temp >1120F	**Max range of the thermocouple is 1120F**
	17:38	STG - HP Inner Casing Lower Metal Temp >1120F	**Max range of the thermocouple is 1120F**
	17:47	STG - Exhaust Pressure > 1st Stage Pressure	**No flow through the HP**
	19:49	STG - 41E Repaired and Closed	**Excitation began, unit ready to synchronize.**
	19:54	STG - 52G Breaker Fails to Close	**Troubleshooting began**
	20:44	**STG - CRH pipe ruptures**	
	20:47	STG - Manually Tripped	
	20:47	GT2 - Manually Tripped	
	23:49	STG - HP Turbine Exhaust Temp <1120F	**Max range of the thermocouple is 1120F**
11/11/2021	2:32	STG - HP Inner Casing Lower Metal Temp <1120F	**Max range of the thermocouple is 1120F**
	5:59	STG - HP Inner Casing Upper Metal Temp <1120F	**Max range of the thermocouple is 1120F**

Figure 9, Timeline of event (Part 2 of 2)

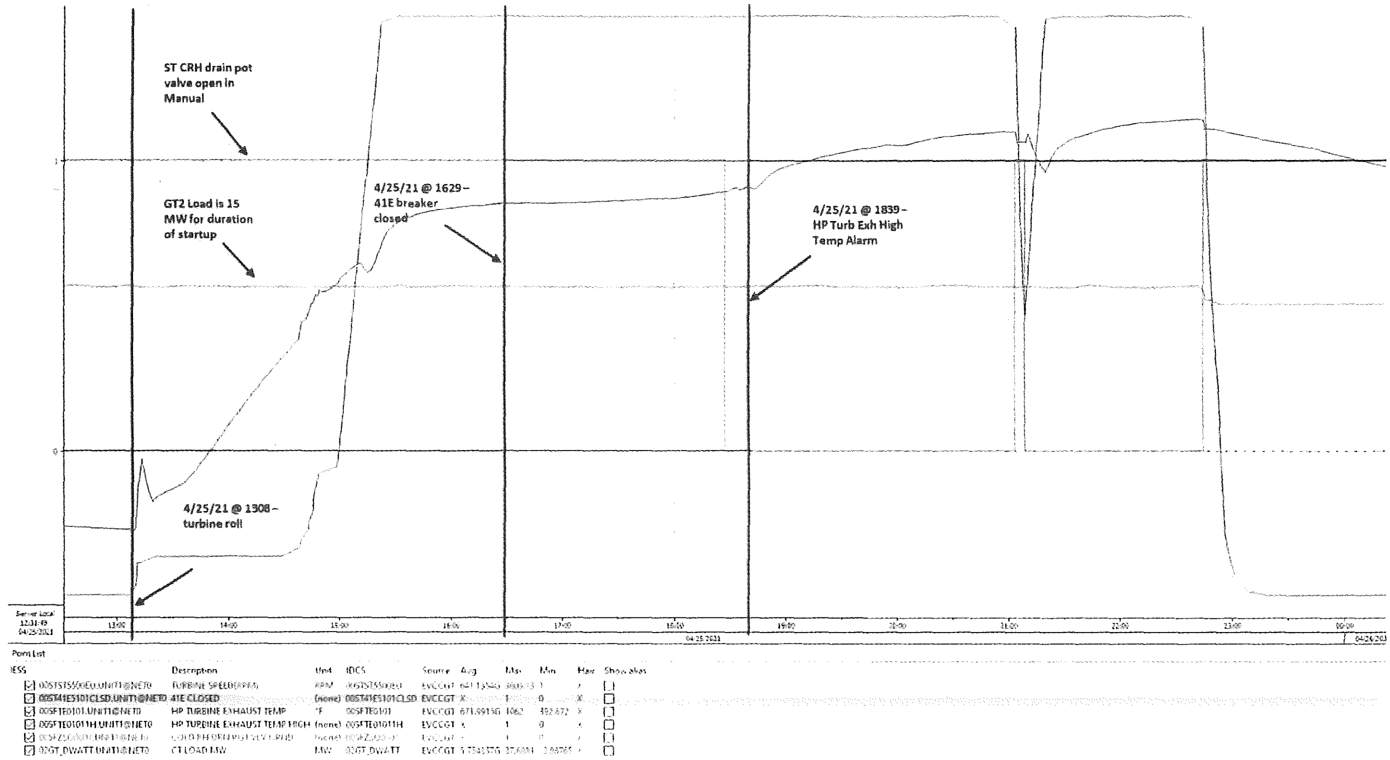


