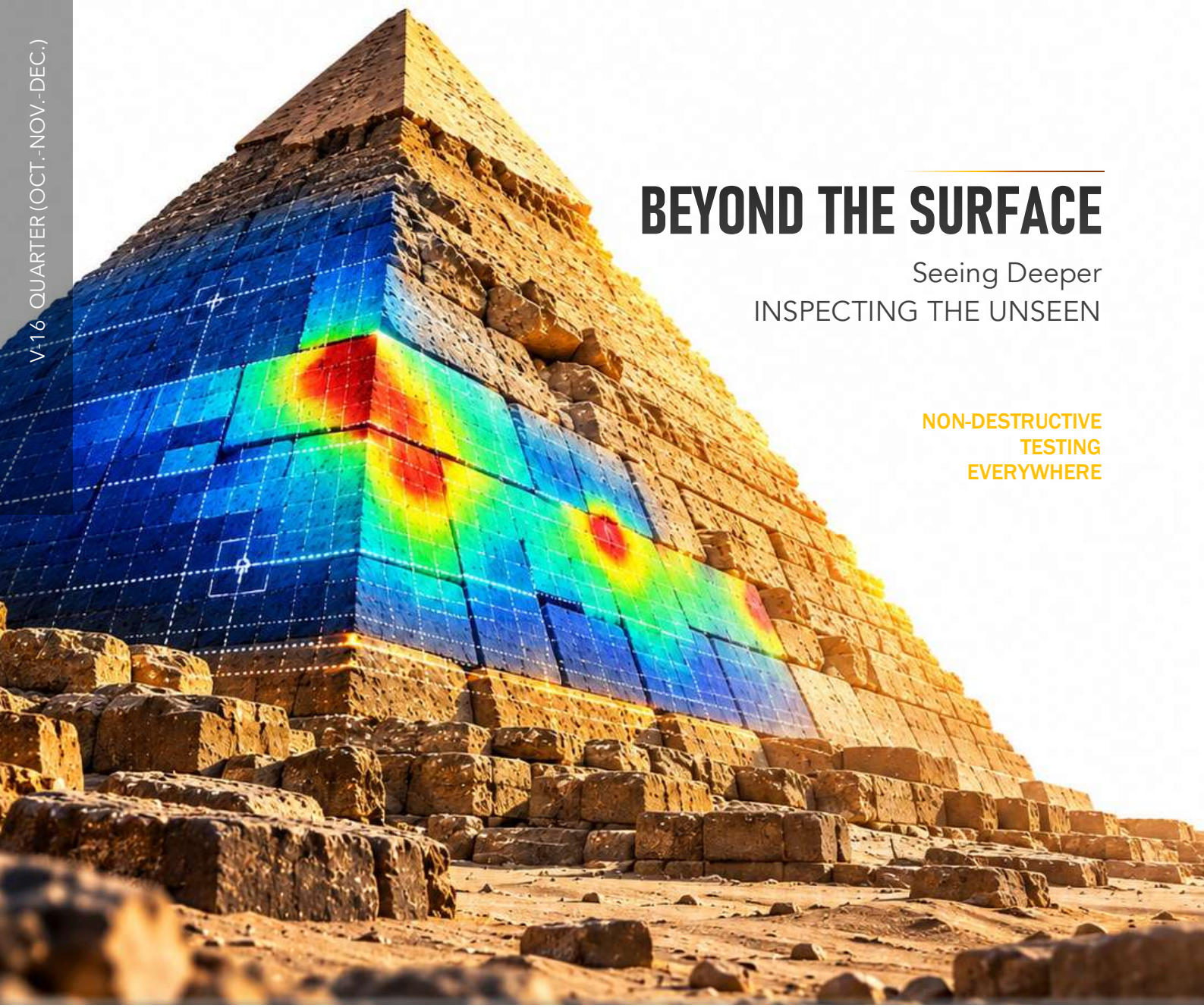
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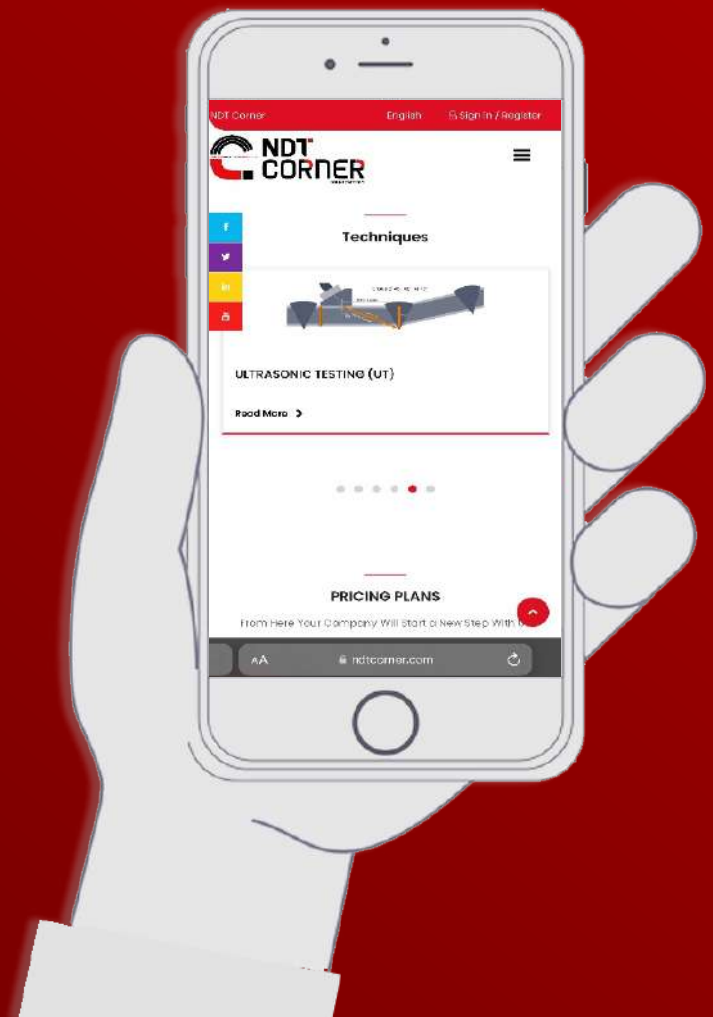
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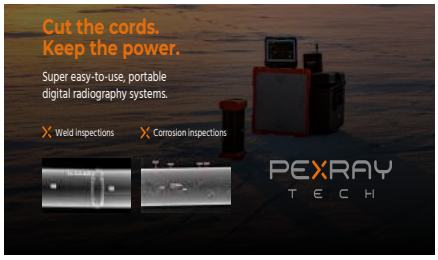
















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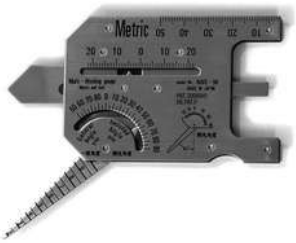
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NEW NDT SOLUTION SPOTLIGHT

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XEO: Compliance & Future-Proof Tech

XEO introduces a new generation of hardware and software capabilities designed to support both today's inspection needs and future compliance requirements. Many of these features operate quietly in the background, yet they play a crucial role in reliability, flexibility, and long term system value. This article highlights key design choices behind XEO and explains how performance, usability, and compliance were intentionally combined into a future-proof inspection platform.

HARDWARE COMPONENTS

Rugged Architecture

XEO's high-performance electronics are protected within an IP65-rated enclosure, with vibration approval. This mechanical design ensures reliable operation in demanding field environments while protecting sensitive components throughout the instrument's full service life.



Figure 1 Rear of the instrument, showing the battery bays. The 2 yellow side lids each conceal the USB-C ports

CONTINUOUS POWER AVAILABILITY

Two hot-swappable batteries provide up to six hours of real inspection time and remain compatible with previous-generation bay chargers. This allows uninterrupted operation during long inspections and simplifies fleet management for existing Sonatest users.

MODULAR CONNECTIVITY WITH MINI-DOCKS

XEO's interchangeable mini-dock system allows inspection to scale from a single PA to a dual PA and up to eight UT channels without external adapters. Mini-docks can be replaced in seconds, enabling the same instrument to support a wide range of PAUT, TOFD & multi-scan applications.



Figure 2 XEO offering a wide range of PA and UT splitter configurations

ENCODER INPUT

A new 3-axis encoder interface using a 16-pin LEMO 1 connector supports encoded inspections. This ensures accurate positional tracking for complex scan plans and supports consistent, auditable inspection results.

USB-C POWER & HIGH-SPEED DATA

XEO's USB-C ports provide both power and high-speed data transfer, supporting device charging and external fast storage like SSDs (up to 7.5 W per port at 10 Gbps). This facilitates modern workflows without compromising performance or data integrity. The external power supply includes a high-power 100-watt USB-C, allowing you to fast-charge compatible USB-C devices.

FLEXIBLE DISPLAY OPTIONS

HDMI & USB-C video outputs support both mirrored and extended screen modes. Flexibile training, remote & advanced analysis workflows. When combined with keyboard and mouse support, XEO functions as a complete workstation, expanding layout space & improving visual clarity **to 4K monitors.**



Figure 3 Extended USB-C display setup: Scanning specimen and get its weld PDF spec sheet at the same time.

HUMAN-CENTERED INTERFACE

The user interface is built around an 11.6-inch HD touchscreen by a 360-degree joystick with a clicker. Touch enables intuitive scan-plan interaction, while full joystick control guarantees usability in wet, cold, or gloved conditions.

SOFTWARE COMPONENTS

INTEGRATED OS TOOLS

XEO runs a KDE Linux environment, providing native access to file management, PDF documentation, and multimedia tools.

Remote Desktop Protocol (RDP) enables secure screen sharing for remote support, training, or collaboration through platforms, such as Microsoft Teams.

SECURITY AND COMPLIANCE FOUNDATIONS

XEO is certified to ISO 18563-1:2022 and ISO 22232-1:2020, covering both phased array performance and general ultrasonic testing requirements.

The system has been designed with cybersecurity in mind, aligning with the requirements of EN 18031-1:2024 under the Radio Equipment Directive (RED) 2014/53/EU.

As ultrasonic instruments increasingly connect to networks, ***software integrity and data protection*** are critical design considerations.

XEO ensures **software integrity through a secure boot architecture** and supports both over-the-air (OTA) and offline updates. Access control and system design measures reduce exposure of connected interfaces, enabling secure deployment in networked environments

Built to Meet Your Requirements

For compliance-related information or application guidance, please contact SONATEST. Our team will be happy to support you in confirming that XEO aligns with your company's inspection procedures and regulatory requirements.



Figure 4 KDE on XEO transforms the device into a full PC.



Figure 5 Operating features, connectivity, not just for NDT.

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Reliability & Asset Management Manager
and Consultant

The Business Value of Reliability

Turning Risk-Based Decisions into Measurable Asset Value

The implementation concepts that connect failure-mode analysis, weighted consequences and RCM strategies with measurable business value in oil and gas and refining.

Reliability creates business value when teams understand how assets can fail, prioritize the consequences, select effective strategies, and complete the necessary interventions. For oil and gas and refining organizations, this requires a connected asset-care process. The financial benefits, reduced exposure, and improved performance provide evidence of how well that process works.

This is consistent with the asset management perspective described by ISO 55001:2024: performance, risk, and expenditure must be balanced against organizational objectives.

The challenge for reliability professionals is to translate engineering decisions into evidence that integrity managers, operations leaders, and finance teams can assess together. [1]



Artificial intelligence has made this challenge more visible. Predictive systems can detect abnormal behavior, while the financial outcome depends on the response. DNV's May 2026 publication on AI risk in energy networks emphasizes assurance, monitoring, and governance. Its focus on accountable digital decisions offers a useful lesson for industrial operators: connect every actionable warning with a responsible owner, a technically sound intervention, and a recorded result. [2]

Start with functions, consequences and value

John Moubray's Reliability-Centered Maintenance, Second Edition, remains an established international reference for connecting maintenance with required functions, failure modes, and consequences. [3] Ron Moore's Making Common Sense Common Practice: Models for Manufacturing Excellence adds a business perspective, linking operating practices, design, procurement, and maintenance to manufacturing performance. Its Beta International case is fictional and informed by industrial experience; the financial evidence in this article comes from separate PETRONAS publications. [4]

An RCM review identifies suitable condition-monitoring, scheduled restoration or replacement, failure-finding, and design-change strategies. [5] The next step is to document each strategy's expected effect: which consequence it controls, whether it reduces failure frequency or severity, what performance it preserves, and what it costs. This makes the RCM output an input to investment and work-priority decisions.

