ARIX®
ANALYTICS | ROBOTICS | INSPECTION

CUI Detection: Strategies and Technologies for Effective Corrosion Control

Dear Asset & Inspection Managers,

A significant part of your role involves corrosion control, which includes developing mitigation strategies based on data collection, anomaly detection, and continuous learning. The data you collect is essential for risk assessment and serves as a decision support tool. Corrosion Under Insulation (CUI) detection typically relies on a few major methods: stripping insulation for visual inspection, Real-Time Radiography (RTR), and Pulsed Eddy Current (PEC). While strip and examine is an effective method, we all know that in the real world, cost and time constraints often limit its feasibility. That's why RTR and PEC are more commonly chosen.

At ARIX Technologies, we're not here to change these proven methods. We rely on industry-established and trusted methods from our technology sensor partners. However, we have revolutionized how data is collected and how decisions are supported.

We've designed and field-tested an in-house robotic system that removes personnel from hazardous environments and performs inspections semi-autonomously. This means safer and faster data collection with enhanced accuracy. Additionally, our robotic crawler uses an autonomous grid scanning function to provide full 360° coverage inspections, reducing the incomplete data and inaccuracies often seen with manual inspections.

For decision support, we've built an digital Inspection Portal from the ground up. This portal integrates diverse data sources—including video feeds, RTR footage, and PEC data—into a seamless 3D model, providing you with a clearer and more comprehensive view of your assets. **With these tools, you're not just collecting data—you're gaining the actionable insights needed to make smarter, more informed decisions.**

Trust ARIX Technologies to empower your business with innovative inspection technologies that enhance safety, integrity, and sustainability-today, tomorrow, and for the life of your assets.

To smarter inspections,

Jeff Johnson
Sr. Field Technician
ARIX Technologies

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Introduction

Corrosion Under Insulation (CUI): The Industry's Unseen Crisis

Corrosion, or rust, is a ubiquitous and unavoidable problem that spans countries and industries. The US Department of Transportation estimated in 2002 that the total direct cost of corrosion in the country is $276 billion—approximately 3.1% of the nation's Gross Domestic Product (GDP) (Koch et al., 2002). Most updated estimations set these costs to $2.5 trillion (equivalent to 3-4% of the global GDP) (Koch et al., 2016; Koch, 2017).

Corrosion, if left unmanaged, can result in catastrophic safety, economic, and environmental incidents. Current manual methods are expensive, slow, and often struggle to collect comprehensive data that field engineers require to make informed decisions.

Corrosion is the most severe threat to refineries, as it causes disruptions in refinery operations, such as unplanned shutdowns, leaks, and product loss. (Obot et al.,2019).

Major oil companies utilize industry guidelines and well-managed operational excellence programs such as Risk-Based Inspection to prevent these catastrophes. Although these programs aim to mitigate corrosion risks and prioritize safety through pipe inspections and risk-based maintenance programs, the existing pipe inspection technology these oil majors use still leaves refineries susceptible to undetected corrosion.

CUI Inspection: Framing and Challenges

If not properly monitored and controlled, pipe thinning can result in leaks or pipe ruptures, resulting in unexpected and expensive downtime, environmental damage, or dangerous safety incidents. Most direct costs typically do not include individual safety or environmental consequences, minor incidents, forced shutdowns, and unplanned maintenance emergency actions. Major oil companies utilize industry guidelines and well-managed operational excellence programs such as risk-based Inspection to prevent these catastrophes. Although these programs aim to mitigate corrosion risks and prioritize safety through pipe inspections and risk-based maintenance programs, the existing pipe inspection technology these oil majors use still leaves refineries susceptible to undetected corrosion.

Unaddressed Needs

- Corrosion on industrial pipes causes unplanned downtime and critical safety/operational issues, leading to financial and downstream impacts on their customers/consumers.
- Current inspections are expensive, very manual, and require much coordination between various parties (3rd party manual inspectors, scaffold companies, insulation removal companies, etc.). Inspection results are also not digitalized, are sparse, and are not always trustworthy.
- Reliability and Corrosion engineers currently work off incomplete and unreliable data to make asset integrity decisions on when to repair or replace piping or have an emergency shut down to prevent disasters.

CUI Inspection: Framing and Challenges cont.

