VOLVER

INNOVATIVE ROBOTIC AND FREE-SWIMMING ILI SOLUTIONS FOR TANK LINE INSPECTION CHALLENGES

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1. Abstract

Tank lines are critical conduits between feeder pipelines and tank farms, connecting individual storage tanks to centralized manifolds. Unlike feeder lines, which are routinely inspected using In-line Inspection (ILI) tools, tank lines have traditionally been considered unpiggable due to a combination of structural and operational constraints, such as limited accessibility, complex geometries, and insufficient flow conditions. Primary integrity threats include bottom-of-the-line corrosion and sediment accumulation, both of which can cause localized wall loss and operational inefficiencies.

This paper presents a technical evaluation of inspection strategies developed to overcome these challenges, based on multiple field deployments. Using a project case example, it highlights the use of free-swimming cleaning pigs and ILI tools engineered to navigate non-standard features such as tight-radius bends, back-to-back configurations, and unbarred full-bore offtakes. Where hydraulic propulsion was not feasible due to low or no flow, tethered robotic inspection tools were deployed to achieve full pipeline coverage.

A combination of inspection technologies was utilized, including Ultrasonic Testing (UT) for high-resolution wall thickness measurement, Magnetic Flux Leakage (MFL) for internal and external metal loss detection, and geometry tools for identifying dents, ovalities, and other deformations. These systems were paired with tailored propulsion methods, ranging from low-flow free-swimming to fully robotic systems to accommodate the unique operational profiles of tank lines.

The paper emphasizes a modular, technology-agnostic approach to tank line inspection, allowing flexible deployment strategies tailored to specific pipeline conditions. Results demonstrate that comprehensive integrity assessments are achievable even in lines previously deemed inaccessible, supporting enhanced risk management, regulatory compliance, and asset longevity across tank farm infrastructure.

2. Nomenclature

Abbreviation	Description
API	American Petroleum Institute
BOLC	Bottom-of-the-Line Corrosion
FAT	Factory Acceptance Testing
FFP	Fitness-for-Purpose
ILI	In-Line Inspection
IMU	Inertial Measurement Unit
MFL	Magnetic Flux Leakage
MFL-A	Magnetic Flux Leakage – Axial

MIC	Microbiologically Influenced Corrosion
P&ID	Piping and Instrumentation Diagram
POI	Probability of Identification
POD	Probability of Detection
POF	Pipeline Operator Forum
RCP	Reversed Cleaning Pig
RLA	Remaining Life Assessment
SAT	Site Acceptance Testing
TAM	Tool Approach Monitoring
TOFD	Time-of-Flight Diffraction
UDC	Under Deposit Corrosion
UT	Ultrasonic Testing

3. Introduction

Tank lines form the critical link between individual storage tanks and central manifolds, enabling the transfer of crude oil and refined products within tank farms. While these lines appear straightforward on a plot plan, their inspection presents significant technical challenges. Unlike mainline pipelines, tank lines often lack permanent launchers and receivers, incorporate tight-radius bends arranged back-to-back, and feature unbarred full-bore offtakes.

Figure 1: Oil storage in a harbor terminal

These geometric constraints severely limit the negotiability of conventional in-line inspection (ILI) tools. Furthermore, tank-line hydraulics are highly unfavorable: flow occurs irregularly, pressure and flow velocity remains low, and operational conditions vary widely. For decades, these factors led operators to classify tank lines as "unpiggable," deferring internal assessments and relying on indirect integrity evaluations. The complexity extends beyond geometry and hydraulics. Integrity threats in tank lines are well documented yet difficult to quantify without direct inspection. Bottom-of-the-line corrosion (BOLC) is the most prevalent mechanism, occurring where water and solids accumulate at the lowest point inside the pipe.