Figure 10, Effect of CRH drain valve on April 25, 2021, STG Startup

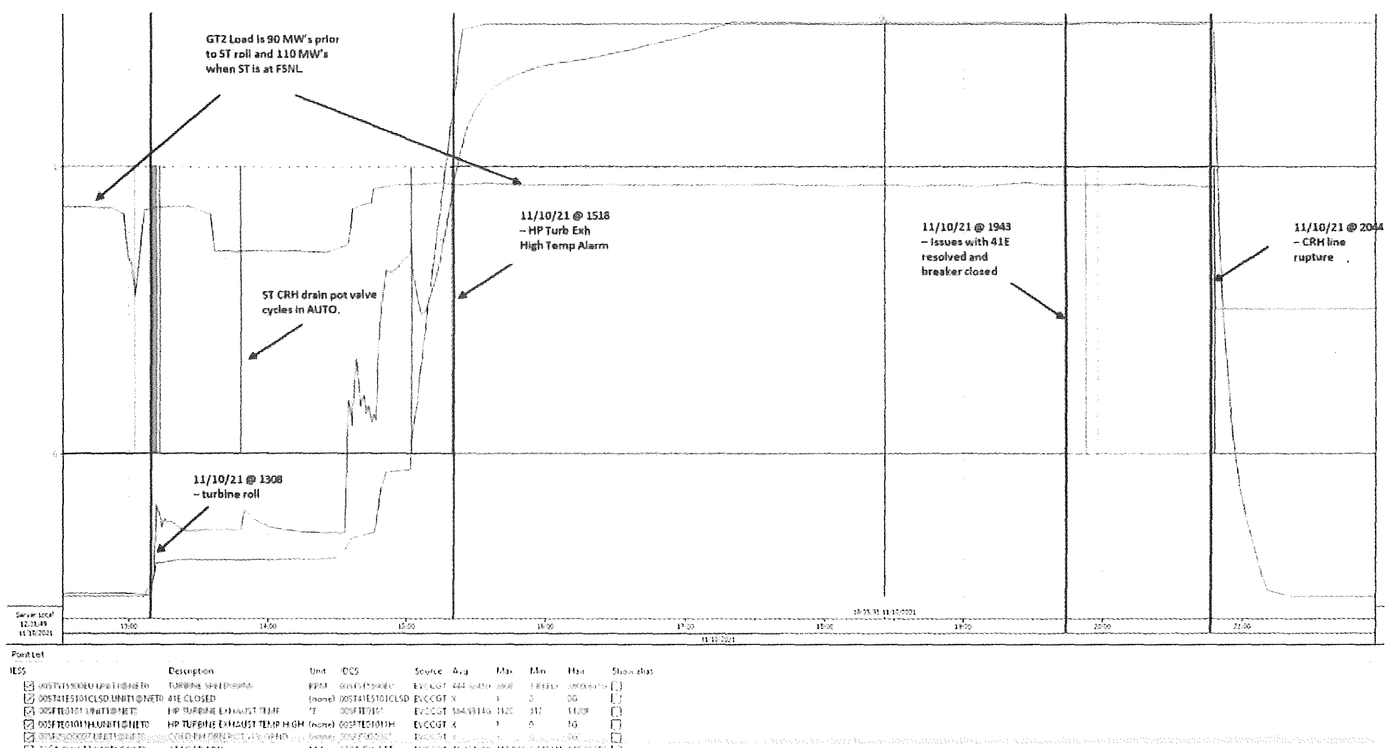


Figure 11, Effect of CRH drain valve on November 10, 2021, STG Startup

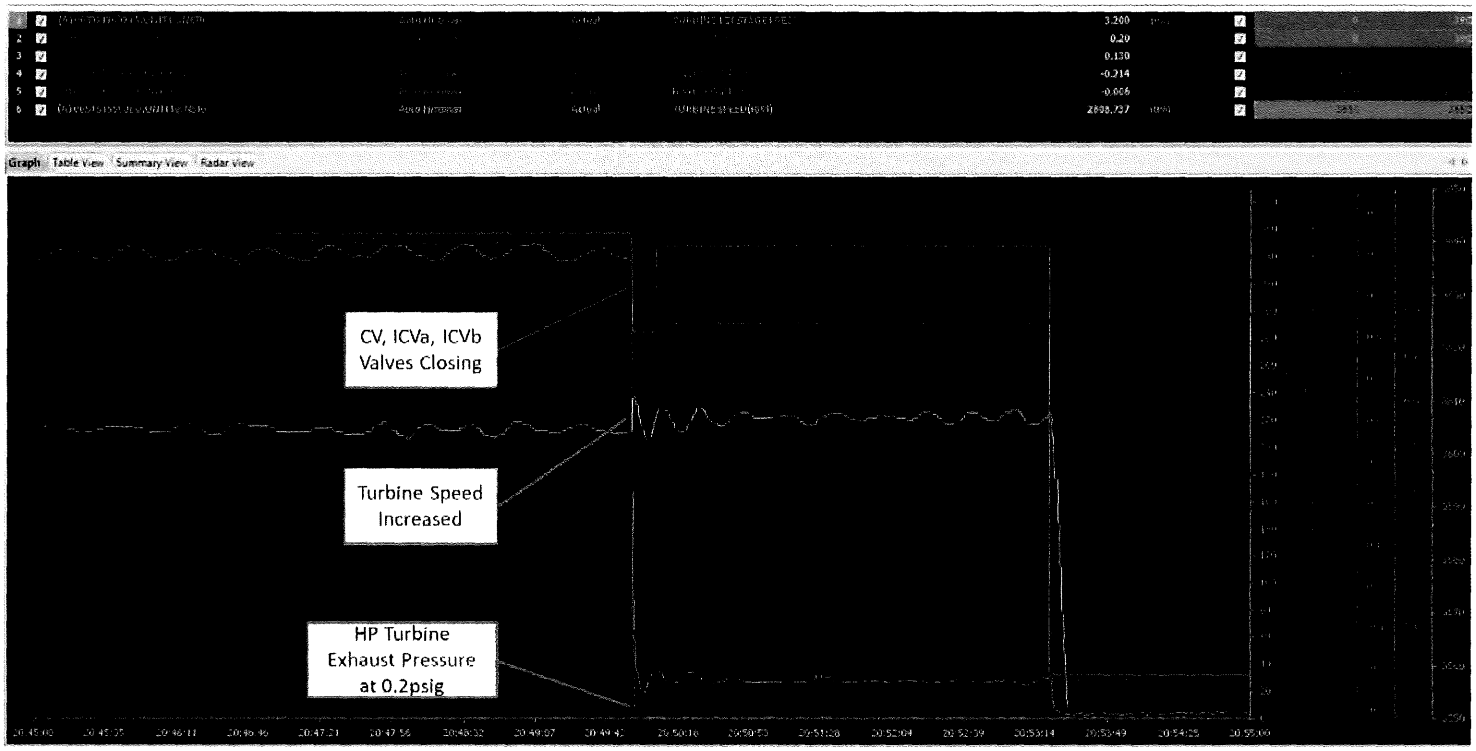


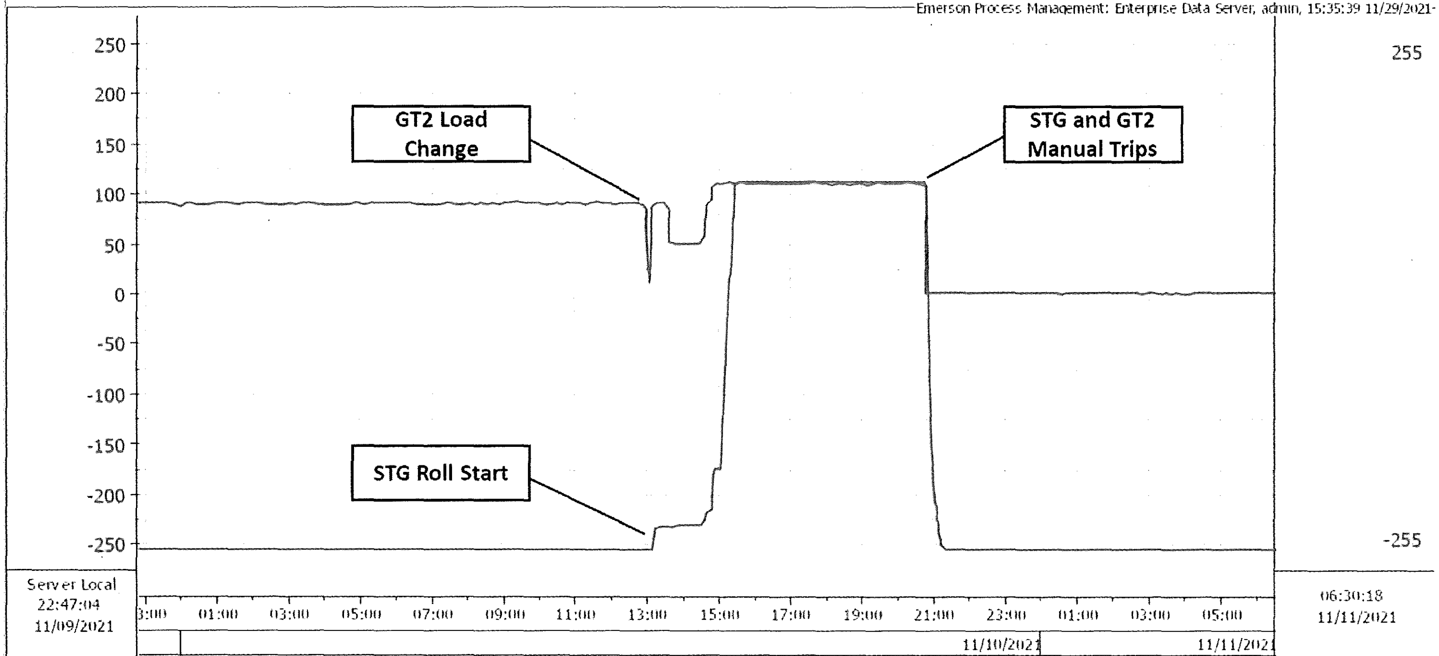
Figure 12, STG Trend data of at time of pipe rupture

[redacted]

Figure 13, Red Lined DCS drawing of IP Bypass Setpoint control logic

[redacted]

Figure 14, Red Lined DCS drawing of HP Bypass Setpoint control logic



IESS	Description	Unit	IDCS	Source	Avg	Max	Min	Hair	Show alias
02GT_DWATT.UNIT1@NET0	CT LOAD MW	MW	02GT_DWATT	EVCCGT	52.68479G	112.823	-4.99605	15.61905G	
00STST5500EU.UNIT1@NET0	TURBINE SPEED(RPM)	RPM	00STST5500EU	EVCCGT	224.4919G	3608	0	0G	

Figure 15, Trend data of GT2 Load and STG Turbine Speed (November 10th STG startup)

