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INSPENET BRIEF

Editorial | Leading the Transition: Energy, Integrity, and the Course Toward a Low-Carbon Future

As global energy demand continues to rise and climate commitments become more urgent, the energy sector faces a dual mandate: to reliably power the world while rapidly decarbonizing. This editorial outlines a strategic path forward.

Is Our Industry Ready to Lead the Largest Energy Transition in History?
It must be. The energy sector is now at a historic inflection point—demand is climbing, while climate agreements are accelerating timelines. Delivering reliable supply while reducing emissions requires a powerful combination of strategic foresight, technical excellence, and collaborative leadership.

From Intention to Execution

Energy markets are evolving at unprecedented speed, and the urgency for cleaner solutions is redefining the very mission of our industry. Innovation is no longer a differentiator—it's a structural imperative.

Liquefied Natural Gas (LNG) demonstrates how a fossil fuel can serve as a strategic enabler of the energy transition: offering operational flexibility, easing renewable integration, and delivering lower emissions compared to legacy fuels. But simply managing this shift is no longer sufficient—oil and gas must lead it by actively deploying hydrogen, carbon capture, and process electrification across the value chain.

Asset Integrity: A True Measure of Industrial Leadership

The performance of critical infrastructure—offshore platforms, storage terminals, subsea pipelines, cryogenic tanks—defines leadership in our industry. These assets operate under extreme conditions of pressure, temperature, fatigue, and corrosion—leaving zero room for failure.

The years ahead will bring growing complexity: advanced materials, harsher dynamic loads, and increasingly stringent environmental regulations. Traditional inspection techniques are no longer enough to ensure safe, long-term operation of aging infrastructure with tighter tolerances.

Today, Non-Destructive Testing (NDT) is merging with digital twins, big data, and artificial intelligence to predict failures before they occur, optimize maintenance cycles, and extend asset life. This convergence of technologies is now a proven driver of safety, efficiency, and business resilience.

Artificial Intelligence and Predictive Maintenance

Modern energy systems generate massive volumes of data: real-time monitoring of cryogenic lines, distributed sensing in subsea pipelines, and high-resolution imaging of critical welds. Machine learning algorithms process these inputs continuously, transforming point-in-time inspections into full lifecycle assessments.

This enables smarter decisions that reduce unplanned downtime, minimize fugitive emissions, and optimize capital deployment. But technology alone won't drive impact.

We need an organizational culture that embeds predictive analytics into the asset lifecycle, equips teams to interpret failure probability models, and maintains supply chain readiness to act before issues arise. Building that mindset is as critical as adopting the tools.

Talent and Knowledge Transfer

No transition will succeed without skilled people. Technical debt and human error—both leading causes of operational incidents—can be mitigated through rigorous certifications, continuous learning, and simulated training environments.

Training must go beyond instruction. It must spark critical thinking, promote interdisciplinary collaboration, and cultivate a mindset of continuous improvement.

Global knowledge exchange is essential. Gastech 2025, to be held in Milan, will be a key platform for advancing discussions on gas, hydrogen, climate technologies, and digital operations. Bringing together operators, suppliers, regulators, and academia will help align standards, accelerate technology adoption, and highlight the emerging talent that will define the future of energy engineering.

A Compass for the Immediate Future

This special edition of Inspenet Brief features insights on asset integrity, critical process automation, advanced materials, and sustainable business models that balance profitability with environmental responsibility. Each article offers real-world data and practical examples to support decision-makers navigating the complexity of energy transformation.

The low-carbon future is no longer a distant vision—it is actively taking shape. Those who combine strategic vision, operational discipline, and a shared sense of purpose will shape its course.

As an industry, we carry both the responsibility and the opportunity to demonstrate that energy security and sustainability can advance hand in hand—powered by science, driven by innovation, and anchored in leadership that meets challenges head-on.

And that leadership begins with the decisions we make every day: specifying a corrosion-resistant material, adopting a more precise inspection protocol, calculating the carbon footprint of a project, or investing in the growth of a young engineer. Step by step, we are building the bridge between the technical legacy that brought us here and the transformation that will secure our relevance for decades to come.

Because the future—while demanding—is already here. And it's ours to lead.

About the Author
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Founder and CEO of Inspenet LLC. Mechanical Engineer and Master in Project Management. With over 35 years of experience, he is a visionary entrepreneur whose leadership brings together deep technical expertise and a dual passion: connecting professional communities and mentoring the next generation of talent in the energy

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Biofuel Processing: Challenges in Corrosion and Material Selection

repsol

Climate change is having a global impact, affecting all regions of the planet. Renewable fuels, emerge as one of the main alternatives to reduce the CO_2 emissions in the transport sector. Moreover, by utilizing organic waste, CO_2 emissions can be reduced by up to 90% compared to the fossil fuels they replace.

The energy transition toward more sustainable sources has driven the refining industry to adapt its processes to incorporate renewable feedstocks. However, this technological evolution brings significant challenges in equipping facilities to select metallurgy suitable for these new raw materials.

Repsol and Its Commitment to decarbonization

Repsol is a multi-energy company capable of meeting all customer energy needs, both at home and in mobility.

The company operates one of the most efficient refining systems in Europe, with the capacity to process over one million barrels of crude oil per day. A key element of its decarbonization strategy is the transformation of its six industrial complexes on the Iberian Peninsula into multi-energy hubs. These facilities are being adapted to process a wide range of feedstocks and waste materials to produce low-carbon products, such as 100% renewable fuels.

In line with its roadmap, Repsol has launched the first industrial-scale plant on the Iberian Peninsula dedicated to the production of these fuels in Cartagena. A second facility is scheduled to begin operations in Puertollano in 2026. The goal is to reach a production capacity of between 1.5 and 1.7 million tons by 2027, and up to 2.7 million tons by 2030.

Additionally, Repsol is planning the construction of the first European plant to convert urban waste into renewable methanol—a fuel that will contribute to the decarbonization of transport and the production of circular products—at its Tarragona industrial complex.

However, projects of this nature present challenges in corrosion and material selection, as outlined below.

Lack of standards

This is one of the main issues faced by engineers when selecting the most suitable materials for biofuel units. There are currently no international standards that address the damage mechanisms associated with these new feedstocks,

nor are there standardized procedures for testing materials and coatings for use in such units. To address this challenge, various international organizations such as API, AMPP, and EFC are actively working to develop, in record time, standards that cover these new damage mechanisms.

Wide range of feedstocks

In general, the feedstocks processed in these renewable fuel production units can be highly diverse, ranging from vegetable oils such as palm, soybean, or rapeseed oil to animal fats or used cooking oils.

All these raw materials contain impurities not typically found in fossil fuels, which are associated with various corrosion mechanisms that are not yet fully understood. Contaminants may include nitrogen, sulfur, chloride, sodium, potassium, calcium, silicon, phosphorus, free fatty acids, and gums.

To ensure the integrity of the units, it is essential to implement a pretreatment process tailored to each type of impurity, located at the inlet of the biofuel production unit. It is also necessary to establish strict technical specifications that limit the levels of these impurities, along with thorough quality control of the feedstocks before processing.

The shift to new renewable feedstocks leads to the emergence of new damage mechanisms or an increase in corrosion in those already known from fossil fuel processing.

New corrosion mechanism

For example, the storage of raw materials for biofuel production presents additional challenges. Depending on the acidity of the feedstock (TAN) and the temperature, it may be necessary to coat carbon steel with appropriate industrial paints to protect the metallurgy.

Vegetable feedstocks contain fatty acids that generate complex and not yet fully understood corrosion mechanisms. Depending on temperature and concentration, the use of certain grades of austenitic stainless steels may not be recommended.

Another major challenge is chloride. Despite efforts to reduce its content in pretreatment units, the levels entering hydrotreatment units remain high. This, combined with the increased amount of water generated in these units, leads to greater corrosivity associated with this element. The same applies to CO_2 corrosion, as the higher oxygen content in new feedstocks results in increased CO_2 formation.

All these corrosion mechanisms are driving the increased use of special alloys such as duplex stainless steels and nickel-based alloys, the coating of some materials with paints, and the implementation of more advanced monitoring techniques to detect these new forms of corrosion.

In conclusion, renewable fuels represent one of the main alternatives for promptly reducing CO_2 emissions from the transport sector and will drive the development of the Spanish and European industries. To achieve this in the most efficient way, a thorough review of material selection, corrosion mitigation strategies, and monitoring approaches is required, along with the standardization of both corrosion mechanisms and testing procedures for materials and coatings.

Diversifying to Decarbonize: The Key to a Resilient Energy Matrix

By: Ana Laura Ludlow
VP Chief Government Affairs &
Sustainability Officer at ENGIE México.

The fight against climate change and the need to ensure a reliable, affordable and sustainable power supply have placed the energy matrix at the center of the global debate. The blend of renewable sources, traditional fuels and emerging technologies has become one of the key strategies to ensure that there will be enough energy to supply a growing population, address climate challenges and warrant economic development in an equitable and sustainable manner.

In 2021, the International Energy Agency (IEA) published the landmark report Net Zero by 2050: *A Roadmap for the Global Energy Sector*, translating the goal of limiting global warming to 1.5°C into a concrete roadmap for transforming the global energy sector. However, progress since its publication has been limited. Far from being reduced, CO_2 emissions from the energy sector reached a new peak in 2022 at 37 gigatons (Gt), evidence of a worrying lack of progress. Demand for fossil fuels increased, as did investment in their production. Meanwhile, access to energy has stagnated and millions of people remain without access to electricity (IEA, 2021).

According to the same agency, almost 90% of countries have updated their Nationally Determined Contributions (NDCs) under the Paris Agreement. While these revisions would reduce projected emissions by 5 Gt by 2030, the gap to long-term net-zero emissions commitments remains huge. Unless policy implementation and adoption of clean technologies are significantly accelerated, the zero net emissions scenario proposed by the IEA will not be accomplished.

Against this backdrop, the World Economic Forum insisted in January 2025 that the energy transition requires an annual investment of 4.5 trillion dollars. In its report *Financing the Energy Transition: Meeting a Rapidly Evolving Electricity Demand*, it warned that only 15% of this investment reaches developing countries, despite the fact that they account for a large part of future growth in energy demand. The document highlights that ensuring the transition requires systems that are affordable, resilient and sustainable. This implies facilitating access to long-term, low-cost financing to reduce capital costs (World Economic Forum, 2025).

Security, affordability and sustainability: the trinomial of the energy transition.

One of the main challenges of this transition is maintaining energy security and affordability. Energy security is not limited to the continuous supply of power, but also involves robust logistical networks, reliable supply chains and political stability.

Affordability, on the other hand, is key to ensuring that families and industries can maintain their quality of life and competitiveness. In this context, diversification of the energy matrix appears as a fundamental strategy. Having an assortment of sources that includes renewable energies, natural gas, hydrogen, bioenergy and storage renders it possible to reduce the risks associated with reliance on a single resource.

This approach facilitates the progressive integration of clean technologies without compromising system stability. Diversification of the energy matrix is a strategy that makes it feasible for emerging economies to move towards energy security and meet net zero carbon targets by 2050 (Nibedita & Irfan, 2024).

Empirical evidence in Europe shows signs of progress. According to Eurostat, power generated from renewable sources reached 47% in 2024 within the European Union, marking a milestone in the transition to a low-carbon economy (Eurostat, 2025).

The electron-molecule alliance: natural gas as a transition pillar.

On this path towards a diversified energy matrix, the alliance between the electron and the molecule becomes crucial. While renewable energies such as solar and wind are gaining ground in electric power generation – the domain of the electron – natural gas continues to play a key role as a flexible and less polluting backup within the molecular universe.

Natural gas, thanks to its capacity to stabilize the grid, replace more carbon-intensive fuels and facilitate the integration of intermittent renewable sources such as solar and wind, has established itself as a strategic ally in the energy transition. In regions such as Mexico, where there is still considerable infrastructure based on fossil fuels and a growing demand for energy in urban and industrial areas, the use of natural gas can offer a more viable decarbonization route in the short and medium term.

The use of this fuel allows an immediate reduction of emissions in the power sector, while building the technical, financial and social conditions necessary for a greater participation of clean energies in the future. Moreover, since it is a resource already available in the country, its rational use can generate local jobs, avoid an abrupt energy transition that affects the most vulnerable communities, and ensure affordable prices for the population. Integrating natural gas into a diversified energy matrix is a technical decision and a necessary step towards a fair transition: one that leaves no one behind and takes into account both the climatic challenges and the economic and social realities of the territory.

In this scenario it is important to point out that storage technologies, especially new generation batteries, take on a leading role as a complement to diversification. The capacity of batteries to store energy when generation is abundant and release it when demand increases or weather conditions disallow renewable production, represents a crucial technical advance to guarantee a continuous and balanced power supply.

Considering both diversification and the use of storage technology amplifies the potential of clean energy by reducing its intermittency and increasing its competitiveness against traditional sources. In countries like Mexico, with high solar radiation and areas with wind potential, the development of robust storage systems can make the difference between a viable transition and a failed one.

However, a diversified energy matrix, complemented by natural gas and storage technologies, constitutes a model that is more resilient, fair and adaptable to the challenges of the 21st century. It is not a matter of choosing between one source or another, but of building an intelligent synergy between molecules and electrons, between technological innovation and social justice. Because the real challenge of the energy transition is not only to reduce emissions, but to ensure that the change benefits all people, in all territories.

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Smarter Emissions Management: Enabling Low-Carbon Operations Across the Energy Value Chain

By: Anthony Gambony, P.E. - Head of Utilities at Project Canary

In today's energy landscape, emissions accountability is no longer optional; it's a strategic imperative. As sectors like LNG, midstream, downstream, upstream, offshore, and new energy pivot toward cleaner operations, new technology is critical in helping companies meet mounting regulatory demands, ESG commitments, and stakeholder expectations. At the forefront of this transformation is a new breed of emissions intelligence: high-fidelity, measurement-based platforms built to capture, analyze, and manage emissions data in real time.

The energy industry is evolving quickly. Gone are the days of estimated inventories and reactive leak detection. Regulatory bodies and voluntary frameworks now demand auditable, source-level emissions data. Customers and investors expect transparency, and operational teams need actionable insights to identify and address leaks before they become liabilities. To meet these demands, operators across the value chain are turning to advanced emissions monitoring technologies, leveraging innovations in sensing, machine learning, and multi-platform data integration.

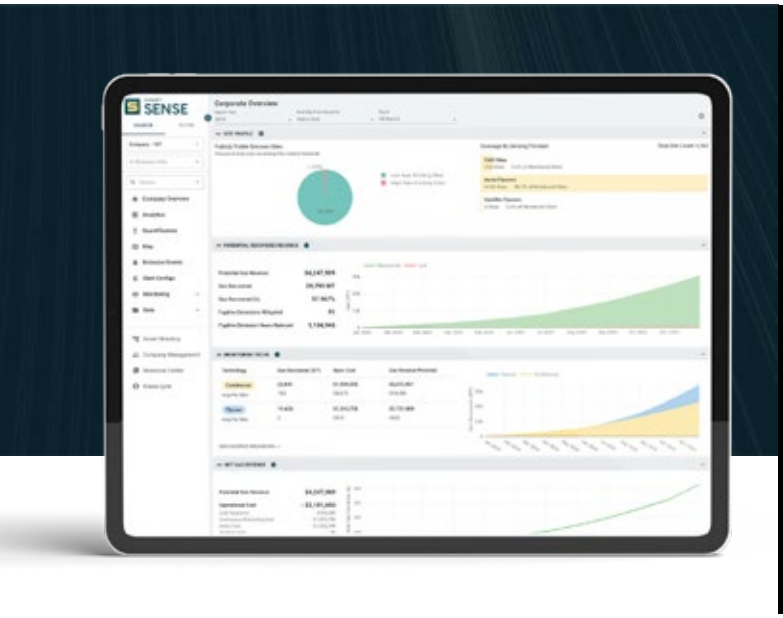
Project Canary is the industry's leader in turning complex emissions data into actionable, reportable insights, helping energy companies reduce risk and meet evolving reporting requirements. Project Canary's software platform simplifies emissions data management, offering an all-in-one solution for regulatory compliance, leak detection and repair, and voluntary programs like OGMP 2.0. By combining deep emissions measurement expertise with a flexible software platform, Project Canary delivers the customized emissions data solutions operators need in today's energy environment.

One of Project Canary's key innovations lies in its use of **mid-infrared (MidIR) laser spectroscopy**, a highly sensitive detection technology capable of measuring methane and ethane at parts-per-billion (ppb) levels. This method is deployed through select mobile and field devices, such as their vehicle-based systems, drone and handheld instruments (RECON, STRATO and PICO, respectively), and is particularly effective in pinpointing leak locations and enabling accurate source attribution. Ethane's correlation with methane provides operators with greater clarity in distinguishing thermogenic emissions from biogenic noise, reducing false positives and ensuring targeted mitigation. These technologies are ideal for leak detection surveys in gathering systems, transmission lines, and complex industrial zones.

For continuous emissions monitoring, Project Canary deploys various technologies and devices from Project Canary's own **Canary X**, a high-fidelity fixed sensor, to other OGI, LiDAR and fixed-point monitors. The platform is designed to deliver real-time environmental data from key assets. Installed across infrastructure such as upstream pads, midstream facilities, compressor stations, storage fields or downstream delivery points, the Canary X and other monitors collects and reports emissions data, localizes emissions events and sends customizable alerts. This helps operators maintain regulatory compliance, detect anomalies faster, and support ESG reporting with confidence.

When paired with **Project Canary's SENSE software platform**, these devices form a cohesive emissions intelligence ecosystem. The platform aggregates and visualizes data from drone, mobile, OGI cameras, flyover, satellite and stationary sensors, offering operators a centralized interface to monitor leaks, track maintenance activities, understand equipment emissions performance, and generate audit-ready compliance reports no matter what their technology stack looks like. The result is a seamless integration of field technology and digital insight that upgrades operational awareness across the enterprise.

For **upstream producers**, this ecosystem supports the proactive identification and mitigation of fugitive emissions from wellheads and gathering infrastructure.



In the **midstream sector**, it enables near-continuous observation of compressor stations, regulator sites, and pipeline routes, helping reduce the risk of regulatory non-compliance or environmental incidents. LNG and **downstream facilities** benefit from verified measurement capabilities that align with frameworks such as **OGMP 2.0**, **Veritas**, and **EPA Subpart W**, increasing trust and competitiveness in international markets. Even **new energy verticals**, such as hydrogen and renewable natural gas (RNG), are leveraging emissions intelligence to validate their sustainability claims and ensure operational transparency.

Project Canary's platform also supports **survey resource allocation**, allowing teams to optimize inspection routes, prioritize high-risk areas, and measure progress against emissions reduction goals. Tools like the **Work Order System** module enable field supervisors to assign regions of interest based on leak probability or operational priority and to pair mobile or handheld technology for real-time investigation. This level of coordination maximizes the efficiency of LDAR (leak detection and repair) programs and supports better risk management.

A significant complement to this operational infrastructure is Project Canary's **Carbon Portal**, an emissions accounting software, that streamlines calculating, tracking, visualizing, centralizing, and reporting of emissions. Carbon Portal provides both a top-down overview of calculated emissions, as well as numerous tools to investigate the details of these emissions. By providing centralized and aggregated emissions information, Carbon Portal simplifies record-keeping to meet varying requirements for regulatory reporting, corporate sustainability governance, and voluntary frameworks. This allows companies to provide transparency and consistency across business units, accuracy across methodologies, and auditability across the entire asset base.

Importantly, the technology is already delivering measurable value. Field deployments have shown that Project Canary's high-resolution monitoring systems can increase leak detection rates by over 30%, while cutting investigation time dramatically. These efficiency gains translate into faster response times, reduced environmental risk, and improved system uptime, outcomes that directly benefit safety, sustainability, and shareholder value.

As the energy transition accelerates, stakeholders are demanding greater proof of environmental performance.

- Investors are evaluating methane management as a proxy for operational excellence.
- Regulators are moving toward direct measurement requirements.
- Buyers are seeking certified low-carbon energy.

In this environment, the ability to detect and mitigate emissions in real time and verify those reductions with third-party data offers a clear competitive edge.

Ultimately, the energy transition is not just about changing fuels; it's about transforming how emissions are measured, managed, and mitigated. Project Canary's combination of advanced sensing, intelligent software, and strategic insight empowers energy companies to lead with confidence and credibility. As expectations for climate accountability grow, so too does the need for tools that turn emissions data into environmental leadership.

Project Canary's end-to-end emissions data solution enables energy operators to stop leaks faster, reduce risk, streamline reporting, and differentiate their operations.

API 18LCM: A Systematic Approach to Oil and Natural Gas Equipment Life Cycle Management

By: Kevin Ferrick, Senior Director of the API Monogram/APIQR Program

American Petroleum Institute

Managing critical oil and natural gas equipment is fraught with challenges. Over the lifespan of a product—from its manufacture to daily usage to eventual decommissioning—it may change ownership multiple times, be maintained by different service providers and undergo repairs in different locations. Without a standardized approach to tracking these events, companies could need to assess incomplete documentation, an uncertain maintenance history or limited visibility into equipment performance. Over time, these can have a cumulative impact on operations, leading to delays, disruptions, unnecessary costs and increased safety risks.

Consider a drilling contractor preparing to use a critical component that has been in service for many years. The component appears functional, but records may be fragmented across multiple organizations and key details, such as its original product specifications and repair history, could be missing. Without a complete record of its service history, the contractor is faced with an operational dilemma: Should they risk using the equipment, replace it or conduct testing of its integrity (perhaps unnecessarily) or invest in resource-intensive testing?

The Need for a Standard.

This is the type of challenge that led to the development of API 18LCM, Product Life Cycle Management System Requirements for the Petroleum and Natural Gas Industries. The standard establishes a comprehensive framework for managing critical industry equipment throughout its life cycle — from manufacturing through decommissioning — ensuring traceability, maintenance and compliance at every stage. The standard applies to service providers that perform life cycle management activities, which includes OEMs, service companies, operators, drilling contractors and repair organizations.

To provide a structured approach to life cycle management, API 18LCM establishes three Life Cycle Management (LCM) classifications: LCM-1, LCM-2, and LCM-3—each defined by the amount of available documentation and traceability at the time of classification.

LCM-1 applies to equipment with the least available documentation. A company may know the general product type but lacks details such as its maintenance history (before it started managing the equipment) or date the equipment was first used.

LCM-2 applies when more detailed records exist. This classification requires a verifiable service history, including when the equipment was first used and an understanding of its maintenance history and original manufacturing details. Many API-marked products with intact nameplates can meet LCM-2 classification.

LCM-3 represents the highest level of documentation and traceability. Equipment classified under LCM-3 has been tracked carefully since its manufacture and there is certainty about its original design, manufacturing specifications, service history and usage.

Meeting API 18LCM Requirements

To comply with API 18LCM, service providers must develop, document and maintain a Life Cycle Management Plan (LCMP) that ensures equipment meets traceability, maintenance, and regulatory requirements. This plan serves as a service quality framework and must align with API Specification Q2,

Quality Management for Service Supply Organizations for the Petroleum and Natural Gas Industry (now in its 2nd edition).

Key components of an LCMP include:

•Description of the managed product, ensuring proper classification under LCM-1, LCM-2, or LCM-3.
•Identification, marking and traceability, ensuring that every product is clearly documented from manufacturing to decommissioning.
•Repair and maintenance records, which must be continuously updated to track the service history of equipment.
•Installation and service environment considerations, ensuring equipment integrity is maintained throughout its operational life.
•Usage history documentation, providing operators with a verifiable record of product performance.
•Decommissioning protocols, ensuring equipment is safely retired in compliance with industry standards.

Once classified, equipment enters the API 18LCM program, where records are maintained and continuously updated. Decisions are made as to what is required to maintain the quality and integrity of the equipment based on the starting information available. If additional information becomes available that was not previously known, equipment can be reclassified.

Implementation Benefits

API 18LCM delivers substantial benefits to operators and service providers by strengthening safety measures, improving operational efficiency and ensuring long-term product integrity. By establishing a structured approach to product traceability and maintenance, the standard helps minimize equipment failures. It also assists organizations in implementing a Q2 quality management framework, reinforcing industry-wide good practices that prioritize safety and risk mitigation.

“Implementing 18LCM has significantly improved several key areas of our business,” said Ahmed El-Shafey, spokesperson for Dubai-based Drilling Engineering Services. “The standardized processes have helped ensure more consistent product outputs, reduce defects, minimize downtime and improve overall efficiency. Safety has also seen a boost as API standards provide a structured framework that enhances our safety protocols, leading to fewer incidents and better compliance.”
“The API 18LCM certification has enabled Sertecpet to establish itself as a global benchmark in product and asset lifecycle management within the energy sector,” said Evelyn Rocio Lucero, spokesperson for Sertecpet, an Ecuadorian energy solutions provider. “This certification supports the quality and reliability of our processes across all our business lines, ensuring complete traceability and operational optimization that translates into greater efficiency and sustainability.”

Organizations that meet API 18LCM’s requirements can apply for official registration through the APIQR Program, demonstrating their commitment to quality, traceability and adherence to the standard’s guidelines. The APIQR Program provides registration for service providers that operate under globally recognized quality management standards, like API Spec Q1 and API Spec Q2. Achieving APIQR registration enhances credibility, strengthens industry confidence and ensures that service providers maintain a high standard of life cycle management.

Mission for Success

API 18LCM provides a recognized framework for strengthening asset reliability and enhancing operational efficiency. By fostering industrywide standardization and improving traceability, API 18LCM helps mitigate risks, supports proactive maintenance strategies and promotes long-term equipment performance, reinforcing API’s leadership in setting the foundation for safe, efficient and sustainable energy operations.

To learn more about API 18LCM and its implementation, **visit www.api.org/18LCM.**

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Pioneering Protection in New Energy: AMPP's Role in CO_2 Transport and Beyond

As the world accelerates its transition toward cleaner, more sustainable energy sources, the infrastructure supporting this shift must evolve just as quickly. Among the most prominent developments in this transition is the increasing role of carbon dioxide (CO_2) transport and injection—a cornerstone of the Carbon Capture, Utilization, and Storage (CCUS) process.

These emerging systems are essential for achieving net-zero targets. They allow CO_2 to be captured from industrial processes or directly from the atmosphere, then transported—often via pipelines or ships—and injected deep underground for long-term storage. But while CO_2 capture may offer environmental benefits, it also presents complex technical challenges that engineers must address, especially concerning corrosion control and materials selection.

The Corrosion Challenge in CO_2 Systems

CO_2 captured from industrial sources, such as power plants and cement plants, can be highly corrosive. Impurities like water, hydrogen sulfide, or nitrogen and sulfur oxides can react to form aggressive products like strong acids. This poses a serious threat to pipeline integrity. Various impurities and operating conditions make CO_2 transport a complex corrosion engineering challenge. As infrastructure ages or scales up, the risks multiply.

