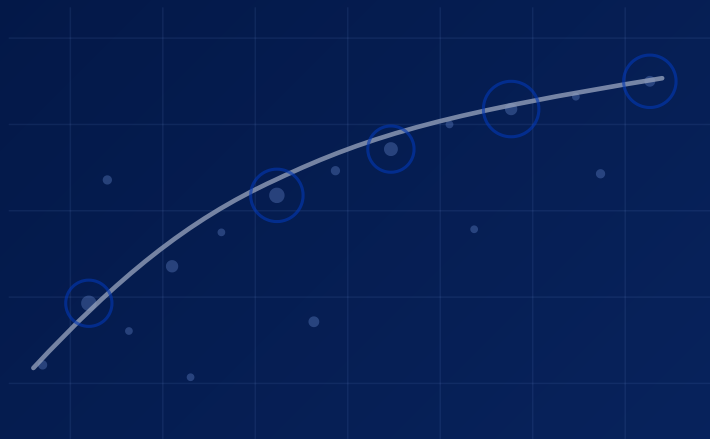




QUALIFICATION AUDIT REPORT

Surrogate Qualification Audit Report

Subject: Steady Thermal-Fluid Field Surrogate Qualification.

Decision: **Conditionally qualified**. This report defines the allowed use, runtime fallback rule, evidence limits, and solver follow-up queue for the surrogate under audit.

DOCUMENT TYPE

Qualification
audit report

DECISION

**Conditionally
qualified**

GENERATED UTC

2026-07-07
08:26:51.562402 UTC

REFERENCE

pl-wp-002-public-
sample



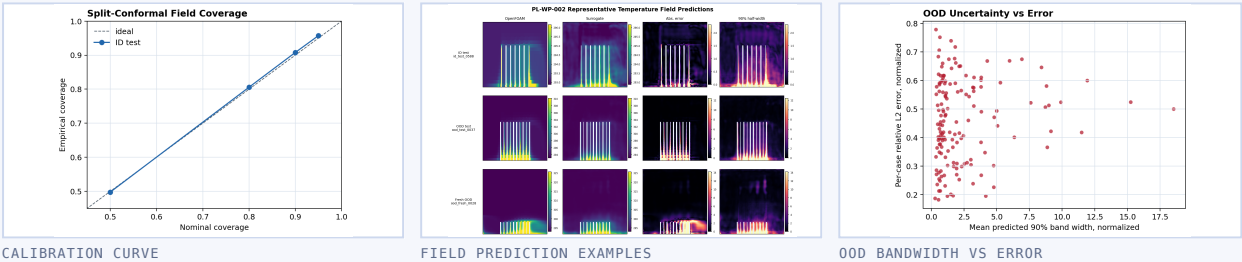
01 Executive Decision

Decision: **Conditionally qualified**. The surrogate may be used only for the stated context of use and only when the runtime gate passes.

Context of use: In-envelope thermal-fluid field prediction for engineering screening.

PREDICTION ROWS 402 cases evaluated in the audit index	ID SERVED 0.9 served fraction in the configured ID pool	OOD ROUTED 1 OOD cases sent to solver by the gate
COVERAGE 90 0.909548 coverage on cases served by surrogate	SCORE THRESHOLD 0.560471 band_width_mean_norm_90	SOLVER ROUTES 222 cases ranked for solver follow-up

EVIDENCE SNAPSHOT



This surrogate may be used for.

- Engineering-screening field prediction inside the declared parameter envelope.
- Runtime surrogate serving when the explicit envelope and uncertainty-score gate both pass.

It must fall back to solver when. The case is outside the explicit envelope, or when `band_width_mean_norm_90 > 0.560471`.

Recommended next action. Serve only inside the declared envelope and only when `band_width_mean_norm_90 <= 0.560471`.

CURRENT EVIDENCE SUPPORTS

402 evaluated cases; ID served fraction 0.9; OOD routed fraction 1; served 90% coverage 0.909548.

CURRENT EVIDENCE DOES NOT SUPPORT

- Certification, safety release, or production signoff without additional context-specific validation.
- This audit supports known parameter-envelope routing, not universal hidden-physics detection.

02 Surrogate Under Audit

FIELD	VALUE
Name	Compact FNO thermal-fluid field operator
Model family	Fourier neural operator ensemble
Version	PL-WP-002 public support release
Predicts	Temperature field, Velocity magnitude field
Inputs	Fluid/solid mask, Signed-distance field, normalized coordinates, <code>h_ch</code> , <code>n_fin</code> , <code>h_fin</code> , <code>d_in</code> , <code>u_in</code> , <code>q_w</code>
Training source	OpenFOAM-derived retained steady thermal-fluid cases
Training cases	446
Calibration cases	100
Test cases	100
OOD cases	202

ALLOWED USE

- Engineering-screening field prediction inside the declared parameter envelope.
- Runtime surrogate serving when the explicit envelope and uncertainty-score gate both pass.

NOT ALLOWED

- Certification, safety release, or production signoff without additional context-specific validation.
- Hidden-regime detection or geometry-family extrapolation claims.