Give failure consequences an explicit weight

Failure modes can affect **safety**, the **environment**, **production**, and **asset costs** differently. A weighted consequence assessment brings these dimensions into a consistent comparison, helping teams explain why one failure mode deserves greater attention. A recognized methodological reference is Thomas Saaty's Analytic Hierarchy Process (AHP), which derives relative weights through structured pairwise comparisons and checks the consistency of expert judgments. [6] Published applications include maintenance-strategy selection at an Italian oil refinery [7] and criteria weighting for failure-mode prioritization. [8] For this article, the following percentages are proposed as an illustrative starting point. Actual implementation should establish and approve the weights through a multidisciplinary assessment.

Consequence	Illustrative weight	Basis for severity score
Safety — S	35%	Potential injury, health effects, and impairment of critical safeguards
Environment — E	25%	Release severity, affected receptors, and recovery requirements
Production — P	25%	System throughput loss, outage duration, bottleneck position, and effective redundancy
Direct asset cost — C	15%	Repair, replacement, and response costs, excluding production losses already assessed above

Illustrative article weights; total = 100%. The cited references support the weighting method; site-specific judgments determine the percentages.

Score each dimension from 0 to 5, using documented site definitions: 0 represents no material consequence and 5 represents the highest defined severity. Apply the same definitions consistently across the assets being compared.

Weighted consequence score = 20 × (0.35S + 0.25E + 0.25P + 0.15C)

For S = 4, E = 3, P = 5, and C = 4:

Score = 20 × (1.40 + 0.75 + 1.25 + 0.60) = 80/100

To justify the weights, representatives from operations, maintenance, reliability, integrity, HSE, and finance should compare the four criteria pairwise. The resulting weights should total 100%, undergo a consistency check, and be tested through sensitivity analysis to determine whether reasonable changes alter the ranking substantially. The result is a semi-quantitative consequence index. Likelihood must be assessed separately through the approved risk process.

Severe safety or environmental exposure and required safeguards retain their own escalation criteria. RCM then determines the technically effective response. Financial benefits require a separate calculation using event frequency, financial consequence, and intervention costs.

Connect each strategy with its value mechanism

A high priority does not automatically justify a particular maintenance task. The selected action must address the mechanism and change the relevant exposure. The following mapping is an engineering synthesis of how an RCM strategy can create value. Monitoring creates information, corrective action changes exposure. For fixed equipment, inspection and corrosion assessment must relate to operating conditions and Integrity Operating Windows. [9] API's RBI framework similarly combines failure likelihood and consequence in risk assessment. [10] Together, these approaches help integrity and reliability teams distinguish a detected defect from a controlled risk.

Strategy	Risk-control mechanism	Potential business benefit
Condition monitoring plus intervention	Detect deterioration in time to act	Less secondary damage, emergency work, and avoidable downtime
Scheduled restoration or replacement	Manage a demonstrated age-related failure mechanism	Fewer applicable failures and more predictable maintenance demand
Failure-finding / functional testing	Reveal hidden failures and restore protection	Lower exposure to combined failures and unavailable safeguards
Design or operating change	Remove a weakness or reduce the initiating cause	Fewer recurring failures, longer asset life, and improved operating capability

Benefits depend on the failure mode, operating context, and completed intervention.

PETRONAS: documented financial value and performance

AVEVA's PETRONAS customer case reports that 200 predictive models generated 51 major early warnings in 2020, including 12 high-impact warnings. Reported first-year value was RM73.1 million, expressed in the publication as US$17.4 million, with a reported 14x ROI. Three documented ex. show where value arose. [11]

Reported intervention	Reported value	Share of these examples
Liquid separator instrumentation fault; asset damage and wasted material avoided	US$222,000	63.1%
Motor deterioration detected through temperature trends; replacement avoided	US$82,000	23.3%
Abnormal water-supply and bearing temperatures detected; escalating damage avoided	US$48,000	13.6%

Source [11]; shares calculated from the three examples.

The US$352,000 subtotal illustrates parts of the reported program value and should not be added to it. The shares show relative financial contribution among these three examples, not comparative safety risk. The source does not disclose enough cost detail to independently reproduce its ROI; its values are reported savings and cost avoidance, rather than audited net-profit figures. [11] A PETRONAS-authored technical paper gives a more operational view. In one case, cleaning a contaminated instrument-air dryer pre-filter avoided a trip and an estimated RM3.42 million loss. In another, resolving a compressor load-sharing problem and responding to increasing vibration avoided a failure scenario involving three days of production deferment. The paper reports an average equipment reliability metric of 96–99%, without a matched baseline from which to calculate a percentage improvement. [12]

Later publications describe broader value: AVEVA reported cumulative savings of US$33 million in March 2024, following implementation in 2019. [13] PETRONAS's *Integrated Report 2024* states that PROTEAN covered more than 500 critical rotating equipment items and helped prevent RM250 million in potential production-deferment losses and major maintenance costs. [14] These measures have different scopes and periods and should remain separate. They demonstrate reliability-program value; the sources do not isolate the return from a formal RCM review.

Express risk reduction in financial terms

For a defined failure scenario, expected annual financial loss can be estimated by multiplying event frequency by average financial consequence. Compare the baseline and residual exposure after the intervention, using consistent assumptions and scope. Where an event has several possible outcomes, account for their probabilities rather than assigning the worst outcome to every occurrence.

Expected annual loss = expected events per year × average financial loss per event

Expected annual risk benefit = baseline expected loss − residual expected loss

The following calculation is illustrative, not a PETRONAS result. Assume a critical-equipment failure frequency of 0.40 events/year, reduced to 0.10 events/year through an effective intervention. Average loss remains US$1 million per event, covering repairs and attributable production margin. Additional annual cost of the strategy is $60K.

Measure	Illustrative result
Baseline expected annual loss	US$400,000/year
Residual expected annual loss	US$100,000/year
Expected annual risk benefit	US$300,000/year
Reduction in expected financial exposure	75%
Expected annual net benefit after strategy cost	US$240,000/year

Planning estimate and no discounting or initial capital cost included.

This is a projected risk benefit, not guaranteed annual cash savings. If initial investment is required, include it in a lifecycle cash-flow assessment. Test uncertainty in frequency, consequence, and intervention effectiveness. Keep mandatory safety and environmental controls as constraints on the decision; financial attractiveness alone cannot establish acceptable residual risk.

The concepts organizations need to implement

The following implementation framework is an engineering synthesis of the article's lessons. Apply it first to a critical system through a team spanning operations, maintenance, integrity, reliability and finance.

1. Functional understanding and failure-mode analysis. Define required functions, performance standards, operating context, and credible failure modes. Use a consistent asset hierarchy and failure history to establish the scope of the review. [5]
2. Weighted consequences and risk prioritization. Apply site-approved consequence scales and justified weights for Safety, Environment, Production and Direct asset cost. Assess likelihood separately through the approved risk process, and retain escalation requirements for safeguards and unacceptable exposure.
3. Technically justified RCM strategies. Select condition monitoring, scheduled restoration or replacement, failure-finding, or design change according to the failure mechanism. Set task intervals using evidence of task applicability and effectiveness. [5]
4. A defined execution and response process. Translate recommendations into CMMS job plans, assigned owners, response times, competent personnel, and available spares. Connect monitoring alerts and integrity operating limits to clear intervention and escalation actions.
5. Baseline measurement and value verification. Record failure frequency, downtime, availability, and maintenance costs before implementation. Check system-level production effects; have finance validate incremental margin and net benefits, deduct costs, and prevent double counting.
6. Continuous learning and strategy review. Use root cause failure analysis for significant or recurring failures. Review task effectiveness, residual risk, and operating changes, then update the asset-care plan and the assumptions supporting its business case.



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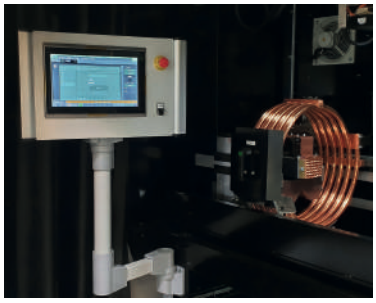
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Three Life-Saving Habits for Field Radiographers in Oil & Gas Facilities

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INTRODUCTION

In the fast-paced environment of offshore and onshore oil & gas facilities, radiographers often work under tight schedules and challenging field conditions. While obtaining a quality radiographic image is essential, radiation safety must never be compromised by production pressure. Radiation safety is not simply a regulatory requirement—it is a daily professional practice. Based on field experience, the following three habits can make a significant difference in preventing radiation incidents and protecting radiographers, coworkers, and other personnel on site

HABIT 1

Use the Appropriate Collimator

Whenever permitted and required by the applicable procedure, using an appropriate collimator is an effective way to control the radiation beam and reduce unnecessary radiation exposure outside the area of interest. Before the exposure, the radiographer should ensure that the collimator is correctly selected, properly installed, securely positioned, and correctly aligned with the area being examined. A properly used collimator can help reduce the radiation field and minimize unnecessary radiation levels in the surrounding work area. Do not consider the collimator a substitute for proper radiation barriers, controlled-area requirements, survey- meter measurements, or the approved radiographic procedure.

HABIT 2

Treat the Source as "Alive"

Always treat a radioactive source as if it is capable of producing radiation exposure until its safe condition has been positively verified. Never touch a radioactive source with your hands, regardless of the circumstances. Sources commonly used in industrial radiography, such as Iridium-192 (Ir-192) and Selenium-75 (Se-75), can produce significant radiation exposure. A source that appears to be safely positioned must never be assumed to be secure without appropriate verification. During source retrieval or exposure operations: -Keep hands away from the source and source assembly. -Use the approved remote handling equipment and techniques. -Maintain control of the crank cable and guide tube. -Monitor radiation levels with a calibrated survey meter. -After source retraction, verify that the source has returned to the shielded position before approaching the exposure device or controlled area. Never rely on assumptions when dealing with a radioactive source. Verify.

HABIT 3

Plan Your Escape Route Before the Exposure

Before beginning an exposure, take a few seconds to look at the work area from a safety perspective.

Identify:

- The designated safe route out of the radiation area.
- Any obstacles, scaffolding, pipes, equipment, or temporary structures that could restrict movement.
- The location of the control point and barriers.
- The position of the survey meter and other essential equipment.
- Potential locations where personnel could unintentionally enter the controlled area.

This becomes particularly important in an abnormal situation, such as a suspected source-retrieval problem. If something goes wrong, you do not want to start thinking about your escape route at that moment. Make sure the area is cleared of unauthorized or unnecessary personnel before the exposure begins, and verify that the established boundaries and warning systems are effective.

CONCLUSION

Good radiographers do not rely on luck or experience alone. They develop simple, repeatable habits that remain effective even under pressure. Control the radiation field. Treat the source as alive. Know your way out. These habits take only a few seconds to apply, but they can prevent serious radiation incidents and help protect everyone working around the radiography operation. Safety must come first—on every exposure, on every job. This article is intended for professional awareness and does not replace the applicable radiation protection regulations, employer's written procedures, or site-specific radiography safety requirements.



Authors
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Sambit Dhar

Connected Nondestructive Testing:

A Standards View of Data Interoperability and Industrial Networks

ABSTRACT—Nondestructive testing (NDT) is moving beyond stand-alone instruments toward inspection workflows in which data are exchanged among acquisition systems, analysis workstations, industrial networks, repositories, and enterprise applications. That transition makes communications standards relevant to NDT, but the relevant standards address different parts of the problem. ASTM DICONDE defines open structures for the display, transfer, and storage of digital nondestructive evaluation data; OPC Unified Architecture (OPC UA) provides a general industrial information and service framework; IEEE time-sensitive networking standards and IEC/IEEE 60802 address deterministic industrial networking; 3GPP specifications define service requirements for 5G and cyber-physical vertical applications; and IEC 62443 addresses security for industrial automation and control systems. This article reviews these standards from an NDT perspective and separates what each one establishes from what it does not. A layered reference model is then proposed to show how NDT information objects, industrial information exchange, network services, and security can be combined without treating any one standard as a complete NDT architecture. The main conclusion is deliberately narrow: the standards reviewed here provide useful building blocks, but their cross-layer use for connected NDT still depends on implementation profiles, shared semantics, and application-specific requirements.

