RCA-2023-004 Unit 2 turbine guide bearing trip and pad wipe

Level 2 root cause analysis

Document	RCA-2023-004
Revision	Final
Date	2023-04-28
Applies to	CCD-U2-BRG-TGB, CH-FR-1987-0043
Owner	Lead: Tom Halvorsen. Team: Ray Okafor, Jake Lindqvist, Dale Whitaker, Lars Bergström (Cromley Hydraulics)
Approved	Elena Marsh, 2023-05-03
Status	Closed (effectiveness verified 2025-04-30; A4 closed 2026-09)

1 Problem statement

On 14 March 2023 at 04:12, Unit 2 tripped on turbine guide bearing (TGB) temperature (pad 1, 90 °C). All four TGB pads were found lightly wiped.

2 Impact

Forced outage of 238 h (9.9 days), approx. 8,300 MWh lost generation. Repair: pad re-scraping by CH field service, oil change and flush, approx. USD 96k including lost revenue. No safety or environmental effect. Linked work order WO-2023-0204.

3 How it was detected

Automatic protection trip on the TGB pad 1 RTD. A total cooling water flow alarm (below 56 L/s) had been raised 52 minutes earlier and acknowledged without action.

4 Timeline

Date / time	Event	Source
11 Jan 2023	Last strainer cleaning on Unit 2 (quarterly PM), DP after 0.05 bar	WO history
1–10 Mar 2023	Spring runoff, river highly turbid	Shift log
13 Mar 22:00	Night rounds: strainer DP field on rounds sheet left blank	Rounds sheet
14 Mar 03:20	Control room: Unit 2 cooling water flow low alarm (54 L/s). Acknowledged; the flowmeter had given several nuisance alarms after rain in February	Alarm log, interview
03:20–04:05	Total flow falls to 48 L/s; TGB pad 1 rises from 66 to 80 °C; thrust and guide bearings rise 4–6 K	SCADA trends
04:05	TGB temperature alarm (80 °C)	Alarm log
04:12	Trip on TGB temperature (90 °C)	Alarm log
14 Mar 07:30	Strainer DP 0.62 bar, basket full of silt	WO-2023-0204
15–23 Mar	TGB opened: pads 1–4 lightly wiped; clearances in tolerance; oil sample tin 31.5 ppm (babbitt)	WO-2023-0204, oil analysis
24 Mar	Unit 2 returned to service	WO-2023-0204

5 Evidence collected

Parts: TGB pads (photographed, kept), strainer basket contents, oil sample before change. Position: debris in basket, wipe pattern on all four pads (uniform, worst at the loaded side). People: statements from the control room operator and shift supervisor C. Paper: SCADA trends (cooling flow, bearing temperatures), alarm log, rounds sheets, PM history, oil analysis Feb 2023 (normal). Paradigms: "the flow alarm always comes after rain, it's the

meter".

6 Hypotheses and verification

#	Hypothesis	Evidence	Result
H1	Loss of cooling water to the TB circuit (strainer blocked)	Total flow 80 → 48 L/s; strainer DP 0.62 bar, silt-filled basket; all bearings warmed, TGB first	**Verified**
H2	TGB oil degradation	Feb 2023 sample normal (TAN 0.17, Sn 2.6 ppm)	Ruled out
H3	Operation in the rough zone	Gate 82 % at the time (outside 35–70 %)	Ruled out
H4	TGB clearance out of tolerance	All segments measured within 0.30 ± 0.05 mm	Ruled out
H5	Instrument fault	All pads wiped; oil temperature rose; other bearings warmed too	Ruled out

Why the TGB failed first: the TGB has its own small cooling circuit (TB, 8 L/s nominal) and the least thermal margin; the generator bearings on the GB circuit warmed but stayed below alarm.

7 Root causes

Type	Root cause	Evidence
Physical	Silt-blocked cooling water strainer reduced TB circuit flow; TGB oil overheated and the oil film broke down: pad wiping	Strainer DP, flow trend, wipe pattern, tin 31.5 ppm
Human	Flow alarm acknowledged without checking the strainer; strainer DP not read on night rounds	Alarm log, rounds sheet, interviews
Latent	Strainer cleaning on a fixed quarterly interval regardless of the silt season	PM plan
Latent	Flowmeter nuisance alarms had taught operators to ignore the flow alarm	Alarm history Jan–Mar 2023
Latent	No circuit-level flow measurement and only one pad per bearing visible in the control room	Design (CH-DOC-DWG-0102)

8 Actions

#	Action	Root	Owner	Due	Status
A1	Monthly strainer cleaning March–June, all units (MOC-2023-006)	Latent 1	Tom Halvorsen	2023-04-15	Closed 2023-04-03
A2	Fix flowmeter nuisance alarms (damping, re-range)	Latent 2	Dale Whitaker	2023-06-30	Closed 2023-06-12
A3	Make strainer DP a mandatory field on rounds sheets	Human	Ray Okafor	2023-05-31	Closed 2023-05-10
A4	Evaluate circuit-level flow and all-pad temperature monitoring (input to monitoring retrofit business case)	Latent 3	Tom Halvorsen	2024-06-30	Closed 2026-09 (CH monitoring PLC retrofit)
A5	Re-scrape TGB pads, oil change and flush	Physical	Tom Halvorsen	2023-03-24	Closed

9 Effectiveness check

No cooling-related bearing alarms or trips on any unit in the 2024 and 2025 runoff seasons (checked 2024-04-30 and 2025-04-30). Effectiveness confirmed.

10 Lessons and FMECA / PM updates

FMECA FM-02 (strainer) occurrence and task updated. Lesson: a cooling problem shows on **all** bearings at once and on the cooling flow; the TGB is first to suffer because of its small circuit.