Introducing AMPP Guide 21532-2023

To help industry professionals meet these challenges head-on, AMPP developed and published AMPP Guide 21532-2023: Guideline for Materials Selection and Corrosion Control for CO_2 Transport and Injection. This guide is a critical resource for engineers, asset owners, and decision-makers working on CO_2 infrastructure design and maintenance.

Unlike prescriptive standards that dictate rigid approaches, AMPP Guide 21532-2023 provides flexible guidance for a variety of projects. Its purpose is to aid in the identification of operating limits and appropriate materials for pipelines and injection systems transporting CO_2. The guide encourages engineers to consider key process variables to identify a safe CO_2 specification and design systems to avoid failures. It references additional standards and documentation supporting comprehensive corrosion mitigation strategies.

A Living Document for a Rapidly Evolving Field

Importantly, this guide is not meant to be the last word. Instead, it reflects the dynamic and evolving nature of this field. New materials, operating experience, and research findings continue to emerge. The guide should be seen as a starting point—a living document that will grow alongside the energy industry. More prescriptive standards will follow as knowledge develops. AMPP is committed to leading CCUS projects in building and maintaining safe and sustainable infrastructure.

SC 26: Advancing Standards for New Energy Frontiers

To stay ahead of rapid developments in carbon management and other energy innovations, AMPP established the Standards Committee (SC) 26—a dedicated body focused on supporting technologies related to Carbon Capture, Alternative Fuels, and Energy Storage.

SC 26 plays a central role in developing materials protection and corrosion control standards in these next-generation energy systems. The committee brings together subject matter experts across sectors to evaluate new challenges, explore innovative solutions, and create harmonized guidance that the global industry can rely on.

From managing the corrosion risks of hydrogen fuel systems to explaining the complex world of CO_2 corrosion testing, SC 26 helps chart a path forward. It bridges the gap between cutting-edge energy solutions and the reliable, safe infrastructure to make them viable.

SC 26 also fosters a collaborative, multidisciplinary environment, drawing participation from researchers, engineers, manufacturers, asset owners, and government entities worldwide. The result is a diverse community united by a shared mission: to protect the assets that will power a more sustainable future.

Why You Should Join the Movement

SC 26 is actively inviting new participants—forward-thinking professionals who want to shape the future of energy and materials protection. Whether deeply experienced in corrosion science or just entering the field with fresh ideas, your voice can make a difference.

By joining SC 26, you'll gain access to an invaluable network of industry leaders and technical experts. You'll help develop standards that guide real-world projects and support emerging technologies. You'll be at the forefront of innovation and have the opportunity to make a meaningful impact on your career and the planet.

To get involved, contact Brad Wilder, PE, CAE, Senior Director of Technical Advancement at AMPP at Brad.Wilder@ampp.org.

As the energy industry transforms, we must ensure that the materials and systems we depend on are up to the challenge. With your help, SC 26 can continue to lead in building safe, secure, and sustainable solutions for the future.

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Computational Detection of Corrosion in Photovoltaic Panels: From Algorithmic Analysis to Artificial Intelligence

By: Yolanda Reyes R

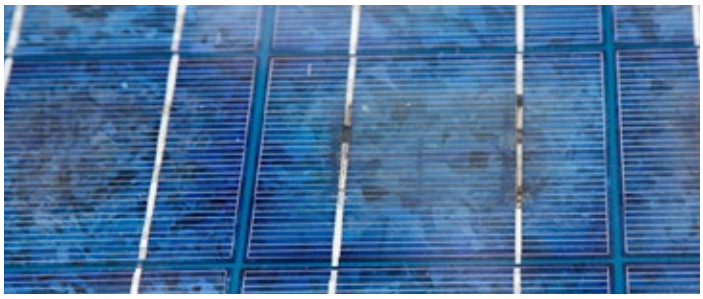
Member of the Technical Editorial Team at INSPENET

A technical look at algorithmic tools in the optimization of the monitoring of solar installations exposed to aggressive environments.

Introduction

Photovoltaic energy has experienced exponential growth in the last decade consolidating itself as one of the most widespread renewable energy sources in the world. The global expansion of solar PV systems has been a strong response to the energy and climate challenges. However, installations in hostile environments, such as maritime areas with high salinity, deserts with extreme thermal changes or urban regions with atmospheric pollutants, have shown corrosion problems that directly affect operational reliability and require integrated technological monitoring solutions for proper control.

Although solar modules are designed and built with materials resistant to aggressive weather conditions, the metallic structures (frames, anchors, hardware) and electrical components (connectors, tracks, junction boxes) are exposed to corrosive processes that deteriorate the physical structure and reduce the useful life of these assets. Hence the importance of detecting corrosion of solar structures in these environments; however, traditional methods for this purpose do not offer the speed, objectivity or coverage required for large-scale installations. Faced with this limitation, the renewable energy sector, in particular photovoltaics, is incorporating computational detection solutions, which integrate mathematical algorithms, computer vision and even artificial intelligence models, to optimize the monitoring of corrosion deterioration.



Solar panel affected by corrosion.

Corrosion in photovoltaic systems

Corrosion in photovoltaic systems is a significant problem in the photovoltaic industry. Prolonged exposure to aggressive atmospheric environments, such as humidity, atmospheric pollutants (SO_2, NO_x, chlorides), ultraviolet radiation and thermal variations, induce corrosive mechanisms that compromise both the operational reliability and lifetime of solar panels; affecting the integrity of the structural frames by crevice or pitting corrosion phenomena, while in the electrical elements (connectors, junction boxes, conductive tracks), the formation of oxides and sulfides can generate increases in contact resistance and arcing failures. The following image shows how corrosion affects the structure of these systems.

Computational tools for corrosion detection

Computational detection comprises a spectrum of techniques, from traditional image processing to machine learning algorithms; both strands can act in a complementary manner, depending on the desired level of complexity and accuracy. These are then classical approaches and AI approaches

Classic approaches:

Image processing (OpenCV, MATLAB): Techniques such as edge detection (Sobel, Canny), thresholding, texture analysis or mathematical morphology allow identifying visual patterns of surface corrosion, discolorations or cracks.
Spectral analysis: Algorithms detect alterations in spectral, hyperspectral or infrared images; associated with corrosion products or other degradation indicators.
Temporal comparison: Automatic analysis of images acquired in time series to detect and quantify the evolution of structural or surface deterioration.

These methods do not require training with large datasets but may have limitations under variable lighting conditions or complex damage patterns.

Artificial intelligence approaches:

Today, with the development of computational techniques, artificial intelligence (AI) is playing an increasingly important role in the field of scientific research. The incorporation of AI in computational detection has overcome some of the previous limitations.

The most commonly used models are:

- **Convolutional neural networks (CNN): trained on thousands of images of panels with and without corrosion, these networks can detect defects even in challenging lighting conditions.**
- **Classification models (YOLO, Faster R-CNN): They can identify multiple types of damage simultaneously in the same image (pitting corrosion, surface rust, moisture stains).**
- **Semantic segmentation (U-Net): Delimit the exact areas affected, estimating their surface area and degree of deterioration.**
- **Temporal analysis with LSTM networks: Used in installations with continuous monitoring, these networks can predict the evolution of corrosion over time.**

Although the training of these models requires large databases with identified images, once implemented, they far exceed the capabilities of conventional methods, especially under varying conditions. Compatible with SCADA platforms or predictive maintenance software.

Real applications and tangible benefits

Currently, industrial photovoltaic plants have already incorporated computational detection systems with verifiable results, achieving a reduction of more than 70% in inspection times, reduced direct intervention of technical personnel and lower corrective maintenance costs. In harsh environments, such as deserts in northern Chile1 or coastal areas in Saudi Arabia2, these technologies have established themselves as key tools to protect critical solar assets.

Current and future challenges

Despite the benefits, computational corrosion detection in PV systems still faces challenges. The availability of specialized databases with images representing different types of panels and environmental conditions is required. Barriers also remain, such as adapting algorithms to various solar module configurations, integration with existing infrastructures and interoperability with SCADA platforms or maintenance software. The development points towards hybrid solutions that combine computer vision, with Artificial Intelligence, to form intelligent simulation models for corrosion detection in photovoltaic systems.

Conclusion

Computational sensing, with and without artificial intelligence, is transforming the way to assess the integrity of solar PV systems. In the context of global energy transition, protecting these assets against corrosion is a strategic necessity. The integration of conventional algorithms with artificial intelligence in computational corrosion detection represents a breakthrough in solar system maintenance engineering, strengthening the sustainability and cost-effectiveness of PV installations in the face of challenging environmental conditions.

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Inline Inspection (ILI) vs. External Corrosion Direct Assessment (ECDA)

Choosing the Right Tool for Pipeline Integrity Management

Prepared by:
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Project Team, AsInt, Inc.

Inline Inspection (ILI) vs. External Corrosion Direct Assessment (ECDA): Choosing the Right Tool

Pipeline operators face ongoing threats from corrosion and other anomalies in buried pipelines. To manage integrity, two primary assessment methods are employed: Inline Inspection (ILI) and External Corrosion Direct Assessment (ECDA). Both are formally recognized by regulators (e.g., PHMSA 49 CFR Parts 192/195, CSA Z662, NACE SP0502) as valid integrity assessment techniques. ILI tools (sometimes called "smart pigs") physically traverse a live pipeline to collect data on wall condition. ECDA is a structured, four-phase process that uses above-ground surveys and targeted digs to assess external corrosion. Each method has advantages, limitations, and suited use-cases. The sections below compare ILI and ECDA in terms of typical applications, cost, reliability, and regulatory requirements, with a summary table and guidance for choosing the appropriate method.

Inline Inspection (ILI)

Overview: ILI refers to running instrumented "smart PIGs" through the pipeline during service. These devices house nondestructive testing sensors (e.g., Magnetic Flux Leakage (MFL), Ultrasonic Testing (UT) and geometric "gauge" tools) that measure wall thickness, detect metal loss, cracks, dents, and other anomalies. A smart pig is launched and retrieved via special fittings (launchers/receivers) and uses the pipeline's product flow for propulsion, so inspections can often be done without a full shutdown.

Capabilities: Modern ILI tools provide comprehensive, high-resolution data on pipeline integrity. For example, MFL pig detects corrosion pits and quantify metal loss, while UT pig precisely measures remaining wall thickness and even image cracks. A well-executed ILI run anomalies maps by location and size along the entire inspected length. This data allows operators to prioritize repairs or replacements before failures occur. As one integrity review notes, "periodic [ILI] assessments... help mitigate risks by enabling detection and control" of corrosion and defects. In practice, ILI is the most direct means to assess both external and internal corrosion (if a liquid is present) and is typically required on high-pressure transmission pipelines where feasible.

Advantages: Key advantages of ILI include non-intrusive operation (no prolonged shutdown), extremely detailed inspection data, and automated mapping of defects. Inline tools provide quantitative wall-thickness and anomaly sizing, supporting preventive maintenance. By catching defects early, ILI can reduce unplanned outages and environmental incidents. Many operators find ILI "cost-effective" in the long run because it limits emergency repairs.

Limitations: ILI requires a piggable pipeline. This means the line must be of sufficient diameter (typically ≥4 inches), have internal geometry compatible with pigs (no complex constrictions or unmapped elbows), and allow pig launching/receiving. Non-metallic pipe segments, severely corroded casings, or unbarred tees/valves can block pigs. Preparing a pipeline for ILI also adds cost: it often requires cleaning ("dirt pigs") and line passages, plus dedicated personnel. As one industry study notes, "the cost of inline inspection can be high;" expenses include pig runs, extra personnel, production downtime, and the inspection tool itself. These costs mean ILI is usually done on major transmission lines at multi-year intervals which may not fulfill corporate or jurisdictional minimum inspection requirements.

Reliability: When conducted properly, ILI is highly reliable for detecting and quantifying pipeline defects. Inline tools must be qualified (e.g., per API 1163) and their performance validated, but they are generally the best way to find small corrosion pits and cracks over long distances. The downside is that if a pig does not transit or if the tool is unsuitable for a given pipeline, the inspection may be incomplete. Also, ILI typically cannot inspect extremely small diameter lines or pipe legs, and by definition it only assesses areas the pig can reach.

External Corrosion Direct Assessment (ECDA)

Overview: ECDA is a four-phase structured process focused on external corrosion threats. It is outlined in NACE SP0502/NACE SP0504 (now under AMPP) and recognized by regulators. In brief,
ECDA involves:
1. Pre-Assessment (data gathering and region identification)

2. Indirect Inspection (above-ground surveys such as close-interval potential surveys, DCVG/ACVG, and soil testing)
3. Direct Examination (targeted excavations of the pipe at locations indicated by indirect tools)
4. Post-assessment (analysis and reporting).

The goal is to "assess and reduce the impact of external corrosion on pipeline integrity." By locating existing corrosion activity and enabling repairs, ECDA helps prevent defects from growing unchecked. It is typically repeated cyclically (e.g., every 5–7 years) as part of the integrity management plan.

Figure: External pipe run (exposed to the environment). ECDA methods use above-ground electrical surveys and soil tests on pipelines to identify coating faults or cathodic protection issues (e.g. corrosion shown by rust spots) before excavating for detailed examination

Capabilities: ECDA uses indirect techniques to find potential corrosion. For example, Close Interval Surveys (CIS) measure cathodic protection (CP) effectiveness, DCVG/ACVG detect coating "holidays" and anomalies, and soil resistivity/pH tests gauge corrosivity. These data are analyzed to flag pipeline regions of concern. In the direct examination phase, the operator then excavates at high-risk spots, inspects the coating, measures corrosion damage and remaining thickness, and evaluates CP performance. The combination of survey data and confirmatory digs enables operators to identify actual corrosion defects and "fix them" while addressing root causes. Afterward, a post-assessment report documents findings and sets re-assessment intervals.

Advantages: ECDA can be done without taking the pipeline out of service. (According to Matcor, "Unlike inline inspection, ECDA does not require shutting down the pipeline, making it a more efficient and less costly option.") It is often the only practical choice for pipelines that cannot be pigged – e.g., very old lines, small-diameter distribution mains, lines with "unpiggable" fittings or tight bends. ECDA is mandated or allowed by regulations in such cases. It provides targeted corrosion monitoring along buried pipes, and by focusing on electrical signals it can highlight hidden coating failures that might be missed by random digs alone.

Limitations: ECDA does not directly inspect the entire pipe wall. Its accuracy depends on selecting and analyzing indirect indicators; zones with no alarming signals might still have hidden defects. In addition, ECDA requires multiple phases of work (data gathering, surveys, excavation crews) and involves digging up the pipe at numerous points, which adds complexity and cost. The labor and resources for soil surveys, data interpretation, and excavation can be significant. If indirect tools miss a corrosion site, the defect can only be caught later in a subsequent cycle. Therefore, ECDA results must be carefully validated; in practice the "direct examination" digs are the final confirmation of any identified anomalies.

Use Cases and Scenarios

Piggable Transmission Pipelines: For long, high-pressure oil/gas pipelines of sufficient diameter and with well-defined launchers, ILI is usually preferred. Such pipelines benefit from the high resolution "picture" of wall condition that ILI provides. For example, a gas transmission line in corrosive soil will be pigged with MFL/UT tools to catch external corrosion "hot spots" along hundreds of miles. Inline data allows operators to plan repairs precisely and to maintain safe operation with minimal unplanned downtime.

Unpiggable or Small Pipelines: ECDA shines on pipelines where smart pigs cannot go. Distribution pipelines (smaller diameters, many service taps or bends) often use ECDA to meet integrity requirements. Similarly, cross-country pipelines that have certain unpiggable sections (e.g., many block valves, complex geometry, or legacy casings) may use ECDA on those segments. As one corrosion consultant notes, "inline inspection can be limited due to pipeline geometry; in these situations, an ECDA program is necessary to meet government regulations." ECDA is also used on short special sections (casings, road, or river crossings) where pigging is not feasible. Essentially, any pipeline segment that regulators deem externally corrodible but cannot be fully pigged often uses the ECDA process.

High-Consequence Areas (HCAs): PHMSA's integrity management rules permit either ILI or DA as a reassessment method for HCAs. For some urban pipelines or critical feeders, an operator might choose ECDA to minimize the risk of large-scale shut-ins, or ILI if the pipeline is fully piggable. The PHMSA gas rule explicitly recognizes that DA (including ECDA) "is needed where ILI or hydrostatic pressure testing cannot be used," and it can serve as an "effective, equivalent alternative to ILI" in certain cases. In practice, operators often use risk assessments to decide whether pigging or DA best mitigates the threats to each pipeline segment.

Regulatory Standards: Both methods are governed by industry and government standards. NACE SP0502 (now ANSI/AMPP SP0502) specifies the ECDA process. API documents (such as API 1163 for ILI tool qualification, and API 1160 for liquid pipeline integrity management) provide guidance on performing inline inspections and integrity programs. CSA Z662 (Canadian Oil & Gas Pipeline Systems) and PHMSA regulations (49 CFR 192.925 for gas, 195.452 for liquids) permit ECDA as an alternate integrity assessment method. In summary, either ILI or ECDA (when done according to standards) can fulfill regulatory requirements if applied correctly.

Figure: Above-ground oil/gas pipeline in a forested area. Remote pipelines may require periodic III pigging for data-rich assessment, or alternately ECDA surveys if shutdown or pigging is impractical. ECDA is a "continuous improvement process" and part of the asset management plan for such pipelines

Quantum LiDAR: Transforming Methane Emissions Monitoring for the Global Natural Gas Utility Market

By: Robert Vaughn
Vice President of Sales and Operations, Americas

Introduction: The Silent Threat of Methane Emissions

Methane is a greenhouse gas, more than 80 times more potent than carbon dioxide over a 20-year period. Despite representing a smaller proportion of total greenhouse gas emissions, its impact on global warming is disproportionately large. For the global natural gas industry — particularly utilities in Latin America, North America, Europe, and Asia — methane emissions pose not just an environmental challenge, but a regulatory and reputational risk.

Until now, traditional methane detection methods have lacked the resolution, accuracy, and adaptability necessary for complete and cost-effective monitoring. In this context, QLM Technology Ltd. is leading a critical shift with its quantum LiDAR camera solution, enabling utilities to accurately visualize, quantify, and mitigate methane leaks in real time — and at scale.

Revolutionizing Detection: The Quantum LiDAR Breakthrough

QLM's methane detection platform leverages quantum LiDAR technology — a fusion of infrared semiconductor lasers and advanced gas spectroscopy. At its core, this technology uses time-correlated single photon avalanche detection to capture 3D images of methane plumes, detecting leaks at ranges from 10 to .from 10 to over 250 meters.

This breakthrough allows utilities to perform real-time, high-resolution 3D scanning of methane emissions, drastically outperforming legacy detection methods such as handheld optical gas imaging (OGI) cameras, which rely heavily on operator interpretation and visual line-of-sight.

With 10 granted patents and more pending across the UK, Europe, and the US, QLM's technology has quickly become one of the most robust and scalable platforms in the methane detection space. Utilities across the Americas, Europe, and Asia can now deploy a proven, future-ready tool for high-precision monitoring.

Versatility in Action: Monitoring Across Complex Utility Environments

Unlike fixed-sensor or satellite-based systems, QLM's LiDAR cameras are built for versatility. The system can be deployed on permanent masts, trailers, mobile masts, tripods, or mounted on existing infrastructure, making it ideal for a variety of use cases in the gas value chain — from upstream well pads to midstream compressor stations and downstream utility infrastructure such as:

- Compressor Stations
- Measurement & Regulation (M&R) Stations
- City Gate Stations
- Underground Storage Facilities
- LNG Terminals

In Latin America, where rugged terrain and aging infrastructure present unique challenges, this portability enables broad deployment across difficult-to-access sites. In North America and Europe, where regulatory compliance and ESG reporting are central concerns, the ability to conduct continuous, automated monitoring ensures greater accountability and operational transparency. In Asia, the technology supports fast-growing utility networks and biogas operations, including those using anaerobic digestion in agriculture and waste management.

Environmental ruggedness is built in: operating temperatures from -40°C to +70°C, IP67 environmental rating, and 360° pan capability make the system suitable for any climate or geography. Whether in the high-altitude gas fields of Bolivia, the frozen operations of Alberta, or the industrial centers of Germany and China, QLM's cameras offer unmatched resilience and adaptability.

Accuracy Redefined: Emissions Quantification with Confidence

While many systems can detect methane, few can quantify it with actionable accuracy. QLM's cameras include a sealed methane calibration cell to ensure continuous internal calibration. This allows the system to measure only methane, distinguishing it from background gases like CO_2 or water vapor.

By integrating distance-to-leak data with concentration metrics, QLM can estimate emission rates with a factor-of-two accuracy — a major leap forward in detection fidelity. This performance has been independently validated through blind testing at the Methane Emissions Technology Evaluation Center (METEC) in Colorado, one of the world's most rigorous testing environments.

Utilities seeking to meet or exceed voluntary emissions reduction targets or prepare for stricter mandates — such as the EU Methane Strategy or the U.S. Inflation Reduction Act's methane fees — now have a solution capable of auditable, science-grade quantification.

Intelligent Data Management:
Cloud-Based Environmental Intelligence

Detection is only the first step. What makes QLM's system truly transformative is the data intelligence ecosystem built around its cameras.

Each deployment includes an Edge Controller that encrypts, stores, and transmits data securely. Users can access the system through any standard web browser, gaining real-time control of cameras, live video feeds, custom dashboards, and historical emissions data.

Connectivity is designed for global deployment:

- 4G
- Satellite
- Wi-Fi
- Ethernet

This ensures reliable data flow whether monitoring a refinery in Texas, a remote field in Argentina, or a gas plant in Southeast Asia. Utilities can customize alert thresholds, receive automated reports, and integrate emission data into corporate ESG and regulatory frameworks with ease.

By turning complex environmental data into actionable insights, QLM empowers operators, regulators, and stakeholders to make informed decisions — from preventive maintenance to carbon offset strategies.

Regulatory Compliance and a Future-Ready Platform

With methane regulations tightening worldwide, QLM's technology is built to meet evolving global compliance needs.

The company is actively pursuing U.S. EPA Alternative Test Method (ATM) qualification as an intermittent methane detection solution. The qualification is expected in Q3 2025, opening the door to broad regulatory acceptance in the United States and beyond.

Moreover, the system supports alignment with international frameworks, including:

- OGMP 2.0 (Oil and Gas Methane Partnership)
- EU Methane Regulation
- GHGRP (Greenhouse Gas Reporting Program)
- ISO 14064 GHG Quantification Standards

By offering a standards-compliant, future-proof solution, QLM helps utilities reduce the burden of regulatory compliance while accelerating their transition to a low-emissions operating model.

Conclusion: A New Era in Methane Monitoring

As the natural gas utility market navigates the twin imperatives of climate responsibility and operational resilience, methane monitoring is no longer optional — it is strategic. QLM Technology Ltd. is redefining what's possible in emissions management with its advanced quantum LiDAR platform, delivering:

- Unmatched accuracy in leak detection and quantification
- Flexible deployment across upstream, midstream, and downstream assets
- Secure, cloud-connected data intelligence for decision-making
- Compliance support for a rapidly changing global regulatory landscape

From Buenos Aires to Boston, from Berlin to Bangkok, natural gas operators now have a powerful new ally in the fight against methane. QLM's solution is more than a camera — it's a transformational platform for environmental accountability, safety, and operational excellence.

In a world where every molecule of methane matters, QLM provides the clarity, confidence, and control the global energy sector needs to thrive in a decarbonizing future.

LNG: Key to a Global and Sustainable Energy Future

By: Mario Toyo
Member of the Technical Editorial Team at INSPENET

In an international landscape shaped by geopolitical tensions, logistical constraints, and an urgent need for decarbonization, Liquefied Natural Gas (LNG) is solidifying its role as a central player in the new energy paradigm. Its capacity for maritime transport enables countries to diversify supply routes, reduce dependence on single suppliers, and enhance global energy security.

Increasingly valued by nations redesigning their energy matrices around reliability and sustainability, LNG serves as a critical buffer during emergencies or seasonal demand peaks. Its strategic versatility grants governments greater control over national energy policies and ensures economic and industrial continuity, even under adverse conditions.

Energy Transition and Sustainble Mobility

In the global effort to reduce emissions, LNG is emerging as a cleaner alternative to traditional fossil fuels. Acting as a bridge fuel, it enables the progressive replacement of coal and oil without compromising energy continuity.

Power plants fueled by LNG provide rapid response capabilities to manage the variability of intermittent renewable sources such as solar and wind, thereby reinforcing the reliability of electric grids. Furthermore, its infrastructure is **adaptable to future networks for green hydrogen and renewable gases**, positioning it as a **key component in transitional energy ecosystems**.

In the transportation sector, the use of **LNG-powered engines in ships and freight vehicles** is expanding rapidly. This technology **significantly reduces sulfur and nitrogen oxide emissions**, supporting regulatory compliance. Simultaneously, the expansion of **specialized port infrastructure** enables an **effective energy transition**, driving **cleaner and more efficient logistics solutions**, both environmentally and economically.

Technological Innovation and Environmental Sustainability

Technological advances have expanded the operational frontiers of LNG. Floating units such as Floating Liquefied Natural Gas (**FLNG**) and Floating Storage and Regasification Units (**FSRU**) enable gas to be liquefied, stored, and regasified directly offshore, **reducing logistics costs and accelerating commercialization**.

The industry is also investing in digital tools and automation. Artificial intelligence systems are being applied to monitor emissions, forecast consumption, and optimize regasification—**enhancing efficiency and reducing environmental impact**.

One of the main challenges is **methane emission mitigation**, due to its high global warming potential. In response, the sector is deploying leak detection technologies, advancing Carbon Capture and Storage (CCS), and exploring the use of **renewable electricity** in the liquefaction process to lower lifecycle emissions.

Latin America and Its Strategic Role in the LNG Economy

Latin America is emerging as a **s**trategic hub in the global LNG economy. Countries such as **Chile, Colombia, and Panama** are strengthening their **import and regasification capacities**, enhancing energy resilience and attracting investment.

At the same time, **export-oriented nations** like **Mexico, Argentina, and Trinidad & Tobago** are developing infrastructure to serve international markets. The promotion of joint terminals and regional gas pipeline networks points to a path toward Latin American energy integration, reinforcing LNG's role as a catalyst for economic growth and technological innovation in the region.

The Future of LNG: Cleaner, Smarter, and More Competitive

The LNG sector is evolving toward a cleaner, more digitally integrated model. Intelligent platforms and digital traceability systems are transforming the logistics chain—optimizing turnaround times, minimizing product loss, and enhancing transparency for stakeholders.

Moreover, the integration of **blockchain technologies for cargo tracking** is reinforcing trust in international LNG trading operations.

Green bond financing and adherence to ESG (Environmental, Social, and Governance) criteria are gaining significant traction, aligning LNG development with global sustainability standards. A prominent case is the **Energía Costa Azul (ECA LNG) project**, developed by Sempra Infrastructure and TotalEnergies, which was partially funded through green bonds and incorporates environmental monitoring and energy efficiency practices.