Why Communication Standards Matter to NDT

Nondestructive testing has traditionally been organized around the inspection method: ultrasonic testing, radiography, eddy current, thermography, or another technique. In a stand-alone workflow, the instrument acquires the data, the operator interprets it, and the result is stored locally or transferred as a report. Digital inspection changes the boundary of that workflow. Encoded ultrasonic data, digital radiographs, equipment status, scan coordinates, and evaluation results may now move between several systems before the inspection record is complete. That does not turn NDT into a telecommunications discipline. It does, however, create a standards problem that communications engineers will recognize. A receiving system must be able to identify the data, understand the associated metadata, preserve timing and context where those attributes matter, and protect the record against unauthorized modification. In automated or remote inspection, network behavior may also affect when information becomes available to another component of the system. The useful question is therefore not whether NDT should adopt one communications technology. It is narrower: which existing standards can carry different parts of a connected inspection workflow, and where are their boundaries? This article takes that approach. It is a tutorial review of standards rather than a proposal for new inspection acceptance criteria, network performance limits, or safety requirements. [1][16]

What a Connected NDT System Exchanges

A connected inspection does not exchange a single type of information. At least three categories can be separated. The first is the inspection evidence itself: waveforms, images, reconstructed views, or other acquired data. The second is context: component identity, inspection method, equipment and probe information, calibration-related information, coordinates, acquisition settings, timestamps, and the relationship between a result and the data from which it was derived. The third is operational traffic, such as equipment status, scan position, commands, alarms, or health information. These categories can share a physical network, but they should not be treated as interchangeable. A large image file being transferred for later review has a different communications need from a timing or control message used inside an automated inspection cell. Likewise, preserving an inspection record for later engineering review is primarily an information-integrity and context problem; it is not automatically a low-latency networking problem.

This separation helps avoid a common design error: selecting a network technology first and assuming that interoperability follows. Connectivity answers whether systems can exchange bits. NDT interoperability also depends on whether the receiving system can interpret the inspection object and its metadata correctly. DICONDE addresses much of that information-layer problem.

DICONDE and the NDT Data Layer

ASTM E2339-21 defines the base practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE). ASTM describes DICONDE as an industrial adaptation of Digital Imaging and Communications in Medicine (DICOM) and states that the base practice is to be used with method-specific DICONDE practices and the DICOM standard for a complete modality implementation [2][3]. The current ASTM guide, E3169-26, organizes the DICONDE family around display, transfer, storage, archiving, and interoperability use cases [2][3].

For ultrasonic testing, ASTM E2663-25 specifies DICONDE information needed for ultrasonic methods and covers image data transfer and archival storage [4]. For digital X-ray methods, ASTM E2699-23 provides the corresponding method-specific practice [5]. ASTM also maintains DICONDE practices for other nondestructive evaluation methods, including computed radiography, eddy current, computed tomography, and thermography; E3169-26 provides the current guide to that standards family [2].

Two boundaries are important. First, DICONDE does not define the overall functions of an integrated inspection system. E2339 explicitly excludes the overall feature set expected when multiple conforming devices are integrated [3]. Second, conformance is a separate issue from merely adopting a file structure. ASTM E3147-25 provides procedures for evaluating DICONDE compliance and interoperability of NDT and inspection systems, and it explicitly states that it does not establish examination-system performance limits [6].

The distinction matters in practice. DICONDE can serve as the inspection-object layer because it standardizes how digital inspection information is represented and exchanged. It should not be described as a plant network architecture, a deterministic transport protocol, or a cybersecurity framework. ASTM E3267-21 addresses archiving and information-model considerations for managing DICONDE data, which is relevant when inspection records must remain interpretable after the original acquisition system has changed [7].

TABLE I. WHAT THE REVIEWED STANDARDS ESTABLISH - AND WHERE THEIR SCOPE STOPS

Standard family	Role in this article and scope boundary
DICONDE (ASTM E2339 family)	Defines NDT-oriented data and metadata structures for display, transfer and storage; companion practices cover methods and interoperability. It does not define a plant network, deterministic transport, or an NDT cybersecurity program.
OPC UA (OPC 10000 series)	Provides general industrial information models and communication services. It does not, by itself, define NDT method semantics or inspection acceptance criteria.
IEEE 802.1AS / IEC/IEEE 60802	Provide timing/synchronization and an industrial-automation TSN profile. They do not define NDT data objects or universal NDT performance targets.
3GPP TS 22.104 / 22.261	Define service requirements for cyber-physical vertical applications and the 5G system. They are not NDT application profiles.
IEC 62443-3-3 / 4-2	Define industrial system- and component-security requirements. They do not define the meaning or completeness of an NDT inspection record.

Industrial Information Exchange: Where OPC UA Fits

OPC Unified Architecture (OPC UA) addresses a different layer. OPC UA is a general industrial architecture with an information model, services, client/server and publish-subscribe concepts, discovery, and security mechanisms. The current Part 1 specification is OPC 10000-1, Release 1.05.06 [8][9]. It does not define NDT acceptance rules or the internal structure of a DICONDE ultrasonic or radiographic object.

That separation suggests a practical division of responsibility. DICONDE can carry the detailed inspection object, while OPC UA can expose equipment state, identifiers, workflow context, and references to inspection records in a form intended for broader industrial integration. In this arrangement, an application does not need to force high-volume NDT data into every operational message. It can exchange the context required by the factory or asset system and retain the detailed inspection object in an appropriate DICONDE repository.

Nondestructive evaluation (NDE) 4.0 literature has discussed semantic interoperability as a standardization issue and identifies vendor-independent OPC UA companion specifications and DICONDE information models as possible mechanisms [8]. This article therefore treats OPC UA as an established industrial building block but does not assume that a standardized NDT-specific OPC UA information model already exists. Any NDT mapping would have to be defined and validated before an interoperability claim could rest on it.

Network Services: Time-Sensitive Networking and 5G

Network requirements depend on the inspection application. A post-process transfer of an ultrasonic data set can tolerate behavior that would be inappropriate for synchronized motion or time-sensitive control. For this reason, time-sensitive networking should be discussed only where the application has a defined timing requirement.

IEEE 802.1AS-2025 specifies timing and synchronization over local area networks for time-sensitive applications [10]. IEC/IEEE 60802:2026 goes further for industrial automation by defining profiles that select features, options, configurations, protocols, and procedures from time-sensitive networking technologies for industrial automation networks [11]. These standards are relevant building blocks when an automated inspection system genuinely depends on synchronized time or deterministic industrial communication. They do not prescribe NDT data models, defect acceptance criteria, or an NDT-specific latency target. Wireless inspection has a different motivation. Robotic crawlers, mobile platforms, temporary inspection installations, or remote monitoring systems may benefit from mobility where a wired connection is inconvenient or impractical. Third Generation Partnership Project (3GPP) TS 22.104 defines service requirements for cyber-physical control applications in vertical domains, while TS 22.261 defines broader service requirements for the 5G system [12], [13]. Those specifications support a standards-based discussion of industrial wireless requirements, but neither document is an NDT application standard. Accordingly, this article does not assign a universal latency, reliability, or throughput requirement to NDT. Those values are properties of a particular inspection architecture. A remotely reviewed radiograph, an automated ultrasonic production line, and a wireless inspection robot may all use digital communications, yet their traffic patterns and consequences of delay are different.

Security and Trust of the Digital Inspection Record

Once inspection equipment is networked, cybersecurity can affect confidence in the digital inspection record. The relevant concern is not that every NDT instrument becomes part of a control system in the same way as a PLC.

The narrower point is that unauthorized changes to configuration, identity, stored data, or transmitted results can undermine traceability of the evidence used for an engineering decision. IEC 62443 provides an industrial security framework that can be applied when connected NDT components are deployed within industrial automation and control system (IACS) environments. IEC 62443-3-3 specifies system security requirements and security levels, while IEC 62443-4-2 specifies technical security requirements for IACS components [14], [15]. These documents address such areas as identification and authentication, use control, system integrity, data confidentiality, restricted data flow, response to events, and resource availability. IEC 62443 does not define what constitutes a valid ultrasonic calibration record or a complete radiographic inspection object. DICONDE, in turn, is not a substitute for an industrial cybersecurity program. A connected-NDT implementation therefore needs both information semantics and security controls, with responsibilities assigned according to the system architecture and the governing quality or regulatory framework.

A Layered Reference Model for Connected NDT

Figure 1 combines the standards into a layered view. It is a synthesis for engineering discussion, not an architecture required by ASTM, OPC Foundation, IEEE, IEC, or 3GPP. The bottom layer contains the acquisition equipment. Above it, DICONDE represents the detailed NDT information object. OPC UA can provide a broader industrial information and service layer. Network services provide the actual connectivity, with TSN-related mechanisms used only where timing requirements justify them and 5G considered where wireless mobility is useful. Enterprise applications and archives consume the information at the top of the stack.

The vertical concern in the figure is assurance: security, identity, configuration control, and auditability cut across several layers. None of those concerns is solved simply by choosing a data format or a network bearer. The layered view is useful precisely because it prevents a standard from being asked to do work outside its scope.

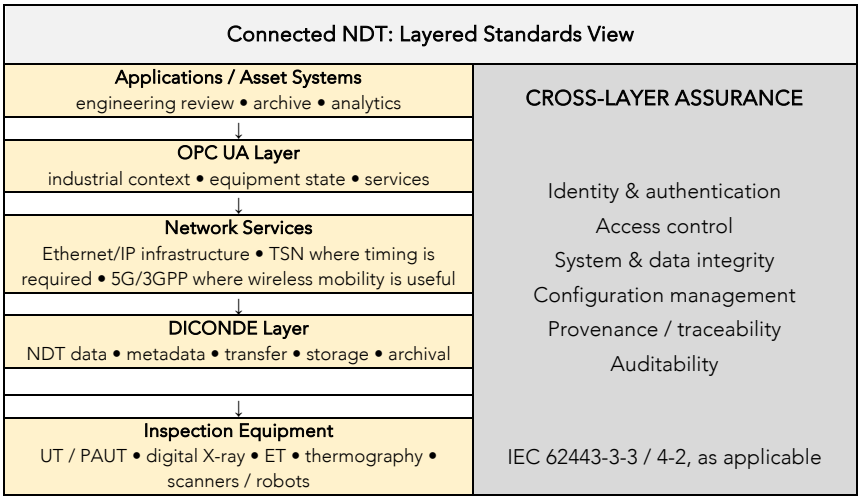


Fig. 1. Proposed layered view of connected NDT. The figure is an author synthesis; it is not an architecture mandated by any one cited standard.

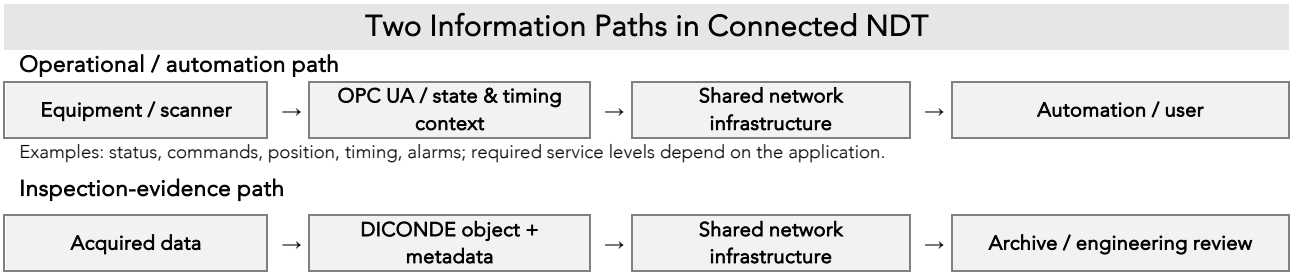


Fig. 2. Operational traffic and inspection evidence can share infrastructure while retaining different information and assurance needs. The division is conceptual, not normative.

Application Profiles, Not One NDT Network

Table II gives a qualitative classification of four representative NDT use cases. The table is illustrative; it is not a normative performance specification. Its purpose is to show why a common semantic layer can coexist with different network choices.

For manual or post-process inspection, the dominant requirement is often preservation of the record and the information needed to interpret it later. For automated production inspection, timing and equipment-state exchange may become more important because acquisition is coordinated with motion and production flow. Robotic or mobile inspection adds a wireless link and may also carry control or video traffic. Long-term monitoring may favor periodic or event-driven transmission and scalable device management rather than continuous transfer of every raw sample.

The standards question is therefore one of profiling. A useful implementation profile would state which information objects are mandatory, which operational variables are exposed, what timing or delivery behavior is required for each traffic class, and which security controls apply. It would not declare one network technology to be best for every inspection method.

TABLE II. ILLUSTRATIVE COMMUNICATION EMPHASIS FOR REPRESENTATIVE NDT USE CASES

Use case	Illustrative communication emphasis
Manual / post-process review	Emphasis on record completeness, metadata and archive readability. Many transfers are not timing-critical.
Automated production inspection	Time/position correlation and equipment state may matter when acquisition is coordinated with motion or automation.
Robotic / mobile inspection	Inspection data may share a wireless link with control, status or video; required service levels depend on the control architecture.
Long-term monitoring	Identity, time history and event data are central; transmission may be periodic or event-driven depending on the monitoring objective.

Where the Standards Do Not Yet Meet

Across the standards reviewed here, no single document defines the complete path from an NDT acquisition object to industrial context, network quality of service, cybersecurity controls, and long-term engineering use. This is not a criticism of the standards; each was written for a different scope. The integration gap appears at their boundaries. Four boundary issues deserve attention.