Under-deposit corrosion (UDC) and microbiologically influenced corrosion (MIC) further exacerbate wall loss in stagnant zones. Sediment accumulation compounds these risks by altering flow profiles, increasing differential pressure during cleaning, and creating potential blockages near manifolds. Internal coatings, such as epoxy, introduce additional considerations: aggressive cleaning or poorly controlled tool passage can damage internally applied coatings, while residual debris may shield corrosion from sensors, reducing detection confidence.

These challenges demand a departure from conventional pigging practices. Inspection planning for tank lines must integrate enabling works, hydraulic modeling, and technology selection into a cohesive strategy. Temporary infrastructures, such as removable spools, goose-neck assemblies, and oversize barrels, must be engineered to provide safe tool insertion and retrieval. Artificial hydraulic propulsion requires external pumping systems capable of delivering controlled velocities without inducing pressure excursions. Where flow cannot be established, tethered robotic ILI becomes essential, offering deterministic movement and real-time data acquisition.

Figure 2: Bi-directional free-swimming MFL-A inspection tool

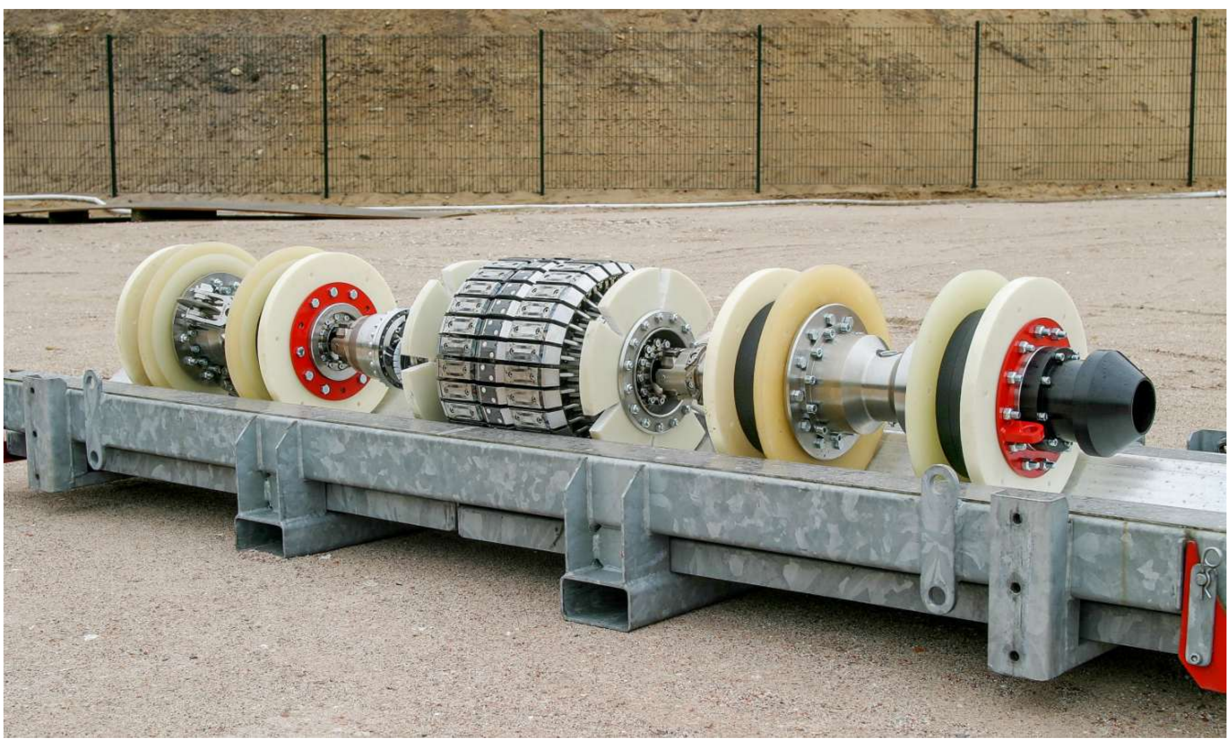
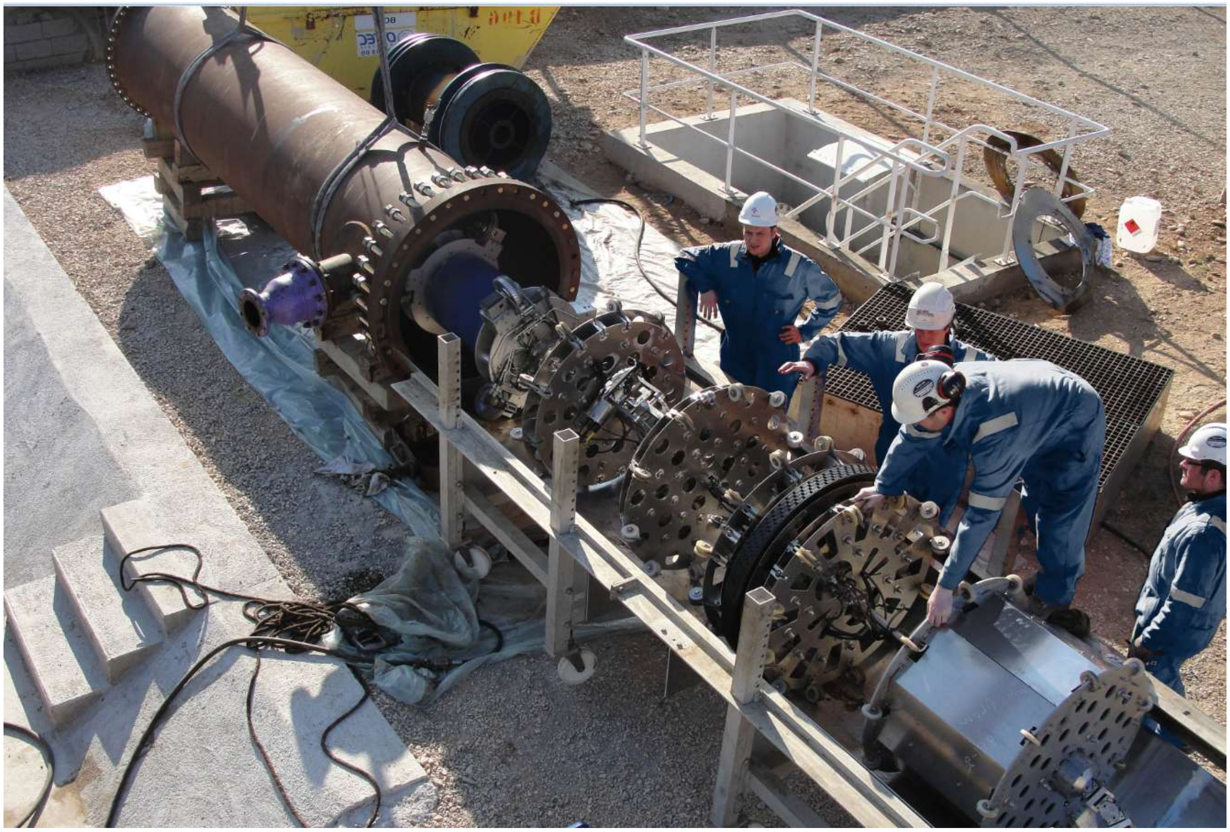


Figure 3: Robotic self-propelled UTWM tool being installed in a spool-piece pipe



The operational complexity underscores the importance of a turnkey approach or close coordination with the operator. Consolidating enabling works, safety procedures, and equipment qualification under a single framework reduces interface risks and ensures compliance with required standards. Multi-modal inspection technologies are critical to achieving comprehensive coverage. Magnetic Flux Leakage (MFL-A) provides an indirect, robust, and highly repeatable method for acquiring data that is ideal for corrosion growth assessment of internal and external metal loss, while Ultrasonic Wall Measurement (UTWM) delivers direct thickness data and geometry characterization. Caliper systems and inertial mapping (IMU) complement these methods by capturing deformation and positional information. Combined data evaluation across these modalities enhances probability of detection and identification, improves sizing accuracy, and supports robust integrity decisions.