POLICY METRICS

POLICY	SERVED CASES	ROUTED CASES	ID SERVED	OOD ROUTED	SERVED COVERAGE 90
<code>explicit_envelope</code>	100	202	1	1	0.907814
<code>learned_score</code>	117	185	0.9	0.866337	0.902871
<code>explicit_then_learned_score</code>	90	212	0.9	1	0.909548

03 Audit Scope And Evidence Contract

This page is the audit contract: what model was reviewed, how evidence was split and calibrated, and who owns the decision.

MODEL LINEAGE

FIELD	VALUE
Training data	Retained PL-WP-002 steady thermal-fluid evidence pack cases
Solver/source	OpenFOAM-derived steady thermal-fluid simulations
Model artifact	Public support release prediction index; checkpoints not included
Training code	scripts/09_train_field_operator.py
Frozen at	PL-WP-002 public support release v1.0.0
Owner	Phyloop public benchmark

VALIDATION PROTOCOL

FIELD	VALUE
Split strategy	ID calibration, ID test, constructed OOD test, and fresh OOD test pools
Calibration method	Split-conformal field uncertainty calibration
Acceptance rule	Served cases must meet configured 90% coverage threshold
Fallback rule	Route outside-envelope or high-score cases to solver
Review boundary	Engineering screening only; not certification or production signoff

DECISION DEFINITIONS

DECISION	MEANING
Conditionally qualified	May be used only for the stated context of use, with <code>runtime_gate.json</code> enforced.
Evidence incomplete	Do not deploy until missing audit evidence is supplied and the audit is rerun.
Not qualified	Do not serve the surrogate for the stated use; route cases to solver or improve the evidence/model.

SIGN-OFF RECORD

FIELD	VALUE
Prepared by	Phyloop qualification audit kit
Review owner	Design-partner CAE lead
Decision owner	Customer simulation owner
Required before production	Customer-specific solver replay, model artifact review, and production-use validation

04 Runtime Gate

The deployment rule is mechanical: serve the surrogate only when the case is inside the explicit parameter envelope and the configured score is below threshold.

Operational artifact. Use `runtime_gate.json` as the serve-or-solver fallback rule for this audit.

VALIDATED ENVELOPE

PARAMETER	ENVELOPE	UNIT
h_ch	4.0 to 10.0	mm
n_fin	4, 5, 6, 7, 8	
h_fin	2.0 to 6.0	mm
d_in	2.0 to 6.0	mm
u_in	0.2 to 1.5	m/s
q_w	5.0 to 50.0	kW/m^2

05 Evidence Gaps And Limitations

AUDIT-DERIVED FINDINGS

- > Served 90% coverage is 0.909548, meeting the configured minimum 0.9.
- > 222 cases are routed to solver; the ranked follow-up list is in `solver_backfill_recommendations.csv`.
- > No blocking evidence gap was detected for the declared context of use when `runtime_gate.json` is enforced.

DECLARED LIMITATIONS

- > This audit supports known parameter-envelope routing, not universal hidden-physics detection.
- > The public evidence pack omits raw OpenFOAM case directories, model checkpoints, and NPZ field tensors.
- > The benchmark is steady thermal-fluid screening evidence, not a production coolant model.

RECOMMENDED NEXT ACTIONS

- > Serve only inside the declared envelope and only when `band_width_mean_norm_90` <= 0.560471.
- > Run solver backfill first on `ood_test_0071` (`ood_test`, `outside_explicit_parameter_envelope`); then review the remaining ranked cases.
- > Use `runtime_gate.json` as the deployment fallback rule.
- > Route all explicit envelope violations to the solver.
- > Use `solver_backfill_recommendations.csv` to prioritize follow-up simulations near routed or high-score cases.

TOP SOLVER BACKFILL CASES

RANK	CASE	POOL	REASON	SCORE	EXPLICIT OOD	NEAREST ID	DIST.	RMSE	REL. L2
1	<code>ood_test_0071</code>	<code>ood_test</code>	Outside envelope	18.5356	true	1.13435		2.98737	0.499774
2	<code>ood_test_pbf03_0091</code>	<code>ood_test</code>	Outside envelope	15.2526	true	1.12772		2.97408	0.52398
3	<code>ood_test_0017</code>	<code>ood_test</code>	Outside envelope	11.93	true	1.1312		3.19252	0.59943
4	<code>ood_test_pbf03_0027</code>	<code>ood_test</code>	Outside envelope	11.5004	true	0.706533		0.990103	0.4178
5	<code>ood_test_pbf03_0034</code>	<code>ood_test</code>	Outside envelope	9.91418	true	1.07459		2.73491	0.52354
6	<code>ood_test_pbf03_0039</code>	<code>ood_test</code>	Outside envelope	9.15376	true	1.19257		1.25899	0.421862

DOCUMENT CONTROL

ARTIFACT

Surrogate qualification audit

DECISION

Conditionally qualified

REFERENCE

pl-wp-002-public-sample

GENERATED UTC

2026-07-07 08:26:51.562402 UTC

This audit defines the stated context of use, runtime gate, evidence limits, and solver follow-up queue for the surrogate under review. It is not a certification artifact or a replacement for customer-specific engineering validation.