First is shared semantics. DICONDE has NDT-specific information structures, while a plant-wide information model needs a consistent way to identify the asset, inspection activity, equipment, data object, and result across systems. Second is coordinate and time context. An inspection result is more useful when its location and time basis remain unambiguous as it moves between applications. Third is provenance: processed results should remain traceable to the source data and relevant processing context. Fourth is conformance.

Interoperability claims are more credible when they can be tested against a declared profile rather than inferred from support for a protocol name.

The first and fourth issues are already visible in the existing standards landscape. ASTM maintains dedicated DICONDE interoperability practices [6], and NDE 4.0 literature discusses semantic information models and OPC UA companion specifications as mechanisms relevant to NDE standardization [8]. A future profile could build on that work rather than introduce another general-purpose transport protocol.

Toward a Connected NDT Communication Profile

A practical next step would be an implementation profile that reuses existing standards and states the interfaces between them. Such a profile could be developed by an appropriate standards community; the elements below are presented as a discussion framework rather than as requirements.

First, the profile should identify the DICONDE objects and metadata that must be retained for the selected NDT method and use case. Second, it should define a small industrial information model for asset identity, inspection activity, equipment state, calibration status, data-object reference, and result status. OPC UA is a plausible framework for that information model, but the mapping should be standardized before interoperability is claimed. Third, the profile should separate traffic classes. Bulk inspection data, event notifications, time synchronization, equipment status, and control messages should not automatically receive the same network treatment. Fourth, the profile should state security assumptions and controls. Where the inspection system is part of an IACS environment, the IEC 62443 series provides established system- and component-level requirements that can inform the design [14], [15]. Fifth, the profile should include conformance tests that demonstrate information can be transferred and interpreted as intended. For the DICONDE portion, ASTM E3147-25 already provides a useful interoperability-testing foundation [6].

The result would not be a new "NDT protocol." It would be a constrained way of using existing standards together. That is an attractive direction for communications standardization because profiles can reduce optionality at system boundaries without duplicating the technical work already contained in DICONDE, OPC UA, TSN, 5G, or industrial cybersecurity standards.[16]

What the Communications Community Can Take from NDT

NDT is a useful industrial case study because the same workflow may contain large inspection objects, machine state, timing information, human review, and records that must remain meaningful after acquisition. The relative importance of these elements varies by application, which makes a layered and profile-based approach more credible than a single end-to-end technology prescription.

It also highlights a broader standards lesson. Semantic interoperability and network performance are related but different engineering problems. A deterministic network does not by itself tell a receiving application what an ultrasonic indication means. A well-structured inspection object does not by itself guarantee timely delivery or protect the surrounding system. Connected NDT needs both, with the boundary between them made explicit.

CONCLUSION

Communications standards can support digital NDT, but only when their roles are stated precisely. DICONDE provides the NDT-specific foundation for digital data representation, transfer, storage, and interoperability. OPC UA can provide a broader industrial information and service framework around inspection equipment and records. IEEE 802.1AS and IEC/IEEE 60802 provide timing and industrial TSN building blocks where deterministic communication is actually required. 3GPP service requirements provide a standards basis for considering wireless cyber-physical and 5G use cases, while IEC 62443 provides industrial cybersecurity requirements.

The standards reviewed here should therefore be viewed as complementary, not interchangeable. The most defensible standardization opportunity is not to create another general communications protocol for NDT. It is to define application profiles that preserve NDT semantics, make industrial context explicit, assign network behavior according to the use case, and test interoperability at the interfaces. That would give connected NDT a clearer path from digital inspection data to interoperable industrial use without extending any standard beyond what it actually specifies.

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Submarine LPG Hose Test & Inspection

1- TECHNICAL SCOPE

Submarine Liquefied Petroleum Gas (LPG) flexible hose assemblies serve as the primary conduit connecting Pipeline End Manifolds (PLEM) on the seabed to Single Point Mooring (SPM) buoys, Conventional Buoy Moorings (CBM), or Floating Storage and Offloading (FSO) vessels. Operating in dynamic subsea environments, these specialized composite rubber and steel structures are subjected to severe continuous cyclic bending, vortex-induced vibrations, hydrodynamic wave action, subsea ambient hydrostatic pressures, and chemical exposure to pressurized liquid propane/butane mixtures.

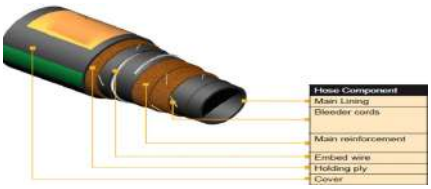


Figure 1 Hose Components

Subjecting LPG marine hoses to standard tests prior to commissioning is mandatory to verify structural integrity, confirm the absence of inner liner damage or carcass layer separation (delamination), validate electrical continuity (or electrical discontinuity, where cathodic protection isolation is required), and ensure 100% leak-tightness reliability before field deployment.

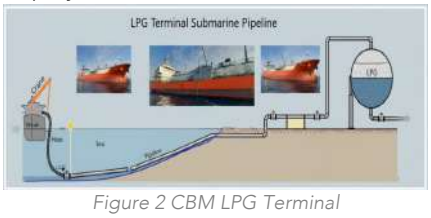


Figure 2 CBM LPG Terminal

To minimize residual stress effects after repair, stress-relief heat treatment is generally applied. Nevertheless, concerns remain

2- HANDLING, STORAGE & SITE PREPARATION

IMPORTANT SAFETY WARNING: Always maintain the specified minimum bending radius during handling and lifting operations. Avoid contact with sharp metal edges, abrasive surfaces, and other potentially damaging materials. Never use unpadded steel wire rope slings for lifting or transportation. Ensure adequate protection is provided to prevent mechanical damage to the hose.

- **Bend Radius Control:** Hoses must be handled strictly within approved Minimum Bend Radius (MBR) envelopes.



Figure 3 Minimum Bend Radius (MBR)

- **Rigging & Support Spacing:** During crane lifts or deck handling, hoses must be suspended using wide fabric slings or cushioned spreader bars attached to a **minimum of 3 evenly spaced support points** to prevent acute localized bending or kinking.

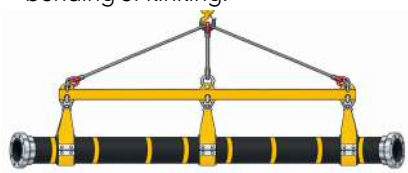


Figure 4 Rigging & Support Spacing

- **Manual Flange Surface Cleaning:** Prior to connecting the hose string, all flange faces, gasket seating surfaces, and bolt holes must be thoroughly cleaned using suitable manual tools, such as wire brushes, to remove sand, dirt, corrosion products, and loose paint residues.



Figure 5 Flange Surface Cleaning

Following cleaning, all flange sealing surfaces must be carefully inspected for mechanical damage, including scratches, dents, pitting, and other surface imperfections that could compromise gasket sealing integrity and lead to leakage during pressure testing or subsequent operations. Any defects identified must be assessed and rectified before flange assembly.



Figure 6 Flange Surface Inspection

- **Subsea Towing & Buoyancy:** Assembled strings launched from shore must be fully dewatered, fitted with rated blind flanges at both ends, and supported by buoyancy modules. The towing speed in open water must not exceed 3 knots (~5.5 km/h).

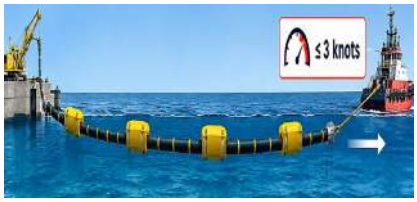


Figure 7 Max Towing Speed

3. DETAILED HYDROSTATIC PRESSURE TESTING PROTOCOL

Hydrostatic pressure testing must be performed on smooth, horizontal support beds or low-friction rollers that permit unhindered longitudinal movement as the hose expands or contracts under hydraulic forces. Fresh water is used as the non-compressible testing medium.

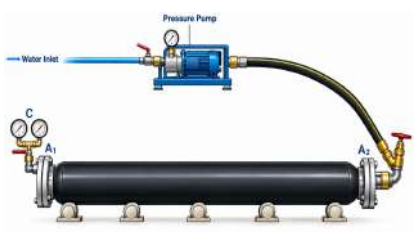


Figure 8 Hydrostatic Pressure Test

A. End Blanking & De-Aeration Setup
Both hose flanges are sealed with pressure-rated blind flanges, each fitted with a 1 /2" PN40 steel ball valve. Water is pumped into the lower flange while elevating the discharge end approximately 30 cm to vent all trapped air. The vent valve is closed once a solid water stream flows.

B. Low-Pressure Stabilization (0.7 bar) Measurement: L_1
Internal water pressure is increased to **0.7 bar (10 psi)** to remove slack and seat internal carcass elements. The distance between flange seating faces is precisely measured with a calibrated steel tape & logged as **L_1**

C. Intermediate Proof Pressure Step (1 3.75 bar)
Pressure is ramped up over a period of **no less than 5 minutes** to 1 3.75 bar (50% nominal test pressure). This pressure is held for **10 minutes** before being gradually depressurized to 0 bar over a duration of at least 5 minutes.

D. Full Nominal Pressure Hold (27.5 bar) Measurement: L_2
Pressure is increased over >5 minutes to the full nominal pressure of **27.5 bar (400 psi)** and held for **10 minutes**. All fittings, end nipples, and hose bodies are visually inspected for leaks. Distance **L_2** and electrical continuity are recorded under full load before depressurizing to 0 bar over >5 minutes.

E. Rest Period & Permanent Set Measurement — Measurement L_3
After a mandatory 15-minute unpressurized rest period, pressure is re-applied to **0.7 bar**. Final length **L_3** and final electrical continuity are recorded to compute temporary and permanent elongation percentages.

Elongation Calculations & Limits

- **Temporary (Elastic) Elongation (%):** $[(L_2 - L_1) / L_1] \times 100$ | *Max allowable per OCIMF: ≤ 7.5%*
- **Permanent Set (Plastic) Elongation (%):** $[(L_3 - L_1) / L_1] \times 100$ | *Max allowable per OCIMF: ≤ 0.7%*

4. VACUUM TESTING & INTERNAL LINER INSPECTION

The vacuum test assesses the adhesive bond strength between the smooth inner elastomeric lining and the primary fabric/steel carcass layers. Under operational conditions, rapid LPG depressurization can cause non-bonded linings to collapse inward (blistering or delamination).

Vacuum testing must be conducted within a **maximum of 4 days** following the hydrostatic pressure test to ensure carcass fibers retain baseline moisture levels without structural alteration.

Vacuum Test Setup & Inspection Protocol

- **Plexiglass Flange Assembly:** Both ends of the hose are sealed with heavy-duty transparent acrylic (plexiglass) blind flanges using soft nitrile rubber gaskets.
- **Vacuum Evacuation Target:** A vacuum pump lowers internal absolute pressure to at least **510 mbar.**
- **Hold Duration & Optical Inspection:** Vacuum is maintained for a minimum of **10 minutes**. High-intensity LED spotlights or mirrored reflectors are shone through the plexiglass to illuminate the full inner bore.
- **Defect Identification:** Internal wall blistering, carcass puckering, air pocket formation, or water droplets weeping through cuts indicate inner liner perforation or delamination, triggering instant scrapping.



Figure 7 Vacuum Test and Internal Inspection

5. ELECTRICAL CONTINUITY & BONDING INTEGRITY

To avoid electrostatic charge build-up during high-velocity liquid LPG transfers, subsea hoses are manufactured as Electrically Continuous (EC). In contrast, where cathodic protection system isolation is required between buoy and manifold, Electrically Discontinuous (ED) hoses are specified.

Comprehensive Defect Evaluation & Scrapping Standards

Hose Component	Observed Defect / Discontinuity	Evaluation & Action Standard
1. Inner Rubber Lining Chemical barrier & fluid boundary	• Deep cuts or gouges exposing fabric/steel plies • Delamination (loss of adhesion between liner & carcass) • Separation of inner liner from metallic end fitting • Ozonation or dry-rot cracking from improper storage	Visual & Vacuum Inspection. Wall swelling or bubble formation under vacuum mandates rejection. SCRAP HOSE
2. Main Carcass Plies Spiral textile/cord tensile reinforcement	• Cord cuts or chafing caused by helix wire movement • Material fatigue / structural cord degradation • Inter-ply delamination across carcass layers	Hydrostatic Test. Excessive temporary (>7.5%) or permanent (>0.7%) elongation. SCRAP HOSE
3. Embedded Helix Wires Crush & vacuum resistance armor	Helix wire displacement or overlapping due to over-bending • Localized wire fracture or wall distortion (belting) • Cover gouges exposing structural wire helix	Visual Inspection. Any visible wire exposure or localized wall belting requires immediate decommissioning. SCRAP HOSE

Continuity Verification Circuit Methodology: Continuity is measured during hydrostatic testing at 27.5 bar and post-test at 0.7 bar using a low-voltage circuit: a 4.5V DC power source wired in series with a 4V, 3A incandescent indicator lamp. Copper test leads are clamped to bare metallic flange surfaces. Steady lamp illumination confirms complete low-resistance electrical bonding through internal spiral wire helices.