Current inspection processes are labor-intensive, costly, and require coordination between third-party inspectors, scaffold teams, and insulation removal crews. These methods often yield limited and unreliable data due to the inherent risks and inefficiencies of manual inspections. Personnel must access pipes using rope or scaffolding, relying on hand-held probes prone to human error.

Engineers and inspectors are often forced to make critical decisions—like when to repair or replace piping or shut down operations—based on sparse and incomplete data. With inspections providing as few as five data points per 1,000 feet of piping, significant blind spots are inevitable, leading to potential oversights. The data, typically stored in simple formats like Excel, is analyzed using basic methods that fail to capture the complexities needed for more informed decisions.

Operations managers, balancing 24/7 workflows, must navigate these blind spots with incomplete information, often without knowing the full extent of the risks. Most inspection data never makes it into a centralized system and instead resides in siloed spreadsheets on individual laptops. This lack of accessible, comprehensive data only heightens the risks, leading to costly decisions that impact safety, operations, and long-term asset integrity.

Corrosion Under Insulation (CUI) Inspection Methodology Guide

Inspection Method	Advantages	Disadvantages
Visual (VT)	• Efficient Detection of CUI • Non-Intrusive Inspection technique. • Time and Cost Savings • Qualitative Inspection • Real-time Monitoring • Immediate validation of results	• Surface visibility limitations due to insulation thickness, coating conditions, or environmental factors. • Requires stripping of all insulation. • Interpreting visual data is subjective and heavily dependent on the inspector's experience and expertise. • Extensive staging or scaffolding may be required. • Slow and has the potential to miss critical locations. • Expensive where hazardous materials are present. • Limited depth assessment • Adverse environmental conditions such as poor lighting and extreme temperatures may hinder the effectiveness of VT.
Conventional Radiography (RT)	• Qualitative and quantitative thickness measurements using radiographic images. • Outer Diameter and Inner Diameter conditions. • Penetrative Capability as no insulation removal is required. • Comprehensive coverage – can cover large areas in a single exposure. • Proven Technology has a long history of successful applications.	• Radiation exposure as the use of ionizing radiation poses potential health risks to inspectors. • Complexity with setup and Setup time requires skilled personnel. • Longer exposure times • Limited Surface detail • Accuracy ± 10% • Film processing is required, leading to delayed results. • Environmental issues with chemicals • Archival restrictions and allow no image adjustments. • Higher upfront costs of acquiring and maintaining radiographic equipment.

QUESTIONS ABOUT THESE METHODS?
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Corrosion Under Insulation (CUI) Inspection Methodology Guide

Computed Digital Radiography (CR/DR)	• Reduced radiation exposure • Qualitative and Quantitative accurate measurement. • Enhanced Image Quality • Immediate Image Availability • No insulation removal is required. • Software image enhancement • Electronic media and Digital storage and retrieval.	• Higher initial Equipment costs • Covers limited area. • Requires direct access to the inspection area. • Cost control is based on access and production rate. • Training requirements for personnel. • Environmental Sensitivities impacting equipment. • Radiation hazards • Limited portability of DR Equipment • Imaging plate care is required.
 **Real-Time Radiography (RTR)**	• Identifies OD Conditions • Fast and immediate results • Dynamic Inspection • Reduced radiation exposure times. • Enhanced portability of equipment. • No insulation removal	• Pipes that run close together and complex pipe shapes can limit inspections. • Work takes longer in confined pipe areas. • The inspection unit is difficult to maneuver in small areas. • Equipment complexity requiring skilled operators. • Limited resolution compared to static radiographic methods. • The initial cost of Equipment can be substantial. • Environmental constraints – sensitive to environmental conditions.
Guided Wave	• Long-range Inspection - Rapid Inspection of long lengths of pipe (1500 – 3500 ft/day) • Minimal Surface preparation • 100% volumetric coverage • Limited insulation removal for inspection • Accurate location of pipe features and corrosion. • Remote inspection capability. • Continuous monitoring. • Semi-qualitative analysis of wall loss. • Temperature range to 550 deg F.	• Identifies and categorizes potential issues. • Limited sensitivity • Complex data analysis • Effectiveness can be influenced by material dependency. • Anomalies need confirmation through additional inspection methods. • Pipe shape and layout can limit inspection coverage. • Initial setup and calibration can be complex.

