

8D Report — Cooling Skid Differential Pressure Nonconformance

Full D1–D8 investigation record including containment, root cause, corrective action, verification and prevention.

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DATE	September 2026	PREPARED BY	Mohammad Al-Araidah
STATUS	Closed — verified	CLASSIFICATION	Synthetic data — not for production use

Independent engineering study. This document was created to demonstrate a structured approach to manufacturing quality for mission-critical equipment. The supplier, equipment, specifications and all results are synthetic. It is not design guidance, not a compliance assessment against any standard, and must not be used on a production programme.

Nonconformance record

FIELD	DETAIL
NCR number	MQA-NCR-014
Raised at	Factory acceptance test, step 150 — performance test (hold point)
Equipment	Northstar Thermal Systems LC-1000, skid serial 003
Requirement	250 kPa minimum differential pressure at design flow
Observed	195 kPa (78% of requirement)
Design flow	1,440 L/min (24 L/s)
Repeatability	Repeatable across 3 consecutive tests in the same configuration

Disposition history

The shipment decision is a function of the evidence available at each stage. Containment does not make equipment acceptable, and a repaired unit does not close a systemic cause.

STAGE	DISPOSITION	BASIS
At discovery (D2)	HOLD	Performance acceptance criterion not achieved at design flow — 195 kPa against a 250 kPa minimum, repeatable across three tests. No approved deviation.
After containment (D3)	HOLD	Containment in place and the affected population identified, but no root cause established. Containment limits spread; it does not make equipment acceptable.
After corrective action (D5)	HOLD	Equipment corrected and the immediate performance restored, but the systemic cause was still open — the same error could have been present on other units and undetected by the existing controls.

STAGE	DISPOSITION	BASIS
After verification (D6)	CONDITIONAL RELEASE	Performance demonstrated on three consecutive units and the affected population re-inspected. Prevention actions were approved but not yet evidenced in the process documents, so release was conditional on that closure.
At closure (D8)	RELEASED	Prevention actions implemented and evidenced, ITP revised to Rev B, and the full shipment release checklist satisfied with objective evidence.

D1 — Team

ROLE	RESPONSIBILITY
Owner quality engineer (investigation lead)	Investigation structure, disposition recommendation, closure evidence standard.
Supplier quality manager	Containment execution, records quarantine, corrective action delivery.
Supplier mechanical engineer	Hydraulic analysis, pump configuration verification, retest execution.
Supplier controls engineer	Instrument scaling verification, control-mode confirmation.
Supplier production supervisor	Assembly record retrieval, affected-unit identification.
Owner mechanical engineer	Acceptance criterion interpretation, deviation assessment, retest witness.

D2 — Problem definition

During factory acceptance testing of Northstar Thermal Systems LC-1000, skid serial 003 at ITP step 150 (performance test hold point), the skid achieved 195 kPa differential pressure on the secondary circuit at the design flow of 1,440 L/min (24 L/s), against a specified minimum of 250 kPa — 78% of the acceptance requirement, a shortfall of 55 kPa. The result was repeatable across 3 consecutive tests with flow confirmed at the design value and the pumps at rated speed.

Is / is not. Present on the secondary circuit at design flow on the affected serial, at rated pump speed, in both single-pump and changeover configurations. Not a thermal shortfall — heat transfer met the acceptance band — and not present on the primary circuit.

D3 — Containment

- ☒ Shipment of skid serial 003 placed on HOLD; release blocked in the shipping release gate, not only noted on the test record.
- ☒ FAT on skid serial 004 paused before the performance test to avoid generating a second ambiguous result.
- ☒ Configuration frozen on all skids in build: no assembly, parameter or component changes without investigation approval.
- ☒ Pump, control valve, sensor and assembly records for serials 003 and 004 quarantined as investigation evidence.
- ☒ Affected population identified by purchase-order line rather than by build date: all pumps received against that line, including spares in stock.
- ☒ Owner engineering notified within the same working day, with the measured values and the containment already in place.
- ☒ Sub-tier supplier notified and asked to confirm what was shipped against the order line.

D4 — Root cause analysis

Cause enumeration and elimination

CATEGORY	CANDIDATE CAUSE	STATUS	BASIS
Machine	Pump impeller configuration	confirmed	Physical inspection found an impeller trim smaller than the BOM required.
Machine	Control valve Cv undersized	eliminated	Valve verified against the BOM; test performed with the valve at the design position.
Machine	VFD speed limit set below rated	eliminated	Drive parameters read out; pump running at rated speed during the test.
Machine	Strainer or filter partially blocked	eliminated	Differential across the filter within normal range; elements inspected clean.
Measurement	Differential-pressure sensor scaling error	eliminated	Loop check against an applied reference at two points; indication within instrument accuracy.
Measurement	Flowmeter calibration error	eliminated	Calibration certificate current; flow cross-checked against pump curve and absorbed power.
Measurement	Test instrumentation range or resolution inadequate	eliminated	Instrument ranges reviewed; the 55 kPa shortfall is far outside combined measurement uncertainty.
Method	Test loop resistance not set to the design operating point	eliminated	Flow confirmed at design value while differential pressure was recorded; the operating point was correct.
Method	Valve lineup incorrect during the test	eliminated	Lineup verified against the P&ID before each of the three test repeats.
Method	Control mode not at constant differential-pressure setpoint	eliminated	Control mode and setpoint read from the PLC before the test.
Material	Incorrect impeller supplied against the purchase order	contributing	The received impeller matched the sub-tier packing list; the purchase order line itself carried the wrong trim.
Material	Piping internal diameter or fitting mismatch	eliminated	As-built piping verified against the drawing; no restriction found.
People / method of verification	No independent verification of impeller trim at assembly	confirmed	Assembly work instruction required the pump part number but not confirmation of impeller trim identification.
People / method of verification	Operator error during assembly	eliminated	The pump was installed as received; the error was upstream of assembly.