Figure 10 External Surface Damage

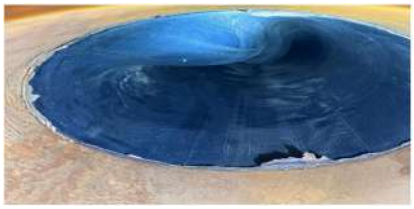
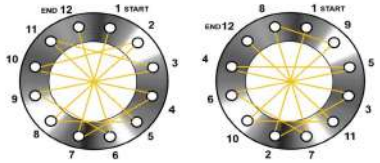


Figure 11 Internal Damage

6. PRE-DEPLOYMENT SUBSEA VERIFICATION STEPS

- **Bolting & Torque Sequencing**: All flange bolts must be lubricated with marine-grade anti-seize compound and tightened using calibrated hydraulic torque wrenches in a star/cross pattern to 100% target torque.



- **Gasket Material Compatibility**: Flange connections must be proper gaskets with pressurized liquid propane and butane.

- **Breakaway Coupling (MBC) Integration**: Marine Breakaway Couplings must be installed in the subsea string to provide automatic dual dry-break closure in the event of an emergency tanker breakout.

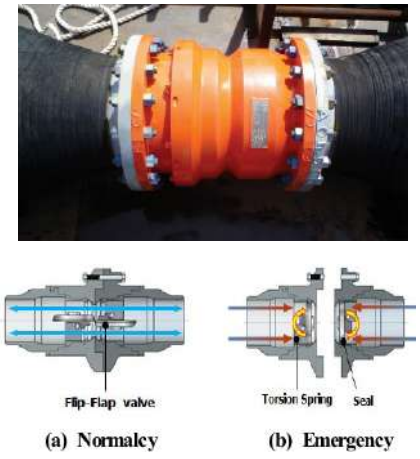


Figure 9 Marine Breakway Coupling

7. FINAL DOCUMENTATION & RECORD RETENTION

Dossier Archiving Requirement: All test records, non-destructive testing (NDT) reports, third-party witness certificates, and calibration records must be systematically maintained in the terminal operations database.

Records must be organized chronologically and linked to the inspection and testing schedule to ensure traceability and support effective planning. Before each subsequent inspection or test, previous records must be reviewed. This systematic approach is essential to maintaining equipment integrity and ensuring safe terminal operations.

8. CONCLUSIONS

Submarine LPG hose integrity depends on a documented connection between design, operating duty, observed condition and release authority. Hydrostatic, vacuum and electrical tests provide complementary evidence, while handling controls and subsea survey establish whether that evidence remains relevant after installation.

Manufacturer specific acceptance limits, competent interpretation and timely intervention are essential.

The strongest program treats testing as one element of mechanical integrity management and links it to marine operations and process safety barriers.

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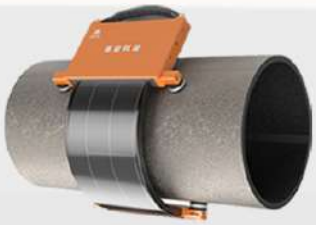


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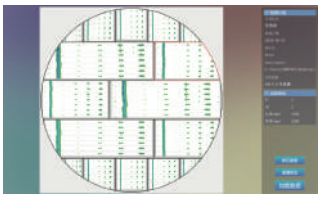




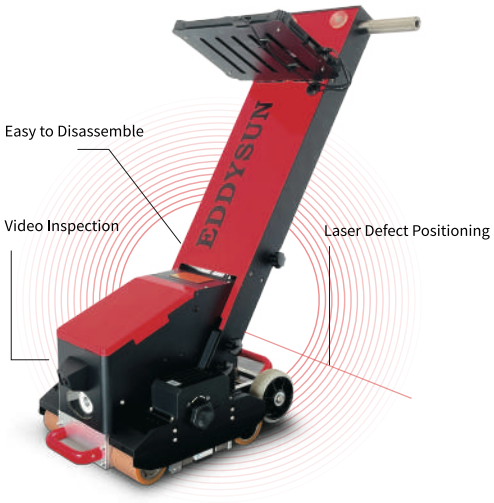
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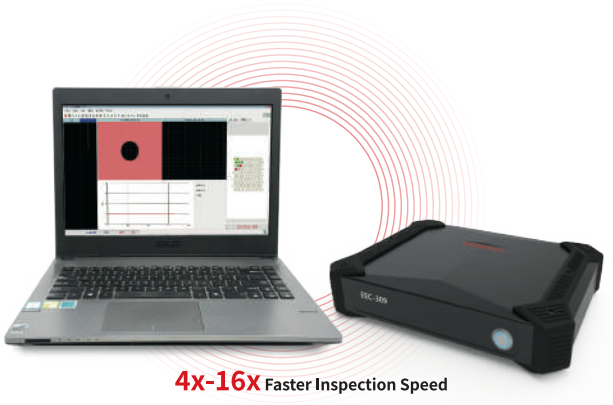
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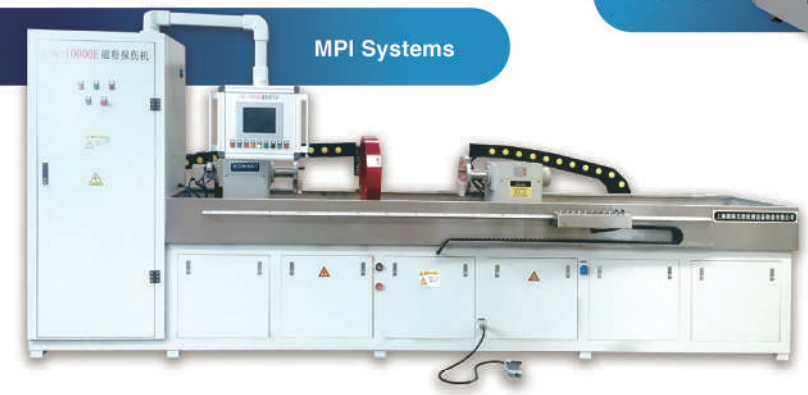


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The Asset Integrity Challenges in Flowlines:
The Interplay of Cl^-/SO_4^{2-} Ratios and Flow-Accelerated Corrosion

ABSTRACT
Managing production piping integrity requires balancing fluid chemistry with hydrodynamic effects on piping failure. This paper evaluates asset integrity risks by focusing on the chloride-to-sulfate (Cl^-/SO_4^{2-}) concentration ratio across different oil fields. While historical data shows failure frequencies peak in fields with high Cl^-/SO_4^{2-} ratios due to accelerated electrochemical corrosion, this investigation demonstrates that hydrodynamic anomalies can completely override chemical protection. Specifically, this paper presents a case study of a check valve where internal components damage altered flow geometry, creating high-velocity turbulence and aggressive impingement. This extreme shear stress physically stripped away protective scales, causing rapid Flow-Accelerated Corrosion (FAC) and wall perforation. Ultimately, this study demonstrates that localized flow dynamics can completely bypass chemical protection, highlighting a critical degradation threat of FAC that persists even in seemingly low-corrosivity environments.

Keywords: Flow-Accelerated Corrosion (FAC); CO2, Asset integrity; Hydrodynamics; Chloride-to-sulfate ratio.

1. INTRODUCTION

Internal corrosion of carbon-steel flowlines is a major asset-integrity concern in oil and gas production systems because the degradation process is governed by the interaction of fluid chemistry, water availability, operating conditions, material characteristics, and hydrodynamic behavior. Although corrosion assessment commonly relies on bulk fluid chemistry and operating data, field experience demonstrates that corrosion severity and damage location cannot always be explained by the bulk chemical environment alone. Local variations in flow conditions can significantly modify the interaction between the aqueous environment and the steel surface and may therefore contribute to localized and accelerated metal loss. [1,2,4,5,6,7,8,9,10,23,24,25]

Water chemistry represents one of the fundamental factors controlling the internal corrosion behavior of carbon-steel equipment and flowlines. Produced water chemistry can vary considerably between oil fields and between different production systems within the same field. Parameters such as pH, chloride concentration, sulfate concentration, alkalinity, temperature, water availability, and the presence of other dissolved species influence the stability of corrosion products and protective surface films and consequently affect the susceptibility of carbon steel to corrosion. For this reason, comparison of corrosion behavior between different production environments requires consideration of the overall chemical context rather than reliance on a single water-quality parameter. [1,3,4,13,19,20,21,22,24]

The relationship between chloride and sulfate provides a useful comparative indicator of the aqueous chemical environment. Where the relevant water-chemistry conditions are present, the combined effect of chloride and sulfate has traditionally been considered using the Larson–Skold Index (LR); its equation is mentioned below. However, the applicability and interpretation of LR depend on the characteristics of the water chemistry and on the presence and behavior of carbonate and bicarbonate alkalinity. [1,3,19,20,21,22]

$$LR = \frac{Cl + SO4}{HCO3 + CO3}$$

Consequently, LR should not be treated as a universally applicable corrosion criterion for all produced-water systems. In systems with limited or negligible alkalinity, the direct Cl^-/SO_4^{2-} ratio can instead be used as a comparative chemical-context variable, provided that it is interpreted together with other relevant corrosion parameters. [1,3,4]

A relatively higher Cl^-/SO_4^{2-} ratio represents a more chloride-dominated chemical environment, while a relatively lower ratio represents a greater contribution from sulfate. The ratio is therefore considered in this study as an indicator for comparing the chemical environments associated with different production systems rather than as a standalone predictor of corrosion failure. Its significance must be considered together with parameters such as pH, water availability, temperature, flow regime, deposit formation, protective-film stability, and the effectiveness of corrosion-control measures. [1,19,20,21,22]

However, the influence of flow conditions introduces an additional dimension to internal corrosion assessment. In production flowlines, the local hydrodynamic environment controls mass transfer, wall shear stress, phase distribution, and the stability of corrosion products or other protective surface films. The average production flow rate may therefore not adequately represent the conditions experienced by a specific location on the pipe wall. Changes in geometry associated with welds, fittings, reducers, joints, valves, or damaged internal components can generate velocity gradients, turbulence, recirculation, and impingement. These localized effects can increase the transport of corrosive species to the steel surface and may disturb protective deposits or corrosion-product films. Figure (1) shows Local velocity gradients generated by a geometric discontinuity such as a weld bead. [11,14,15,17,23,24,25]

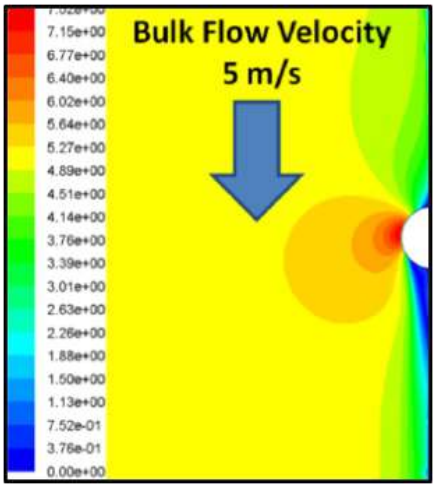


Figure 1. Schematic representation of the velocity gradient associated with a geometric disturbance such as a weld bead.

The relationship between geometric discontinuities and local hydrodynamic conditions is also reflected in the distribution of wall shear stress. Figure 2 illustrates the influence of a geometric discontinuity, such as a weld bead, on local wall shear stress. A localized increase in velocity gradient can produce a corresponding increase in shear acting on the pipe-wall surface. Repeated exposure to such localized hydrodynamic conditions can disrupt the stability of surface films and contribute to accelerated localized metal loss, particularly where flow disturbances become dominant at the component level. [11,15,17]

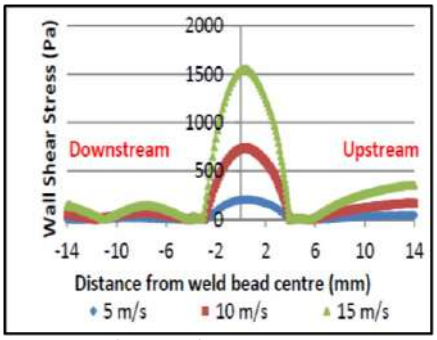


Figure 2. Influence of a geometric disturbance such as a weld bead on local wall shear stress.

These effects become particularly relevant in components and flow configurations where restrictions, changes in flow direction, or other geometric features cause the local flow conditions to deviate significantly from the bulk operating conditions.