4. <u>Inspection Project Planning</u>

4.1. **Threat Detection**

Multiple technologies are available for tank-line integrity assessment. Ultrasonic Testing (UT) and Time-of-Flight Diffraction (TOFD) provide high-resolution wall measurement and crack detection. Magnetic Flux Leakage (MFL) identifies and characterizes internal and external metal loss, enabling signal comparison. Geometric and mapping tools detect deformations, while propulsion methods, free-swimming and robotic systems, ensure tool passage under varying hydraulic conditions. This integrated technology suite enables comprehensive inspection and accurate threat characterization.

4.2. Project Planning

Effective planning is the foundation of a successful tank-line inspection campaign. Unlike conventional pipeline pigging, tank-line projects require a tailored approach due to unique geometry, hydraulic constraints, variable operating profiles, and limited permanent access hardware. Planning begins with structured collaboration between the operator and inspection provider to define scope, objectives, success criteria, and operational boundaries. This includes agreeing on entry strategy, enabling works, technology mix, safety protocols, and establishing data-quality requirements such as sensor types, sampling density, calibration checks, and acceptance thresholds for coverage.

A robust workflow typically includes desktop reviews of P&IDs, as-built drawings, and historical operations; site surveys to confirm geometry, clearances, and lifting access; and compatibility checks for product properties, viscosity, solids content, and temperature. A technical and operational risk assessment should be integral to project planning.

Data acceptance criteria, including sensor and distance coverage, are defined upfront to ensure reliable and actionable inspection data. Finally, communication protocols such as progress meetings, including deliverables are formalized to maintain clarity from planning through demobilization.

4.3. Entry Point

Selecting the entry point is a critical early decision. Most tank lines lack permanent launchers or receivers, making tool insertion and retrieval challenging. Temporary access is typically created by removing a short spool or adjacent bend near the tank valve, then installing a goose-neck assembly with a temporary trap comprising a neck, reducer, and oversize barrel at the highest practical point. This configuration provides a secure staging area for tool preparation, minimizes air entrapment, and enables bi-directional installation and retrieval.

Figure 4: Option of bend removal and using this as entry point

Where spool removal is impractical, alternative configurations may include a vertical riser with a swept bend or a slide to reduce space requirements.

Figure 5 Installing a robotic UTWM tool using a slide into a spool-piece's removed entry point.

4.4. Hydraulic Considerations

Hydraulic planning is equally important. Free-swimming tools require sufficient flow and differential pressure for controlled movement; in tank lines, these conditions rarely exist under normal operations, necessitating temporary pumping systems. A conservative tool velocity of approximately 0.3 m/s is typically targeted to balance negotiability through tight-radius bends, back-to-back bends, and diameter restrictions.

Temporary systems include crude-oil-capable centrifugal pumps sized for expected viscosity and target velocity, flexible hoses and bends to route flow between tank, pump, and trap, and control valves to modulate differential pressure.

Where hydraulic propulsion cannot be guaranteed, tethered robotic inspection becomes the preferred solution. Robotic crawlers provide deterministic motion control, precise positioning, and real-time data acquisition independent of flow, with forward/reverse capability to navigate complex geometries and ensuring maintain full inspection data coverage under low-pressure conditions.

4.5. Inspection Requirements

To achieve optimal results, full inspection coverage is essential, extending as close as possible to the manifold. Tool Approach Monitoring (TAM) combined with a robust tracking strategy is critical for maneuvering the inspection tool toward the manifold to maximize data acquisition. This process requires coordinated control of pump flow and pressure, and precise operation of upstream and downstream valves along the tank line. Inspections must ensure safe operation at all times, with accurate positional control of the tool to prevent overshooting and avoid any risk of damaging the manifold.