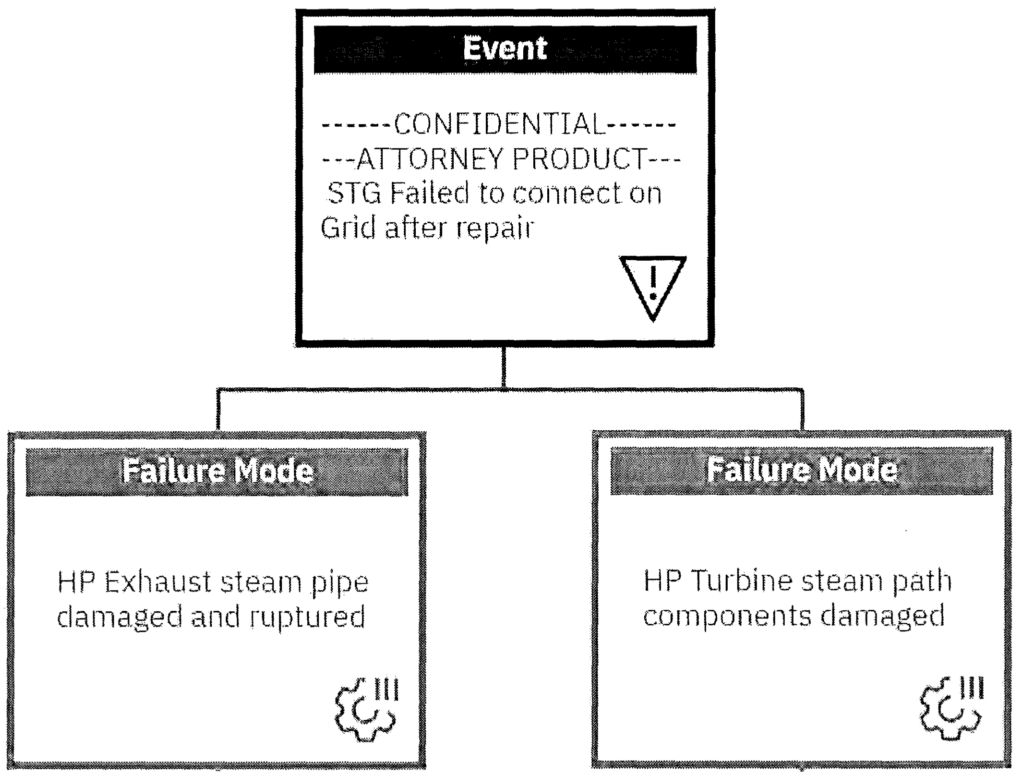
[redacted]

Figure 16, Comparison of Cold Startup curves (Actual vs Design)

PROACT® Logic Tree

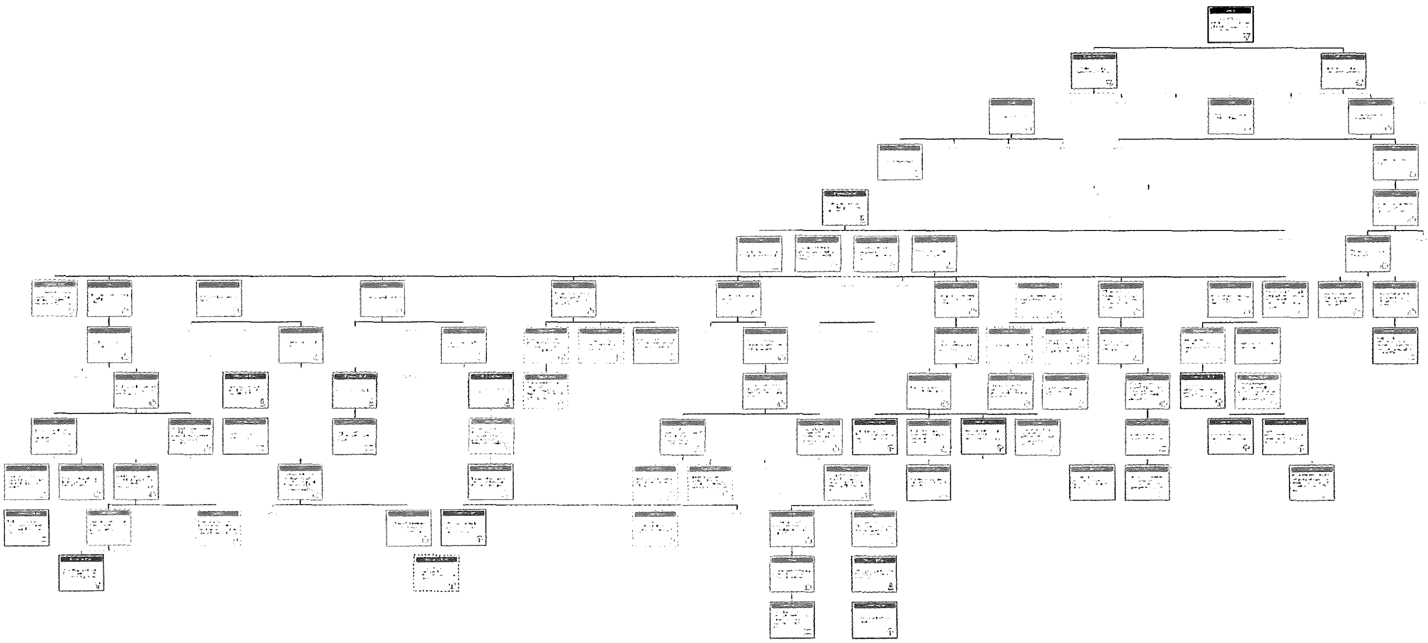
Any undesirable outcome is a result of a series of "cause-and-effect" relationships. The data provided by AES, in-person interviews and on-site visits, serve as proof (evidence) as to what did or what did not occur. A Logic Tree was utilized in the PROACT® application to graphically express the "cause-and-effect" relationships. In this approach, the top two levels of blocks represent the EVENT (Level 1) and the MODE (Level 2). From-level-to-level the path represents a "cause-and-effect" relationship. These levels specifically represent the "undesirable outcomes" that did occur (facts only). From the MODE Level, the analysts do not know why they have occurred, just that they did occur. From this point the analysis becomes hypothetical and the analysts repeatedly ask the question "How Can?". As hypotheses are developed in this fashion, the evidence collected is used to verify what is true and what is not true. In this fashion, facts lead the analysis not assumptions. This process is reiterated until true root causes are uncovered; the reasons why people make decision errors that lead to undesirable outcome. Root causes originate from vulnerabilities in the organizational systems upon which employees depend to make informed decisions. These are called Latent Root Causes or Organizational Root Causes. Vulnerabilities in organizational systems lead to poor decisions being made by well-intentioned individuals. These decisions are referred to as Human Root Causes. Decision errors lead to the Physical Root Causes, or events or conditions that are visible. When the Latent Roots or Organizational System Roots are identified and addressed, the investigation becomes a true and effective Root Cause Analysis.