Consequently, the average flow rate may not adequately represent the hydrodynamic environment experienced at a specific location within the system. This distinction is important when evaluating corrosion failures because significant local damage may develop even when the bulk chemical environment does not indicate a highly aggressive corrosion condition. The interaction between bulk water chemistry and local hydrodynamic conditions is further examined through the check-valve failure case study presented in this paper. [11,14,15,17]

From an asset-integrity perspective, reliable evaluation of internal corrosion requires consideration of both the chemical environment and the physical conditions experienced by the flowline. Bulk water chemistry provides important information on the corrosivity of the produced fluid; however, degradation is also influenced by operating conditions, flow behavior, component geometry, surface condition, and localized hydrodynamic effects. Consequently, the conditions experienced at a specific location may differ from those represented by bulk process measurements. [1,4,10,11]

This distinction is particularly relevant where geometric discontinuities, flow restrictions, fittings, valves, or changes in flow direction modify the local flow field. Average operating parameters may not fully represent localized velocity, turbulence, impingement, or wall shear conditions, which can affect surface-film stability and the development of localized metal loss. Such effects should therefore be considered when identifying credible degradation mechanisms and evaluating their potential significance. [11,15,17]

Within an asset-integrity framework, combining chemical, operational, hydrodynamic, and inspection information provides a more representative basis for understanding degradation and defining appropriate inspection and mitigation strategies. This approach recognizes that the condition of a flowline is governed by the interaction of the corrosive environment with the local physical conditions experienced by the asset, rather than by any single parameter considered independently. [1,4,10,11]

2. ASSESSMENT METHODOLOGY

This section describes the assessment methodology used to examine the relationship between water chemistry and internal-corrosion occurrence in carbon-steel flowlines across eight oil fields. The field assessment evaluates how variations in produced-water chemistry, likes to the Cl^-/SO_4^{2-} relationship and pH, are associated with the observed frequency of corrosion-related failures. Flow rate and water resistivity are considered as operating and environmental variables that can modify this relationship. A separate check-valve case study is assessed to demonstrate the importance of localized hydrodynamic effects, particularly where the bulk water chemistry indicates a relatively minor corrosion environment and no corresponding corrosion failures are observed in the associated piping. The case therefore examines how local flow conditions within a component can produce significant localized damage despite the relatively low corrosion severity indicated by the bulk chemical environment. [1,10,13,14,15,17]

2.1 Field-Based Assessment of Water Chemistry and Corrosion Occurrence:

The field assessment uses corrosion history and representative operating and water-chemistry data from eight oil fields. For each field, the assessment considers the occurrence of localized internal-corrosion anomalies over the available observation period and compares this behavior with the corresponding aqueous environment and operating conditions. The purpose is to identify relationships between changes in water chemistry and the observed field failure rate rather than to assign a universal corrosion threshold to any individual chemical parameter. The factors that will be contributed to assessing corrosion are listed below considering all piping system have continuous bottom-water wetting of the lower pipe wall because of considerable high water cut: [13,14,15,17]

- ✓ Operating flow rate
- ✓ Water availability/water cut
- ✓ CO_2 exposure
- ✓ Water chemistry: pH, Cl^-/SO_4^{2-} and resistivity
- ✓ Internal deposits from pigging, it will be from pipeline of each field.

Because localized corrosion may not be adequately represented by an average metal-loss rate, corrosion occurrence is assessed using the annual frequency of recorded anomaly cases: FPY = N / T

Where N is the number of corrosion-related anomaly cases and T is the assessment period in years. FPY represents the frequency of corrosion occurrence at field level and is not equivalent to a direct corrosion rate (mm/y).

Flow rate and water resistivity are included because the field assessment indicates that chemical conditions do not act independently of the physical flow environment. Water resistivity provides an indication of the electrical conductivity of the aqueous phase, while flow rate represents the bulk operating condition that can influence mass transfer, surface-film stability, and flow-induced degradation. The combined assessment therefore considers the interaction of: [1,11,14,15,17]

pH + water resistivity + Cl^-/SO_4^{2-} + CO_2 + flow condition + internal deposits → observed corrosion occurrence

This approach is particularly important when comparing fields with different operating conditions. A change in the Cl^-/SO_4^{2-} ratio should therefore be interpreted together with the prevailing pH, resistivity, and flow conditions rather than as an isolated chemical measure. [1,13,19,20,21,22]

2.2 Check-Valve Case: Localized Hydrodynamic Assessment:

The check-valve case is assessed using an integrated examination of the component condition, internal flow configuration, inspection history of the associated flowline, and produced-water chemistry. Visual and dimensional examination is used to characterize the location, morphology, and directionality of internal metal loss, with particular attention to localized grooves, penetration depth, and through-wall defects. The condition of internal valve components, including the disc and hinge assembly, is also considered because component degradation can modify the internal flow path and generate localized flow disturbances. [11,15,17]

The inspection history of the associated flowline is reviewed to determine whether comparable internal corrosion is present in the upstream and downstream piping. Historical UT measurements and recorded corrosion anomalies are used to establish the baseline corrosion behavior of the flowline surrounding the valve. The produced-water chemistry is evaluated using available pH, chloride, sulfate, bicarbonate, TDS, and water-resistivity data to establish the general corrosivity of the bulk fluid.

The chemical assessment is then compared with the observed corrosion condition of the associated flowline and the localized damage within the valve. [13,19,20,21,22]

Where the bulk chemical environment and the adjacent flowline indicate relatively low corrosion activity, the assessment further considers whether abnormal internal component conditions could have altered the local flow field. Particular attention is given to flow impingement, turbulence, recirculation, and localized flow acceleration resulting from changes in valve geometry or movement of internal components. This approach allows the contribution of localized hydrodynamic conditions to be assessed separately from the general corrosivity of the produced water. [11,15,17]

3. RESULTS AND DISCUSSION

3.1 Field-Level Operating, Water-Chemistry and Anomaly Data

Across the eight fields, FPY ranged from 0.2 to 8.1. F1 exhibited the highest FPY (8.1), followed by F4 (2.7), whereas F6 and F5 exhibited the lowest FPY values (0.2 and 0.3, respectively). The differences between fields are not represented by a single measured variable and are therefore evaluated using the combined operating, water-throughput, aqueous-chemistry and CO_2 data presented in Table 1. The lower half of each piping system is continuously occupied by water, with oil forming the upper layer. Therefore, persistent water wetting of the lower pipe wall is common to all eight fields. BWPD is consequently interpreted as a measure of water throughput rather than as an indicator of whether water is present at the pipe wall.

Field	FPY	Flow Rate (10^3 x BBL/d)	BWPD (10^3 x BBL/d)	pH	Resistivity (Ω·m)	Cl^-/SO_4^{2-}	CO2 (mole %)	
							Max	Max
F1	8.1	65	51	5.50	0.031	550.8	2.12	2.12
F2	1.3	34	28	6.09	0.039	124.8	2.91	2.91
F3	1.4	21	17	5.36	0.029	466.8	0.71	0.71
F4	2.7	49	41	5.83	0.029	100.9	0.94	0.94
F5	0.3	11	9	5.64	0.022	279.9	3.07	3.07
F6	0.2	27	14	6.14	0.042	24.3	2.25	2.25
F7	1.0	15	12	6.58	0.061	24.0	0.74	0.74
F8	1.2	35	27	6.27	0.036	40.5	0.85	0.85

Table 1. Field operating conditions, water throughput, and anomaly frequency

Note: FPY denotes the observed field anomaly frequency per year. BWPD denotes produced-water rate. The Cl^-/SO_4^{2-} ratio is calculated from the reported chloride and sulfate concentrations in ppm units. The operating data show a wide range of flow and water throughput. F1 and F4 combine relatively high flow with the highest and second-highest FPY values, respectively. In contrast, F5 has the lowest flow and a low FPY, while F6 retains moderate-high flow but has the lowest FPY. These contrasts indicate that higher flow may be associated with greater anomaly occurrence in some fields, but the field response cannot be interpreted from flow alone. [11,14,15,17]

The aqueous data also vary substantially between fields. F1 combines relatively low pH and resistivity with a high Cl^-/SO_4^{2-} ratio, while F3 shows similarly low pH and resistivity and a high ratio but at lower flow. F5 has the highest average CO_2 together with low pH and very low resistivity, yet its FPY remains low. F6 has moderate CO_2 exposure but higher pH and resistivity and a much lower Cl^-/SO_4^{2-} ratio, consistent with its very low FPY. These comparisons show that CO_2, pH, resistivity and ionic composition provide different aspects of the aqueous environment and should be interpreted together rather than individually. [13,14,19,20,21,22]

Pigging records from the corresponding pipelines were used to characterize the internal deposits present within the piping systems. Scale, sand, paraffin and mixed deposits were recovered across the eight fields. The recovered masses are summarized in Table 2 so that the table describes the deposit pattern. [12,16]

Field	Deposit Type	Recovered Mass in three different periods (kg)
F1	Scale	10, 5, 2
F2	Sand	40, 20, 20
F3	Sand; Sand + paraffin	5, 10; 15
F4	Sand + paraffin	25
F5	Paraffin; Sand; Sand + paraffin	30; 5; 50
F6	Paraffin	20, 20, 20
F7	Paraffin + scale; Paraffin	20, 20; 20
F8	Sand/scale; Paraffin + sand	10; 10, 50

Table 2. Summary of pigging records and recovered internal deposits for the eight fields

Note: Recovered mass represents the material reported from pigging and is used to characterize the internal deposition environment. It is not treated as a direct measure of corrosion rate or as proof that the recovered deposit caused the reported anomalies. The pigging records provide field evidence that the internal environment contains persistent deposits of different types. F1 repeatedly recovered scale, F2 consistently recovered sand, F5 showed paraffin and mixed sand/paraffin recovery, and F6 repeatedly recovered paraffin. Mixed deposits were also observed in F3, F4, F7 and F8. The records therefore distinguish the fields not only by water chemistry and operating conditions but also by the type of material present within the piping system. [12,16]

3.1.1 Field Comparison and Qualitative Classification

To provide a transparent comparison, the principal contributing parameters were classified qualitatively as High, Medium or Low using ranges derived from the investigated field dataset. The classification is used to identify combinations of conditions associated with the observed FPY. Table 3 shows the qualitative classifications, while table 4 shows the integrated qualitative assessment of corrosion-contributing factors with corresponding FPY in each field.

Parameter	High	Medium	Low
Flow (10^3 BBL/d)	> 40	20–40	< 20
pH	< 5.70	5.70–6.20	> 6.20
Resistivity (Ω·m)	< 0.030	0.030–0.045	> 0.045
Cl^-/SO_4^{2-} ratio	> 250	50–250	< 50
Average CO_2	> 2.0	1.0–2.0	< 1.0
Internal deposit condition	Repeated scale or mixed deposits	Persistent single deposit type	Limited deposit evidence

Table 3. Qualitative Classification Criteria for the Investigated Corrosion Environment

The above ranges are reference categories for the present dataset. They are intended to support qualitative field comparison. The deposit category describes the observed deposition condition from pigging records and is not treated as direct proof of deposit-induced corrosion.

Field	Flow	pH	Resistivity	Cl^-/SO_4^{2-}	Average CO_2	Deposit condition	FPY
F1	High	High	Medium	High	Medium	High	8.1
F2	Medium	Medium	Medium	Medium	High	Medium	1.3
F3	Medium	High	High	High	Low	Medium	1.4
F4	High	Medium	High	Medium	Low	High	2.7
F5	Low	High	High	High	High	High	0.3
F6	Medium	Medium	Medium	Low	Medium	Medium	0.2
F7	Low	Low	Low	Low	Low	High	1.0
F8	Medium	Low	Medium	Low	Low	High	1.2

Table 4. Qualitative Classification of Corrosion-Contributing Factors and Observed FPY

Based on the combined qualitative classification of operating flow, produced-water chemistry, CO_2 exposure, and internal deposits, the eight fields were grouped into three qualitative FPY conditions, as summarized in Table 5.