The Tool Approach Monitoring process will be reviewed and agreed with the operator and is part of the Operational Method Statement. Part of the process is to define:

- Definition End of Inspection Point
- Tracking points location before End of Inspection Point (e.g. 200m, 50m, 10m, 0m)
- Pumping strategy
    - Reducing flow rate when the tool is reaching the End of Inspection Point
- Valve handling procedure
- Communication Plan
    - Pump Operator – Tracking Crew – Valve Operators – Site Lead

4.6. Turnkey Approach

Given the complexity of tank-line inspections, a turnkey delivery model offers clear advantages with minimal overhead. Under a single contract, the service provider delivers enabling works, temporary equipment, and operational execution, reducing interface risk and compressing schedules. Typical scope covers temporary pig traps, pumps sized for target velocity and pressure, flexible hoses and bends for routing, and ancillary components such as valves and crossovers. Equipment is pressure-tested and functionally verified prior to shipment; on-site operations follow method statements, permit systems, and structured communications to maintain control. With one point of accountability, governance is simplified, engineering and execution remain aligned, and the operator avoids coordinating multiple vendors while keeping oversight and decision-making focused.

4.7. Safety and Quality Assurance

Safety and quality assurance are integral to planning and execution. Comprehensive method statements govern each phase: trap installation, tool preparation, launch, tracking, controlled approach near the manifold, reversal, and retrieval. Risk assessments address hazards such as differential-pressure excursions, debris movement, coating damage, static discharge, and inadvertent manifold ingress.

Contingency procedures cover tool stalls, unexpected restrictions, retrieval using bi-directional control, and transition to tethered robotics if hydraulic conditions deteriorate. Factory Acceptance Testing (FAT) is conducted on pumps, traps, and inspection tools to confirm pressure ratings, functional requirements, and sensor performance before mobilization.

Site Acceptance Testing (SAT) verifies integration of temporary equipment, instrumentation, and communication systems. Pumps are managed to avoid hydraulic shock; stop/reverse operations near the manifold proceed under strict supervision with predefined tracking and stopping points. Environmental measures address product handling, waste management, and spill mitigation, with documented chain-of-custody for data and calibration records to ensure traceability.

Quality assurance extends to data integrity. Pre- and post-run tool and data checks validate sensor coverage and quality; velocity and sampling-density verification confirm coverage; and defect detection thresholds meet agreed acceptance criteria. A readiness review before launch and a lessons-learned session after demobilization close the loop, feeding improvements into subsequent campaigns.

5. Free-Swimming Inspection Overview

Bi-directional tools enable pipeline inspection from a single access point, operating at minimal flow velocity and pressure to reduce energy requirements and simplify operations. These ultra-compact tools are fully articulated, allowing passage through tight bends, consecutive narrow bend combinations, and internal diameter (ID) restrictions up to 20%. Sensor carriers mounted on flexible components provide accurate measurements while maintaining clearance through restrictions. Contact forces are controlled to prevent coating damage, preserving internal epoxy integrity where present.

Customized cleaning tools, such as bi-directional reversed cleaning pigs (RCP), prepare pipelines for inspection while minimizing debris accumulation. Their asymmetric design enhances effectiveness: during the forward run, debris remains in the pipeline, whereas during the reverse run, it is transported back to the launcher, preventing manifold blockage. This functionality is enabled by applying a scraping-disc contact force that is 5–7 times higher in the reverse run compared to the forward run, where the contact force is intentionally reduced.