Top Box (problem definition)



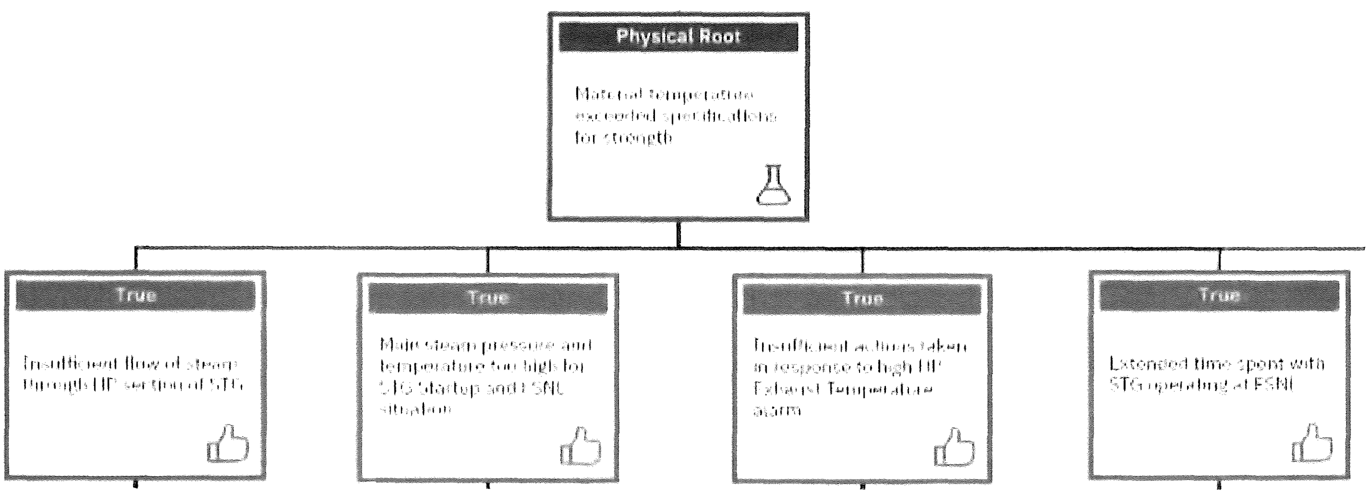
PROACT® Logic Tree Top Box

Entire Logic Tree



PROACT® Logic Tree

Logic Tree for material temperature exceeded specifications for strength.