Qualitative FPY Condition	Fields	Observed FPY	Common Characteristic of Contributing Factors	Interpretation
High FPY	F1	8.1	High operating flow combined with several High-severity chemical indicators and persistent internal deposition	Represents the strongest concurrence of unfavorable operating, chemical, and deposition conditions
Intermediate FPY	F4	2.7	Moderate-to-high operating exposure with a mixture of Medium and High chemical-severity indicators; deposits present	Represents combined conditions of intermediate severity, with no single factor dominating the observed FPY
	F3	1.4		
	F2	1.3		
	F8	1.2		
	F7	1.0		
Low FPY	F5	0.3	Low operating flow and/or predominantly Medium-to-Low chemical severity, although deposits are present	Indicates that persistent deposits or individual unfavorable parameters do not necessarily result in high FPY
	F6	0.2		

Table 5. Qualitative Grouping of Fields by FPY Condition and Corrosion-Contributing Factors

3.2 Check-Valve Failure Case: Localized Hydrodynamic Effect Under a Relatively Low-Corrosivity Bulk-Water Environment

The check-valve case is included as a component-level example to complement the eight-field assessment. The field-level analysis shows that bulk operating and water-chemistry conditions act together to influence anomaly frequency, whereas this case demonstrates that a local change in flow configuration can create severe, highly localized damage even when the surrounding bulk-water environment is assessed as relatively low in corrosivity. [11,15,17]

3.2.1 Bulk-Water Chemistry and Straight-Flowline Corrosion History

The failure analysis for a 4" oil flowline's check-valve leak caused by a through-wall pinhole. Figure 3 shows the photograph of the external valve body.



Figure 3. Check-valve external condition

The historical UT record provides an important comparison with the failure location. Successive wall thickness measurements indicated minimal corrosion along the straight sections of the oil flowline, with calculated corrosion rates generally within the acceptable range.

Furthermore, no recorded internal-corrosion anomaly or failure was identified along the 4-in. oil flowline outside the failed valve. Thus, the straight-pipe inspection history provides evidence that the bulk flowline environment was not producing a comparable level of localized wall loss before valve failure.

The water analysis also shows relatively stable chemistry. The failure analysis assessed the produced water as baseline low-corrosivity under normal operating conditions, and this assessment was consistent with the minimal corrosion observed in the straight flowline. The important point for the present study is therefore not that the water was non-corrosive, but that the bulk chemistry alone did not correspond to the severe localized wall loss observed at the check valve.

3.2.2 Failure Morphology and Localization of Damage

Visual examination of the dismantled valve identified significant damage confined to a distinct internal zone. The morphology consisted of an elongated groove aligned with the flow direction, increasing penetration depth in the direction of flow and terminating in a through-wall pinhole at the deepest portion. That with absence of widespread pitting or colonies of isolated pits. The external location of the pinhole is shown in Figure 4(a), while Figure 4(b) shows the internal appearance and light transmission through the through-wall defect. The morphology shown in Figure 4 is significant because the damage is directional and spatially confined rather than randomly distributed. A flow-directional groove with a progressively deeper profile toward the final penetration is consistent with a localized flow effect. The morphology therefore provides a different type of evidence from the field-wide FPY analysis: it identifies the component and location where the local environment became substantially more severe than the bulk flowline condition. [11,15,17]

3.2.3 Change in Local Hydrodynamic Conditions Following Disc Detachment

The failure analysis records feedback that the check-valve disc (clapper) had detached from its hinge pin. The consequence was uncontrolled movement of the disc within the valve body, with the possibility of directing the flow toward the affected area and generating turbulent flow. The detached internal component and hinge region are shown in Figure 5(a), while Figure 5(b) shows the normal check-valve configuration.

Figure 4. Localized groove and through-wall pinhole identified in the failed check valve.



(a) Pinhole location on valve body

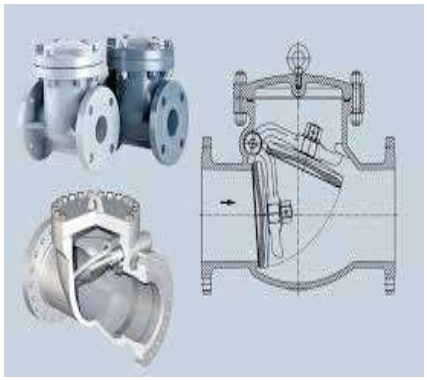


(b) Internal damage and through-wall defect

Figure 5. Evidence of internal-component degradation and the corresponding normal check-valve configuration.



(a) Detached/loose internal disc-hinge assembly



(b) Check-valve normal configuration

Table 6 demonstrates that the observed failure is a component-specific response to the altered hydraulic environment, rather than a direct reflection of the baseline water corrosivity. The failure sequence indicates that once the equipment internals were damaged, the resulting disturbance of the local flow field provided conditions for concentrated and directional metal loss. This distinction is important for the present assessment because it shows that bulk-water chemistry can define the background corrosion environment, while local geometric and hydrodynamic conditions associated with equipment internals determine where corrosion becomes severe and localized. Thus, assessment of internal-corrosion risk should consider not only the chemistry and general operating conditions of the flowline, but also the condition and flow-disturbing behavior of valve's internals. [11,15,17]

Evidence	Observation from the Case	Interpretation
Bulk-water chemistry	pH 6.18/5.74; resistivity 0.040/0.039 Ω·m; stable chemistry in two different period analyses	Relatively stable baseline aqueous environment; insufficient by itself to explain the localized failure.
Straight-flowline inspection	Minimal corrosion rate; no recorded internal-corrosion anomaly	Supports low baseline corrosion severity in stable straight-pipe flow.
Damage morphology	Flow-directional groove with increasing penetration and a through-wall pinhole	Indicates strong spatial and directional localization of wall loss.
Internal component condition	Disc detached from hinge pin / uncontrolled internal movement	Changed local geometry and altered the flow path within the valve.
Hydrodynamic response	Turbulence, possible impingement and local recirculation	Provides a mechanism for local protective film disruption and accelerated localized wall loss.
Final outcome	Through-wall penetration at the deepest part of the groove	Demonstrates severe component-level damage despite relatively low baseline flowline corrosion.

Table 6. Evidence Chain Linking Bulk-Water Conditions, Local Flow Disturbance and Check-Valve Damage

3.2.4 Integrated Findings of the Check-Valve Case

The check-valve case demonstrates that bulk-water chemistry may indicate a relatively low baseline corrosion environment while localized damage develops under abnormal component-level flow conditions. The associated straight flowline showed minimal corrosion, whereas the valve developed a flow-directional groove and through-wall pinhole. Detachment of the internal disc altered the local flow path, generating turbulence, flow impingement and recirculation that promoted concentrated wall loss. This case therefore complemented the field-level assessment by demonstrating that bulk chemistry defines the baseline corrosion environment, while local equipment geometry and hydrodynamic conditions can control the severity and location of localized damage. Consequently, assessment of localized internal-corrosion risk should consider both the bulk operating and chemical environment and the condition and flow behavior of equipment internals. [11,15,17]

4. CONCLUSIONS

1. Failure frequency (FPY) in oil production fields was influenced by the combined operating and produced-water environment rather than by any single parameter.

2. Higher FPY conditions were generally associated with high operating flow combined with several unfavorable chemical indicators, whereas unfavorable individual chemical conditions did not necessarily result in high FPY when operating flow was low; meaning, lower-FPY conditions were generally associated with lower operating exposure and/or less severe combined conditions

3. Pigging records, from corresponding pipeline for each field, confirmed persistent internal deposition in the investigated pipes, including scale, sand, paraffin and mixed deposits. However, deposit type or recovered quantity alone did not show a direct relationship with FPY; deposits are therefore best considered as part of the internal corrosion environment rather than as a direct measure of corrosion severity.

4. The check-valve case demonstrated that bulk-water chemistry may indicate a relatively low baseline corrosion environment while severe localized damage develops under abnormal component-level flow conditions. Local equipment geometry and hydrodynamic behavior can therefore determine the severity and location of localized damage even when the surrounding bulk environment is relatively mild.

5. Overall, the results support an integrated asset-integrity assessment in which bulk water chemistry, operating conditions, CO_2 exposure, internal deposits, inspection history and the condition of equipment internals are considered together when evaluating internal-corrosion risk.

5. ENGINEERING IMPLICATIONS

Corrosion screening. The combined qualitative classification of flow, pH, resistivity, Cl^-/SO_4^{2-} ratio, CO_2 and internal-deposit condition can be used as a screening approach for identifying flowlines that warrant closer internal-corrosion assessment. [1,4,10]

Inspection planning. Fields showing a concurrence of high operating exposure and several unfavorable chemical indicators should receive increased attention in inspection planning, particularly where previous anomaly or wall-thickness history is available. [4,10,12]

Pigging and deposit monitoring. Pigging records should be maintained as part of the corrosion-assessment database because deposit type and recovered mass provide field evidence of changes in the internal deposition environment. [12,16]

Equipment-level assessment. Valves and other equipment containing flow-disrupting internals should be assessed separately when localized damage is suspected. Internal-component condition and local flow behavior should be included in the damage-mechanism assessment. [11,15,17]

Use and limitation of the classification. The qualitative classification is intended to support engineering screening and prioritization within the range represented by the fields investigated. It should complement, rather than replace, NDE results, measured corrosion rates, inspection history and component-specific engineering assessment.
Overall engineering implication. Internal-corrosion risk should be assessed by combining the bulk chemical and operating environment with internal deposition and equipment-level hydrodynamic conditions.

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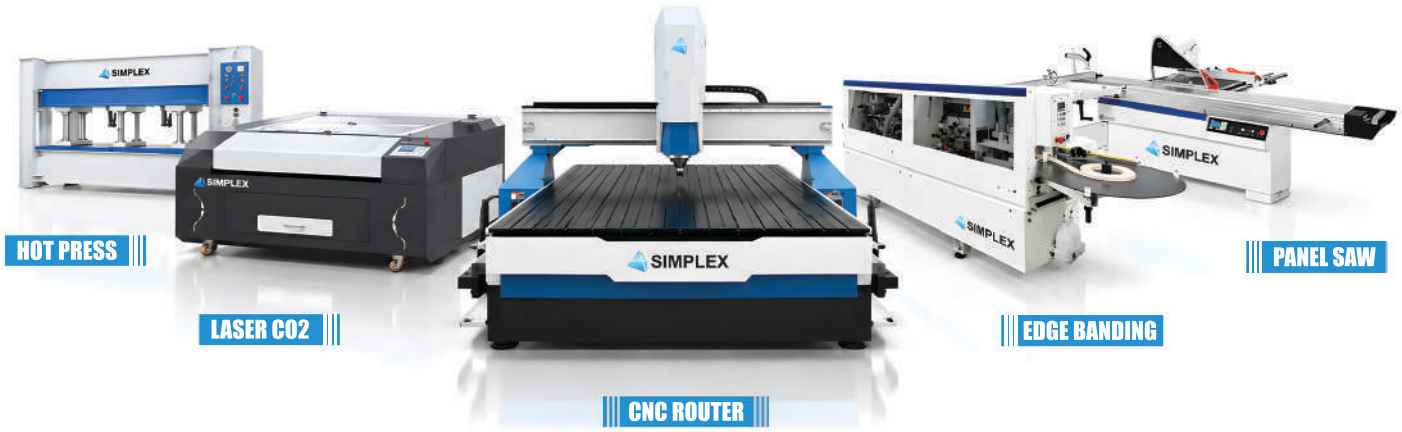
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The Cheapest Inspection Can Become Your Most Expensive Mistake

The Hidden Cost of Inspection Cutbacks and the Strategic Value of Advanced NDT, Specialized Expertise, and Risk-Based Decision-Making

Are you reducing inspection costs or increasing the cost of future failure?

In asset-intensive industries, cost optimization is essential. But when inspection budgets are cut without understanding the technical and operational consequences, apparent savings can create hidden liabilities. In the oil and gas, petrochemical, and power generation sectors, inspection is not simply an operating expense; it is a critical safeguard for personnel, equipment, production, and business continuity. The real danger is not spending too much on inspection. It is saving too little today and paying far more tomorrow.



The most costly failures often begin with damage that goes undetected. Corrosion, erosion, fatigue cracking, and other degradation mechanisms can develop inside welds, pipelines, pressure vessels, and critical equipment long before visible warning signs appear. Inadequate inspection coverage, unsuitable testing methods, or unreliable interpretation can allow these threats to progress unnoticed. The consequences may include emergency repairs, unplanned shutdowns, production losses, environmental damage, and serious safety incidents. What begins as a small, undetected defect can become a major operational and financial liability?



Advanced NDT transforms inspection from routine testing into a more powerful source of engineering intelligence. Technologies such as Phased Array Ultrasonic Testing (PAUT), Time-of-Flight Diffraction (TOFD), and advanced ultrasonic corrosion mapping can improve examination coverage and provide valuable information about material condition and relevant discontinuities.

When properly selected and applied, these methods help inspection teams characterize potential defects and support better-informed integrity decisions. However, sophisticated technology alone cannot guarantee reliable results. Its effectiveness depends on the damage mechanism, inspection procedure, component geometry, data quality, and the competence of the personnel involved.

Technology provides the capability. Specialized expertise delivers the confidence to act. Qualified inspection professionals must understand where damage is likely to occur, which method is suitable, how indications should be interpreted, and when further examination or engineering assessment is required. Reliable inspection is not simply about collecting data; it is about converting that data into accurate findings, sound judgments, and appropriate actions. Without technical competence, even advanced inspection equipment can fail to deliver its intended value.