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Corrosion Under Insulation (CUI) Inspection Methodology Guide

Magnetic Flux Leakage (MFL) Inline Inspection (ILI)	• High Sensitivity to corrosion • Can be used on all ferromagnetic materials. • Highly portable • Rapid-speed inspection • Detects gradual wall loss and subsurface cracks. By providing quantitative thickness measurements. • Distinguish between internal and external defects. • Highly versatile • Data Integrity • Minimal disruption.	• Pipelines must be stopped and cleaned before inspection. • Limited to Ferrous Materials • Characterizes defects without exact measurements. • Surface preparation is required. • Limitation in detecting minor defects; like axial cracks. • Can introduce additional safety hazards during operations. • Results often require confirmation using alternative NDT techniques. • Challenges in complex geometry. • Complex data analysis • Cost Considerations
Automated Radiography	• Utilizes digital imaging with rapid inspection results. • Consistent Image Quality • Enhanced safety • No insulation/coating removal is required. • Small exclusion zones. • Increased Efficiency. • Digital Data management.	• Higher upfront costs for Equipment • Requires data storage space. • Additional training is required to operate equipment. • Complexities in initial setup. • Limited flexibility in complex Geometry. • Dependency on power sources.
Pulsed Eddy Current (PEC)	• Detects very small surface defects. • Identifies issues through multiple layers. • Quick, simple, and reliable for regular testing. • Measures material conductivity and nonconductive coatings. • Portable and easy to carry. • Supports automated inspection. • Contactless inspection method.	• Sensitive to changes in magnetic permeability. • Limited to conductive materials. • Cannot detect parallel surface defects. • Requires careful signal interpretation. • Challenging for large areas and complex geometries.

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Technology Designed to Transform CUI Inspections

The previous sections outlined the pros and cons of traditional and advanced NDT techniques, demonstrating how you can detect CUI while maintaining uptime, preserving insulation, and reducing costs. Now, discover how ARIX's leading-edge NDT robot revolutionizes CUI detection, making inspections more economical, efficient, and safer for your integrity management team.

VENUS: A Groundbreaking Non-Invasive Solution for CUI Inspection

The ARIX robot can perform pipe inspections safely and remotely while providing more data that tangibly enhances asset management, operational strategy, and risk mitigation at refineries, which may prevent catastrophic industrial accidents.

ARIX's inspection technology creates significant footprints servicing pipe assets across industries. The technology and experiences can inform and be integrated with other technologies and innovations to enable old assets to move towards digitally advanced (smart) infrastructure to improve decision-making and progress towards end-to-end innovative management of industrial and societal infrastructure and, thus, a safer world.

VENUS: Transforming CUI Detection

VENUS captures high-resolution digital images during pipeline inspections, allowing operators to simultaneously review inspection video and analyze PEC (pulsed eddy current) data. This integrated approach accelerates data collection, processing, and analysis, providing a more efficient and comprehensive inspection process.

ARIX Technologies revolutionizes pipe inspections with robots like VENUS, designed to reduce the need for scaffolding and rope crews, ensuring faster, safer, and more cost-effective inspections. By removing humans from hazardous heights and allowing for ground-based control, ARIX robots continuously gather reliable data, offering industrial facilities an accurate, comprehensive 360° view of asset health. **This technology not only prevents costly leaks and shutdowns but also integrates seamlessly into advanced infrastructure systems, enabling better decision-making through data compilation and analysis.**

Unlike traditional methods, ARIX's robots provide a holistic view of a asset's condition, enabling more accurate financial, operational, and safety decisions. Compared to internal pipe robots (PIGs) and flying drones, ARIX robots excel in environments where other technologies fail, such as "inside the fence" inspections, handling complex piping systems, and delivering consistent data without the safety risks associated with flying or magnetic robots. **ARIX robots have proven to significantly reduce inspection time and costs, offering unparalleled efficiency and reliability in maintaining industrial integrity.**

ARIX Technologies' robots, like VENUS, revolutionize pipe inspections by reducing the need for scaffolding and rope crews, delivering accurate, comprehensive inspection data that enhances decision-making and reduces costs and risks.

Accurate CUI Detection Enables Key Decisions

VENUS can evaluate 85-100% of a pipe while manual inspection methods only cover around 7% in that same timeframe. Operating at speeds that frequently surpass 1000 feet daily in downstream settings, the technology excels as a comprehensive screening solution. This rapid coverage helps operators pinpoint exactly which pipeline areas need closer examination.

