Digital Twin for Asset Integrity

A pragmatic white paper: the ISO digital-twin standards, how Credo3D maps to them, and where the real-world benefit lands for the integrity engineer.

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1. Executive summary

A digital twin is a live digital representation of physical equipment, kept in step with the real asset through data connections, so an engineer can see current condition, replay history and forecast the future. The ISO standards define what a digital twin is and how to structure it — they do not prescribe which engineering models run inside it.

Credo3D, the 3D module of Credo AI, already implements the core of the ISO framework: the digital representation (3D model, HUD and structured data) and the observable equipment. Once connected to PI or a similar data feed, it also provides the live data connection, synchronization and data collection. Two further layers complete the picture: the app's API 581 damage models, and an AI/LLM layer that reasons over the same equipment data and inspection history to write findings and reports. The remaining piece is the forecasting layer, which builds on the damage models.

This paper summarises the ISO requirements, maps Credo3D against them, and explains in practical terms where the genuine benefit arises for the engineer — and where a pragmatic implementation draws the line against an "ideal" system.

2. What a digital twin is — in plain terms

ISO/IEC 30173:2023 defines a digital twin as "a digital representation of a target entity with data connections that enable convergence between the physical and digital states at an appropriate rate of synchronization." Four words carry the meaning:

- Target entity — the physical thing: the pressure equipment, its measurement points and tags.
- Digital representation — the structured digital model that mirrors it.
- Data connections — the live link that carries readings from physical to digital.
- Convergence, at an appropriate rate — the two states stay in step, refreshed as often as the physics requires.

The phrase "at an appropriate rate of synchronization" matters. Integrity parameters — wall thickness, temperature drift, pressure cycling, corrosion — change on a minute-to-month timescale. A poll of the historian every 30–60 seconds is the appropriate rate; millisecond streaming is not required, and not worth its cost.

3. The ISO requirements, summarised

3.1 ISO/IEC 30173:2023 — concepts and terminology

A cross-domain terminology standard. It defines the vocabulary (target entity, digital twin entity, digital representation, data connection, convergence, synchronization) and sets the quality bar that the representation can be trusted to reflect the behaviour of the real asset. It defines no maturity levels.

3.2 ISO 23247:2021 — digital twin framework for manufacturing

A four-part reference architecture. Part 2 partitions a digital-twin system into three domains — manufacturing (the observable manufacturing element, or OME), digital twin (the digital twin entity, or DTE) and user — connected by cross-domain functional entities such as device communication and data collection. It is deliberately tool- and analytics-agnostic: it says where the pieces go, not which physics or damage models to run.

The key point: the ISO standards specify structure and vocabulary, not engineering content. API 581 (damage mechanisms) sits inside the digital twin entity as its analytics capability — compatible with, but not mandated by, the framework.

4. Credo3D mapped to the ISO framework

The table traces each ISO concept to its concrete realisation in Credo3D, and to its current status. “Live on PI” means implemented, and activated when the app is connected to a PI or similar data feed.

ISO concept	Standard	Credo3D mapping	Status
Target entity	ISO/IEC 30173	Pressure equipment, measurement points and equipment tags	Live
Digital representation	ISO/IEC 30173	3D model, HUD and the structured IOW data model	Live
Observable manufacturing element	ISO 23247	Equipment and integrity points — the IOW schema	Live
Digital twin entity	ISO 23247	The Credo3D viewer, HUD and data layer	Live
Data connection	ISO/IEC 30173	Live historian link — one-way, read-only	Live on PI
Convergence / synchronization	ISO/IEC 30173	Live status, refreshed at the appropriate rate (≤ 60 s)	Live on PI
Device communication	ISO 23247	Historian adapter — PI Web API or file drop	Live on PI
Data collection	ISO 23247	Ingestion of readings into the time-series store	Live on PI
Damage modelling	API 581	Damage mechanisms — screening plus corrosion-rate, damage-factor and susceptibility models	Live
AI / LLM analysis	Capability	Natural-language analysis and report writing over equipment data and inspection history	Live
Forecasting	Capability	Corrosion progression, crack growth and thermal models — built on the API 581 damage engine	Specified
Device control / write-back	ISO 23247	Actuating plant equipment — outside the integrity team’s role	Out of scope

Status legend — Live: running in Credo3D today. Live on PI: implemented, active once connected to a data feed. Specified: designed and on the build path. Out of scope: deliberately excluded.

5. The real-world use case — where the benefit genuinely lands

An integrity engineer’s condition data today lives in disconnected systems: design data in one database, thickness history in a spreadsheet, inspection events in an asset registry, documents and radiography in a file store. The 3D context is missing, so answering “where on this vessel is the problem, and what has happened there over time?” is slow, manual work.