Risk-Based Inspection (RBI) puts resources where they matter most. Not every component presents the same risk, and not every inspection requires the same approach.

By evaluating credible damage mechanisms, operating conditions, equipment history, likelihood of failure, and consequences of failure, RBI helps organizations prioritize critical assets and optimize inspection plans. When supported by reliable data and competent engineering, this approach can reduce unnecessary expenditure while maintaining the required level of safety and integrity. The objective is not to inspect less indiscriminately, but to inspect intelligently and control risk effectively.

The true cost of inspection extends far beyond the inspection invoice. A low-cost examination that fails to identify consequential damage can contribute to expensive repairs, extended downtime, premature equipment replacement, and avoidable production losses. Conversely, an appropriately designed inspection strategy can improve maintenance planning, reduce uncertainty, and support more effective use of resources. Asset owners must therefore evaluate inspection decisions against lifecycle costs, failure consequences, equipment reliability, and the effectiveness of risk controls—not price alone.



The greatest value emerges when NDT findings are integrated with asset integrity management, corrosion control, maintenance planning, and engineering assessments. Reliable inspection data can support degradation trending, remaining-life evaluations, repair prioritization, and Fitness-for-Service (FFS) assessments where appropriate. This integrated approach enables organizations to move beyond reactive maintenance and make proactive, evidence-based decisions that protect equipment, strengthen reliability, and support operational continuity.

For asset owners and executive leadership, inspection is a strategic investment in risk control, asset preservation, and business performance not merely a cost to cut. The right inspection strategy combines advanced technology, specialized expertise, and risk-based decision-making to protect people, preserve asset value, and reduce avoidable losses. Cost optimization should eliminate inefficiency, never compromise essential safeguards.

The Bottom Line

Do not measure inspection success by how little you spend. Measure it by how effectively you prevent failure, protect asset integrity, and control lifecycle costs.

Advanced NDT Technologies + Specialized Expertise + Risk-Based Decision-Making = Smarter Inspections. Stronger Asset Integrity. Lower Lifecycle Costs. Better Risk Control.

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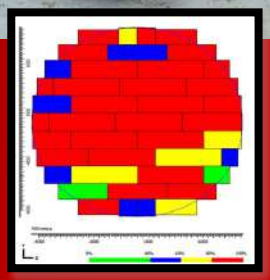
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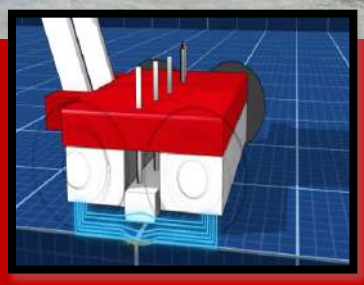
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Reading Weld Films with a Second Pair of Eyes

How assisted interpretation checks the film, flags the indications and drafts the report, while the inspector makes the call

Third in the MasterAIR RT series. Earlier notes covered measuring profile films and sizing CUI defects through insulation. This one follows a weld film from scanner to signed report.

The problem

A weld RT campaign produces films by the hundred. Each one needs the same sequence of checks before anyone looks at a single indication: is the density in range, is the IQI visible at the required wire, are the position markers and identification text legible and matched to the right weld. Only then does the real interpretation begin, followed by sizing, acceptance and a report.

None of this is difficult. It is repetitive, and repetition is where fatigue and inconsistency creep in. A film that should have been reshot gets interpreted anyway. A marker is mistyped in the report. Two interpreters read the same indication differently at the end of a long shift.

The concept

MasterAIM treats weld film review as a pipeline, with a validity check at the front. The film is digitized, and the software confirms it is fit to interpret before it looks for defects. Only then does it flag indications, classify and size them, and compare them against the acceptance criteria the inspector has selected. The output is a draft report and a project dashboard, ready for review and signature.

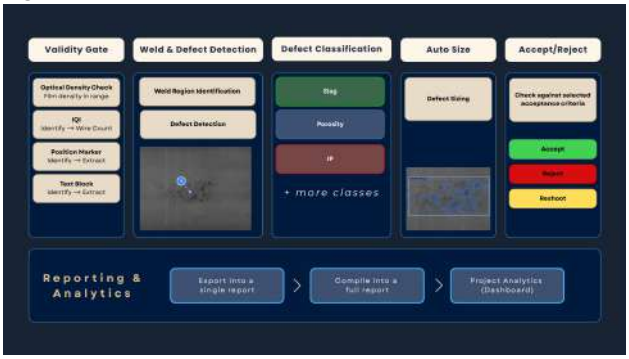


Figure 1. The weld RT workflow in MasterAIM, from validity checks to reporting and analytics.

What happens to each film

Stage	What the software does
Digitize	Films are scanned in batches with consistent settings on an archival-grade laser digitizer and filed as DICONDE.
Validity gate	Checks film density is in range, identifies the IQI and reads its wire count, then locates and reads position markers and identification text blocks.
Defect detection	Flags defect candidates on the film for the inspector to review.
Classification	Assigns each indication a class, such as slag or porosity, with more classes supported.
Sizing	Measures flagged indications in the digital image.
Accept/reject/reshoot	Compares the measurements to the selected acceptance criteria and proposes accept, reject or reshoot.
Reporting	Compiles weld metadata and findings into a full report, with project-level analytics on a dashboard.

Table 1. Stages of assisted weld film interpretation.

Early validation

We have been testing the validity-gate checks; the software finds the IQI, the position markers and the identification text blocks in 85 to 88% of films, and 95 to 98% of its flags were correct. These are early results on the checks that decide whether a film is fit to interpret.

What it looks like on the film

Flagged indications are outlined and labelled directly on the digitized film, with the measured size and local density shown beside them, so the inspector sees what the software saw and can accept, adjust or dismiss each one.

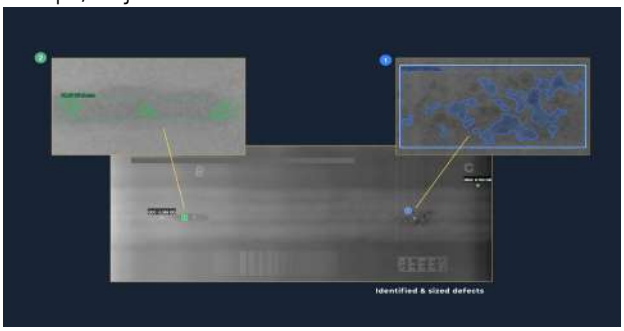


Figure 2. Identified and sized indications on a weld RT image.

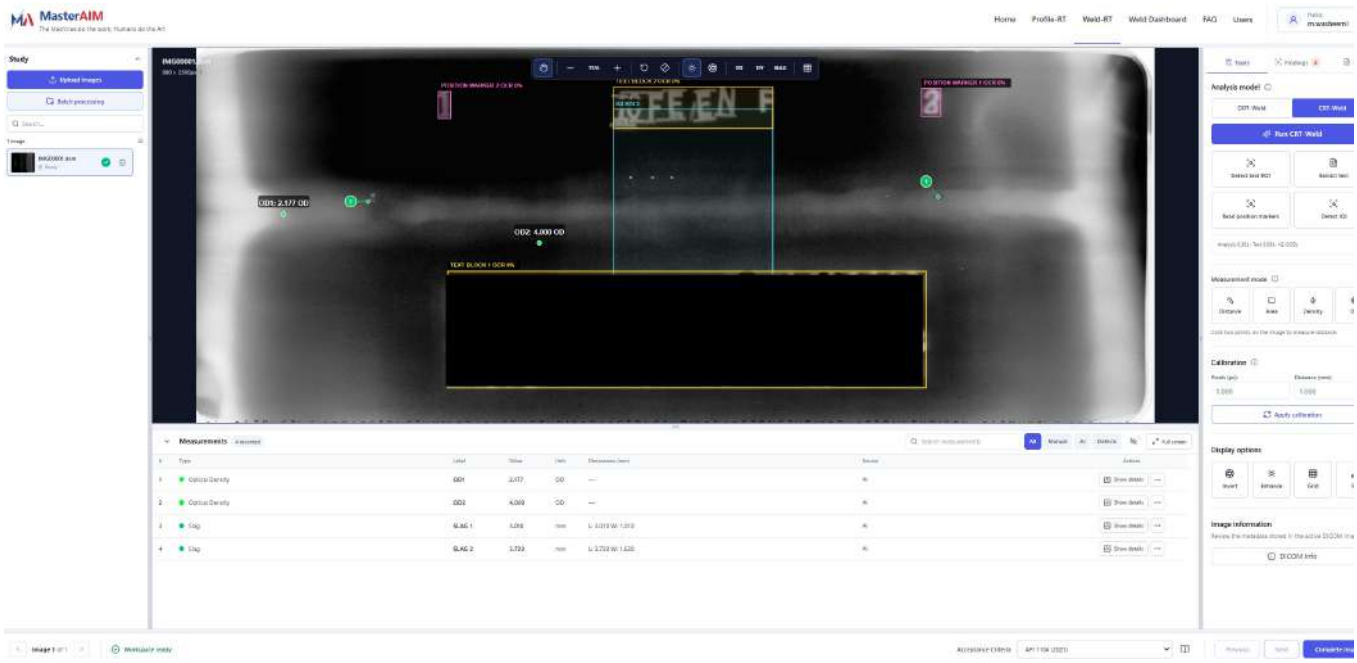


Figure 3. The MasterAIM Weld-RT workspace, with validity checks, density readings, measurements and the selected acceptance criteria

What it means in practice

- ***Bad films are caught early.*** The validity gate flags density, IQI and marker problems before interpretation time is spent, which supports a reshoot decision at the right moment.

- ***Less transcription.*** Identification text and markers are read from the film and carried into the report, rather than retyped.

- ***More consistent calls***. Every film goes through the same sequence against the same acceptance criteria, and the reasoning is visible on the image.

- ***Project visibility***. Welder performance, defect patterns and trends across a whole campaign appear on one dashboard.

The role of MasterAIM

MasterAIM is screening and assistive technology. It prepares the film, points at what deserves attention and drafts the paperwork. The interpretation, the acceptance decision and the signature stay with the qualified inspector. The machines do the work. The humans do the art.

Where we go from here

We are looking for operators, fabricators and inspection companies with archived or live weld film who want to try this on their own work. A pilot on a sample of your films, run against your own acceptance criteria and reporting format, is the fastest way to see where it helps and where it does not.

Want to run a pilot on your weld films?
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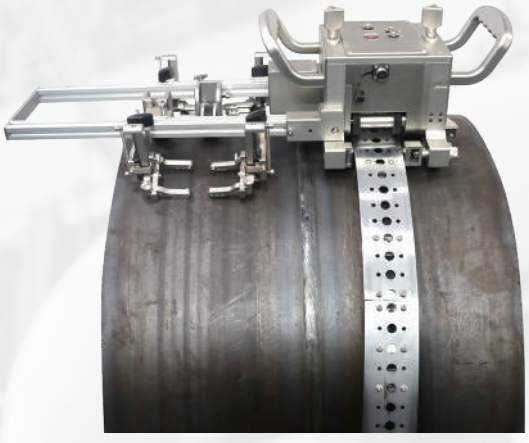


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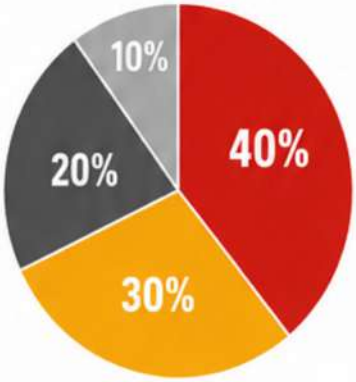
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LOCALIZATION & REGULATIONS:

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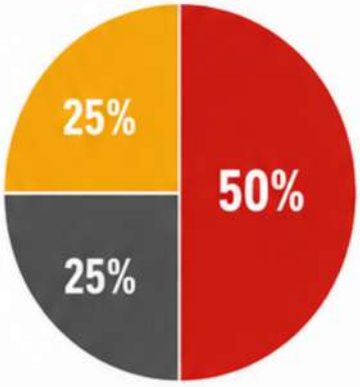
02 TARGETED VISITOR PROFILE

BY INDUSTRIAL SECTOR



- **40 %** Oil, Gas & Petrochemicals
- **30 %** Manufacturing & Industrial Plants
- **20 %** Energy, Power, Heavy Construction.
- **10 %** Marine, Offshore & Aerospace, Trans.

BY JOB FUNCTION & AUTHORITY



- **25 %** C-Level Executives & Ultimate Decision Makers
- **50 %** QA/QC/ Maintenance, Fabrication, Asset Integrity Managers & S.Engineers.
- **25 %** NDT, Weld, QC, Corrosion Specialists, Inspectors & Procurement Officers.

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