Our technology enables integrity and inspection teams to identify specific areas requiring remediation without disturbing insulation on healthy pipe sections. VENUS provides complete visibility of asset integrity without the need for full-line inspections that can exceed budgets or limited sampling that risks overlooking defects. Teams can also implement flexible deployment strategies using VENUS for quick, widespread screening initially, then performing detailed inspections on identified problem areas.

VENUS CUI Screening Benefits

- Disruptive pricing on high-cost lines
- Inspection of difficult-to-access piping
- Elimination of complete pipe insulation removal and reinstallation
- More comprehensive data
- Clear and Robust reporting
- Reduction of humans working from heights

Client Case Study: Petromax Refining

Petromax Refining needed a faster, safer, and more cost-effective way to detect Corrosion Under Insulation (CUI) across its industrial pipe circuits. Traditional inspections—reliant on scaffolding, rope crews, and spot-checking—are costly, slow, and carried significant safety risks.

By partnering with ARIX Technologies, Petromax leveraged robotic CUI inspection, drastically improving efficiency, safety, and data quality. ARIX's leading-edge solution delivered:

- **7x faster inspections (20 days vs. 11 months)**
- **63% cost savings over conventional methods**
- **85%+ full-coverage scans, eliminating blind spots**
- **Near-zero scaffolding requirements, reducing risk**

With ARIX, Petromax achieved comprehensive, high-accuracy inspections while reducing downtime and operational costs—setting a new benchmark for CUI detection.

7x faster **37% cheaper**

than traditional inspection methods

A Trusted Inspection Partner

ARIX's field robotic operations teams bring unparalleled expertise in pipe inspection. With years of industry experience and specialized training, including **ASNT Level II Certified Inspectors and state-certified radiographers**, our teams navigate complex inspection environments, identify potential issues, and provide accurate data. **Adhering to a zero-incident safety culture**, we ensure reliable, efficient, and precise field inspections, guaranteeing **quality, speed, and cost-effectiveness** for all your projects.

Our tailored inspection plans begin with a comprehensive consultation and are executed by highly skilled teams, ensuring adherence to safety protocols and budget constraints.

We provide preliminary results on-site and deliver final reports within 48 hours, ensuring efficiency and accuracy from start to finish.

We deliver exceptional customer service and professionalism throughout the entire inspection process.

Explore additional resources that will help you identify CUI more rapidly and cost-effectively than ever before.

ARIX Technologies' Inspection Services

ARIX Technologies Services Flyer

Full CUI Client Case Study

ARIX Technologies Website

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ARIX Technologies Services Flyer

Full CUI Client Case Study

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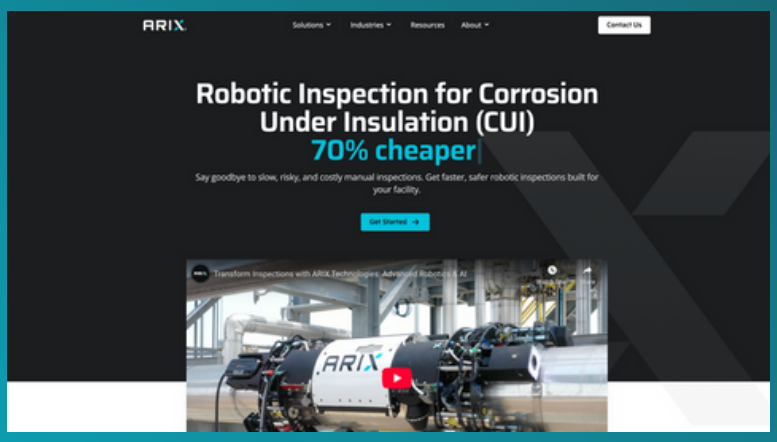

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ARIX Technologies was built by industry veterans and robotics innovators to solve real-world inspection challenges with leading-edge technology. Our mission is to transform inspection and maintenance programs through advanced robotics and AI-powered analytics, enhancing safety, integrity, and sustainability.

We build, own, and operate robotic inspection systems that eliminate guesswork, reduce costs, and minimize risk for industrial asset owners. By replacing slow, costly, and hazardous manual methods, ARIX empowers businesses with data-driven insights that secure the future of critical infrastructure.

Trust ARIX to deliver innovation that works—today, tomorrow, and for the life of your assets.

Discover more at arixtech.com

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