A digital twin changes the economics of that question:

- See condition on the equipment — a callout sits at the exact x/y/z point, not in a row of a table.

- Replay excursions in time and space — scrub history and watch where and for how long a limit was breached.
- Forecast remaining life — run “what if we run hotter or cycle more” and see the date-to-MAWT move.
- Audit-ready traceability — every result shows its working, so a decision survives review.

Concrete example. A line is approaching minimum thickness. Today the engineer assembles the answer from several systems. With the twin, the line’s thickness history is already on the model; the API 581 damage engine gives the corrosion rate; a calibrated forecast shows remaining life under the current operating profile — and, in one what-if run, under a hotter or more cyclic profile. The engineer moves from data-gathering to a defensible inspection decision.

6. How Credo3D supports the engineer

- Locate — the 3D model with pins, callouts and areas puts every finding in physical context.
- Investigate — the HUD stacks design, inspection, thickness and document cards for the selected point.
- Monitor — with PI connected, live IOW status colours the model and flags excursions.
- Assess — the API 581 damage engine quantifies corrosion rate, damage factor and susceptibility.
- Ask — prompt the AI in natural language and get a synthesized, report-ready answer from the same data.
- Decide — remaining-life and what-if scenarios turn condition into an inspection plan.
- Record — reports and documents are opened in place and retained as evidence.

6.1 AI-assisted analysis — the flexible layer

Credo3D includes an AI/LLM layer that prompts a large language model using the available equipment data and inspection history — the same inputs that feed the HUD and the damage engine. This adds a flexible analysis layer over the digital twin: rather than only displaying the converged state, it reasons over it. Where the deterministic models give fixed, code-based answers, the LLM answers open-ended questions and writes the narrative. Because the prompt carries the actual values and the response cites them, the output stays traceable to the twin’s data.

The AI feature assists the engineer in several concrete ways:

- Design-data validation — cross-checks the material against the governing design code, reconciles minimum allowable thickness, and sense-checks the corrosion rate, flagging errors a human might miss (a material designation the code does not recognise, or a physically impossible negative corrosion rate).
- Report writing — turns the findings into a standards-based integrity report (API 510 / 570 / 581), ready to review, sign and store.
- Natural-language querying — the engineer can ask an open question (“what is the integrity risk for this line, given its history?”) and receive a synthesized answer, without assembling data across systems by hand.
- Traceability — every prompt and response is saved as a transcript, so the analysis is auditable and survives review.

The AI layer complements rather than replaces the deterministic models. It reasons over the twin’s data and writes the analysis, while remaining-life prediction stays on transparent, auditable physics — the LLM does not do the forecasting.

7. The ideal versus the pragmatic

An “ideal” digital twin — full closed-loop control, real-time streaming, CFD/FEA field solvers and machine-learning forecasting — is technically impressive but misaligned with what an integrity team needs.

Ideal system	Pragmatic implementation
Two-way: write setpoints back to the DCS	One-way, read-only: observe and advise

Millisecond streaming, event buses, edge devices	Polled at the appropriate rate (≤ 60 s)
Full CFD / FEA field solvers on demand	API 581 + reduced-order physics models
Machine-learning forecasting	Deterministic, auditable engineering models
Closed-loop actuation	Advisory — integrity teams advise, they do not actuate

The balance is deliberate. Integrity parameters move slowly, so polling is sufficient; the governing failure modes are well-understood physics, so transparent reduced-order models are preferable to opaque machine learning; and an integrity team is advisory, so there is no safety case for writing back to the plant. Under ISO/IEC 30173 this is a conformant digital twin — a digital representation with data connections and an appropriate synchronization rate. Under the stricter two-way “twin” reading it is a predictive digital shadow. The specification commits to the former, and documents the latter as the line it deliberately does not cross.

8. Conclusion

The highest-value, lowest-risk digital twin for an integrity team is a live condition mirror plus predictive forecasting — not a closed-loop control system. Credo3D already has the representation and, with PI, the data connection; the forecasting layer completes it. That is the pragmatic balance: standards-conformant, engineering-grade, and focused on the questions the engineer actually asks.

9. References

- ISO 23247:2021 — Automation systems and integration — Digital twin framework for manufacturing (Parts 1–4).
- ISO/IEC 30173:2023 — Digital twin — Concepts and terminology.
- CredoSoft — Digital Twin Design specification (Documentation/Digital Twin/Digital Twin Design.md).