Conclusion: A Vital Ally for the Global Energy System

LNG represents more than just a transition fuel—it is a strategic pillar of global energy stability. Its adaptability, compatibility with low-carbon technologies, and role in transportation, power generation, and industry position it as a **reliable enabler of a sustainable energy future**.

Far from being part of the problem, **LNG is increasingly seen as part of the solution**.

Neal Couture:
Leading the Transformation of Nondestructive Testing in the Digital Era

Neal Couture, CEO de ASNT

From the PANNDT 2025 Conference in Niagara Falls, Inspenet had the privilege of speaking with Neal Couture, CEO of the American Society for Nondestructive Testing (ASNT). His professional path, strategic vision, and commitment to the global NDT community have positioned him as a key player in the evolution of the discipline.

Editorial Introduction

In an era where Non-Destructive Testing (NDT) is facing the dual challenge of accelerating digital transformation and an urgent generational renewal, many professionals are wondering how to remain relevant, well-prepared, and connected to global innovation.

That's where Neal Couture comes in. As CEO of the American Society for Nondestructive Testing (ASNT), Couture brings not only leadership, but a clear roadmap for those navigating this changing landscape. From advocating for NDT on Capitol Hill to pioneering AI standards and workforce development strategies, his voice represents a guiding light in uncertain times.

In this exclusive interview for Inspenet Brief, recorded during the PANNDT 2025 conference in Niagara Falls, we explore with him the core questions that concern the NDT community today.

If you are looking for clarity, direction, and strategic inspiration in the world of NDT, this conversation will give you precisely that.

Interview

Inspenet Brief: Neal, thank you for joining us at PANNDT 2025. What brings you and ASNT to this conference?

Neal Couture: This is our community. As one of the largest national societies dedicated to NDT, many of the attendees here are our members, customers, and certified professionals. Being here is essential—not just for visibility, but as part of our active commitment to the profession

IB: Could you share your professional journey and how you became the CEO of ASNT?

NC: My path has been somewhat unconventional. I didn't come from the NDT world. I began my career as a military officer, then moved into the aerospace and defense industry. Later, I transitioned into association management and eventually academia—though I quickly realized I needed a faster pace. I joined ASNT in 2019, bringing an external perspective that I believe is helping us lead with a fresh and inclusive outlook.

IB: You took over the role just before the pandemic. How did that context impact your leadership?

NC: It was definitely a challenge. Two months after starting, I attended my first ASNT conference in Las Vegas and lost my voice before a key presentation. Shortly after, the pandemic hit, forcing us to quickly digitize all our educational offerings, adopt new technologies, and rethink how we connect with members. That moment of crisis became a catalyst for necessary transformation.

IB: Since joining, what do you consider your most significant contribution to ASNT and the NDT community?

NC: I'm especially proud of our expansion into government and policy advocacy. In 2024, we opened our Washington, D.C. office to begin direct conversations with lawmakers about the value of NDT. We launched our first "Fly-in Day," bringing over 45 professionals to Capitol Hill to advocate for the field. These efforts are helping position NDT as a vital contributor to public safety and economic development.

IB: What have you discovered through this engagement with the federal government?

NC: The biggest realization is that very few people know what NDT is. I didn't even know before joining ASNT. But once we explain it, interest grows quickly. There's genuine curiosity and appreciation for the role NDT plays in safety, infrastructure, and industry. We're also exploring how to access federal funding for research and workforce development.

IB: And at the state level?

NC: It's more complex. There are 50 states, each with its own system. Our plan is to rely on our national member network for local outreach—knocking on doors, introducing NDT, and showing how state governments can support the sector.

IB: How would you describe ASNT's current relationship with regulatory agencies?

NC: Very positive. We're not political—we don't endorse candidates or agendas. Our role is to educate. We offer technical knowledge to ensure that regulations are effective, not harmful. Agencies like the NRC appreciate this neutrality. We aim to be a reliable technical reference.

IB: What role does ASNT play within organizations like ICNDT and PANNDT?

NC: We're active members. These networks are essential for sharing best practices, identifying emerging challenges like AI, and fostering global dialogue. In four years, ASNT will host the next PANNDT conference, which is a major step for our international presence.

IB: Speaking of AI and digital transformation, how is ASNT responding?

NC: Traditionally, standard-setting organizations move slowly—on 5 to 10-year cycles. But the world is moving faster. We recently released a draft standard for using AI in NDT. It outlines best practices and what to avoid. That's our role—to guide the industry through change responsibly.

IB: The industry is also facing a generational challenge. How do we attract new talent?

NC: The real concern isn't just attracting young people. According to a study by McKinsey we reviewed, the issue is demographic—there simply aren't enough working-age people to meet demand across all sectors. We need deeper solutions, including automation, cross-training, and inclusive recruitment. Competing over a few graduates won't solve it—we need national and global strategies.

IB: Lastly, what can the NDT community expect from the upcoming ASNT event in Orlando?

NC: It'll be a celebration of the future of NDT. We'll highlight emerging technologies, revise key standards like SNT-TC-1A, and focus on preparing the workforce for upcoming challenges. Plus, it's at a Disney resort in Florida—the exhibit hall is almost full and registration is open. It's an event not to be missed.

IB: Neal, thank you for being with us and for sharing such a clear, honest, and committed vision for the present and future of Non-Destructive Testing. It's truly been an honor.

NC: The honor is mine. Thank you for giving me the chance to speak to the Inspenet community. I'm confident that together, we'll continue to strengthen this profession across the globe.

IB: See you in Orlando.

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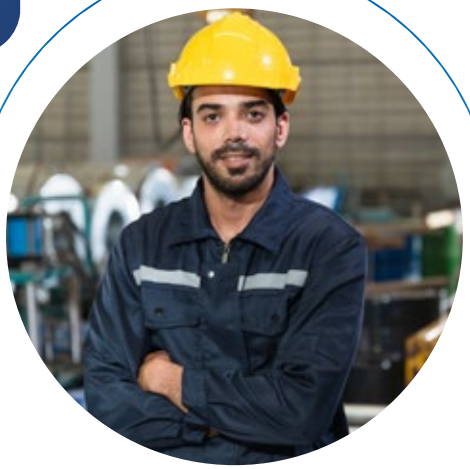

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Interview
Cartagena Port Authority JOSÉ MARÍA GÓMEZ FUSTER, General Manager

Puerto de Cartagena

Autoridad Portuaria de Cartagena

The Port of Cartagena is one of the first Spanish ports in goods traffic. How did it close the year 2024? What sets Cartagena apart?

2024 was the best third year in the history of the Port of Cartagena in its total cargo traffic with 35.6 million tons of total cargo movement on 2,199 vessels, despite an unstable international situation that affected the logistics chain.

From this port we mainly move bulk cargo, both liquid and solid, in fact, we are the first Spanish port in this traffic. We also lead the import, foreign trade and export of live cattle. We are the fourth largest port in Spain and one of the most profitable in the Spanish port system.

Cartagena is one of the most flexible and competitive ports in Spain, offering agile and efficient services, fully liberalized stevedoring and the deepest draft in the Spanish Mediterranean, which allows us to handle the largest ships in the world in record time. This guarantees greater competitiveness to companies, which are assured of immediate unloading of their goods when the ship docks at the pier. And with this objective of providing the best service in an efficient and effective way, our Business Plan contemplates major projects to advance in intermodality, promoting a better connection with Europe, innovation and sustainability with the aim of being a base port for energy transformation.

On the other hand, the uniqueness of our Port, with two docks separated by 7 kilometers, the one in Escombreras, far from Cartagena, and the one in Cartagena, fully in the city, is allowing us to make a transformation of the entire seafront more lively, modern and innovative, as an example of a model of port-city integration. We are talking about 10 kilometers of extension by and for the people of Cartagena, integrated in the Lighthouse to Lighthouse project, which includes several actions, divided into phases, which will make Cartagena a more open city as a tourist capital in the Mediterranean. And of course, as a port of call for cruise ships, we have the challenge of having our cruise terminal electrified by 2025 so that cruise ships entering the mouth of our port can turn off their engines and connect to the network that we will offer them.

Diversification of traffic has been one of the strategic lines of the Port of Cartagena in recent years. Industries such as offshore, LNG traffic or petrochemicals are becoming more and more important in the port. What are the actions being developed by the Port of Cartagena to increase the loyalty of these traffics?

The Port of Cartagena has a trajectory of constant growth as the first economic and logistic engine of the Region of Murcia, moving 60 percent of exports and 80 percent of imports. We have consolidated our position as the fourth Spanish port in goods traffic and number 20 among European ports.

Our diversification policy has allowed us to attend new traffics, consolidate our position, and even be able to become an alternative to urgent market needs, and it is, as I said before, because of our agility in both sea and land operations, as well as because we offer safe services and efficient infrastructures that we are constantly remodeling. Every investment we make is in response to the needs of our customers.

In global figures, liquid bulk traffic still represents more than 77 percent of our total volume of goods, but we have achieved a very significant increase in solid bulk traffic, as the second national port in agri-foodstuffs, as well as being the first Spanish port in live animal exports. We have entered new markets, such as the offshore industry, which is the repair and maintenance of ships and oil platforms, where we are already the alternative in the Mediterranean, as well as scrap metal, salt, project cargo or ro-ro traffic, where we were able to handle the import of 2,000 vehicles in record time, 100 vehicles in one hour, in the first ro-ro traffic operation of vehicles.

The expansion of the Príncipe Felipe dock in Escombreras for the loading and unloading of LNG involved an investment of 9.7 million euros and is a real option as a gateway to Europe for this sustainable fuel, allowing two large LNG tankers to operate at the same time. But also that companies such as Enagás continue to trust us with important investments in their facilities.

What projects does the Port Authority have ahead of it?

We are a leading port in bulk traffic, both liquid and solid. The expansions in our facilities that we have made over the years have made possible the establishment of companies around the Port, in the Escombreras Valley, one of the most important **multi-energy poles** in Spain and Europe, such as Ilboc, Engie or Repsol. That is why our challenge is to be **base port of the energy transformation of Spain and Europe.** We have to ensure that the majority of green energy production leaves through our Port. We are already a reference in natural gas. We were among the first ports to carry out bunkering operations together with Enagás and Repsol, within the framework of the European project CORE LNGas Hive, co-financed by the European Commission, that is to say, to supply LNG to the ship from a terminal located on the quay through a pipeline.

And because we know how to move liquid bulk, continues to expand the pipeline racks on our docks to generate greater competitiveness, efficiency in loading and unloading and reduce times. But also, to be more sustainable, as these racks allow companies to install pipelines to move their liquid cargo from the ship directly to their facilities, or vice versa, avoiding road transport of dangerous goods. One of our key projects is to connect the Port with the **future Logistics Activities Zone of Cartagena** through pipe racks, in order to solve the occupancy problems we have in Escombreras. It is a long-term project with an investment valued

at 42 million euros that will allow us to move towards more sustainable fuels such as ecofrio or green hydrogen. By 2025, we want to start with the feasibility studies and technical projects.

In solid bulk, our dry port project in Algodor, **in Aranjuez**, in a bet for the maritime-port traffic through the railroad that will connect the Port's goods with the center of Spain in a more competitive, effective and efficient way. We will gain relevance in the center of Spain with a weekly train loaded with cereal that will arrive in Cartagena for import, as well as working on other goods such as green ammonia.

In addition, this year the new Border Control Post at the Santa Lucia dock will come into operation, a large modern building with the implementation of new technologies, greater food and livestock safety, greater capacity to bring together the services of Animal Health, Plant Health, Foreign Health, Soivre (Official Service of Inspection, Surveillance and Regulation of Foreign Trade) and Customs, and automation of services, which will improve the operations of perishable goods traffic that have increased in recent years.

On the other hand, we will also have a new shipping terminal for live cattle traffic, in the Príncipe Felipe dock of the Escombreras dock, with top quality facilities and with the highest guarantees of care and respect. The Port of Cartagena is one of the main ports in Europe for the export of live cattle. We are a key logistics platform at the service of livestock companies in the Region and throughout Spain, within its strategy of diversification and opening of new markets.

The AP of Cartagena is one of the most profitable ports in Spain, what bonus policies has the AP implemented?

Cartagena is one of the Spanish ports with the most profitable rates in the Spanish port system, which contributes to the competitiveness of an infrastructure that generates security and confidence for investors. Our solvency and management is demonstrated by being one of the few port authorities without indebtedness and a sufficient solvency to activate rate reductions and bonuses to our potential customers that allow us to give added value to the companies of the Region and our hinterland.

In this sense, in recent years we have implemented a battery of bonuses to help companies in the sector and to encourage freight traffic. In this sense, in recent years we have implemented a series of bonuses to help companies in the sector and to encourage freight traffic: bonuses on ship and passenger taxes for cruise ships, especially in the winter months; the reduction of 40 percent, the maximum allowed by law, to attract and retain traffic in containers bound for the Region of Murcia, as well as in ro-ro, ro-pax and ferry traffic, to help reduce the presence of heavy vehicles on the roads; in merchandise rates for the export of live animals and steel products, fertilizers, cereals, frozen and refrigerated fishing, since in the Cartagena area there are the largest bluefin tuna farms in the Mediterranean, clinker, lubricants, supplies, and for offshore platforms and ships, which is a line of business that is boosting the port of Cartagena. Rates are also reduced by 20 percent in scrap metal traffic.

And with our sights set on the railroad, we are applying the maximum 40% bonus to promote the maritime-terrestrial modality, which will be vital to connect with the center of Spain in cereal traffic.

With this package of measures we will continue to be able to be attractive to private investment and continue to maintain an income statement with profits that few Spanish ports can boast.

The new multi-purpose terminal, Barlomar, is one of the major projects, at what stage is it, and how will it affect the competitiveness of the port and the regional economy?

Indeed, the expansion of Escombreras with the Barlomar Terminal means a qualitative and quantitative leap in the traffic of goods through a multipurpose terminal, one of the most modern and sustainable in the world, which will double the regional productivity as the main exporting port of the products of the Region. We need to grow with infrastructures that meet the needs of the regional and global markets. The process is proceeding more slowly than we would like.

We are talking about an investment of 822 million euros that will generate approximately 10,000 jobs, almost full employment in Cartagena. A project for the future that has the support of the business and social fabric of the Region. The new multipurpose maritime terminal will occupy 58 hectares in the port of Escombreras, will be more eco-efficient, and will be connected to the railroad and the Mediterranean Corridor with the maritime transport lines and with the Logistics Activities Zone of Cartagena, placing the region as the gateway to and from Europe for goods from the rest of the world through its port.

Barlomar will make us competitive in containerized cargo traffic. We will multiply by 10 times the current capacity, being able to serve the largest container ships in the world. Our current Santa Lucia Terminal prevents the entry of 92 percent of the ships of the fleet of the 20 most important shipping lines in the world due to its shallow draft. With Barlomar, we will be able to service all container vessels currently operating.

But it will also position the Region in the off-shore industry (repair and maintenance of offshore platforms, etc.) as a strategic point in the Mediterranean within the club of industrial hubs. And it will allow us to continue growing in solid bulk traffic, where we are leaders among Spanish ports by gaining 180,000 m3 of storage space for cereal traffic.

And the El Gorguel dock project, what would it mean for the Port of Cartagena?

El Gorguel is the best constructive solution in average depths between 25 and 65 meters. The new dock would allow us to open up to new markets, which, today, we are not able to serve due to the current configuration of our port. It would allow us to operate up to 3.8 million containers (mainly transshipment) and 2.3 million tons of RO-RO traffic. With the figures we are currently considering, the construction of a new Port in El Gorguel, would allow the Region to become a major node in the global transport chain, which would entail a huge logistics and distribution activity, as well as increase the volume of business that is currently not possible in Cartagena. We would enter the container traffic which, right now, is a very residual traffic for us.

We are talking about mobilizing more than 1,500 million euros at no cost to the taxpayer, 30,000 jobs (direct, indirect and induced) and an added value of 1,634 million euros per year, once in operation. We would double our contribution to the regional GDP from the current 4% to 8.6%. It would attract new investments, new industrial projects and would be the catalyst for new opportunities.

The Port of Cartagena maintains a very positive trend in cruise traffic. What are the port's forecasts for the year 2025? What promotional actions are being developed?

Cartagena is a consolidated destination in the Mediterranean in cruise traffic and this is not the result of chance, but of a constant promotion and dissemination work since it was decided to bet more than 20 years ago. Fairs and events are very important, but we also belong to international cruise associations such as CLIA and we are in permanent contact with the shipping companies. However, the greatest promotion is the one made by the cruisers who visit us. We have been able to verify this in the surveys that the shipping companies themselves make to the tourists on the ship, where Cartagena always has excellent results and it is because we offer a different and unique destination that they cannot find in another city. No city the size of Cartagena has so many museums and interpretation centers. An offer that is combined with personalized nautical, nature and diving or gastronomic experiences.

We have been able to adapt to the new demands of the sector, anticipating their needs, while continuing to work on a model of an integrating city with an attractive seafront converted into a large square full of social life, activities and restaurants with excellent services.

By 2025, 190 ships and more than 250,000 cruise passengers are expected, consolidating our position as a luxury and super-luxury destination in the Mediterranean that seeks exclusivity and differentiation. A commitment to sustainable and more exclusive tourism, which avoids overcrowding, which has a greater economic impact on the city's hotels and commerce, and which seeks and appreciates destinations with historical and monumental values. It means bringing American or Canadian tourists to Cartagena, who are less likely to choose to visit Cartagena if not through the sea.

In addition, we continue to work on the OPS project to electrify the cruise ship dock so that ships can turn off their engines when entering our Cartagena dock, as well as on the supply of LNG fuel to ships.

What port-city integration project are you carrying out?

The Port Authority of Cartagena is in the midst of remodeling its waterfront with investments and projects covering the 10 kilometers of the Cartagena waterfront for the people of Cartagena. Its objective, in collaboration and coordination with the Cartagena City Council, is to completely open the port to the city in a modern, lively and welcoming integration model that consolidates Cartagena as a great Mediterranean capital through the Lighthouse to Lighthouse project that runs from the beach of Cala Cortina and Faro de Curra to the Christmas Lighthouse through various actions, divided into phases, with the Port of Cartagena as the protagonist through the promotion of accessibility, mobility and sustainability.

This union will go through a pedestrian and bicycle path that will have spaces along its route so that citizens can enjoy the seafront as the center of sports, cultural and social activities in an environment where walking, resting, in addition to promoting the restoration with the opening of new businesses that will contribute to the dynamism of a Cartagena that has its port as the heart of the city.

Having already consolidated the first phase of the project of Plaza Mayor and Plaza Héroes de Cavite, which involved the investment of more than 3 million euros, for the enjoyment of Cartagena and tourists and has been a revitalizing effect with the opening of commercial premises, we continue to take steps in different parts of the waterfront. On the one hand, we are drafting the project for Phase 4 of Plaza Mayor in the vicinity of the Cruise Terminal, which we hope the works can begin in late 2025. This action is important because it is the entrance of foreign tourism to Cartagena through the sea. It is the letter of introduction of Cartagena to cruise passengers and that is why we are working to create a pleasant environment for users with places for rest and recreation where an elongated building for commercial use and services will be implemented as a tourist showcase, with panels that will provide updated information on events, events and local festivals.

In addition, the construction of the new administrative building of Santa Lucia is underway, which is located next to the sea and will free up space in the city for the enjoyment of the neighbors. We want a friendly and attractive environment that will enhance the value of this area of the seafront.

On the other hand, work is progressing on the Vial del Espalmador, with an investment of 3.74 million euros, with the aim of creating a friendly, hiking and sports route for the enjoyment of all citizens, recovering a large area, linked to naval and military history, to make it an attractive area for Cartagena residents and visitors, which in recent years has become a preferred route for sports enthusiasts, and which will give added value to

On the economic scale, we focus on sector positioning, international projection and corporate ethical culture. We have incorporated a guide on green public procurement, which takes into account not only the Green Public Procurement Plan of the National Government, but also the guidelines set by the EU.

Cartagena as a tourist destination with the transformation of the seafront, connecting it with the city.

What other actions is the Port of Cartagena developing in terms of digitalization and new technologies?

We are clear that the Port of Cartagena is an engine of logistics and economic development for the Region, but we also want to be the engine of innovation. To this end, we launched a tool called Portlab, through which we are advising and supporting entrepreneurship and innovation in the logistics-port sector. Portlab is already a source of opportunity as a meeting point to integrate the needs identified by the companies of our Port Community with the ideas and projects to be developed by entrepreneurs, start-ups, PhD students and researchers in our sector, on the path towards a Ports 4.0 model.

Another innovative project we are developing is the LIFE PortSounds project, an ambitious initiative aimed at reducing the impact of underwater noise in the Port of Cartagena, where we participate together with UPCT, UPV and the Naval and Sea Technology Center. It focuses on the identification of underwater noise sources and their influence on marine biodiversity; the development of noise management tools; and the implementation of mitigation measures for cetacean, dolphin and whale populations. This is a pioneering initiative worldwide that we hope will be well received and will help to replicate it in all ports in Spain.

As you can see, we have based ourselves on a culture of innovation with knowledge transfer in all areas; on the development of Smart grids and advances towards a decarbonization and low-emission model; on achieving more efficient and agile port operations with process automation; on the digitization of processes by introducing 4.0 technology and traceability services in Blockchain networks, as well as on the implementation of new business models.

We have created alliances with some thirty public and private entities through the Green Hydrogen Valley Platform of the Region of Murcia, with logistics operators, universities and companies such as Navantia to convert one of the largest multi-energy poles in Spain, the Escombreras Valley in the Green Hydrogen Valley, included in the first green hydrogen corridor of the European Union, the H2MED project, to connect Cartagena as a center of green hydrogen production with France and Portugal. In this sense, we are working on two renewable hydrogen tractor projects.

The Port of Cartagena is developing its Sustainability Plan for the coming years. What are the main axes and objectives that underpin it?

The Port of Cartagena is recognized at European level as one of the most sustainable ports in the Mediterranean. The Sustainability Plan 2022-2025 marks the roadmap to make green the engine of change in the port community, in Cartagena and in the rest of the Region, based on the environmental, social and economic scales, and which has been reflected on the website of the Sustainability Observatory.

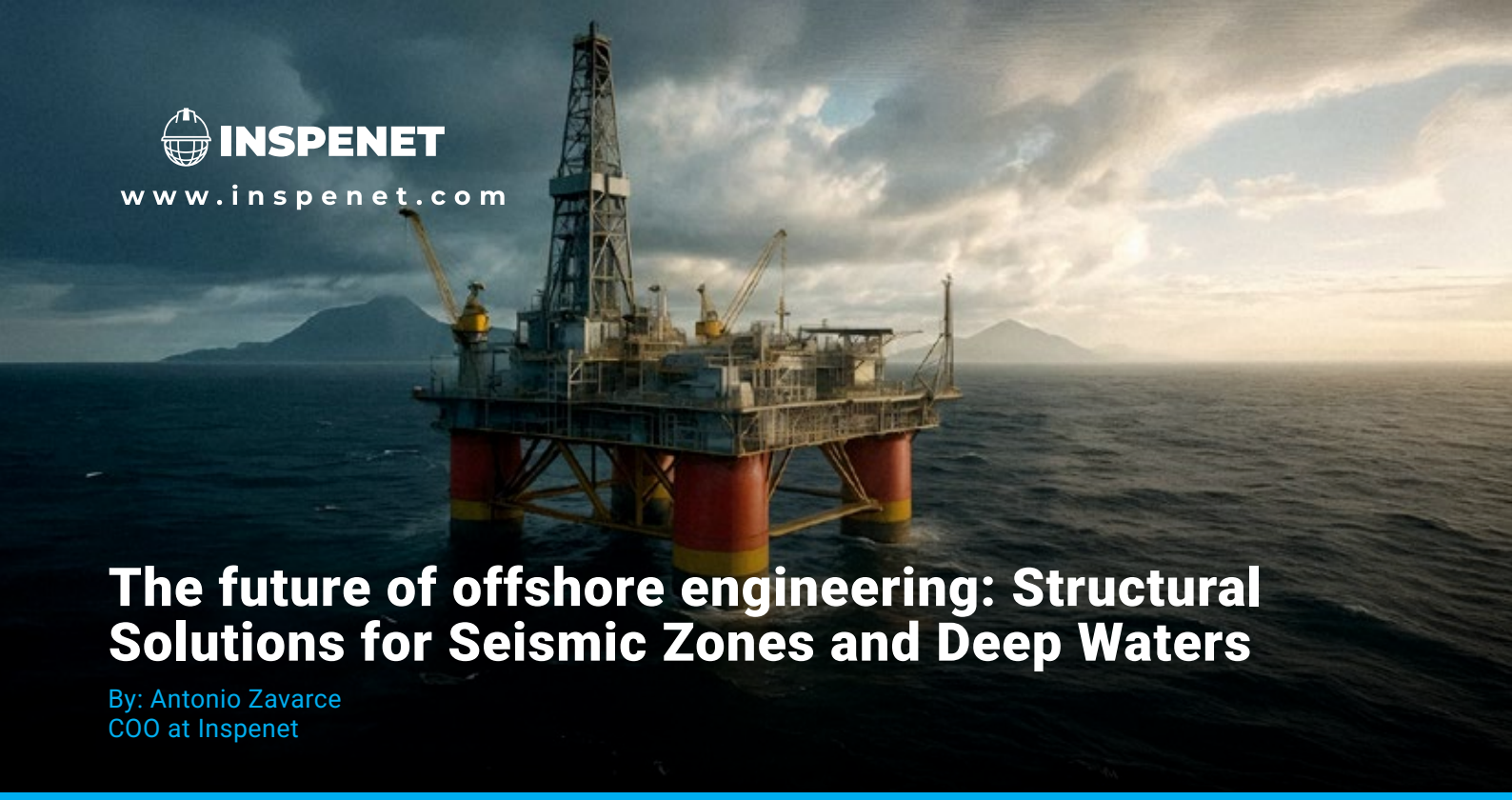
On the environmental scale, there are actions of climate neutrality, air, water and soil quality, biodiversity, energy transition, circular economy, environmental education and management, where we have the highest environmental label recognized by the European Union, the EMAS label. We work together with universities through the Mare Nostrum Chair to establish synergies that promote the transfer of knowledge in favor of our port.

We are pioneers in a pilot project of Reforestation with Posidonia Oceanica, planting 60 fragments of Posidonia Oceanica in the port waters of Tajo de Los Cuervos, with a survival rate of 77%. This is the first time that the reproduction of this endemic plant of the Mediterranean has been attempted in port waters. So much so, that we have been winners of the 'Corresponsables 2023 Award' and finalists in the ESPO Awards and in the IV go!ODS Awards, organized and managed by the UN Global Compact Spain in collaboration with the Rafael del Pino Foundation.

On the social scale, the actions are aimed at quality of life, historical and cultural heritage, port-city integration, promotion of talent and volunteering with several actions aimed at the environmental restoration of the Cabo de Palos Lighthouse. We have been the first port in Spain and Europe to calculate the social value generated by its activity, i.e., incorporating its non-economic benefits, i.e., those that generate value to human capital, the surroundings or the environment, as well as the integrated socio- emotional value. As a result, the social value generated by APC is more than 118 million euros; in particular, the social impact of APC's investment is 9.1 times the economic impact.