Excerpt from PROACT® Logic Tree

Analysis Team Information

RCA Team Charter

To identify the root causes of the STG-1 generator failure to synchronize with grid and the damage to the generator field at the Eagle Valley power plant facility. This includes identifying deficiencies in, or lack of, management systems and oversight. Appropriate recommendations for root causes will be communicated to management for rapid resolution.

Analysis Critical Success Factors

- A cross-functional section of personnel/experts will participate in the analysis.
- All analysis hypotheses will be verified or disproven.
- Management agrees to fairly evaluate the analysis team's findings and recommendations.
- A disciplined RCA approach will be utilized.
- Use of an unbiased team facilitator who is an expert in the PROACT® RCA methodology.

Analysis Team Members

Name	Role	Company	Title
Mark Halbrook	Sponsor	AES	BOP Leader
Alex Halter	Principle Analyst	AES	Operations Leader
Eric Guilkey	Analyst	AES	Data Analysist
Holcombe Baird	Facilitator	Reliability Center, Inc.	Senior Reliability Consultant

Analysis Dates

Event Date: November 10, 2021
Analysis Start Date: November 12, 2021
Analysis Team Completion: January 31, 2022

Appendix A: Notes from the Initial Technical Review

HRSG Ramp Rate Control

In the Nooter Erikson Operation Training Manual N/E Training Manual- [redacted]

[redacted]

During the startup from 11/8/2021 through 11/10/2021, all three of these systems did not operate correctly. First, the steam bypass system did not control correctly due to improper logic in the DCS. Second, it was decided to increase the loading of the gas turbine to 90MW. Third, the startup vent valves are not used in the startup procedure. These three failures contributed to the overheating of the HP turbine and the cold reheat piping.

HRH (IP Turbine) Bypass Valve

[redacted]

Control Narrative

[redacted]

Actual DCS Logic

[redacted]

Table A.1

[redacted]

Control Narrative

[redacted]

Actual DCS Logic

[redacted]

Table A.2

MS (HP Turbine) Bypass Valve

[redacted]

Gas Turbine Exhaust Temp Matching ST Temp

[redacted]

HRSG Startup Vent Valves

[redacted]

Steam Turbine High Inlet Temperature and Pressure During Startup

[redacted]

Toshiba TTIL

Toshiba issued a Toshiba Technical Information Letter TAES-TTIL-KT112001X Revision 1 on February 11, 2021. The subject of the TTIL is "Improving Reliability for Turbine Bypass Start-u [redacted]

Startup Procedure

The startup procedure used was 2x1 Cold Start OI-SRT02 Rev 09. However, when going through the documentation provided by plant personnel, the current version is Rev 13. The newest revision was changed on 11/19/2021.

Appendix B: Reference Documents

Prelim Operational Data review
Toshiba, November 12, 2021

Improving Reliability for Turbine Bypass Start-up
Toshiba Technical Information Letter, TAES-TTIL-KT112001X Revision 1, February 11, 2021,

Inspection of Steam Turbine Cold Reheat SF Piping System
Thielsch Engineering, Inc., November 2021

2x1 Cold Start Procedure, OI-STR02
Eagle Valley Generation Station, Revision 9, August 24, 2021

Steam Turbine Start Up with Turbine Bypass System
Toshiba Operations Manual, Section 7, Document # PCD-GMH-XUEG1-001 Rev.2

Turbine Bypass System Control Narrative
CB&I Control Narrative, Document # 152418-000-IC-SY-TB001, Rev. 1, Dated 5-24-2016

Appendix C: Contributors to Analysis Effort

Billy Hunt – IPL Operator (CRO)
Dave Haymond - IPL Operator (CRO)
Larry Bland – IPL Operator (Outside)
Steve Lambert – IPL Operator (TRO)
Tyler Norton – IPL Operator (Outside)
Gary Lucas – IPL Operator (TRO)
Doug Blackwell – IPL Operator (CRO)
Steve Durham – IPL Operator (TRO)
Ron Stiles – IPL DCS Technician
Jason Hoage – IPL Operations Leader
Brandon Berlin – IPL Maintenance Leader

Revision Log

Rev. No.	Date	Comment
0	April 28, 2022	Issued for Client Use
1	May 20, 2022	Page 17, Text edited to correct statement