5-Why

QUESTION	ANSWER	EVIDENCE
Why did the skid not achieve the required differential pressure at design flow?	The installed pumps could not produce the required head at design flow.	Measured 195 kPa at 1,440 L/min against a 250 kPa minimum, repeatable across three tests at rated pump speed.
Why could the pumps not produce the required head?	The installed impeller trim was smaller than the trim the design required.	Physical inspection: 190 mm impeller installed where the BOM specified a 216 mm trim.

QUESTION	ANSWER	EVIDENCE
Why was the smaller impeller installed?	The pumps were received configured with that trim, and the purchase-order line specified it.	Purchase order line and sub-tier packing list both show the 190 mm trim; goods-in records match.
Why did the purchase order specify the wrong trim?	The two trims differ by one character in the supplier part number and share an identical catalogue description, and the order was placed from the description.	Sub-tier catalogue extract showing both part numbers with the same description text.
Why did the error survive receipt and assembly?	Neither receiving inspection nor the assembly work instruction required the impeller trim to be confirmed against the BOM — only the pump part number, which was itself wrong.	Receiving inspection record and assembly work instruction, neither containing a trim verification step.

Root cause

LEVEL	STATEMENT
Direct cause	Incorrect pump impeller trim installed — 190 mm supplied and fitted where the design required 216 mm.
Systemic cause	Insufficient differentiation between the two impeller part numbers in the sub-tier catalogue, combined with no independent verification of impeller configuration at receipt or at assembly. The ordering error was a single point of failure with no downstream detection.

Quantitative validation. Pump head varies approximately with the square of impeller diameter at constant speed. If the trim is the cause, the shortfall is predictable rather than coincidental.

$$(190 / 216)^2 \times 250 \text{ kPa} = 0.774 \times 250 \text{ kPa} \approx 194 \text{ kPa}$$

Observed: 195 kPa measured. The predicted and observed values agree within measurement uncertainty. The impeller trim accounts for the entire shortfall, which also means no second cause needs to be postulated.

D5 — Corrective action

TYPE	ACTION	OWNER	VERIFICATION
immediate	Replace the impellers on serial 003 with the specified 216 mm trim and repeat the performance test in full.	Supplier mechanical engineering	Performance test record at design flow, witnessed by the owner.
immediate	Correct the purchase-order line and re-inspect all pumps received against it, including stock spares.	Supplier procurement and quality	Inspection record per pump showing the as-received impeller trim.
permanent	Assign unique internal part numbers to the two impeller trims and break the shared catalogue description in the ordering system.	Supplier engineering	Item master extract showing distinct part numbers and distinguishing descriptions.
permanent	Add impeller trim identification to receiving inspection for all pumps, verified against the BOM rather than the packing list.	Supplier quality	Revised receiving inspection instruction plus completed records on the next three receipts.
permanent	Add an independent pump configuration verification step to the assembly traveller, signed by someone other than the installer.	Supplier production	Revised traveller plus completed records on the next three skids.

TYPE	ACTION	OWNER	VERIFICATION
permanent	Add a component configuration verification witness point to the ITP at material receipt for pumps and heat exchanger.	Owner quality engineering	ITP revised to Rev B with the new witness point at step 020.

D6 — Verification of effectiveness

UNIT	FLOW	DIFFERENTIAL PRESSURE (KPA)	MARGIN (KPA)	RESULT
Serial 003 (reworked)	1,440 L/min	263	+13	Pass
Serial 004	1,440 L/min	258	+8	Pass
Serial 005	1,440 L/min	261	+11	Pass

Three consecutive units met the acceptance criterion at design flow after corrective action. Synthetic data, generated for this study — on a real programme this is the evidence that would be required, not evidence that exists.

D7 — Prevention

CONTROLLED DOCUMENT	CHANGE
PFMEA	Added the failure mode "incorrect pump impeller configuration installed" with the detection rating re-scored against the new receipt and assembly verification steps rather than against factory acceptance testing.
Control plan	Added component configuration verification at receipt and at assembly, with the record as the control evidence.
Inspection & test plan	Revised to Rev B: impeller trim verification added as an owner witness point at material receipt (step 020).
Assembly work instruction	Independent pump configuration confirmation added as a signed step before the pump is coupled.
Receiving inspection instruction	Pump configuration verified against the BOM, explicitly not against the supplier packing list.
Supplier audit checklist	Added a check on part-number differentiation for functionally distinct components sharing a catalogue description — the systemic condition, not the specific part.
Sub-tier purchase order template	Configuration-critical attributes stated on the order line rather than relied upon from the catalogue description.

D8 — Closure

- ☒ Three consecutive conforming units at design flow, witnessed and recorded
- ☒ Affected population re-inspected, including stock spares, with a record per pump
- ☒ Configuration-control update implemented: distinct part numbers and distinguishing descriptions in the item master
- ☒ ITP revised to Rev B with the receipt witness point in place
- ☒ PFMEA and control plan updated, with the detection rating re-scored against the new controls
- ☒ Assembly traveller and receiving inspection instruction revised, with completed records on three subsequent units

☒ Effectiveness verification completed under the revised nonconformance procedure before closure

ENGINEERING DECISION

Shipment status: RELEASED

Acceptance criterion met with margin on the affected unit and two subsequent units. Direct cause corrected, systemic cause addressed in controlled documents, affected population including stock spares re-inspected, and effectiveness verification completed under the revised nonconformance procedure. MQA-NCR-014 closed on evidence rather than on explanation.

Investigation lead — name, signature, date

Supplier quality manager — name, signature,
date

Owner engineering — name, signature, date