CSR actions are included in a common strategy that is applied transversally in all areas of the Port Authority. In our commitment to the SDGs, we added more companies to the platform launched in 2021 of "Commitment to the Sustainable Development of the Port of Cartagena", which already integrates a total of 30 organizations that join to work together to achieve a more sustainable, equitable and prosperous port community in Cartagena.

But if there is one thing we are proud of, it is to be the first Port Authority in Spain to launch the educational program "Know the Port of Cartagena", in collaboration with the Ministry of Education of the Region of Murcia. This is the second year that we have carried out this action, which integrates an educational module to raise awareness of the impacts of Climate Change on the marine environment and the vulnerability of ecosystems within the curriculum. An initiative aimed at all public and subsidized educational centers in the Region of Murcia, in which more than 30 educational centers and nearly 2,000 students participated.



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The future of offshore engineering: Structural Solutions for Seismic Zones and Deep Waters

By: Antonio Zavarce
COO at Inspenet

As the offshore industry ventures into increasingly deeper and more hostile waters, structural engineering faces a turning point. Traditional fixed platforms have given way to anchored floating solutions capable of operating under conditions that combine high pressure, seismic activity, and complex logistics. In this new landscape, innovation is not optional, it is imperative.

Platforms such as FPSOs, SPARs, and TLPs, designed to withstand dynamic forces in seismically active locations, represent a new generation of offshore infrastructure. Making these structures viable and safe requires a convergence of modular design, structural resilience, and digital technologies such as digital twins. This article explores how these solutions are reshaping the present and future of marine engineering, with an emphasis on environments of high geotechnical and operational complexity.

Structural Challenges in Next-Generation Floating Platforms

Floating platforms, such as FPSOs (Floating Production Storage and Offloading), TLPs (Tension Leg Platforms), SPARs, and semi-submersible units, operate in dynamic environments that subject their structures to complex and variable loads. One of the primary challenges is the continuous multiaxial movement (heave, roll, pitch, and yaw), driven by waves, currents, and wind, which creates critical cyclic stresses on the superstructure and mooring systems.

Prolonged wave fatigue accelerates the degradation of structural components, while flow-induced vibrations (VIV) can cause dangerous resonance in columns, risers, and umbilicals. Additionally, materials are exposed to thermal cycles, saline humidity, and corrosive agents, which can compromise long-term integrity if not properly selected.

To mitigate these risks, continuous structural health monitoring (SHM) is employed, a strategy that combines sensors, predictive analytics, and early warning systems to provide a comprehensive approach. This technology enables the detection of deformations, wall thickness losses, or incipient cracks, helping optimize maintenance and extend the operational lifespan of offshore facilities.

Modularization as a Strategy for Rapid Offshore Assembly
Modular design has become a key strategy in offshore projects to reduce installation times and mitigate the risks associated with working in open sea conditions. This methodology involves the prefabrication of structural, process, and accommodation components onshore, under controlled conditions that ensure higher precision, quality, and construction efficiency.

Once fabricated, the modules are transported to the site using specialized vessels and positioned with high-capacity floating cranes. Connections between modules are made using quick-coupling systems that reduce the complexity of in-situ assembly. This approach minimizes workers' exposure to adverse weather conditions and reduces the logistical resources required.

Flagship projects such as the Johan Sverdrup field in Norway or developments in the Gulf of Mexico have demonstrated that modularization can reduce offshore project timelines by up to 30%, while also lowering operational costs and improving occupational safety. Furthermore, it facilitates corrective maintenance, as individual modules can be replaced or modified without compromising the integrity of the entire structure.

Seismic Resistant Design in Tectonically Active Zones

Structural design in tectonically active regions poses a critical challenge for offshore platforms operating off the coasts of South America (Pacific side), the Asia-Pacific region, or the Mediterranean. In these areas, detailed geotechnical analysis of the seabed is essential to assess risks such as sediment liquefaction or underwater slope failure, which could compromise the stability of anchoring systems.

Design strategies must account for soil-structure interaction under dynamic conditions, especially in the case of floating platforms anchored using mooring lines or piles. The selection of anchoring type, depth, and seismic energy absorption capacity are key factors in preventing catastrophic failures.

International standards such as API RP 2EQ, ISO 19901-2, and DNVGL provide the design criteria to ensure ductility, redundancy, and structural resilience in the face of seismic events. These guidelines require the modeling of various combined load scenarios (earthquake + extreme wave) and validation of behavior through advanced simulations.

Tools such as Finite Element Method (FEM), Computational Fluid Dynamics (CFD), and spectral analysis enable engineers to design platforms that can absorb deformation without collapsing, ensuring safe operation during significant seismic events.

Technological Integration: Digital Twins and Advanced Simulation

The digital transformation of the offshore sector has introduced advanced tools such as digital twins, IoT sensors, and BIM (Building Information Modeling) platforms, which allow optimization of the entire lifecycle of marine structures from design to operation.

Digital twins replicate the structural behavior of a platform in real time, integrating sensor data that monitor variables such as vibration, deformation, corrosion, and load. This information enables the validation of designs under extreme conditions, the anticipation of potential failures, and the adjustment of operations through predictive decision-making.

In addition, advanced simulation supports scenario planning for critical events like storms or earthquakes and contributes to the development of structural resilience strategies. Together, these technologies not only enhance safety and operational efficiency but also strengthen predictive maintenance approaches in remote and high-risk environments.

Conclusion

loating platforms represent the future of offshore exploration, but they also pose technical challenges that demand innovative and resilient engineering approaches. The integration of modular solutions, advanced seismic design criteria, and digital technologies such as virtual twins is essential for tackling the evolving demands of the marine environment. Sustainability, structural efficiency, and operational safety must become strategic pillars of every new development. Offshore engineering in the future will not only be smarter but also more adaptable and robust in the face of extreme conditions. In this new paradigm, technology will be as vital as experience.

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Pipeline integrity is essential to the energy, petrochemical, and process industries. Critical lines often extend for hundreds of meters and run through locations that are difficult to reach—buried underground, covered with thermal insulation, or installed on elevated structures. Many of these inaccessible sections go unchecked for years, increasing the risk of undetected damage.

Conventional inspection methods rely on direct access to the area of interest, which typically requires costly, disruptive, and time-consuming preparations, such as system shutdowns, insulation removal, or excavation. Guided Wave Testing (GWT) offers a smarter alternative.

With access at just a single location, GWT can screen long sections of pipe for corrosion, wall loss, and other cross-sectional changes. It is non-intrusive and highly efficient, making it ideal for assessing extensive, hard-to-reach pipelines.

For over 25 years, Guided Ultrasonics Ltd. (GUL) has been at the forefront of this technology. The company's patented innovations have shaped how GWT is used around the world—not only by delivering industry-leading equipment, but also by helping define international technical standards.

How Guided Waves Work in Pipe Inspection
Guided waves are ultrasonic waves that travel along the walls of structures—such as plates, pipes, or rails—rather than passing directly through them. Their propagation is guided by the physical boundaries of the material, allowing specific wave modes to cover long distances from a single access point. This makes them particularly effective for rapid, wide-area inspection of structural integrity.

Guided Wave Testing (GWT) is a Non-Destructive Testing (NDT) method that uses these waves to screen assets for corrosion. In pipeline screening, a ring of transducers is placed around the pipe at a single location to transmit and receive signals. When the transmitted waves encounter a change in cross section caused by corrosion, a weld, or a support, part of the signal reflects back to the ring.

These returning echoes are analyzed based on amplitude, timing, and angular distribution. The location of any feature is clearly indicated by its distance from the ring and its clock position around the pipe. Severity is estimated by considering signal amplitude, calibrated against weld reflections, and circumferential spread. Results are shown as A-scan traces and an Unrolled Pipe Display—a C-scan-style view that maps signals around the pipe—for intuitive interpretation.

GWT is effective in detecting general corrosion, localized wall thinning, and internal deposits, and structure features such as welds, clamps, or supports—anything that causes a change in cross-sectional area. Its ability to identify all these features makes this method a powerful tool for efficiently screening large areas and pinpointing regions that may require closer examination.

Inspection Range and Sensitivity
Range and sensitivity are influenced by several factors, including pipe characteristics, such as overall condition, coating, geometry, and support type, as well as the setup used during the test.

On clean, straight, aboveground pipe, inspections can extend beyond 100 meters in each direction (200 meters total). In older pipework, or where corrosion, deposits, or attachments are present, a more typical range is around 30 meters each way. Buried pipe introduces additional attenuation due to the surrounding soil, but ranges of up to 20 meters per direction are still achievable—greater distances are possible when the soil is decoupled from the pipe.

Sensitivity refers to the system's ability to detect small changes in the pipe wall and depends largely on the signal-to-noise ratio. A stronger signal relative to background noise improves the likelihood of identifying real features while avoiding false calls. This ratio is affected by the condition of the pipe and influenced by the frequency of the guided wave signal.

Guided wave inspection operates in a low ultrasonic frequency range, typically between 20 and 80 kHz. Within that band, frequency selection plays an important role. Lower frequencies travel farther but are less responsive to small changes in cross section. Higher frequencies improve sensitivity but are more easily attenuated and scattered by general corrosion. To manage this trade-off, GUL systems sweep across multiple frequencies in each test to maximize both coverage and detection performance.

Applications
Guided wave inspection is especially useful in situations where conventional inspection methods are difficult or impractical. It is routinely used on insulated lines, road or wall crossings, elevated pipework, buried pipelines, offshore risers, and subsea segments—areas where full access is restricted or expensive to achieve. It is also a valuable tool for prioritizing inspections in long pipe runs and monitoring known areas of concern over time.

Key Benefits
With minimal access and setup, large sections of pipe can be screened rapidly without interrupting the flow of the line. GWT reduces the need for surface preparation, insulation removal, or excavation—lowering cost and operational impact. Its ability to detect changes anywhere around the pipe circumference, combined with long-range coverage, makes it an effective screening tool for both one-off surveys and ongoing monitoring. By identifying potential issues early, smarter maintenance decisions are possible and follow-up inspections can be targeted where they are really needed.

Practical Considerations
Certain factors can influence the effectiveness of guided wave inspection and should be considered when planning a test. Geometric features such as closely spaced welds, clamps, supports, bends, or flanges can limit inspection range or affect signal clarity. Similarly, poor pipe condition, heavy corrosion, or thick coatings can reduce signal strength and may influence how much of the pipe can be effectively screened from a single location.

Reliable interpretation requires a clear understanding of the pipe environment and appropriate system setup. Well-trained inspectors play a key role in recognizing relevant signals and confidently distinguishing them from expected reflections. With proper technique and informed analysis, guided wave testing delivers meaningful insights that support more targeted and efficient follow-up inspection activities.

Leadership in Guided Wave Technology
Guided Ultrasonics Ltd. (GUL), founded in 1999, has been the leading force behind the advancement, innovation, and practical adoption of guided wave inspection worldwide. The company's origins are rooted in pioneering research that first established the method at Imperial College London. Over the past 25 years, GUL systems have been deployed globally, supporting pipeline integrity in the oil and gas, power generation, and transportation sectors.

GUL's contribution extends well beyond equipment. It has helped shape industry practice through the development of inspection standard procedures, operator training standards, and test protocols now widely used in the field. The company has actively contributed to the development of international and national standards through organizations such as ISO, ASME, API, PRCI, and BSI—helping promote consistency and quality in guided wave inspection.

GUL operates an industry-leading training program. Its courses, delivered globally and developed by experienced professionals, combine hands-on learning with field-based context. These courses equip users not only with the practical skills to operate the technology, but also with the judgment needed to interpret results with confidence and accuracy.

Wavemaker® G5: Focused on Field Performance

The Wavemaker® G5 is the latest-generation guided wave inspection instrument developed by Guided Ultrasonics Ltd. Built for fast, reliable pipe screening in real-world conditions, the G5 retains the rugged dependability of earlier models while introducing a completely renewed system architecture. Shaped by years of field experience and user feedback, it features a streamlined hardware platform, a modern user interface, and tools designed to improve productivity and data quality, all without compromising on the principles that make guided wave testing effective.

Faster Data, Sharper Insights
Signal processing has been refined in the G5. Software-assisted feature recognition supports confident analysis, even in challenging conditions such as buried or coated pipelines. Advanced signal handling and improvements in frequency response enhance defect visibility in high-attenuation environments, such as soil-covered pipe. Optimized data capture permits simultaneous acquisition of low- and high-frequency sweeps when using Compact™ rings and TRIO modules. This speeds up fieldwork and consolidates multi-frequency results into a single, analysis-ready dataset file for clearer defect visibility

Smart Guidance, Expert Oversight
From simplified connections and automatic transducer detection to on-screen prompts and test validation tools, the G5 reduces setup time and simplifies routine tasks. Procedure-driven workflows guide inspectors through setup, testing, and analysis, helping ensure consistent results from day one. Advanced users benefit from real-time oversight and Wi-Fi-enabled remote access, allowing teams to focus on accurate data collection and timely decision-making.

Inspection at Your Fingertips
Compact and field-ready, the G5's glove-friendly, toughened touchscreen houses a fully integrated onboard computer, allowing data collection and analysis to be performed directly on the device. For added flexibility, laptop operation remains available, though the onboard software makes it optional rather than required.

Versatile by Design
Fully compatible with GUL's range of screening rings and non-ATEX gPIMS® monitoring sensors, the G5 provides continuity with existing equipment while expanding flexibility. Dual hot-swappable batteries and remote calibration capabilities keep inspections running without pause, whether for routine screening or integration into live monitoring programs.

Engineered for the Field, Built for What's Next
The Wavemaker® G5 represents a focused evolution in guided wave testing—engineered to meet the demands of modern inspection teams through faster workflows, clearer results, and seamless integration into maintenance strategies. It delivers more than field efficiency by providing consistent, traceable data that helps prioritize follow-up, reduce unnecessary interventions, and keep inspections aligned with operational priorities.

Shaping the Future of Pipeline Integrity with Wavemaker® G5
As industries evolve toward more efficient, data-driven asset management, the Wavemaker® G5 stands out as more than an advanced inspection tool—it serves as a foundation for better decisions. Guided wave testing offers actionable insight through long-range, non-intrusive inspection, delivering capabilities that conventional methods cannot match. The result is more efficient screening, better-targeted interventions, and traceable data that supports long-term asset planning.

Designed for the realities of the field, the G5 allows earlier detection of hidden threats and more cost-effective, focused responses. Whether deployed for one-off inspections or integrated into monitoring programs, it helps teams stay ahead of deterioration, allocate resources more effectively, and maintain control over pipeline condition without unnecessary disruption.

More than a technical upgrade, the G5 reflects a change in inspection philosophy—from reactive interventions to proactive, condition-based strategies. In environments where access is limited, downtime is costly, and reliability is critical, the G5 empowers asset teams to act with confidence, supporting safer, smarter, and more sustainable operations while extending the life of critical infrastructure.

Disadvantages of Zinc For AC Mitigation Grounding

By: Carlos Melo, Gerald Haynes,
Jorge Vásquez, Alberto Janeta

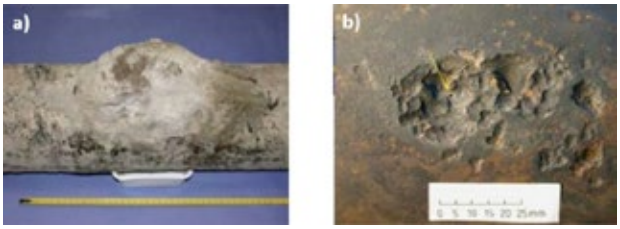
VECOR Pipeline Integrity

Abstract
AC interference has become a growing threat to pipeline safety, especially with modern high-resistance coatings and increased proximity to High Voltage Alternating Current (HVAC) transmission lines. Grounding systems are implemented to mitigate AC effects, often using copper or zinc. While zinc has historically been used to re- duce bi-metallic corrosion concerns, recent studies and field evidence show significant degradation of zinc in AC environments. This paper reviews the limitations of zinc as a grounding material, emphasizing findings from industry studies and standards, and discusses the environmental and operational implications.

1. Introduction

Pipelines are widely regarded as the safest method to transport oil and gas [1], [2]. How- ever, shared corridors with HVAC lines introduce AC interference risks, including corrosion and personnel safety hazards. Earlier assumptions underestimated AC corrosion, but field failures in Germany during the 1980s revealed its potential to damage coated pipelines even under Cathodic Protection (CP). These failures, despite CP polarization levels of -1.000 V, demonstrated the need for more rigorous AC mitigation strategies [3].

AC corrosion has been studied since the early 1900s. Initially, it was believed that corrosion from alternating current (AC) was negligible compared to direct current (DC) and that polarization through cathodic protection would prevent damage. However, this view changed with field experience and experimental data. In particular, failures in low-resistivity soil challenged prior assumptions, highlighting that AC current densities above 20 A/m2 can initiate corrosion, especially in high-impedance coatings. As pipeline coatings improved in dielectric strength, they became more susceptible to interference due to reduced leakage paths to ground. This, in turn, increased the importance of grounding system design for effective AC mitigation.



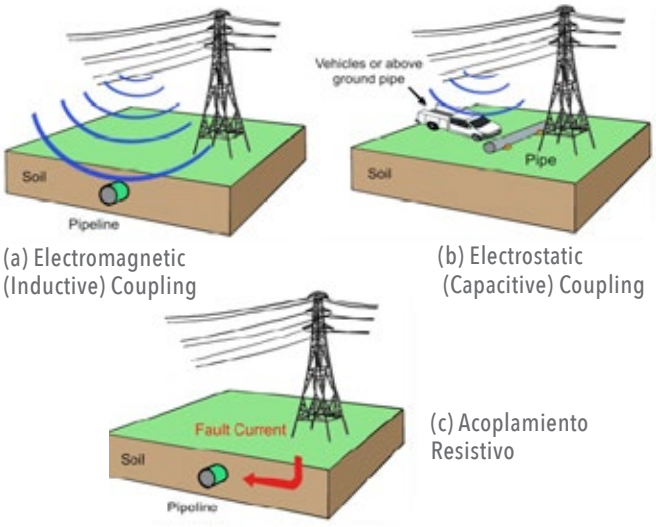
(a) Bulges "Corrosion Product"

(b) "Crater-Like" pits below corrosion

Figure 1: AC Corrosion Leak Site [3]

Figure 1 shows a field failure attributed to AC corrosion, where external bulging caused by corrosion product buildup eventually exposed the underlying metal loss and perforation. These visual indicators support laboratory findings and demonstrate the severity of AC interference.

The three types of AC interference that can affect a pipeline are Electromagnetic (Induc- tive Coupling), Electrostatic (Capacitive Coupling), and Conductive (Resistive Coupling) [4], [5]. In inductive coupling (Fig. 2a), the level of interference decreases with the separation between the HVAC conductors. Additionally, the magnetic field strength is directly proportional to the current that circulates in the HVAC conductors and inversely propor- tional to the distance between the conductor and the pipe. Inductive coupling interference normally peaks at discontinuity locations [3], [4]. In electrostatic coupling (Fig. 2b), two conductors separated by a dielectric material create a capacitor. The electromagnetic field between the HVAC line and the pipeline builds up electrical charge, which is stored in the capacitor (Fig. 3a) until a connection to the ground is made (Fig. 3b) [4], [5]. Finally, resistive coupling (Fig. 2c) occurs when a HVAC line sends a fault current to the ground. These faults generally occur during lightning, and even though the duration is measured in frac- tions of a second (milliseconds), fault currents can reach hundreds of thousands of amperes, which can be detrimental to the coating of the pipeline, the integrity of the pipe, and the safety of the pipeline personnel and the public [4], [5].



(a) Electromagnetic (Inductive) Coupling

(b) Electrostatic (Capacitive) Coupling

(c) Acoplamiento Resistivo

(c) Conductive (Resistive) Coupling

Figure 2: Types of AC Induced Interference on Pipelines

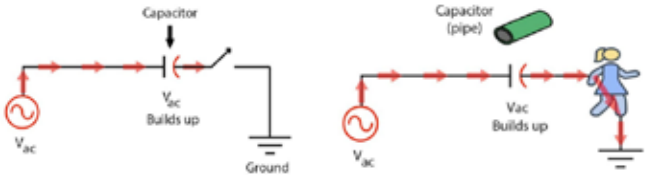


Figure 3: Capacitive effect in pipelines

2. AC Interference Evaluation and Mitigation

Pipeline operators evaluate interference using pipe-to-soil potentials, Longitudinal Electric Field (LEF)surveys, and soil resistivity [6], [7]. HVAC system data such as tower specs and current loads feed into Computer Aided Engineering (CAE) software, which simulates induced voltages and recommends mitigation.

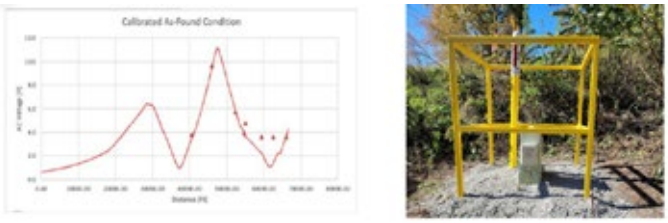
Mitigation often involves installing grounding systems: horizontal or vertical rods con- nected via decouplers to the pipeline. Decouplers prevent CP current drainage while allowing AC faults to ground safely. Grounding material selection—typically copper or zinc—plays a critical role in long-term system integrity [8].

The Institute of Electrical and Electronics Engineers (IEEE) and European Norm (EN) standards provide criteria for acceptable voltage levels and current densities on pipelines. Typical mitigation goals include maintaining current density below 30 A/m2 and reducing AC

References
[1] X. Chen, Z. Wu, W. Chen, R. Kang, X. He, and Y. Miao, "Selection of key indicators for reputation loss in oil and gas pipeline failure event," Engineering Failure Analysis, vol. 99, pp. 69–84, 2019. doi: https://doi.org/10.1016/j.engfailanal.2019.01.

071. [Online]. Available: https://www.sciencedirect.com/science/article/pii/ S1350630718302802.

voltage to less than 15 V under steady-state conditions. CAE models guide grounding placement to meet these thresholds. Field validation using AC coupons ensures that pre- dicted performance matches reality. DC decouplers, required to fail safe, must isolate CP systems from the ground without compromising personnel safety during fault conditions.



(a) Example of model validation (b) DC Decoupler on a pipeline

Figure 4: Design of AC Mitigation Systems

Figure 4 illustrates the use of modeled voltage gradients along a pipeline and the practical field implementation of a decoupler device to manage induced AC. Proper integration of both aspects is critical to reliable AC mitigation.

3. The History of Zinc for AC Mitigation

Copper was traditionally favored, but concerns over bi-metallic corrosion led to zinc's adop- tion [9]. However, IEEE Std. 80 [10] and DIN 50929-3 [11] require soil testing to justify zinc use due to its potential corrosion in varying conditions.

These standards emphasize that zinc may only be acceptable when detailed testing con- firms stable corrosion behavior in the intended environment. The DIN standard, in particu- lar, includes classifications for soil aggressiveness and corrosion rates under various chemical compositions. Zinc often falls short in acidic or sulfate-rich environments and may passivate unpredictably in carbonate systems. Long-route pipeline projects face challenges with this requirement. Moreover, insufficient studies exist on zinc's long-term behavior under continuous AC exposure. Backfill choices, passivation, alkaline and acidic environments, and CP interaction raise further concerns about zinc reliability.

Zinc can passivate in carbonate-forming and sulfate-rich soils, including those impacted by agricultural fertilizers, which are common in pipeline rights-of-way. In other conditions, zinc corrosion is exacerbated by chloride and sulfur-containing environments. Additionally, cathodic protection systems can increase alkalinity near zinc surfaces, promoting rapid dis- solution, yet this effect is often underestimated in practice.

In addition, operators have reported inconsistent field performance of zinc ribbon systems. In some locations, zinc remains largely intact after years of service. In others, severe pitting or total dissolution occurs in a fraction of the design life. This variability creates uncertainty and risk when planning mitigation programs.

4. Issues with Zinc for AC Mitigation

4.1. Case Study: NACE Paper 12828

This study reported corrosion rates of over 40 mpy in zinc exposed to corrosive soils, while copper under similar conditions corroded at less than 1 mpy [5]. scanning electron microscopy (SEM), energy dispersive X-ray spectrometry (EDS), and X-ray diffraction (XRD) confirmed white rust and corrosion layers 30–50 mils thick. Chlorine and sulfur compounds were present, exacerbating zinc deterioration. Figs. 5a and 5b present images of the severely corroded zinc ribbon [5].

This paper concluded that zinc is highly reactive in soils with a high chloride or sulfur content. Furthermore, the degradation of the backfill and poor field construction practices may contribute to the exposure of zinc to aggressive soil layers. The authors recommended that zinc must be voided unless extensive testing is performed to verify compatibility with site conditions.

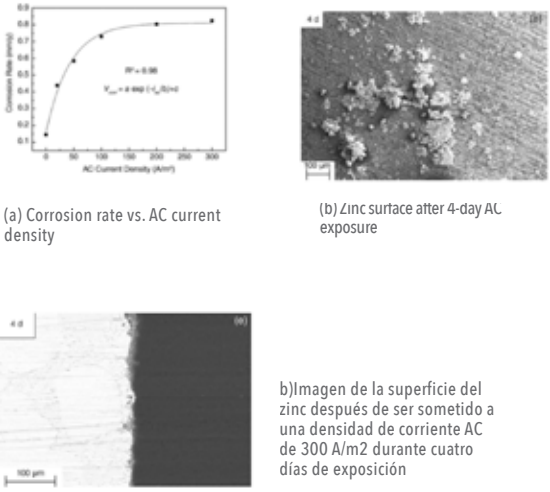
(a) Corroded zinc ribbon from corrosive soil (b) Removed corrosion products for analysis (c) Cross-sectional micrograph showing cor- rosion layers

Figure 5: Findings from NACE Paper No. 12828 [5

4.2. Journal Article: Corrosion Vol. 71, No. 6

The tests showed that the zinc corrosion rate increased from 6 mpy (no AC) to 32.7 mpy at 300 A/m2 AC current density [8]. Fig. 6a shows a plot of the corrosion rates of zinc as a function of the AC current density. As observed, there is a significant increase when the AC current densities approach 100 A/m². AC oscillation damaged protective films, accelerated corrosion, and prevented passivation. Electrochemical Impedance Spectroscopy (EIS) showed significant loss of film resistance, from 633 to 30 ohms. SEM images confirmed cracking and micropores in the film structure. Fig. 6b shows the corrosion product film after four days of exposure to 300 A/m² of AC current density.

The article also explained that high AC densities not only corrode zinc faster but also destabilize the corrosion products that may initially provided some barrier to further attack. The result is a feedback loop where the corrosion accelerates over time. The absence of passivity under AC conditions makes zinc less predictable and less durable.



