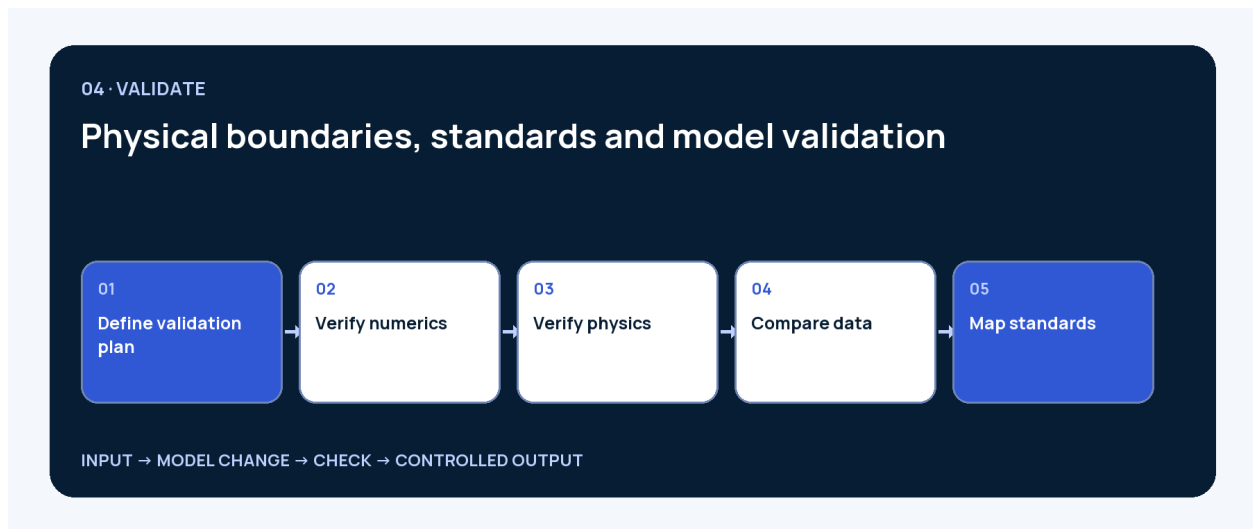




Physical boundaries, standards and model validation

Turn a calculated result into a traceable engineering statement





Prepare the model

Input	Why it is required	Ready when
Intended use	Defines acceptance criteria and required evidence.	Decision, population, scale and risk are explicit.
Physical boundaries	Limits working volume, oxygen, temperature, shear, ammonium and lactate.	Boundary, unit, source, action and range are documented.
Validation dataset	Tests prediction outside calibration.	An independent dataset and comparison plan exist.
Standards and requirements	Connects engineering, GMP, safety and project requirements.	Applicability, version, owner and evidence are recorded.
Approval roles	Establishes independent review and controlled approval.	Author, reviewer and approver are separated.

Preflight check

- Confirm the correct project, branch and controlled version
- Verify units, provenance and permissions
- Save a restore point before a decision-relevant change
- Keep blocking gaps visible

APPLICABILITY LIMIT

Axion organises evidence and tests; qualified people and approved company processes own regulated, safety and investment approval.



Workflow

1. Define validation plan

1. Document intended use, risk, datasets, metrics and tolerances.

VISIBLE RESULT

The plan is versioned before results are inspected.

2. Verify numerics

2. Assess closure, solver, convergence, discretisation and reproducibility.

VISIBLE RESULT

Numerical health has no unexplained blocker.

3. Verify physics

3. Evaluate process, equipment and quality bounds against trajectories.

VISIBLE RESULT

Violations include time, magnitude and action.

4. Compare data

4. Compare prediction and measurement with residuals, bias and intervals.

VISIBLE RESULT

Pass/fail is traceable for every criterion.

5. Map standards

5. Map applicable requirements to model, data, operation and documents.

VISIBLE RESULT

The matrix shows evidence or gap.

6. Set maturity

6. Select Screening, Calibrated, Validated or Not decision-ready by evidence gates.

VISIBLE RESULT

State, rationale, reviewer and date are stored.



7. Approve or reject

7. Close findings and sign a controlled version.

VISIBLE RESULT

Audit trail and residual uncertainty are complete.



Review the result

Review criterion	Pass condition	If it fails
Scope and structure	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Units and balances	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Evidence and uncertainty	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Reproducibility	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.
Review state	The documented criterion is satisfied and supported by traceable evidence.	Correct the model or keep the output Not decision-ready.

DECISION RULE

Axion organises evidence and tests; qualified people and approved company processes own regulated, safety and investment approval.



Troubleshooting

Observation	Likely cause	Correction
The result looks plausible but cannot be explained	Inputs, units, model version or evidence are missing.	Open the relevant register, restore traceability and rerun.
A change affects unexpected outputs	Dependencies or imported mappings were not reviewed.	Inspect the change plan and before/after diff; undo if required.
The module appears complete but readiness is low	Required industrial evidence is still missing.	Assign the visible gaps and keep maturity at Screening or Not decision-ready.



Handover and next steps

Artifact	Recipient	Must contain
Module result package	Engineering reviewer	Inputs, calculations, results, units, intervals, maturity
Readiness register	Model owner	Gap, required work, owner, due date, intended use
Controlled version	Project team	Branch, version, change note, reviewer and restore point

Completion check

- The active project, branch, version and intended use are visible.
- All inputs have units, provenance, review state and uncertainty where relevant.
- Blocking model, physical, numerical and evidence gaps are closed or assigned.
- The result maturity matches the available evidence.
- A controlled output package opens correctly and includes limitations.

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