(a) Corrosion rate vs. AC current density

(b) Zinc surface after 4-day AC exposure

b)Imagen de la superficie del zinc después de ser sometido a una densidad de corriente AC de 300 A/m2 durante cuatro días de exposición

Figure 6: Data from Corrosion Journal [8]

4.3. Operator Experience and Environmental Concerns

Field data reveal frequent zinc failure near decouplers, where current densities exceed 100 A/m2 [5], [8]. CAE models confirm these elevated current zones. Zinc dissolution contam- inates soil and the high bioavailability of the metal raises ecological concerns. Excess zinc in soil is known to be phytotoxic and detrimental to yield quality [12]. With increasing regulatory attention, particularly in the EU, future restrictions on zinc use may also impact copper-based systems.

5. Conclusion

Zinc corrosion susceptibility under AC conditions presents a reliability and environmental risk to mitigation systems. Although IEEE allows zinc with soil testing, evidence from field failures and laboratory studies indicates that copper is generally more stable. Operators must carefully assess the selection of grounding material to ensure the longevity of the grounding system and environmental safety.

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Smart Midstream: How Digitization is Driving Efficiency and Sustainability

By: Mayuly Rodriguez

Member of the Technical Editorial Team at INSPENET

In the hydrocarbon value chain, the midstream segment - responsible for transportation, storage and upstream processing - is undergoing a transformation process through the integration of digital technologies, advanced automation and sustainability-oriented solutions. This change responds to the need to improve operability, reduce losses, comply with environmental regulations and preserve the integrity of critical assets.

Digitization and real-time operational monitoring

The transformation to an intelligent midstream is based on the implementation of distributed monitoring systems that operate in real time. The strategic deployment of wireless sensor networks, based on robust and energy-efficient communication protocols, allows recording parameters in pipelines, pumping stations and terminals, such as internal pressure, temperature, vibration, flow and corrosion conditions.

This data is processed locally through edge computing platforms, reducing latency and enabling immediate operational responses. Integrated with next-generation SCADA systems, perimeter analytics solutions generate intelligent alerts and predictive dashboards to anticipate deviations, detect incipient leaks or respond to transient events.

Internal inspection using instrumented tools such as smart pigging incorporates ultrasonic and magnetic flux leakage (MFL) technologies, equipped with ultrasonic or magnetic sensors, which allow mapping residual thicknesses, identifying geometric deformations and locating areas with metal loss due to corrosion. These techniques are applied in-line, without the need to interrupt product flow, and provide high-resolution quantitative data for structural integrity assessment in pipelines and piping.

Predictive analytics and adaptive control applied to operational efficiency

Operational efficiency in the smart midstream context relies on advanced predictive analytics techniques based on statistical inference and machine learning algorithms. Models such as ARIMA (AutoRegressive Integrated Moving Average), Prophet and recurrent neural networks (RNN) allow to anticipate with high accuracy anomalous events, failures or deviations, based on historical patterns and dynamic variations of the system.

These models feed adaptive control systems capable of adjusting, in real time, operating variables according to demand and load conditions. The fast response time optimizes performance in pumping stations, compressors and interconnected networks, promoting a dynamic hydraulic balance that minimizes mechanical wear and tear on assets.

Operational safety is strengthened by early warning mechanisms based on dynamic thresholds and multivariate analysis. In addition, resilient, fault-tolerant architectures-including functional redundancy and backup communication channels-ensure operational continuity at strategic nodes in the face of technical events or cyber threats.

Sustainability and environmental mitigation in the smart midstream

The smart midstream incorporates advanced continuous monitoring technologies for early and accurate detection of emissions, with the aim of reducing the environmental footprint, especially in the face of fugitive methane emissions. These include tunable diode laser spectrometry (TDLAS), remote optical sensors and unmanned aerial platforms (drones) equipped with high-resolution hyperspectral cameras.

Additionally, in facilities such as sour gas treatment plants, carbon capture and storage (CCS) systems are integrated to separate CO_2 and H_2S, facilitating their reinjection into geological formations. These strategies are complemented with the electrification of compressor and pumping stations with on-site renewable energy, aligning hydrocarbon transportation with the decarbonization and sustainability objectives of the energy sector.

Operational challenges and technological projections

Although digital progress in the midstream is significant, many facilities still operate with obsolete infrastructure that limits technological integration without a prior physical modernization strategy. Interoperability between legacy systems and digital platforms requires structured investments in cybersecurity, protocol standardization and regulatory compliance.

In parallel, the energy transition poses additional challenges: transporting green hydrogen, advanced biofuels and synthetic fuels requires redesigning materials, purge systems and network configurations to ensure chemical compatibility and operational integrity.

Against this backdrop, emerging technologies such as digital twins - real-time virtual replicas of physical assets - allow operations to be modeled, event responses to be validated, and personnel to be trained safely. Combined with augmented reality and perimeter artificial intelligence (edge-AI), they optimize decision making in complex environments.

In short, the intelligent midstream is no longer a futuristic concept but a strategic necessity. The integration of predictive analytics, electrification, digital inspection and data-driven management enables the industry to modernize its assets, reduce risks and align with decarbonization goals. This approach consolidates the sector as an operational pillar in the 21st century energy ecosystem.

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COMPANIES PROFILES

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The American Society for Nondestructive Testing (ASNT) is the world's largest technical society for nondestructive testing (NDT) professionals. Founded in 1941, ASNT advances the field of NDT through certification, education, research, publications, and standards development. It serves a global community by promoting the safe and effective use of NDT technologies across industries to ensure public safety and asset integrity.

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SLOM

SLOM is a regional organization of oil maritime terminal and SBM operators in Latin America. It promotes safety, efficiency, and sustainability in maritime operations through technical cooperation, training, and knowledge sharing among its members.

Transpetro Invests in Innovation for its Marine Monobuoy System

By: Adriana Andrade (Executive Manager of Logistics Integrations at Transpetro)

Artificial intelligence to enhance efficiency and safety in ship mooring, remote real-time monitoring of equipment positioning via GPS, collision protection and alert technology, and the use of ROVs for underwater inspections: Transpetro, the largest multimodal logistics company for oil and derivatives in Latin America, has no shortage of innovative and exclusive solutions already adopted or on its radar for its marine monobuoy system. Technology will increasingly play a role, as the company continually invests to meet future challenges and expand its multimodal logistics system.

The scale of Transpetro's operations in the marine monobuoy system justifies this strategy. Last year, the company handled over 25.7 million cubic meters of products through these floating terminals, where oil tankers dock for loading and unloading. In 2025, the trend of expansion has remained steady, with over 10.6 million cubic meters moved in just the first five months of the year.

Currently, the company operates four marine monobuoys: two in Tramandaí (RS), one in São Francisco do Sul (SC), and one in Northern Espírito Santo (near the city of São Mateus).

The marine monobuoy system in Southern Brazil is crucial for the entry of oil and derivatives that supply the refineries servicing the region's fuel market, while the one in Northern Espírito Santo is responsible for the evacuation of terrestrial production in the area.

Artificial Intelligence

Transpetro has been using artificial intelligence (AI) for ship mooring since 2021. Through continuous testing, the tool achieved 92% accuracy in 2024, becoming a benchmark in this type of innovation. The goal is always to provide decision support, offering maneuvering captains, managers, and logistics teams a quantitative analysis of a ship's docking probability and the subsequent supply to the market.

This innovation is already being studied for other applications, such as ship-to-ship and port operations, as well as for predicting pier maintenance, among other possibilities.

Transpetro has installed current meters and wave buoys offshore, near the marine monobuoy system of the Southern terminals. With the implementation of these new instruments and the use of anemometers (meteorological devices that measure wind speed and direction) installed onshore, it is possible to calibrate this new tool, increasing its accuracy. This real-time approach significantly enhances the safety and efficiency of operations, providing decision support to the maneuvering pilot.

Other Solutions

Transpetro has been testing the use of Mini ROVs (Remotely Operated Vehicles) to assist in underwater visual inspections. This technology will enable inspections of the equipment that is part of the underwater marine monobuoys, even under adverse conditions, reinforcing the commitment to increasingly safe operations.

In addition to this tool, the use of GPS (Global Positioning System) installed on the single point mooring allows for real-time tracking of its position, while the AIS (Automatic Identification System) creates a virtual "fence" around the structure, alerting to possible collision risks from nearby vessels.

For maintenance, repair, and decommissioning services of marine monobuoys, Transpetro conducts periodic evaluations and assesses intervention needs on a case-by-case basis.

These exclusive innovative solutions provide logistical benefits to the company and to Brazil, particularly in the Southern Region, while also considering the potential for scaling. Transpetro possesses the intellectual capital necessary to enhance and expand its use in different contexts.

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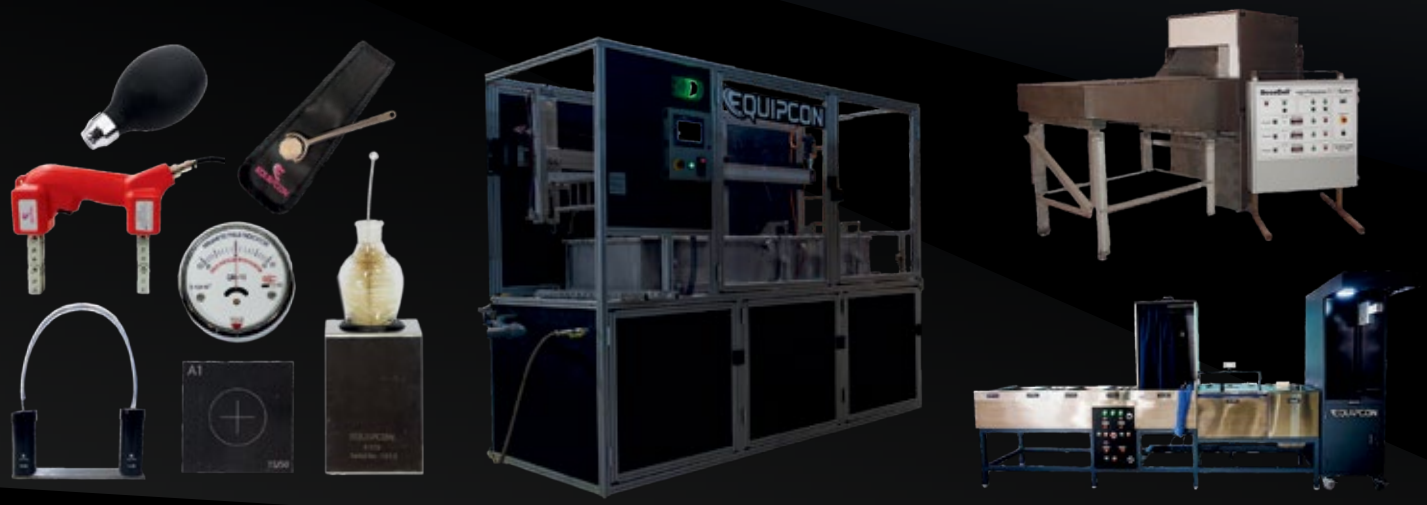

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Digital Transformation in the Downstream: Strategy for a more Efficient and Sustainable Operation

By: Euclides Quiñonez
Member of the Technical Editorial Team at INSPENET

Introduction

The downstream sector (refining, distribution and marketing of petroleum products) is facing unprecedented challenges: tight margins, stricter environmental regulations and increasing pressure for decarbonization. In this context, digital transformation represents a strategic necessity to ensure operational efficiency, asset safety and business sustainability.

Downstream digitization: Beyond automation

Currently a large number of refineries and petrochemical plants have been incorporating automation technologies for decades, true digital transformation involves integrating advanced data platforms, artificial intelligence (AI), machine learning, advanced SCADA systems, digital twins, and IoT (Internet of Things) technologies to achieve a holistic, real-time view of the value chain, which, moves from a reactive to a predictive and, moreover, prescriptive strategy, with capabilities to simulate scenarios, anticipate critical failures and optimize resources on a plant or corporate scale.

Strategic applications of digital transformation

The following are some of the applications that are redefining downstream management:

1. Data-driven predictive maintenance

The integration of IoT sensors in rotating equipment, distillation towers, heat exchangers and pumping systems allows obtaining real-time operating parameters. By combining this data with machine learning algorithms, it is possible to anticipate failures more accurately, significantly reduce unscheduled shutdowns and optimize spare parts inventory management. As a result, it is possible to achieve a 30-50% reduction in unplanned maintenance events and increase operational availability to 98%.

2. Optimization of process units through digital twins

Using digital twin technology, it is possible to simulate the behavior of critical units (catalytic cracking, reforming, hydrotreating, etc.) under variable operating conditions, enabling real-time adjustments to maximize yields, minimize energy losses and reduce the carbon footprint per unit produced.

3. Intelligent management of terminals and logistics

In the distribution phase, the use of integrated management platforms with AI and geolocation makes it possible to plan optimal routes, reduce loading and unloading times, and ensure full traceability of the product from the terminal to the end customer; this has a direct impact on the efficiency of the supply chain and on improving indicators such as OTIF (On Time In Full).

4. Industrial cybersecurity

Digitalization increases exposure to cyber threats. Hence the need to integrate OT (Operational Technology) environments with industrial-grade security architectures, network segmentation, early anomaly detection and incident response protocols to ensure operational continuity.

Considerations for successful adoption

Implementing an effective downstream digital strategy requires a clear vision from top management and a roadmap aligned with business objectives. Here are some of the elements to consider:

- Digital maturity assessment: establish the starting point and prioritize high-impact areas.
- Data governance: ensure the quality, accessibility and security of operational information.
- Technical training: the development of digital competencies in plant personnel is as important as the technological infrastructure.
- Strategic alliances: collaboration with technology integrators, universities and industrial startups to accelerate innovation.
- Barriers to digital transformation in the Downstream
- Despite the potential of digital transformation in refineries and petrochemical plants, there are barriers that slow down its adoption.
- Legacy infrastructure: Most systems operate with obsolete technologies that make it difficult to integrate modern solutions such as IoT, AI or digital twins.
- Digital talent shortage: Shortage of professionals with expertise in advanced analytics, industrial cybersecurity and intelligent automation.
- Cybersecurity: The growing exposure of critical assets to digital networks increases the risk of attacks, generating reluctance to digitize.
- Implementation costs: Initial investment in hardware, software, integration and training tends to be high, especially for large-scale projects, generating caution in decision making.
- Organizational culture resistant to change: Digitization requires collaboration between operations, maintenance, information technology (IT) and management. However, this collaboration does not always come naturally.
- Difficulty in demonstrating an immediate return on investment (ROI): The tangible benefits of digitization are usually evident in the medium or long term, which complicates its approval by senior management in context of financial pressure.

Conclusion

Downstream is entering a new era where the ability to transform data into real-time operational decisions will be the differentiating factor. Digitization represents a tool to improve efficiency or reduce costs; it is the path to redefine resilience and competitiveness in an industry under unprecedented economic, environmental and social pressures.

Making decisions today that enable the digital infrastructure of tomorrow is not a gamble, it is a strategic necessity.

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Hydrogen Revolution: Mexico is becoming a leader in clean energy.

By Israel Hurtado, Chief Executive Officer, Mexican Hydrogen and Energy Transition Association

H2México
ASOCIACIÓN MEXICANA DE HIDRÓGENO

Green hydrogen is emerging as a key player in the global energy transition, and Mexico is no exception to this trend. With a series of projects underway and significant investment, the country is seeking to position itself as a major player in the production and use of this clean energy source.

There are currently 26 green hydrogen projects underway—18 of them in different stages of development and 8 in planning—spread across 14 states, with a total estimated investment of US$21.227 billion.
These initiatives have the potential to generate 3 million jobs and prevent the emission of 53 million tons of CO_2 during the period 2030–2050.

Among the most notable projects is the plant in Salina Cruz, Oaxaca, announced by former President López Obrador, which involves an investment of $10 billion from a Danish fund.

The project in Campeche is a hydrogen-ammonia plant with an estimated investment of US$1.1 billion.

There is also the "Pacífico Mexinol" project in Sinaloa, announced by former US ambassador Ken Salazar, which seeks to produce green and blue methanol, with an investment of US$2.2 billion.

Likewise, there is a project in Durango, developed by companies with Dutch participation, with an investment of $1.2 billion,and the project in Baja California, which stems from the announcement by a French company of an investment of $2.5 billion in green hydrogen projects in the country.

These projects not only seek to supply the domestic market, but also to position Mexico as an exporter of green hydrogen, taking advantage of its strategic location and natural resources.
Investments in green hydrogen in Mexico are distributed across various regions of the country, with projects also underway in states such as Sonora, Guanajuato, Yucatán, Nuevo León, and San Luis Potosí, among others.

The Mexican Hydrogen Association (H2México) estimates that by 2050, investments in this sector could reach $60 billion.

The diversification of production is not limited to hydrogen: it is projected to reach an annual production of approximately 196,707 tons of green hydrogen, along with the production of 970,000 tons of green ammonia and 2. 1 million tons of methanol (green and blue), products intended for various applications ranging from mobility, through industrial decarbonization, to power generation in combined cycle power plants.

Mexico can learn from international experiences in green hydrogen development Chile was the first country in Latin America to establish a National Green Hydrogen Strategy, with the goal of producing 25 GW by 2030 at a competitive cost. It currently has thirteen projects in development and has attracted the interest of multinational companies. Colombia has made significant progress since the publication of its hydrogen roadmap in 2021. It already has two green hydrogen pilot tests in Cartagena that use solar-powered electrolysers.

Spain has made a strong commitment to green hydrogen, tripling its targets for the next six years and submitting the largest number of projects to the European Hydrogen Bank. Projects such as the Iberian Hydrogen Corridor will facilitate the export of green hydrogen from Spain to Europe.

What is needed?
The Mexican Hydrogen and Energy Transition Association, made up of nearly 60 companies, has been a catalyst for growth in the sector. Not only does it act as a bridge between developers, investors, and authorities, but it has also actively promoted the generation of technical and regulatory proposals, such as the Roadmap and the Clean Hydrogen Industrial Strategy.

In these documents, the Association proposes the promotion of a new national value chain that includes everything from the manufacture of hydrogen vehicles to electrolysers, storage tanks and hydrogen-powered electric turbines.

One of the main challenges identified by H2México is the absence of a National Green Hydrogen Strategy. Unlike other countries that have already drawn up concrete plans, Mexico still lacks a public policy that articulates the development of this industry.

Collaboration between the government and the private sector will be key to unlocking the potential of green hydrogen in the country. H2México has proposed specific commitments to the State: from designing a clear regulatory framework and establishing fiscal and financial incentives to guaranteeing access to renewable energy for its production.

This would enable current projects, which already account for almost 10% of the total amount of the Mexico Plan announced by President Claudia Sheinbaum, to become a real lever for economic and sustainable development.

The push for green hydrogen in Mexico is undoubtedly a strategic move that combines investment, innovation, and the urgency to adapt to the demands of the global energy transition.

Consolidating an industry based on this technology will not only enable the country to achieve important decarbonization goals, but also position it as a global leader in clean energy generation and in restructuring its industrial model for a sustainable future.


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Engineering Efficiency at the Energy Frontier: Upstream oil and Gas

By: José López
Member of the Technical Editorial Team at INSPENET

The upstream oil and gas sector represents the strategic starting point of the hydrocarbon value chain, encompassing all operations related to the exploration and extraction of crude oil and natural gas. As the initial stage in the petroleum value chain, the upstream sector remains the engine room that drives global energy production, supplying both midstream and downstream refining.

Intelligent exploration, drilling and completion

Once viable formations are located, drilling begins, now driven by increasingly intelligent systems. Technologies such as real-time downhole telemetry and directional drilling allow engineers to access complex geologies, reach previously inaccessible reserves and reduce surface impact.

Intelligent completions, equipped with downhole sensors, offer continuous monitoring of pressure, temperature and flow. These systems enable dynamic reservoir management, improve recovery rates and protect formation integrity through data-driven interventions.

Optimized production and digital platforms

Production focuses on maximizing hydrocarbon extraction while maintaining reservoir pressure and stability. Enhanced Oil Recovery (EOR) techniques, such as water, CO_2 and chemical injection, extend the life of aging reservoirs.

Today, integrated digital platforms enable centralized, real-time monitoring of operating parameters. These intelligent systems automatically adjust operating conditions, improving uptime, optimizing production and reducing operating costs.

Emerging innovations in the upstream sector

The upstream sector is being transformed by technological advances that are redefining operating paradigms, including:

- Automation and robotics: Autonomous drilling systems and robotic tools for well intervention reduce human exposure to hazardous environments and increase operational efficiency.
- Digital twins: Virtual replicas of physical assets allow simulating operational scenarios before executing interventions, optimizing production decisions.
- Emission reduction technologies: Pollutant detection systems, electrification of operations and carbon capture help reduce the environmental footprint.
- Data analytics: Advanced analytics platforms convert large volumes of data into predictive and operational actions.

Strategic impact and economic sustainability

Investment in the upstream segment is critical to ensure global energy security, especially in the face of growing demand. Despite the use of advanced technologies, exploration remains a high-risk activity, with commercial success rates often below 30%.

The sector's profitability is heavily dependent on commodity prices, requiring robust risk management strategies. However, upstream operations remain significant, in the short-term supply of energy, and a financial enabler for renewable energy portfolios across the industry.

Key Performance Indicators (KPIs) related to environmental sustainability are now being integrated into exploration and development decisions, recognizing that environmental performance directly influences long-term economic viability. Although the energy transition is advancing, upstream development remains important to meet immediate energy demand and financially support low-carbon initiatives.

Conclusion

The upstream sector continues to demonstrate remarkable resilience and adaptability in the face of market volatility, technological disruption and new regulatory frameworks. By integrating digitalization, automation and sustainability, operators are positioned to remain relevant in a transforming energy landscape.

In a global context heading towards decarbonization, technological innovation in upstream will be key to meeting the dual challenge of meeting growing energy demand and reducing environmental impact. The companies that manage to align these objectives will survive, and will lead the creation of value in this new energy era.

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Project engineering:
Innovation and precision for unique challenges

Engineering in complex projects is the key to transforming unique challenges into tangible and safe solutions. In the dynamic energy and maritime sector, special projects, such as offshore LNG project operations, require a combination of creativity and advanced, detailed engineering that presents unusual features or requirements, including extreme conditions, high technical complexity, customized needs, or innovations that do not exist in the market.

From a complex structure located in seismic zones to an industrial plant designed for unique processes, these projects require an engineering development different from the conventional one. In them, creativity and precision are essential to turn complex ideas into concrete and safe solutions.

What differentiates a common project from a special project?
To answer this question, I will turn to the definition of a project: "It is a temporary effort to create a unique product or service". Within this universally accepted definition, a project by nature is finite, is not cyclical or continuous, and creates or gives rise to a single result.

From the description above, I highlight two concepts that will help us answer our initial question: the project lifetime and the efficient use of this time to create the product or service. Nowadays, we have technological tools and project management methodologies that help us structure the stages, steps, and phases in an orderly manner, giving us direction and allowing us to estimate the project's timeline.

Unlike conventional initiatives, special projects are characterized by their innovative nature and unique challenges. They must meet tight budgets and timelines, just like any other project. However, their distinction lies in the need to devise and implement solutions that do not yet exist in the market.

Distinctive features of special projects
Some characteristics of the special projects, without being limiting, are:

1. **High technical complexity:** They involve structural calculations and simulations that exceed conventional standards.

1. **Operating boundary conditions:** Hostile environments such as tidal, explosive environments, high pressures, corrosive environments, or confined spaces.

2. **Customized design:** Need for customized solutions due to functional, regulatory, or integration requirements with pre-existing systems.

Success story: Offshore LNG project in Mexico
Background of the special project
Mexico's Pacific coast shortens maritime routes to Asia compared to other regions, reducing transportation times and costs. This factor positions Mexico with great potential to become a major exporter of liquefied natural gas, capable of competing directly with countries such as Qatar and Australia.

In this context, the development of specialized LNG infrastructure has attracted foreign interest and investment, requiring the creation of new terminals and pipelines, as well as the modernization and expansion of existing infrastructure.

Requirements and needs
In the current context of upgrading and expanding infrastructure for massive LNG exports to Asia, the owners and operators of an LNG plant on the Mexican Pacific coast have the specific need to replace its four (4) marine loading arms (MLA): two (2) dedicated to liquid handling, one (1) for steam and one (1) hybrid.

This replacement responds to the natural wear and tear generated after 15 years of continuous operation, a period during which 68 vessels have been unloaded. The renovation seeks to extend the useful life of the facilities for at least 15 additional years and optimize the costs associated with the unloading process.

Project feasibility The owner of the LNG plant requested a comprehensive feasibility study of the project from a specialized international consultant. This process began with detailed technical, economic, and regulatory analyses to comprehensively assess its feasibility, considering the challenges inherent to offshore projects. The results highlighted that there is no comparable or similar project previously executed worldwide.

During this stage, the LNG plant managers contacted our company, recognizing us as the only possible local suppliers capable of executing the required services. The other potential suppliers were located in the United States, Panama, Chile, Holland, France, and Australia.

Unique features that make the project special
This project stands out for several exceptional factors: the loading arms to be replaced are the heaviest ever manufactured by the supplier (60 tons). This implies a significant challenge in lifting maneuvers, especially considering that the physical limitations of the plant make a ground replacement impossible.

Therefore, the operation had to be planned offshore. In addition, the climatic conditions of the Mexican Pacific, the limited availability of specialized equipment, and the operational need to maintain three functional arms significantly reduced the execution windows.

Applying project engineering, in the conceptual engineering phase, it was established that the maneuver should be carried out by sea between the months of July and September. This implied having a self-raising barge with a minimum capacity of 400 tons and a crane capable of lifting at least 250 tons. It was also necessary to design specific accessories to guarantee safe transportation and adequate anchoring of the loading arms.

Finally, it was identified that most of the suppliers qualified to perform these tasks were located outside Mexico. This condition added logistical and operational complexity to the project, requiring a greater effort in the management and international coordination of the teams and specialists involved.

Detailed engineering, new challenges, and simulations
Once our project engineering group was assigned the scope of the assembly, replacement, installation, and transfer of the new and existing loading arms to their final destination, we were proud to be the only Mexican company actively involved in the detailed engineering and execution of the project. Our team worked closely with the technical staff of the LNG plant, the manufacturer of the arms (MLA), and specialized consultants.

Immediately, a thorough planning process was initiated, carefully analyzing every resource necessary for the execution of the project. One of the most significant challenges was the limited availability of a Jack-Up Barge in the international market. In the absence of immediate options, it was decided to acquire a JUB Combifloat C7 naval vessel located in Panama.

Although this decision allowed progress to be made, new technical requirements arose. It was determined that the required capacity of the crane was 300 tons, instead of the 250 tons initially planned. This implied reevaluating critical aspects of stability and navigation of the barge, since there was no history of using a crane of this size on a C7 platform.

Due to this situation, a specialized firm recommended by the manufacturer was called in to perform detailed stability and navigation analyses and simulations of possible operational failures. Also, given the uniqueness of the project, the international reinsurers required additional technical documentation, increasing the administrative and logistical complexity.

The delay caused by customs problems and other operational factors forced the maneuvers to be performed outside the ideal weather window, exposing the equipment to more adverse conditions typical of the Mexican Pacific. Specific critical risks were identified, such as the potential recontact of the arms with the vessel during the lifting maneuvers.

Finally, with the support of a Norwegian firm with expertise in maritime operations under extreme North Sea conditions, the technical feasibility of the project was confirmed. A detailed boundary conditions matrix was developed that integrated physical, meteorological, and operational variables. This rigorous planning was essential to mitigate risks and ensure the success of the project.

Implementation and lessons learned
Thanks to the application of project engineering, which included meticulous planning and the integration of technological innovations, the offshore project was successfully executed in only 7 weeks, considerably reducing the time initially planned, despite facing adverse weather conditions. The eight critical maneuvers were carried out without incident, rigorously complying with the highest safety standards and guaranteeing at all times the well-being of the team involved.

Three months later came the final test: the actual discharge of 140,000 m^3 of LNG. This operation fully validated the applied engineering and confirmed the quality of the previous project preparation. The performance achieved was optimal, fully achieving the proposed objectives: to extend the useful life of the facilities for another 15 years and to offer an innovative technical solution to successfully meet an unprecedented challenge.

Conclusions
This article, based on the experience of our group, aims to highlight and internalize that engineering development in special projects, including those in offshore environments, represents a fundamental pillar in the creation of technical solutions to complex and unique challenges.

Through the effective combination of innovation, rigorous analysis, and advanced methodologies, these projects make it possible to turn seemingly impossible challenges into operational realities, significantly driving technological progress and contributing to the well-being of mankind.

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PROFESSIONAL PROFILES

Earl J. Crochet, PE

Earl has been working since 1988 and has served on various API committees since 1994: SCAST, API 2350, and others. He has been a Certified API 653 Tank Inspector since 1993. He has a BSME and an MBA from LSU, is a Registered Professional Engineer in 4 States, and holds 4 U. S. Patents.

Malvin Delgado

Malvin Delgado is a global energy executive with 30+ years of leadership in oil & gas, power, and manufacturing. As Founder & CEO of Trustwell Energy, he drives strategic growth, sustainability, and operational excellence. A seasoned expert in business management, business development, and energy transition, Malvin leads multinational teams and advances decarbonization across Latin America and global markets.

Mohammed A. Abufour

Mohammed Abufour graduated from the University of Northampton (UK) with a bachelor's degree in Nondestructive Testing. He is a Lifetime Member of ASNT with over 41 years of experience in the oil and energy industry.
Mohammed's career has been defined by overcoming inspection challenges, gaining invaluable insights from setbacks, and achieving significant milestones. From his early pursuit of top-tier NDT training abroad to his current role as an Advanced NDT Technologies Engineering Specialist, he has consistently contributed to innovative NDT techniques that push the boundaries of conventional practices.

Joshua de Monbrun

Joshua de Monbrun, CEng, has over 20 years of NDT and Engineering experience. He holds multiple certifications, including ASNT NDT Level III and is a Chartered Engineer. With over 10 years at MISTRAS Group, he contributed to NDT training and innovation. A US Air Force veteran, he serves as Chair of ASNT's Underwater NDT Committee and is active in various industry organizations. He advocates for integrating new technologies in NDT.

Yolanda Villega

She holds a degree from the Tecnológico de Monterrey (ITESM) and has completed a Master's and Doctorate in Humanistic Studies with a focus on water and energy. She has over 18 years of experience in corporate, international, energy, and intellectual property law. From 2019 to 2023, she was recognized for five consecutive years by Petróleo y Energía magazine as one of the 100 leaders in Mexico's energy sector.

Jorge Vásquez

Jorge Vásquez is a Metallurgical Engineer with over 35 years of experience in corrosion control and pipeline integrity. He is President of Vecor Pipeline Integrity and specializes in cathodic protection, AC mitigation, and direct assessment. Certified as a CP Technologist (CP-3), he has led projects across the U.S. and internationally, combining field expertise with regulatory and engineering insight.

Leslie Ward

Ms. Leslie Ward is a multi-certified API Inspector who joined Kiefner in June 2024. She received her Civil Engineering degree from Auburn University. Ms. Ward started her career in downstream refining, where she developed her knowledge of mechanical integrity. Previously, she worked for Enbridge GTM, implementing a new Facility Integrity program. Ms. Ward founded Women in Mechanical Integrity.

Gerald Haynes

Gerald Haynes is a Chartered Engineer with a degree in Metallurgical and Materials Engineering. Since 2022, he has partnered with Vecor as a subject matter expert on AC interference projects. With over 20 years of experience, he specializes in fieldwork and computational modeling for AC/DC interference, AC calibration, mitigation strategies, and CAE-based cathodic protection design for aboveground storage tanks.

Kevin Ferrick

Kevin Ferrick serves as Senior Director of the API Monogram/ APIQR Program. Companies licensed or registered under Monogram/APIQR have proven to API that they manufacture products and operate in accordance with quality management systems that meet API's stringent requirements.

Brad Wilder

Brad Wilder, PE, CAE, is the Senior Director of Technical Advancement at AMPP, where he leads efforts to strengthen industry knowledge, innovation, and best practices in materials protection. He has over a decade of experience in bridge preservation and protective coatings and a strong background in standards, accreditation, and association governance. As a licensed Professional Engineer and Certified Association Executive, Brad combines technical expertise with strategic leadership to advance the profession and support global infrastructure resilience.

María José Yanes

María José Yanes is Manager of the Pressure Vessel and Metallurgical Department at Repsol's Engineering Division. A specialist in corrosion, materials selection, fabrication, welding, and inspection, she has been with Repsol for 27 years. She currently serves on the Board of the AMPP Spain Chapter, where she has been actively involved for the past 17 years.

Ana Laura Ludlow

Ana Laura Ludlow is Vice President of Government Affairs and Sustainability at ENGIE Mexico, with over 25 years of experience in the energy sector in both Mexico and the United States.
She has led key projects such as the Los Ramones Sur pipeline. She was recognized as one of the Top 100 leaders in the energy sector in 2023, 2024, and 2025, and has participated as a speaker in more than 40 national and international forums.

José María Gómez Fuster

CEO (General Manager), Ph.D. in Civil Engineering, with over 20 years of experience, most of them in the port sector. I remain eager to keep learning and growing. I have been fortunate to work alongside outstanding professionals who have taught me both technically and personally, shaping the professional I am today. I am results-driven, passionate about organizational transformation, and committed to turning ideas into tangible realities.

MarioToyo

Mario Toyo, industrial engineer with management studies at IESA and NDT specialization at the Canadian Institute for NDT. With over 40 years in the oil and gas industry, he has led 200+ plant overhauls and advised companies on reliability and asset integrity. As Content Director at Inspenet.com, he promotes technical knowledge on energy, sustainability, and industrial innovation.

Carlos Melo

Carlos Melo holds a Ph.D. and Bachelor's in Mechanical Engineering, and an MSc in Corrosion Control Engineering. He worked in Ecuador for nearly 15 years in corrosion-related roles. Since 2020, he has served as Regional Manager for Vecor Pipeline Integrity in the U.S. He is a certified professional and also serves as an instructor for AMPP in cathodic protection and pipeline integrity.

Alberto Janeta

Alberto Janeta is a Senior Pipeline Integrity Engineer and General Manager at Vecor's Quito, Ecuador office. He holds a BSc in Mechanical Engineering and an MSc in Environmental Management and Sustainability. Certified in cathodic protection, coating inspection, and ultrasonic testing, he specializes in corrosion control, ECDA/ICDA, AC mitigation, and the design, evaluation, and troubleshooting of cathodic protection systems.

PROFESSIONAL PROFILES

Euclides Quiñonez

Mechanical engineer with 45 years of strategic experience in inspection, maintenance, plant shutdowns, and industrial asset management. Specialist in industrial maintenance with certifications in NDT and corrosion. Strong technical background and proven leadership in critical projects. Has held managerial and advisory positions in the oil and gas industry. Recognized for his expertise, sound technical judgment, and contribution to specialized content development.

Antonio Zavarce

Antonio Zavarce is a professional with over 35 years of experience in mechanical integrity, asset evaluation, and non-destructive testing within the oil, gas, and maritime industries. Throughout his career, he has participated in inspection programs, corrosion control, and technical consulting for both offshore infrastructure and onshore facilities. His work spans refineries, pipelines, terminals, and shipyard operations across various industrial environments, providing strategic support for integrity and maintenance programs in diverse operational contexts.
He is a regular contributor to Inspenet Brief, where he shares field expertise and technical insights to support professionals in the energy and industrial sectors.

Mayuly Rodríguez

Mechanical Engineer with experience in the oil and gas industry, specialized in static equipment inspection, project control and quality assurance. She actively participates in the exchange of knowledge and the dissemination of best practices through the writing of technical articles focused on the energy sector.

Yolanda Reyes

Ph.D. Electrochemistry and Corrosion, with over 30 years of technical and scientific experience in Corrosion Science and Chemical Process Technology, in both academic and industrial environments. Focused on practical solutions based on scientific principles.

José López

José López is an experienced Technical Leader with over 40 years in Venezuela's oil industry. A certified NDT Inspector and Senior Industrial Technician, he specializes in rotating and static equipment, particularly turbogenerators, compressors, and pumps. His expertise includes predictive maintenance and the commissioning of major oil facilities, such as the Paraguaná Refining Center.

Anita Gregorian

Anita Gregorian is a Materials Engineers with a focus on non-destructive testing methods. She works in the aerospace industry. When not supporting flight programs, she actively researches advanced non-destructive methods. She also serves on the Board of Directors for the American Society for Non-destructive Testing (ASNT), promoting innovation and education in the field.

Anthony Gambony

Anthony (Tony) Gambony, P.E.
- Head of Utilities at Project Canary
Anthony (Tony) Gambony, P.E., is a seasoned engineering and operations leader with over two decades of experience in the energy and utilities sector. Known for driving innovation in environmental compliance and emissions management, he combines technical expertise with strategic leadership to deliver scalable solutions that align with evolving regulatory standards and sustainability goals across the energy value chain.

Jorge Reyna

Jorge T. Reyna is an internationally certified inspector and instructor by ASNT (NDT Level III), AWS (SCWI), and AMPP (MCI, PCS, CIP Level 3), the only professional in the world to hold all of these accreditations. He is the Director of JRSA Engineering and Lerne, and has worked in Mexico, the U.S., Ecuador, Panama, and Mongolia, training professionals in welding, coatings, and non-destructive testing.

Tim Bieri

Tim Bieri has worked in corrosion and asset integrity management for more than 30 years. He is a trusted advisor and enjoys seeing those around him succeed. He is a registered professional engineer, AMPP IC Specialist and CP Specialist. Tim was the inaugural Chairman of the AMPP Board of Directors and serves on the ASNT Foundation Board.

Dushyant Kale

Dushyant Kale is a seasoned professional with over 9 years of experience in the oil and gas industry, specializing in asset inspection data analysis, pipeline integrity, and risk assessment. He possesses deep expertise in interpreting high-resolution in-line inspection (ILI) data using MFL and DEF technologies to detect and classify critical anomalies in accordance with industry standards. Dushyant excels at translating complex inspection datasets into actionable insights that support safe operations, maintenance planning, and regulatory compliance. His project portfolio includes successful delivery of both onshore and offshore pipeline assessments, including direct evaluations of non-piggable assets. With strong capabilities in client engagement, quality assurance, and technical reporting, he consistently delivers value through precision-driven diagnostics and data-informed integrity solutions.

Neal Couture

Neal Couture, CEO of ASNT since 2019, has led the organization through major transitions, including a digital transformation and strategic overhaul. A seasoned nonprofit executive, he serves on multiple boards, including APFNDT and Council of Engineering and Scientific Society Executives. A Certified Association Executive (CAE) and Fellow of ASAE, Neal is a recognized expert in association management and leadership.

Eddie Pompa

Eddie C. Pompa is an ASNT Level III (#107661) with over two decades of experience in aerospace and oil & gas inspections. He currently serves as Responsible Level III at Astrion, NDT Professor at Lone Star College, and NDT Advocate with 4 Point NDT. Eddie specializes in cross-sector inspection training, code compliance, and mentoring the next generation of NDT professionals.

Adriana Aparecida de Andrade

Adriana Aparecida de Andrade - executive manager of Logistics Integrations at Transpetro
Environmental Engineer, specialized in Occupational Safety from Mackenzie University and holding an Executive MBA in Business Management from Fundação Getúlio Vargas (FGV), she has 22 years of experience in the Oil and Gas industry and is currently the Executive Manager of Logistics Integrations at Transpetro. She has held various positions within the company, focusing on operational safety, people, and the environment.

Kimberley Hayes

Kimberley Hayes is the Founder and Chief Technical Officer at Valkim Technologies LLC, where she leads the development of IECEx/ATEX-certified robotic systems for confined and hazardous environments. With 30 years of industry experience, she is committed to advancing robotic inspection that keeps people safe and productive assets.

Moises Bobadilla Flores

Master of Civil Engineering with over 15 years of experience in managing maritime and infrastructure projects. Specialist in the planning, execution, and control of port works, energy, and Oil & Gas. Certified engineer with a background in engineering and project management. Skilled in leadership, business processes, and leading high-performance teams in complex environments.

Israel Hurtado

Israel Hurtado is a renowned expert in energy and energy transition. He has held high-level positions in the Mexican government and is the founder and president of the Mexican Hydrogen and Energy Transition Association. A scholar at ITAM and the Escuela Libre de Derecho, his leadership has made him a key figure in promoting clean hydrogen in Latin America.

Enzo Di Taranto

Enzo di Taranto is a globally recognized diplomat and sustainability strategist. He has led UN initiatives, advised governments and CEOs, and founded XZEN Technologies–an ecosystem focused on climate, technology, and sustainable development. As host of the PLANET GOLD podcast, he is celebrated worldwide for his leadership and innovation in climate action, with features in top media and international events.

Robert Vaughn

Is a seasoned energy industry professional with extensive experience in pipeline integrity, inspection technologies, and asset management. With a strong background in engineering and leadership roles across North America, he has contributed to advancing pipeline safety and operational efficiency. Robert is known for his strategic insight and commitment to innovation in oil and gas infrastructure.

Addressing Internal Corrosion in Deadlegs: A Comprehensive Review and Challenges in Data Collection

By: Leslie Ward
Civil Engineer, Mechanical Integrity Leader for Fixed and Static Pressure Equipment

The oil and gas (O&G) industry has long grappled with internal corrosion (IC), particularly in deadlegs, which are difficult to monitor and manage. Although extensive data has been collected over the years regarding the causes of failures, pinpointing IC in deadlegs as the cause of failures remains elusive. Efforts to identify, mitigate, and prevent corrosion-related failures in deadlegs have gained momentum, particularly with the involvement of the API Data Mining Team (DMT).

API Data Mining Team's Recommendations

Since 2003, the DMT has issued several advisories to improve IC management, especially in deadlegs. Most recently, the PPTS Operator Advisory: Updating Findings on Releases from Facility Piping (2016-1) examines data from 2010 to 2015.[1] This advisory reveals a striking statistic: "Of the facility releases caused by IC, at least 50% occurred at the low point in the pipe..." In its advisory, API recognizes common factors shared by deadlegs, intermittently used facility lines, drain lines, and relief lines—limited or sporadic flow. These characteristics create an environment conducive to IC.

Recommendations for Operators

The 2016-1 advisory offers recommendations for operators, including:
1. Consider draining and isolating deadlegs, particularly in crude oil service, that serve no further process purpose.
2. Develop plans for phasing out deadlegs over time, which aligns with the guidance provided in two other advisories.
3. Schedule flushing deadlegs and intermittently used lines. One other advisory highlighted the importance of flushing to manage corrosion risks.
4. Develop a program for managing deadlegs, ensuring that these potentially hazardous areas are consistently monitored and maintained.
5. Develop a piping inspection program. Three previous advisories emphasized the importance of routine inspections and monitoring to prevent corrosion failures.

Data Challenges and Inconsistencies

Challenges remain in accurately identifying and reporting corrosion failures, particularly in deadlegs. A review of PHMSA's Pipeline Failure Investigation reports revealed inconsistencies in categorizing corrosion failures. Of the 113 investigations listed, only a few directly mention deadleg failures, and discrepancies exist in the reported causes.[2] These inconsistencies complicate efforts to track corrosion trends and address the underlying issues effectively. Fifteen incident reports were reviewed; six were attributed to deadleg failures, while two additional incidents involved low points in piping that resembled deadlegs.

Deadleg Designation and Reporting Gaps

A further review of PHMSA incident data between 2010 and 2024 for gas transmission, hazardous liquids, and gas distribution incidents reveals gaps in how deadlegs are reported. In the Gas Transmission Gathering data, a field documents whether a failure occurred in a deadleg. However, this field is only used in a small percentage of incidents: 0.48% for gas transmission and 1.85% for hazardous liquids. Even more troubling, several incidents in a deadleg did not appear in the field, suggesting that the designation is underreported or inconsistently applied.

The Gas Distribution data, covering incidents between 2010 and 2024, did not include any specific designation for deadlegs but did document one incident that was attributed to a deadleg. The lack of a field for deadleg identification in the gas distribution data further complicates efforts to track and manage these risks. Many deadleg failures may not meet the reporting threshold required by PHMSA, thus contributing to the underrepresentation of this issue in official reports.

Addressing the Root Causes

In response to the challenges in identifying causes of corrosion failure, API has initiated interviews with companies with PHMSA reportable incidents. API aims to uncover the true causes of corrosion-related failures and provide better guidance for operators in the future. To assist with this initiative, a comprehensive survey has been developed to guide discussions and identify key factors contributing to corrosion in deadlegs. This effort is critical in shaping future guidance and developing targeted solutions for the industry.

An example of a header deadleg and low point drain excavated for inspection. [3]

Terminology Dilemma

An often-overlooked issue in the search for better data is the variation in the spelling and terminology used to describe deadlegs. The term "deadleg" has been spelled in numerous ways: as two words, hyphenated, and as a single word. In some cases, it is referred to as "dead ends." These variations create more challenges when searching for relevant data across multiple databases and documents. Standardizing the term and its spelling would streamline future research and improve reporting accuracy.

Conclusion: Standardization and Improved Reporting

As the industry continues to refine its understanding of IC in deadlegs, standardizing terminology, improving reporting practices, and enhancing data collection methods are crucial steps in addressing the issue. API's ongoing efforts to uncover the root causes of corrosion failures through surveys and interviews, combined with the recommendations in its advisories, will help operators better manage this persistent threat. The goal is to reduce failures, improve safety, and ensure the long-term integrity of the O&G infrastructure.

Addressing these challenges, the O&G industry can continue to evolve toward more effective corrosion management practices, aiming to minimize downtime, reduce risks, and ensure safe, efficient operations across the sector.

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Smart NDT Technologies for Detecting Hidden CUI Risks in Oil and Gas Facilities

By: Mohammed A. Abufour
Global Advisor-Advanced NDT Technologies and Engineering Specialist.

The oil and gas industry relies on thermal insulation to maintain process efficiency, reduce energy loss, and enhance workplace safety. However, insulation also presents a significant challenge—Corrosion Under Insulation (CUI). CUI is one of the most persistent and costly integrity threats, developing undetected beneath insulation and leading to structural degradation, leaks, and potential failures.

CUI is particularly common in piping systems exposed to cyclic temperatures, especially those operating between -4°C and 175°C, where condensation is likely to occur. If left undetected, CUI can result in costly repairs, unplanned shutdowns, and serious safety hazards. Traditional inspection methods, such as visual examination or random insulation removal, are often ineffective, labor-intensive, and costly.

Addressing these risks requires proactive measures, effective inspection strategies, and advanced monitoring technologies to ensure early detection and mitigation. As insulation degrades over time, the likelihood of CUI increases, making periodic inspection essential for maintaining asset integrity.

To overcome these challenges, the industry is increasingly adopting smart monitoring solutions that integrate advanced Non-Destructive Testing (NDT) technologies, embedded sensors, and data analytics. These innovative approaches enhance early detection, reduce maintenance costs, and ensure the long-term safety and reliability of critical infrastructure.

Latest NDT Innovations for Continuous CUI Monitoring

Real-time monitoring technologies are revolutionizing how industries manage corrosion under insulation. Wireless corrosion sensors, installed under insulation in high-risk areas such as offshore platforms, plant piping's and LNG terminals, provide continuous monitoring of moisture levels—the primary cause of CUI. These sensors detect water ingress in real time, enabling early intervention and reducing reliance on costly, labor-intensive periodic inspections. By integrating cloud-based data transmission, operators can remotely access corrosion data, analyze trends, and implement predictive maintenance strategies.

To ensure accuracy, sensor data must be validated using advanced NDT techniques such as Guided Wave Ultrasonics, Pulsed Eddy Current, Digital Radiography. These non-intrusive methods assess corrosion severity without removing insulation, enabling targeted inspections. This combination of smart monitoring and advanced NDT minimizes false positives, optimizes inspection efforts, and enhances asset reliability.

Smart NDT technologies work alongside intelligent sensors to verify all reported indications, ensuring a more accurate assessment of CUI risks. By integrating real-time monitoring with advanced inspection techniques, industries can strengthen plant integrity, prevent unexpected failures, and maintain safe, reliable operations. A proactive approach utilizing both technologies helps industries mitigate CUI-related damage while optimizing maintenance resources.

By shifting from reactive to predictive maintenance, industries can significantly lower inspection costs while improving safety and infrastructure integrity. Continuous CUI monitoring minimizes unplanned downtime and extends asset life, ensuring compliance with industry regulations. As digitalization advances, integrating real-time monitoring with NDT validation will be key to achieving long-term operational efficiency and reliability.

Smart Advanced NDT Techniques for CUI Detection and Verification

1. Pulsed Eddy Current (PEC)

PEC is an advanced electromagnetic inspection technique designed to detect corrosion and wall loss in insulated and coated components without requiring direct surface contact. It is particularly useful for detecting CUI in piping, pipelines, storage tanks, and process vessels, where traditional methods would require costly insulation removal. As a smart NDT solution, PEC serves as a valuable verification tool, validating hidden CUI risks identified by intelligent sensors while providing fast and reliable screening across large surface areas.

2. Guided Wave Ultrasonics (GWUT)

GWUT is a long-range inspection technique that uses low-frequency ultrasonic waves to detect anomalies such as internal and external corrosion in pipes and structural components. These waves travel along the length of the pipe, allowing for rapid screening of extended sections, even when covered by insulation, coatings, or buried underground. GWUT's ability to detect CUI without direct access makes it a powerful complement to intelligent sensors, verifying hidden corrosion risks in challenging environments. Its capability to assess pipe integrity over long distances minimizes the need for intrusive inspections, improving efficiency and reducing downtime.

3. Robotic Inspection Using Digital Radiography (DR)

Robotic inspection utilizing Digital Radiography (DR) combines automation with high-resolution X-ray imaging to detect internal corrosion, external pitting, and material loss in both insulated and uninsulated assets. DR technology captures digital images of internal structures without requiring insulation removal, making it highly effective for assessing CUI. The integration of robotics allows for remote inspection of hard-to-reach areas, reducing safety risks and human intervention. By providing detailed, real-time imaging, DR-based robotic inspection enhances the verification process of hidden CUI risks reported by intelligent sensors, ensuring accurate and data-driven maintenance decisions.

Conclusion

CUI remains one of the most challenging integrity threats in the oil and gas industry due to its hidden nature and potentially severe consequences. Traditional inspection methods are often insufficient, making smart NDT solutions essential for effective detection and management.

By integrating real-time monitoring, advanced NDT techniques, and predictive maintenance strategies, industries can significantly enhance their ability to detect and mitigate CUI risks. This proactive approach ensures long-term asset integrity, minimizes operational disruptions, and strengthens the safety and reliability of critical infrastructure.

From Legacy to Leadership: How the Oil & Gas Industry Can Lead the Energy Transition Era

"The energy transition is not a threat to oil and gas, it's the industry's greatest opportunity to lead."

By: Eng. Malvin Delgado
CEO Trustwell Energy

As the global push toward decarbonization accelerates, the oil and gas industry faces a defining moment: will it lag behind as the world pivots toward cleaner energy, or will it leverage its expertise, capital, and infrastructure to lead the energy transition?

Historically, the sector has been painted as part of the problem, but today, it has a rare opportunity to be part of the solution. By embracing new energy technologies, investing in innovation, and aligning with sustainability goals, oil and gas companies can transform from legacy players into drivers of the low-carbon economy.
Here's how.

Here's how.

The Business Case for Transition

Global energy systems are undergoing unprecedented changes. Climate commitments under the Paris Agreement, regulatory frameworks like the EU Green Deal, and investor pressure for ESG performance are pushing industries to reduce carbon intensity, mitigate risks, and unlock new value streams.

For oil and gas, the opportunity isn't just about avoiding stranded assets, it's about capturing competitive advantage:

Key Areas of Opportunity

1. Hydrogen Integration

El hidrógeno, en particular el verde y azul, tiene un enorme potencial como portador de energía versátil y bajo en carbono. Las empresas de petróleo y gas están en una posición única para liderar:

- Repurposing gas infrastructure for hydrogen transport and storage
- Deploying steam methane reforming (SMR) with carbon capture (for blue hydrogen)
- Investing in electrolysis projects using renewable power (for green hydrogen)
- Reutilizando la infraestructura de gas para transporte y almacenamiento de hidrógeno

Hydrogen hubs, blending projects, and pilot facilities are already reshaping industrial energy systems, and oil and gas players are at the forefront.

2. Carbon Capture, Utilization, and Storage (CCUS)

Decarbonizing hard-to-abate sectors like steel, cement, and chemicals hinges on CCUS, an area where upstream and midstream expertise can make the difference.

- Capturing CO_2 at industrial sites
- Transporting and safely storing CO_2 in geological formations
- Exploring carbon utilization pathways (synthetic fuels, materials)

CCUS is not just a regulatory compliance tool; it's a future revenue stream for companies that move early.

3. Renewable Energy and Electrification

Many oil and gas operators are integrating renewables into their operations:

- Powering offshore rigs with offshore wind
- Electrifying upstream processes to reduce Scope 1 and 2 emissions
- Investing in hybrid projects combining solar, wind, and energy storage

This diversification reduces operational carbon intensity and positions companies for long-term resilience.

4. Methane Emissions Management

Methane, a greenhouse gas over 80 times more potent than CO_2 in the near term, is a critical focus. Leading companies are:

- Deploying continuous leak detection and repair (LDAR) technologies
- Participating in global methane pledges and reporting frameworks
- Leveraging digital tools to track, report, and mitigate methane losses

Cutting methane isn't just good for the climate, it's an efficiency and revenue play.

The Role of Leadership

For executives, the energy transition is no longer an "if", it's a "how fast" and "how well."

To succeed:

- Set clear, measurable decarbonization goals aligned with science-based targets
- Embed sustainability into core business strategy, not as a side project
- Collaborate across sectors, supply chains, and governments to scale impact

Critically, leadership must communicate the value of transition efforts to investors, employees, and the public, transforming reputation risk into reputational strength.

Shaping the Future Together

The energy transition is not about eliminating hydrocarbons overnight, it's about transforming the system over time, balancing security, affordability, and sustainability.

Oil and gas companies that act boldly now will:

- Capture early-mover advantages in emerging markets
- Attract top talent seeking purpose-driven work
- Build portfolios that withstand future policy and market shifts

This is the moment for the oil and gas industry to redefine itself, not as the industry of the past, but as the energy architects of the future.

By investing in new energies, prioritizing decarbonization, and embracing innovation, the sector can transform its role in the global economy and secure its place at the center of the net-zero transition.

The world is watching, and the leaders will be those who move first, fast, and with purpose.

Tank inspections using drones and robots: **The Good, The Bad, and The Not Yet**

By: Earl Crochet
Owner at Crochet Midstream Consulting

The use of drones and robots has become more commonplace in the world today and has even started impacting the inspections on Aboveground Storage Tanks (ASTs). I wrote an article last year that was more generic and had some minor speculation of what might happen in the future. This article will discuss what inspections are required, what can be done today with a drone and/or a robot (walking, crawling, swimming), and what might be done relatively soon, and more importantly practical.

Currently, drones are used for detection of emissions from ASTs and facilities and overall site inspections. Drones are often used today to take videos of tanks, perform ultrasonic spot (UT) inspections, pressure wash tanks and even sometimes even paint ASTs.

Per API Standard 653, the following inspections are required: Routine In-service (monthly), External (5-year visual), Ultrasonic (15-year UT), and internal (out of service).

Monthly inspections can be performed by anyone that per API 653 "should be knowledgeable of the storage facility operations, the tank, and the characteristics of the product stored". This is the only inspection on ASTs per API 653 that can be performed by someone other than an API 653 authorized inspector.

There are Owner/Operators that are using drones to "look" at their ASTs. However, in my opinion, there is a potential issue with this approach as API 653 doesn't mention drones or robots or any other method for performing the visual inspections currently. It should also be noted that there is a list of items in API 653, that, if observed, need to be evaluated by an authorized inspector. While drones can perform these visual inspections, there needs to be more done to comply with API 653.

Robots that can "walk" are another potential way to collect video and pictures. However, there are some potential issues with using a robot. First in my mind is the cost of the robot. While I am sure the costs will continue come down and the capabilities will increase, I'm not sure that it will make sense anytime soon. In addition, there are often obstacles that limits the ability of current robots to "walk" around the ASTs. Also, for many ASTs, electrical area classifications will limit the viability of using a robot.

Both the 5-year visual and 15-year UT inspections are required to be performed by an API 653 inspector. Drones and robots can both be used to assist in these inspections, but their practicality varies. Each of the inspections will be discussed in more detail along with how drones and robots might be able to help.

For the 5-year visual, a drone can certainly take video of an AST to be reviewed by an authorized API 653 inspector. Again, I'm not convinced of the practicality or cost effectiveness. Again, API 653 does not currently address an authorized inspector who does not perform the visual inspection themselves.

For a 15-year UT, one advantage of using a drone or a crawling type of robot is the ability to take UT readings at locations that cannot be easily accessed by an API 653 inspector under normal conditions. From a practical standpoint, I'm not convinced that the extra data is worth the extra costs and time.

The last, and in my opinion, the most important inspection, is the internal inspection. These inspections are traditionally performed by emptying the tank of product, cleaning, and then sending people and equipment into the AST. The 3 primary purposes of an internal inspection are:1) ensure that the bottom is not severely corroded or leaking; 2) gather data for minimum bottom and shell thickness; and 3) identify and evaluate bottom settlement. First, drones are obviously not practical due to the AST being full of liquid. However, robots, both crawling and swimming types, have been used for almost 30 years to inspect ASTs while they are in service. While robots have limits on the type of products they can be used in, today's robots are certainly a more viable option than in the past. As the various technologies used by robots continue to improve, I think the use of robots to perform internal inspections will increase. You may find it surprising that robots (and other on-stream inspection methods) have been allowed by API 653 for more than 25 years to perform the internal inspections without taking ASTs out of service.

So, what is an Owner/Operator to do? Tank inspections are still primarily performed by people, but the use of drones and robots will continue to increase. API 653 and regulations will need to adapt to technological advancements. Owner/Operators must evaluate the cost versus value of these technologies versus traditional methods.

How Artificial Intelligence Is Transforming the Energy Sector

By: PhD. Yolanda Villegas Energy Specialist

Technological advances in the digital domain are increasingly remarkable, spanning from the latest mobile devices to promising developments in fields such as medicine and engineering. Within the energy sector, digital transformation is no longer a distant aspiration—it has become a strategic imperative. Artificial Intelligence (AI) has emerged as a pivotal tool for enhancing operational efficiency across various segments, optimizing resource utilization, and accelerating the transition toward cleaner, more sustainable energy systems.

From forecasting electricity demand to enabling intelligent grid management and predictive maintenance of infrastructure, AI is redefining how energy is produced, distributed, and consumed.

Optimizing Energy Supply and Demand

One of the most immediate and tangible applications of AI in the energy sector is the optimization of energy supply and demand. Leveraging extensive historical data and modern machine learning algorithms, AI systems can analyze vast volumes of data collected from sensors, smart meters, weather stations, and other IoT devices. This enables accurate forecasting of consumption peaks and dynamic adjustment of generation plant operations.

A widely cited case is that of Google, which, according to its own data, reduced energy consumption for data center cooling by up to 40% through the use of AI developed by DeepMind. This issue has gained renewed relevance in light of recent reports highlighting the considerable water and energy demands of AI systems. Such AI-driven solutions not only achieve significant cost savings but also contribute to reducing carbon footprints.

Integrating Intermittent Renewable Energy

One of the most compelling applications of AI in the energy domain lies in managing intermittent renewable sources such as solar and wind. Integrating these into the energy matrix presents challenges for grid stability. AI enables the development of smart grids that adapt in real time to changing conditions, automatically balancing energy supply and demand.

According to data from Credence Research, the smart grid modernization market in Latin America is projected to reach USD 7.359 billion by 2032, with a compound annual growth rate (CAGR) of 16.6%. This rapid growth underscores the region's strong interest in adopting technologies that dramatically improve grid efficiency.

Predictive Maintenance

Another major advantage of AI in the electricity sector is predictive maintenance. Rather than relying on periodic maintenance—which may be unnecessary or inefficient—AI algorithms can predict mechanical or electrical failures before they occur by analyzing historical patterns and real-time data.

This translates into reduced operational costs and downtime, enhanced worker safety, and improved service continuity for end users. In the oil and gas industry, for instance, a single hour of unplanned downtime can result in losses of up to USD 500,000, highlighting the economic importance of AI-enabled predictive maintenance strategies.

Energy System Planning and Management

AI is also revolutionizing the planning and operation of complex energy systems. It enables the execution of advanced simulations to assess decarbonization scenarios, identify optimal locations for new renewable energy projects, and manage electric vehicle fleets in real time. Furthermore, AI supports the management of renewable energy certificates and emission tracking, offering automated verification and traceability—a growing necessity in light of ESG (Environmental, Social, and Governance) requirements. AI can also serve as a powerful tool to combat so-called "greenwashing" by enhancing transparency and accountability.

Challenges of AI Integration

Despite the substantial benefits of AI implementation, its adoption also presents significant challenges. Issues such as data privacy from smart meters, algorithmic transparency, and potential bias in automated decision-making require both technical scrutiny and regulatory oversight. It is essential to establish clear regulatory frameworks to ensure ethical, fair, and responsible use of AI, preventing distortions in competition.

Additionally, upskilling the energy workforce is critical to foster effective collaboration between human operators and intelligent systems.

Progress in Mexico

Mexico has made notable strides in this area through initiatives such as the National Smart Metering Network and efforts by CENACE (National Energy Control Center) to integrate digital technologies into energy dispatch operations. As part of these efforts, CENACE has partnered with Huawei to implement a 10 Gbps communications network aimed at improving the stability and efficiency of the national power system.

In conclusion, AI is a tool with countless applications across various sectors. In the case of the energy sector, its implementation can be the determining factor between a slow and fragmented energy transition or one that is accelerated and efficient. To achieve this, it is imperative to align technological innovation with visionary public policies, robust ethical frameworks, and a strong commitment to human capital.

Vanishing Eyes: The Crisis Facing Nondestructive Evaluation

By: Anita Gregorian
Materials Engineer

In this era of extraordinary machines and astonishing ambition—where rockets ascend beyond the stratosphere and passenger aircraft thread the skies by the minute—there remains a discipline upon which all this progress rests. It does not shine in presentations nor sing in promotional reels. It does not ask for applause. But without it, towers fall, wings fail, and missions perish. That discipline is Nondestructive evaluation (NDE).

And it is vanishing. Not from our launch pads or our aircraft hangars, but from our universities. It is fading from the very institutions charged with preparing the stewards of safety for the next century.

NDE is not a footnote. It is a multidisciplinary craft that marries materials science, physics, fracture mechanics, and signal interpretation. It is how we interrogate a structure without dismantling it, how we uncover hidden faults before they become failures. To practice NDE is to think like a detective, perceive like a physicist, and to intervene before harm begins. It is, in every sense, a preemptive science.

And yet, in far too many industries, it has become an afterthought. A checklist item. This mindset is not merely flawed—it is dangerous.

The tragic loss of the OceanGate Titan submersible in 2023 stands as a sobering example of what happens when warning signs are not just missed—but actively dismissed. The company relied on acoustic emission (AE) monitoring, a method that detects internal stress by listening for the microscopic sounds of deformation. But the data was reportedly ignored, and its interpretation misunderstood. The phenomenon of the Kaiser effect—where prior stress can mask new damage until a higher load is reached—was either not accounted for or disregarded. Even more troubling, the CEO publicly claimed that the cracking noises heard during dives were "normal." Rather than treat these emissions as warnings, the signals were rationalized, and the NDE data was avoided. Compounding the issue, the sub was constructed primarily from carbon fiber composites—materials known for their strength in tension but poorly suited to withstand the extreme compressive forces of the deep ocean. This was not simply a materials failure. It was a systemic dismissal of engineering limits and nondestructive evaluation itself—at the precise moment both were most needed.

Let us remind ourselves: the most successful aerospace programs in history did not relegate NDE to the margins. They wove it into the very fabric of design and production. At Skunk Works, Lockheed Martin's crucible of innovation, inspection was not a separate function—it was embedded on the shop floor. NDE engineers conferred daily with machinists and designers. Non-destructive principles were not confined to a back office—it stood watch at the source. With inspection embedded into the rhythm of the work, scrutiny became second nature, and excellence the expectation. This was not delay—it was discipline. It was rigor. And it produced some of the most enduring engineering marvels of the modern age.

We no longer live in an age where mistakes can be afforded. Space is no longer the exclusive domain of nations; it is the playground of billionaires, the highway of data, the battleground of strategy. Hypersonic systems are being tested in secrecy, while aging aircraft fly well beyond their intended lifespans. And while the air is thick with innovation, the foundations grow brittle. Additive manufacturing, bonded composites, and autonomous systems introduce new failure modes that our old inspection regimes struggle to address.

And amid all this, nations trade missile technologies with a frequency that should chill the conscience of any clear-thinking observer. In such a world, there is no margin for error.

When failure comes now, it does not merely break hardware—it breaks trust, grounds fleets, and reshapes policy. NDE remains one of the last disciplines capable of seeing the danger before it becomes disaster. But only if it is empowered to act early. Only if it is taught. Funded. Respected.

We must return NDE to the center of engineering education—not as an elective or an afterthought, but as a foundational pillar. We must invest in new minds as well as new machines. And we must rebuild a culture where engineers and NDE professionals collaborate from day one, not day 101. The best programs will not wait until failure reminds them what they chose to ignore.

Let us be clear: technology alone will not save us. No algorithm will substitute for instinct. No automated scanner will replace the judgment forged through years of experience. We need NDE engineers—trained, trusted, and present—because the structures we build today are too complex, too critical, and too unforgiving to leave their integrity to chance.

Nondestructive evaluation may never headline a press release. It may never stand center stage at the launch countdown. But it is the quiet guardian of reliability, the discipline that sees the crack before the rupture, the signal before the silence.

And if we choose to ignore it—if we allow it to wither from the classroom and be sidelined in the boardroom—we will face the consequences not in speculation, but in wreckage.

Pushing Boundaries in Tank Inspection: A Safe and Certified Robotic Platform for Hazardous Environments

By: Kimberley Hayes, CTO, Valkim Technologies LLC

VALKIM TECHNOLOGIES

In the global energy sector, the urgency to balance safety, operational uptime, and environmental stewardship has never been greater. Nowhere is this more evident than in the inspection of aboveground storage tanks (ASTs) — critical infrastructure assets in midstream and downstream operations that often contain highly volatile products. The tension between inspection rigor and asset availability has long been a bottleneck — until now.

Traditionally, comprehensive inspections require draining, cleaning, and manual entry — processes that pose significant risks, interrupt operations, and introduce safety, environmental, and financial liabilities. Recognizing these persistent limitations, Valkim Technologies, in close partnership with HMT, Chevron Terminals, and a cadre of veteran API 653 professionals, has developed and field- deployed a fully pneumatic, IECEx/ATEX Zone 0-certified robotic platform capable of delivering in- service inspection data — without personnel ever breaching manways or shutting down operations.

This paper outlines the evolution, technical approach, and real-world application of this platform, representing a tangible step toward safer, smarter, and more sustainable inspection practices in flammable vapor space environments across the energy value chain.

Designing for the Extreme: A True Zone 0 Solution

While many robotic systems claim "confined space" capabilities, few are certified for continuous- use in explosive atmospheres (Zone 0) — and fewer still are designed from the ground up for mechanical, non-electric operation. Our response to this challenge is the PneuBot: a compact, non-electric crawler engineered specifically for in-tank deployment during live service.

PneuBot is powered entirely by compressed air, eliminating ignition risk. All motors, valves, and actuators are pneumatically actuated. It carries a tethered sensor suite with its own certifications; therefore, a variety of mission objectives can be addressed.

Critically, the system allows precise UT readings to be taken directly from structural components without needing tank shutdowns or confined space entry. The absence of onboard electronics
enables IECEx Zone 0 certification, a necessary requirement for flammable atmospheres found in the vapor space of many tanks with internal floating roofs.

Real-World Validation: External and Internal Floating Roof Tanks

This system has already been successfully deployed on two external floating roof tanks and one internal floating roof (IFR) tank in live service. During these inspections, we collected API 653- compliant UT readings from several critical locations:

- Horizontal UT on the deck, sketch plates, and pontoons
- Vertical UT at manways, rim plates, gauge poles, and floating roof leg sleeves
- Visual assessment of internal IFR components via high-resolution ATEX-rated camera, including the topside of the floating roof and support structures

These inspections were performed while tanks remained online and operational, delivering regulatory-grade data to the asset owner without requiring degassing, cleaning, or shutdown.

Unlike drones, which provide valuable remote visual data but are not IECEx Zone 0 compliant, our system is capable of contact-based wall thickness measurements inside flammable vapor
atmospheres — addressing a critical gap in robotic inspection. In essence, we bridged the space where aerial visual meets certified contact NDT, creating a hybrid model grounded in safety and precision.

Collaborative Engineering: Partners Driving Progress

This platform was not developed in isolation. Our work with HMT, one of the world's most experienced tank manufacturers and inspection solution providers, helped guide practical engineering decisions from the earliest design reviews to field deployment strategies. Their
understanding of floating roof dynamics, material interfaces, and client operational constraints directly influenced the platform's durability and mobility features.

Likewise, Chevron Terminals provided operational access, performance feedback, and internal alignment across health, safety, and engineering disciplines. Field leads such as Eric Hardien, and technical reviewers including Daniel Ramirez, Mauricio Calva, and Derek Hibler, ensured the
robotic system aligned with real-world inspection needs — not just regulatory minimums, but actual performance under field pressures.

Their shared mindset — "If we're not evolving together, it won't happen." — became a mantra that helped us push through legacy constraints and legacy thinking.

Embedded Expertise: Learning from the API 653 Field

A critical component of this journey has been the oversight and guidance of Curtis Stewart, a 30- year API 653 expert who has lived every step of tank inspection — from internal visual assessments to code interpretation and reporting standards. His mentorship was essential in ensuring that our inspection workflow delivered data that was not only innovative but also defensible, auditable, and ready for engineer-of-record review.

We believe inspection shouldn't be a dare.

If your core value is human safety, then we're aligned.

Valkim Technologies has developed the **world's first ATEX/IECEx Zone 0 robotic system** for **in-service API 653 inspections —** including visual and ultrasonic — **with zero human entry.**

Keep the tank in-service. Keep the human off the roof.™

By validating our UT data collection and positional documentation against API 653 and SNT-TC-1A standards, Curtis helped solidify the platform's role as a true in-service substitute for manual inspection — not just a novel robot.

From Proof to Practice: Repeatability and Results

With field deployments now underway, the PneuBot platform is demonstrating strong outcomes:

- Operational Continuity – Eliminates tank shutdowns, reduces inspection impact to operations
- Worker Safety – No confined space entry or exposure to flammable atmospheres
- Inspection Accuracy – Captures location-tagged UT and RVI data that enables digital twin integration
- Turnaround Efficiency – Reduces typical inspection cycles from weeks to less than 24 hours in many cases

All inspections to date have been performed in accordance with ASTM E2853/E2853M-22, which governs remote visual examination systems. This standard provides the assurance needed by inspection engineers and regulators that robotic data is equivalent in quality and process control to human-in-the-tank work.

Next Steps: Creating a Robotic Inspection Standard

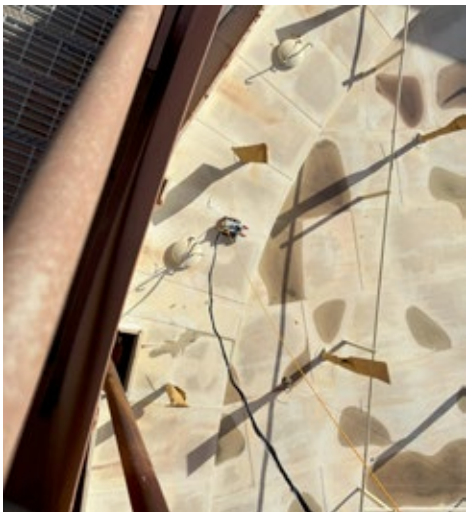
We recognize that technology alone does not move the industry forward — standards do. Valkim is currently authoring a Recommended Practice (RP) for robotic in-service tank inspection, integrating SNT-TC-1A-compliant personnel procedures, API 653 equivalency, and ASTM inspection protocols.

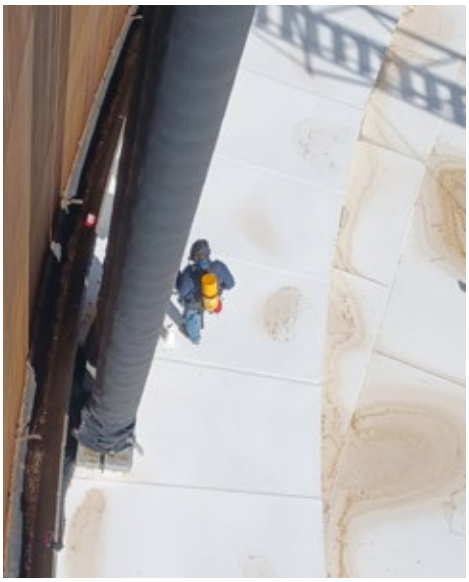
Our goal is not just to make robots usable — but to make robotic inspection certifiable.

Collaboration Over Invention

This platform represents more than engineering success. It represents a cultural shift in how asset owners, service providers, and innovators work together. By combining industry-tested knowledge with cutting-edge mechanical design and validating each decision in the field with partners like HMT, Chevron, and Curtis Stewart, we've created a new class of inspection tool: one that is fit for purpose, certified for risk, and ready for repeatable deployment.

We are proud to share this milestone with the global community, not as a finished product, but as the beginning of a movement — toward smarter, safer, and more collaborative inspection solutions that leave no one behind.





From Oxidation to Occupation: How to Build a Career That Won't Corrode

By: Tim Bieri Senior Corrosion and Asset Integrity Engineer

Most people in our industry know what corrosion looks like. Metal that once had strength and structure starts breaking down. Slowly. Quietly. You might not notice it until it's already impacted safety or reliability.

Careers can be like that too.

You start with momentum. You build experience. You take on bigger roles. Then something shifts - burnout, office politics, a company reorg, a new boss who doesn't get it. Before you know it, the passion fades and you start wondering, "What happened?"

Here's the thing: corrosion and careers have more in common than you'd think. And if we manage our jobs the way we manage materials, we might hang onto both a little longer.

What Corrosion Teaches Us About Work

Corrosion is a natural process. Metal wants to go back to its original state—iron to iron oxide. That process speeds up when you've got the right (or wrong) environment. Typically, corrosion doesn't happen overnight, but it happens. We manage corrosion by understanding the internal and external threats, design appropriate barriers and perform regular assurance activities. It takes energy and investment to manage corrosion.

Your career has the same setup. Internal threats include things like self-doubt, fear of failure or stress. External threats include things like impact of technology, layoffs, market swings, or bad leadership. If there's no barrier in place, your career can start to corrode. Slowly at first. Then faster.

So how do we fight back?

Build Your Barriers

In corrosion management, we talk about barriers—things like coatings, cathodic protection, or material selection. In your career, your barriers look like this:

- **Mentorship:** Someone to give you perspective when things get messy
- **Networking:** Build relationships inside and outside of your company
- **Understand how work happens:** To be outstanding in your field, you need to spend time standing in the field.
- **Continuous learning:** Keeps your skills sharp and relevant
- **Self-awareness:** So you know when you're burning out before it's too late
- **Boundaries:** Protect your time, your energy, and your mental health

You don't need to build a fortress. But you do need a layer of protection. Otherwise, little things—bad meetings, unclear goals, missed promotions—start to wear you down.

The Cycle That Gets People Stuck

In corrosion, there's a pattern: first, no one pays attention. Then something fails. Then we overreact. After a while, we calm down, learn a few things, fix a few things… until the cycle starts over.

Careers follow a similar loop:

1. Complacency: "I'm fine. Nothing's wrong."
2. Crisis: "Why am I miserable all of a sudden?"
3. Fix-it mode: Take a class, change roles, breathe again
4. Forget-it mode: "That's in the past, time for Autopilot"

The challenge is to avoid this unhealthy cycle and use a continuous improvement cycle instead

Use a Continuous Improvement Loop for Your Career

Most folks in industry know the Plan-Do-Check-Act cycle. It's a simple continuous improvement process. You can use the same approach to run your career.

- Plan: Set goals. Pick the skills you want to build.
- Do: Learn something. Say yes to new projects. Help others.
- Check: Ask for feedback. Look at what's working and what's not.
- Act: Adjust your path. Make changes before you have to.

It doesn't need to be fancy. It just needs to be honest. Once a year, sit down and ask: ***Am I still going in the right direction?*** If not, do something about it.

Make Your Own Luck

People say luck plays a big role in careers and it certainly can. But here's the other truth: luck favors the visible, the ready, and the connected.

That means you can weight the dice in your favor.

- Build real relationships
- Show up—online and in person
- Be prepared when opportunity knocks
- Say yes even if it's not perfect timing

Jim Collins called it "Return on Luck." You can't control when luck hits. But you can control how prepared you are when it does.

What Is a Career, Really?

A career isn't just a job. It's the full course of your working life—how your roles, skills, and choices stack up over time

- A series of connected jobs and experiences
- A pursuit of steady progress in your field
- The long-term story of how you grow and what you build

It's shaped less by luck and more by the decisions you make along the way.

> *"I am not a product of my circumstances. I am a product of my decisions."*
>
> —Stephen Covey

What Happens If You Don't

A comparison between managed (in action) versus unmanaged (inaction).

Tank Car

Long career in service with appropriate corrosion management. A tank car went into service in the 1920s. It was still around in the 1990s; not because it was indestructible, but because people understood the threats, barrier and assurance.

About the photo – Personal photo from a railway museum in Australia https://nrm.org.au/collection/fuel-tank-tc8463/)

Rusted hull of a ship

For a time, everything was going to plan. Then there was a series of events with no management plan. Now it is washed up and corroding away.

About the photo – Photo from Unsplash and should be OK to use under their license https://unsplash.com/photos/brown-ship-on-sea-during-daytime-QiL4uFzIwuc
About the shipwreck - https://en.wikipedia.org/wiki/Dimitrios(shipwreck)

LMost careers don't get the 'train' kind of care. People just assume they'll last. Until they don't.

- Two outcomes usually happen with inaction:
- Best case: You get lucky. Things turn out okay.

More likely: You look back wondering, Where did it go wrong? You can't fix everything. But you can stay involved in your own future.

Final Thought

LCorrosion is natural process. So is career drift. Both can be managed once you recognize the threats, establish proper barriers and routinely evaluate the performance. And both are easier to deal with before things fall apart, i.e. good news is bad news early.

"So visualize your current situation.". Understand your threats. Inspect the damage. Build the barriers. Call a mentor. Update your plan. And don't be afraid to recoat when needed.

Rust never sleeps. Neither should you on your career.

A career isn't just a job. It's the full course of your working life—how your roles, skills, and choices stack up over time.

Think of it as:

- A series of connected jobs and experiences
- A pursuit of steady progress in your field
- The long-term story of how you grow and what you build

It's shaped less by luck and more by the decisions you make along the way.

"I am not a product of my circumstances. I am a product of my decisions." —Stephen Covey

Plan: Set career goals, identify areas for improvement, and plan proactive measures.

Do: Implement your career plan, engage in activities that promote growth, and actively participate in your professional network.
Check: Regularly assess your progress and seek feedback from mentors or colleagues.

Act: Based on the feedback and assessments, take action to adjust your strategies, address weaknesses, and capitalize on strengths.

Beyond the Inspector's Reach: Automation and the Future of NDT

By: Joshua de Monbrun, Ceng
Founder &CEO
SUBSEA NDT &Engineering

In the post-boom landscape of oil and gas, much of the global infrastructure is aging, overstretched, and overdue for reinvention. Decades-old pipelines, refineries built to outdated standards, and inspection routines designed for analog processes are now being pushed beyond their original design limits.. While digital transformation has taken hold in many industries, field inspection has remained stubbornly manual—until now.

Today, robotic inspection technologies and advanced non-destructive testing (NDT) systems are bridging the gap between aging infrastructure and modern reliability expectations. These innovations are not just optimizing workflows; they're extending asset life, improving safety, and enabling predictive maintenance in ways that were simply not feasible a decade ago.

The Inspection Bottleneck

In traditional midstream and upstream operations, inspection remains one of the biggest bottlenecks. Manual techniques like radiography, ultrasonic testing, and visual inspection are time-consuming, labor-intensive, and often dangerous. Inspectors must access elevated platforms, confined spaces, or insulated piping — all of which introduce delays, risks, and cost overruns.

The issue is compounded by an industry culture that has grown increasingly complacent. Many inspection companies have grown comfortable with outdated methods, often guided more by shareholder expectations and quarterly margins than by quality or innovation. The "that's the way we've always done it" mentality still dominates, and as a result, investment in technician training and new technology adoption has lagged behind other sectors. In a business where asset failures can cost millions — or even lives — this resistance to change is no longer tenable.

Enter the Robot: A New Class of Inspectors

Robotic inspection systems are changing that narrative. These aren't science fiction prototypes — they're real-world machines already deployed across refineries, terminals, offshore rigs, and gas transmission lines. Robotic platforms, for instance, can travel along insulated pipelines and perform in-service inspections such as digital radiography or electromagnetic testing without the need to remove insulation or erect scaffolding.

These platforms integrate high-resolution sensors, precise encoder feedback, and wireless data transmission to reduce inspection time and human exposure, while drastically improving coverage and repeatability. Where a rope-access RT crew might inspect 10% of a system over several days, robotic platforms can provide significantly more coverage in a fraction of the time, with less disruption and often while assets remain in operation.

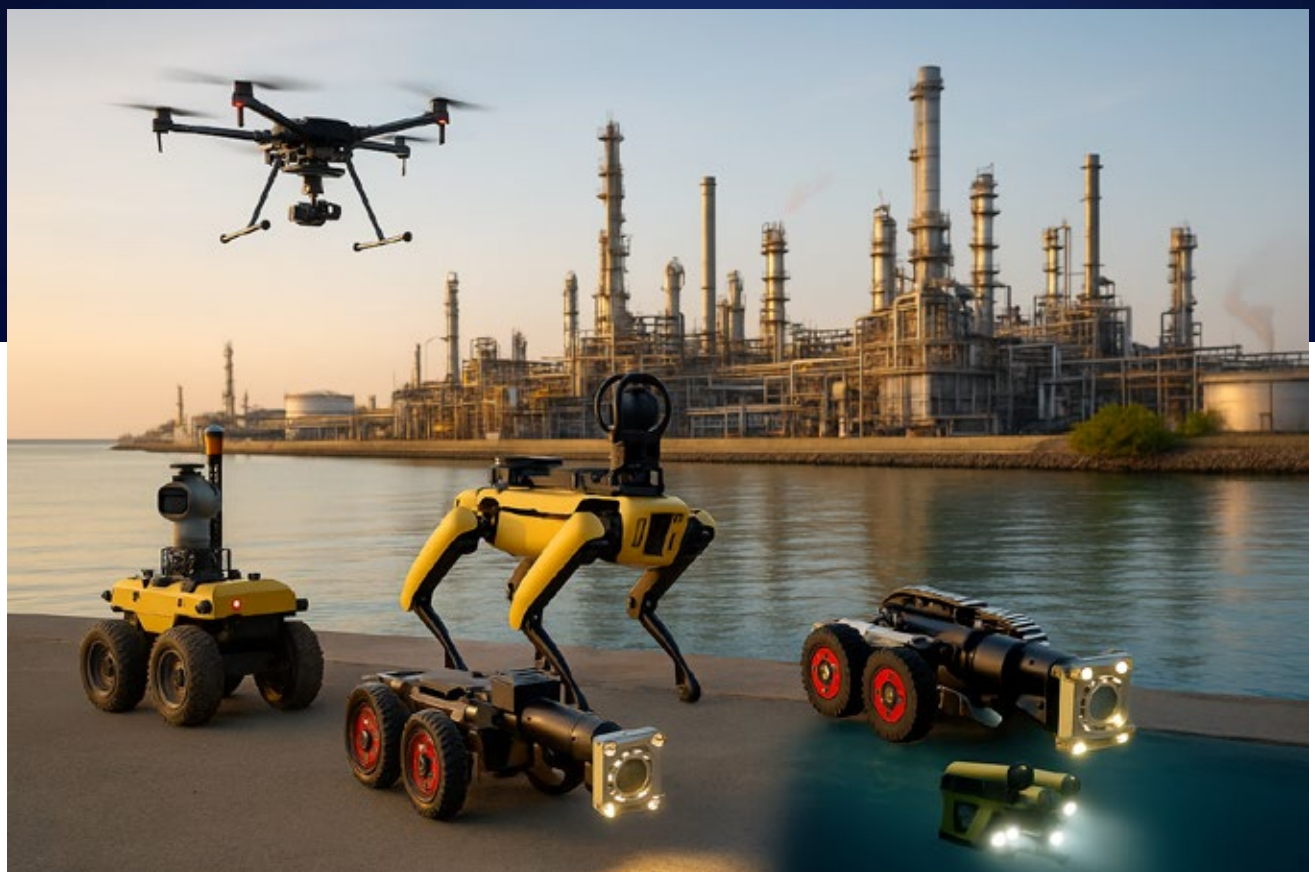
Equally important is consistency. Robotic systems follow defined paths, calibrated speeds, and software-based routines that eliminate the variability introduced by human fatigue or environmental challenges. Over time, this consistency enables more accurate trend analysis, facilitating condition-based maintenance instead of reactive repairs.

The Data Revolution Behind the Machine

The hardware is only half the story. Modern robotic systems are designed with data in mind — capturing inspection images, waveform data, and positional metadata in a way that supports advanced analytics and digital records. Paired with AI-assisted defect recognition, these platforms can now help inspectors prioritize areas of concern, detect small anomalies that might go unnoticed, and flag suspect readings for additional review.

Machine learning models, trained on vast datasets of weld flaws, corrosion signatures, and noise patterns, are enhancing the speed and accuracy of interpretation. This is particularly valuable for facilities with limited NDT personnel or large inspection scopes. The goal is not to replace human inspectors, but to equip them with better tools for faster and more confident decision-making.

This shift from paper reports and isolated scans to a **full digital chain of custody** is a fundamental change in how inspection supports asset integrity. When inspections are repeatable, traceable, and reviewable — and when defect trends can be graphed over time — asset owners can finally move toward predictive maintenance with absolute confidence.



Safer, Faster, and Aligned with ESG
Robotic inspection also supports the industry's ESG goals by reducing the need for high-risk access and minimizing shutdown-related emissions. By reducing manual access (scaffolding, lifts, rope crews), inspection teams can operate with smaller footprints, less exposure to hazardous environments, and reduced travel time.

Furthermore, by enabling real-time data acquisition, robotics can often reduce the duration and frequency of planned shutdowns, helping facilities operate more efficiently. Some digital radiography systems now allow for live inspection in low-dose configurations, making it possible to keep personnel nearby without large radiation exclusion zones.

Applications Across the Energy Spectrum
These technologies are already making an impact in a wide range of environments. In petrochemical facilities, robotic tools are navigating complex piping networks to inspect for corrosion under insulation (CUI). Robotic platforms are traveling hundreds of feet along elevated pipelines — often without disturbing cladding or insulation. They are even being deployed in hazardous conditions where human access is impractical or unsafe.

Even in the renewable and transitional energy sectors — including hydrogen, ammonia, and carbon capture — robotic and advanced NDT technologies are assuming critical new roles. From drones surveying elevated tanks and flare stacks to ROVs inspecting subsea pipelines and offshore infrastructure, these tools provide safe, efficient access to assets that were once difficult or dangerous to inspect. The ability to assess these assets without intrusive methods is accelerating the safe deployment of next-generation energy systems.

The Future Is Autonomous, But Not Disconnected
As the industry modernizes, inspection will become increasingly autonomous — but the human element will remain critical. Robots and AI are powerful tools, but it's the experience of qualified NDT personnel that ensures safe interpretation and meaningful outcomes.

The real opportunity lies in hybrid systems — where automated platforms collect high-fidelity data, AI accelerates analysis and reporting, and humans make the final determinations. This model allows experienced personnel to focus on critical thinking and decision-making, rather than repetitive data collection.

In an industry known for inertia and legacy thinking, robotic NDT represents a rare convergence of innovation, safety, and operational efficiency. And in a world where the margin for error is shrinking, adopting these tools isn't a luxury — it's a necessity.

From the Stars to the Sea: My Journey Through NDT

By: Eddie C. Pompa, ASNT Level III (#107661), Responsible Level III – Astrion, NDT Professor – Lone Star College, NDT Advocate – 4 Point NDT

The field of Non-Destructive Testing (NDT) is one of the few professions that blends science, engineering, hands-on problem solving, and global opportunity. It's a career path that, for many—including myself—begins in one place and leads to destinations never imagined. My journey through NDT has taken me from manufacturing and inspecting spaceflight hardware for NASA to working in the high-stakes world of oil and gas—often in environments as unforgiving as outer space. And while the industries and standards differ, one thing remains the same: the responsibility of the inspector is vital to human safety, environmental protection, and equipment reliability.

I began my career as a machinist with moderate skills and even more modest expectations. Growing up in a middle-class family, I never imagined that one day I would be working in aerospace or traveling across the country inspecting mission-critical components. I found employment with Lockheed Martin under the Engineering Contract at NASA's Johnson Space Center (JSC), where I initially produced Probability of Detection (POD) samples for the Non-Destructive Evaluation (NDE) Special Projects Program. The work was rewarding but routine—until one Monday morning, I was offered a chance that would change everything.

The program manager asked if I wanted to sit in on an Eddy Current training session being held in our lab. The condition was simple: if a machining job came in, it would take priority, and I'd have to leave the class. I quickly agreed, not realizing at the time that this decision would mark the beginning of a life-changing career. That training was my first step into the world of NDT—a field that would come to define my professional identity and provide a passport to experiences I had only seen in comics and documentaries.

As I immersed myself in NDT, I realized how broad and technically diverse the field truly is. It encompasses numerous inspection methods—Ultrasonic Testing (UT), Radiography Testing (RT), Eddy Current Testing (ECT), Magnetic Particle (MT), Liquid Penetrant (PT), and more—each with its own purpose and complexities. But beyond the technology, it was the application of these tools across industries that truly opened my eyes.

Transitioning from the inspection of aerospace hardware to that of oilfield equipment was an illuminating experience. In aerospace, especially with man-rated hardware, the stakes are extraordinarily high. Materials are often lightweight, high-strength alloys designed for maximum performance under minimal tolerances. Flaws as small as 0.025 inches (0.635 mm) can be unacceptable due to the critical nature of the application. Everything is calculated with an abundance of caution. The flaw detection process for such parts is rigorous, including probability of detection studies at a 90/95 confidence level and mandatory practical testing to ensure the inspector can consistently identify defects at or below these thresholds.

Conversely, oil and gas components are typically much larger and thicker. Drill pipe, risers, wellheads, and pressure control equipment may not carry astronauts, but they do operate under extreme pressures and environmental hazards. While the flaw sizes accepted in oil and gas are sometimes larger due to structural redundancy and design margins, failure in these systems can be catastrophic—particularly in offshore environments where repair is complex, and environmental risks are high.

Despite the differences in material, function, and risk, both industries rely heavily on NDT to ensure safety and reliability. As technologies continue to evolve, we are seeing significant crossover. The commercialization of space has created new demand for quality inspectors with experience in both aerospace and energy. Likewise, advanced inspection methods like Phased Array Ultrasonic Testing (PAUT), Digital Radiography (DR), and Computed Tomography (CT)—long used in the aerospace sector—are being adopted in the oilfield to improve detection accuracy and data traceability.

Another major point of differentiation between the two industries lies in personnel certification and standardization. Aerospace technicians are typically qualified under NAS-410, which includes stringent requirements for classroom training, on-the-job experience, and documented performance. This standard reflects the critical nature of flight hardware, where even minor lapses can endanger lives.

In contrast, oil and gas technicians are most often certified under ASNT SNT-TC-1A or ANSI/ASNT CP-189. These standards allow more flexibility, particularly when programs are employer-based. Though not inherently less rigorous,

they place greater responsibility on the employer to define training, testing, and recertification criteria.

Additionally, inspection parameters differ significantly. In oil and gas, gamma radiography is more common due to its ability to penetrate thick-walled materials in the field, while visible (Type II) dye penetrants are often preferred over fluorescent for surface crack detection. Ultrasonic inspections frequently involve the use of specific shear wave angles tailored to weld geometry and thickness. In aerospace, inspections are more likely to involve fluorescent penetrants, micro-focused x-ray systems, and ultrasonic methods designed for thin, intricate geometries.

Navigating the wide variety of applicable standards and customer-specific requirements has been one of the most challenging—and educational—parts of my career. In oil and gas, the American Petroleum Institute (API) sets the foundation for equipment design and inspection, with standards like API 5CT, API 6A, and others guiding the testing of drill pipe, wellheads, and pressure control equipment. These often reference or integrate the ASME Boiler and Pressure Vessel Code, Section V, which remains the universal backbone for NDT procedures across industries.

In aerospace and spaceflight, specifications are often military in origin or issued by NASA. Man-rated and fracture-critical hardware must meet additional levels of scrutiny, including specialized flaw size detection thresholds and the mandatory use of POD trials. The intersection of NASA standards and ASME codes ensures technical consistency, but the documentation, audits, and reviews in aerospace remain on a level of their own.

Perhaps what's most rewarding is the shared reliance on the inspector. No matter the industry, technology, or standard, it is ultimately the skill, integrity, and professionalism of the NDT technician that ensures flaws are properly detected, evaluated, and documented. That responsibility has taken me from cleanrooms to rig decks, from ultrasonic scans of spaceflight tubing to shear wave inspections of subsea welds.

Today, I have the honor of serving not only as the Responsible Level III at **Astrion**, but also as an **NDT Professor at Lone Star College** and an **NDT Advocate with 4 Point NDT**. Sharing my experiences with students and professionals alike allows me to give back to a profession that gave me purpose and opportunity. Whether I'm helping to train the next generation of inspectors or advocating for higher standards across industries, I remain driven by the belief that NDT is a cornerstone of modern safety and engineering integrity.

From the stars to the sea, my NDT journey has been one of growth, challenge, and discovery—and it's far from over.

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Cadmium Coating on Welds: Advanced Corrosion Protection Through Controlled Application and Inspection

By:Jorge T. Reyna:
ASNT NDT Level III/ AWS SCWI / AMPP PCS &. MCI/ ACI field inspector/ Instructor

I'll admit it—when I first heard the word *cadmizing*, it didn't really catch my attention. It sounded like one of those lab-based techniques that rarely make it to the field. But all it takes is one look at a threaded connection on a landing gear or a structural element exposed on an offshore platform to understand why this coating is still relevant—even in a world where environmental awareness is reshaping traditional methods. Today, I want to walk you through how this surface treatment, when applied and inspected properly on welds, becomes a true armor against corrosion.

Can cadmium be applied on welds?

Yes, and not only **can** it be done—in many cases, it **should**. Welds, as we know in the inspection world, are high-energy zones with complex microstructures and a natural vulnerability to corrosion, especially in coastal, industrial, or aerospace environments. The key is to understand that applying cadmium over a weld isn't just about coating it— it's about **protecting it intelligently**, with respect for its metallurgical properties and assurance that no surface defects will interfere with adhesion.

Standards like **AMS-QQ-P-416** (formerly MIL-QQ-P-416) and **ASTM B766** explicitly allow cadmium plating on welded surfaces, as long as strict process controls are in place. This is not a job for amateurs.

And while the **aerospace industry** has begun restricting cadmium in certain applications due to environmental and toxicity concerns, the truth is that in **critical components**—like aircraft fasteners or galvanized interfaces—it remains the gold standard. Why? Because it **works**, and when failure isn't an option, cadmium is still trusted.

How is cadmium applied?

There are three main methods, and each has its strengths:

1. **Electroplating (Galvanic Cadmizing)**: The most common and precise technique. A layer of cadmium is deposited using electric current in a chemical bath. Thickness is tightly controlled (typically **5 to 25 microns**), and finishes may include clear or yellow chromates.
   - **Standard:** *AMS-QQ-P-416 Type I (as-plated), Type II (clear chromate), Type III (yellow chromate).*
2. **Diffusion Coating:** The component is covered in cadmium powder and heat treated at **300°C to 450°C**, allowing the cadmium to penetrate the metal surface. This is ideal for complex geometries like **weld roots** or inner fillet joints.
   - **Standard:** *ASTM A1059, ISO 9588.*
3. **Thermal Spraying:** Less common, but used for large surfaces or field repairs. The cadmium is melted and sprayed onto the substrate with a thermal spray gun.

Regardless of the method, **surface preparation is everything.** You can't apply cadmium on a weld that's poorly cleaned or has slag residue. Abrasive blasting (with alumina or non-ferrous media), chemical degreasing, or even vibratory cleaning are essential. And in the case of welds, I always recommend **pre-inspection using liquid penetrant (ASTM E165) or radiographic testing (ASTM E1742)** to rule out any cracks or porosity before coating.

What do we inspect after cadmium application?

Once applied, **the job isn't over.** Inspection is critical to ensuring long-term performance. I break it down into three essential stages:

1. **Visual Inspection:** First, observe. Look for uniformity, proper color, absence of flaking or uncovered areas. Good lighting and a trained eye go a long way.
2. **Thickness Measurement:** We use non-destructive methods like **eddy current (ASTM B499)** or magnetic pull-off techniques such as **ASTM B530**.
3. **Adhesion Testing:** A good coating is useless if it peels off. **Cross-cut tape testing (ASTM D3359)** or high-adhesion tape methods give us peace of mind.

For critical components—like fasteners for aircraft or subsea connectors—I recommend going further: **salt spray testing (ASTM B117)** or **porosity analysis using electron microscopy** can make the difference between a safe part and a vulnerable one.

So, what's the point of cadmium coating on welds?

Welds aren't innocent. Thermodynamically, they're altered zones, often with microstructures ranging from austenite to martensite, depending on the material and welding process. And when you're dealing with **dissimilar metals** (say, stainless steel to carbon steel), **galvanic risk shoots up.** That's where cadmium steps in as a shield: **it acts as a sacrificial anode,** protecting the base metal even when the coating is slightly damaged.
It also offers **natural lubricity**, which makes it great for threaded components, and **moderate abrasion resistance,** extending the life of bolts, studs, and other elements exposed to harsh conditions.

In my experience, cadmium coating isn't just another surface treatment—it's a **silent ally** in the battle against corrosion. When paired with good welding, proper surface prep, and rigorous inspection, it can extend a component's life by **years.**

Is it worth it? Absolutely. Does it require technical knowledge and commitment? Without question. But those of us in the inspection world know that what we protect today prevents failures tomorrow. And cadmium, when done right, protects—and protects **well.**

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Investing in Climate Resilience & Extreme Technologies

By: ENZO DI TARANTO - President, XZEN Technologies Inc. (USA)

Global warming, rising sea levels, and the intensification of extreme weather events are no longer distant threats, but sad realities. While Impact Investing and mitigation efforts have been increasing in recent years, adaptation remains chronically under-financed. Fortunately, both, governments and private investors, today, better understand the strategic importance and profitability of investing in adaptation solutions, for instance through capacity-building programs and climate-tech solutions

For instance, in a country like India - with a large population, growing economy and significant climate vulnerabilities - mitigation investments have surged significantly, raising nearly USD 4.7 billion in 2023 alone. Yet, adaptation financing remains woefully short, with only USD 899 million deployed to date across all resilience sectors, thereby presenting an excellent opportunity for investors in India and worldwide.

Framing the Investors' Dilemma

Adaptation defies simple categorization: it spans from agricultural inputs, to engineered infrastructure, technology platforms and insurance products. Unlike carbon credit projects - where tonnage calculations can provide clear quantitative valuation - adaptation investments require bespoke metrics that capture avoided damages, enhanced productivity and strengthened community resilience.

Yet, the macroeconomic rationale is powerful: the United Nations Environment Programme (UNEP) estimates that trillions of dollars will be needed each year by 2030 to build climate resilient systems. The business opportunity for both investors and entrepreneurs is vast.

Consider that heat stress alone reduces labor productivity in key manufacturing hubs. Furthermore, crop failure threatens one third of global caloric supply; and that water scarcity undermines urban growth trajectories, also fostering inter-state and inter-community conflicts worldwide, from Ethiopia, Egypt and Sudan, to Dominican Republic and Haiti. Each of these challenges demands market ready innovations capable of delivering both resilience and revenue in the short-term and medium terms.

Navigating the Adaptation Opportunity

To translate opportunity into action, investors can apply a simple four-pillar decision framework that screens prospective solutions by:

- Alignment to climate risks (e.g. heatwaves, floods);
- Degree of sensitivity reduction (protecting people, assets or ecosystems);
- Point of intervention (early warning systems versus response & recovery);
- Enterprise profile (start-up versus established operator)

This structured approach helps prioritize segments with both high impact and clear value-chain propositions where revenues derive directly from resilience outcomes

High-Potential Adaptation Themes

Based on market size, technology readiness and policy support, the following areas stand out:

- Sustainable Food Systems

Erratic weather patterns and water stress already threaten global crop yields. Investable models include climate-smart seeds, precision irrigation platforms, and decentralized cold-chain networks that minimize post-harvest losses..

- Sustainable Cooling Solutions

Rising temperatures are driving demand for cooling that does not exacerbate energy strain. Off-grid and district cooling technologies—ranging from leased "cooling as a service" offerings to solar-driven cold storage—represent attractive, growth-oriented propositions.

- Access to Water

With freshwater sources under pressure worldwide, decentralized purification units, wastewater recycling systems, and cutting-edge atmospheric water generation are moving toward commercial scale, offering both social and financial returns.

- Adaptive Built Infrastructure

From modular housing for climate migrants to storm-resilient transport corridors, innovative materials, prefabrication techniques, and even on-site 3D construction can accelerate resilient development while optimizing costs.

- Data, Analytics & Resilience Finance
Early warning systems, parametric insurance and resilience-intelligence platforms are emerging as critical tools. They empower governments, corporates and communities to plan and respond, unlocking new revenue streams for technology providers.

Mobilizing Capital and Partnerships

Development finance institutions – like the World Bank and Inter-American Development Bank - have led the way in pioneering early adaptation deals. The next wave of growth, however, will be driven by strategic corporate investors seeking to hedge physical-asset risks. Acting as both equity partners and anchor customers, impact investors can validate innovative solutions, and accelerate both scale and profit.

The emergence of adaptation-focused investment vehicles—structured similarly to thematic private-equity funds - can catalyze capital flows into nascent segments. By combining concessional grant capital with risk-sharing mechanisms, these vehicles reduce downside exposure for commercial investors, enabling larger-ticket investments over time.

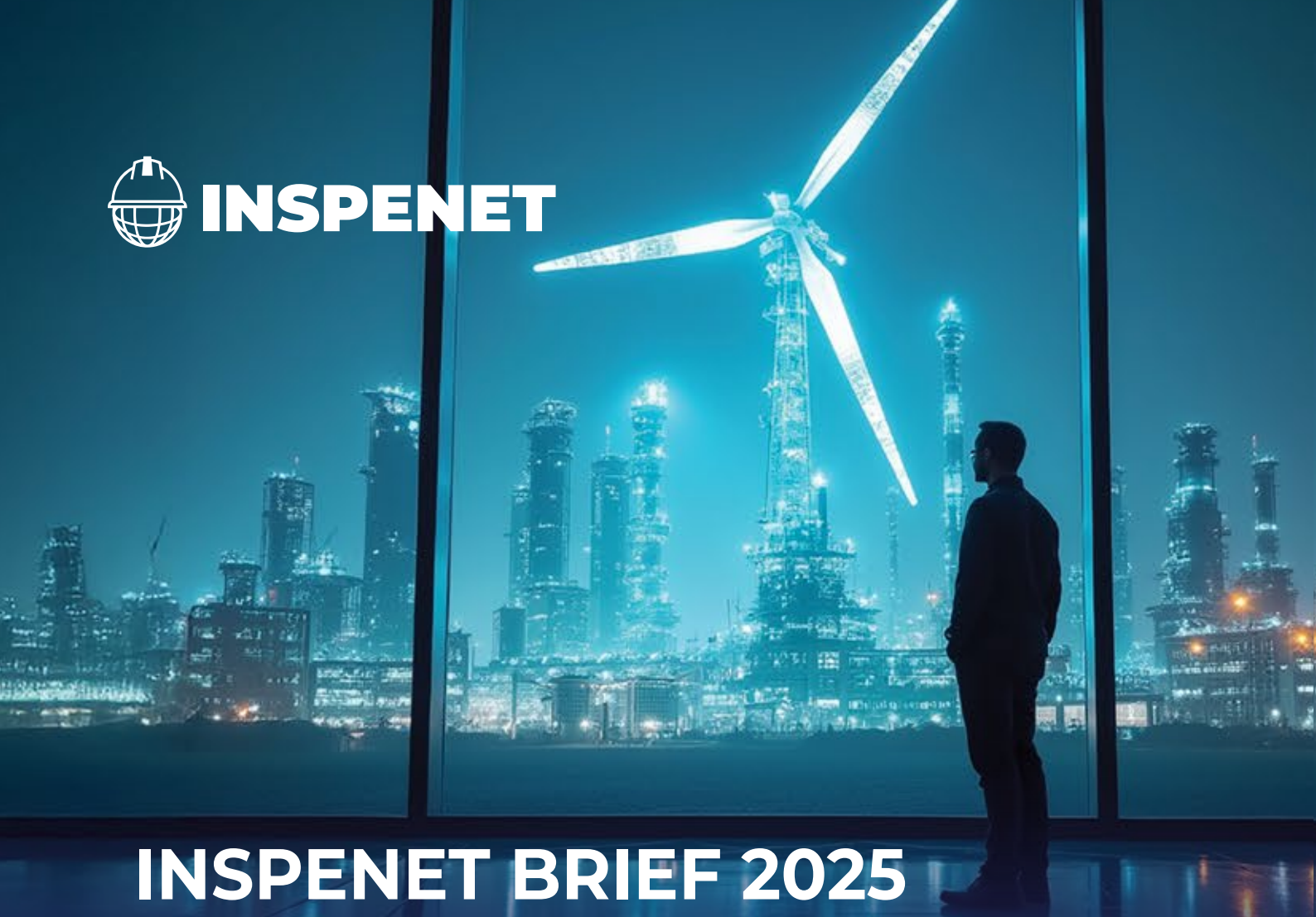
Furthermore, innovative "bundling" of adaptation with mitigation strategies - such as pairing ecosystem restoration (which delivers carbon sequestration) with community flood defenses -can unlock diversified revenue streams, and align resilience objectives with existing carbon-market incentives.

Conclusions

Adaptation Finance represents a pivotal yet underserved segment of the broader Climate Finance market. By applying a disciplined decision framework, investors can identify ventures poised for both resilience impact and commercial success. Focusing on five core themes, structuring blended capital instruments, engaging strategic corporate partners and bundling adaptation with mitigation can accelerate the flow of private capital into solutions that safeguard lives, livelihoods and long term value.

In a hotter, more volatile world, adaptation is both an imperative and a frontier of innovation, one where astute investors can generate sustainable returns while building a more resilient future.

If you need specialized climate finance and/or impact investing advisory, please email founder@xzen.tv



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