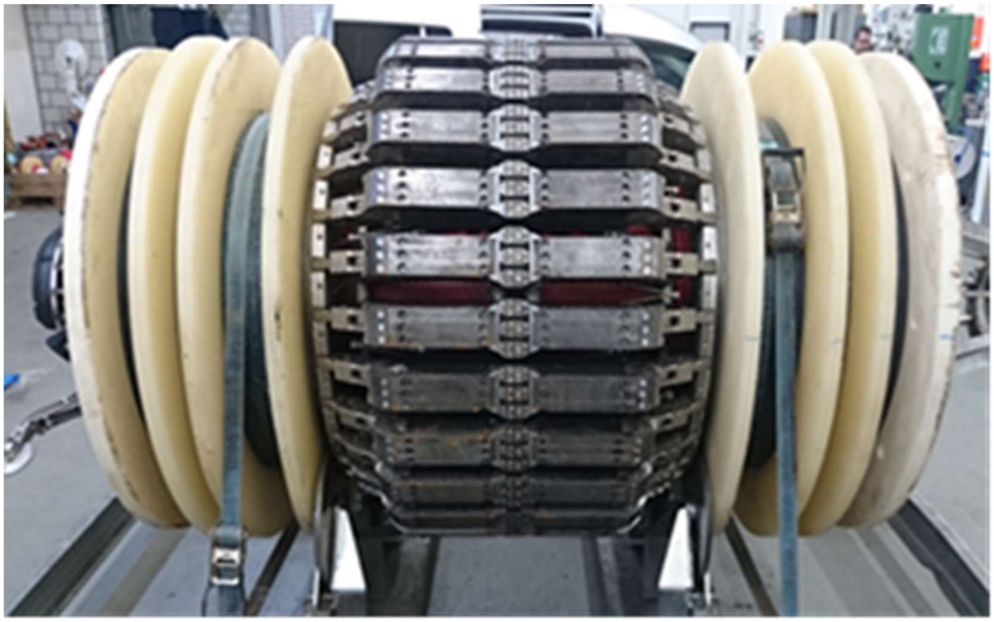
Figure 6: Reversed Cleaning Pig (RCP)

Free-swimming inspection tools include the following meassurement technologies:

- RoGeo MD – Bi-directional inline passage analysis using multiple caliper measurements for deformation detection.
- RoGeo XYZ Mapping – High-resolution geolocation mapping via inertial measurement units (IMU) capturing angular and acceleration data in three axes.
- RoCorr MFL-A – Magnetic flux leakage technology for internal and external corrosion assessment with full signal recording.
- RoCorr UTWM – Ultrasonic wall measurement for direct thickness evaluation and structural profiling.
- RoCD UT-A – Ultrasonic crack detection using bi-directional shear wave technology.

These tools provide circumferential and axial coverage and can be combined within a single inspection tool to acquire multiple datasets in one pass, improving operational efficiency.

Figure 7: Bi-directional high-resolution RoCorr MFL-A Inspection tool



6. **Robotic Inspection Overview**

Tethered self-propelled in-line inspection (ILI) systems offer enhanced adaptability for complex pipeline conditions. Constructed from lightweight materials such as titanium, these systems maintain support buoyancy neutrality in water and oil environments. Propulsion is achieved via crawlers or tractors, enabling bi-directional movement through tight bends and complex geometries.

Sensor carriers are configurable based on threat type and transmit real-time data through a tethered cable to a control station for continuous monitoring.

The robotic system comprises:

- Inspection Tool – A multi-segment tool incorporating propulsion modules and measurement segments equipped with sensors for geometry, wall thickness, corrosion, crack detection, video, and sonar. Additional modules for grinding, mapping, and cleaning can be integrated. An odometer ensures precise positional tracking at intervals of approximately 1 mm.
- Tethered Cable – Provides power, bidirectional movement control, and real-time data transfer. Its buoyancy-neutral design minimizes drag and serves as a retrieval safety line.
- Winch – Facilitates deployment and retrieval over distances from 0.5 km to 12 km, extendable to 24 km.
- Entry Interface – Typically via flange or pig trap, with guide wheels ensuring controlled cable routing.

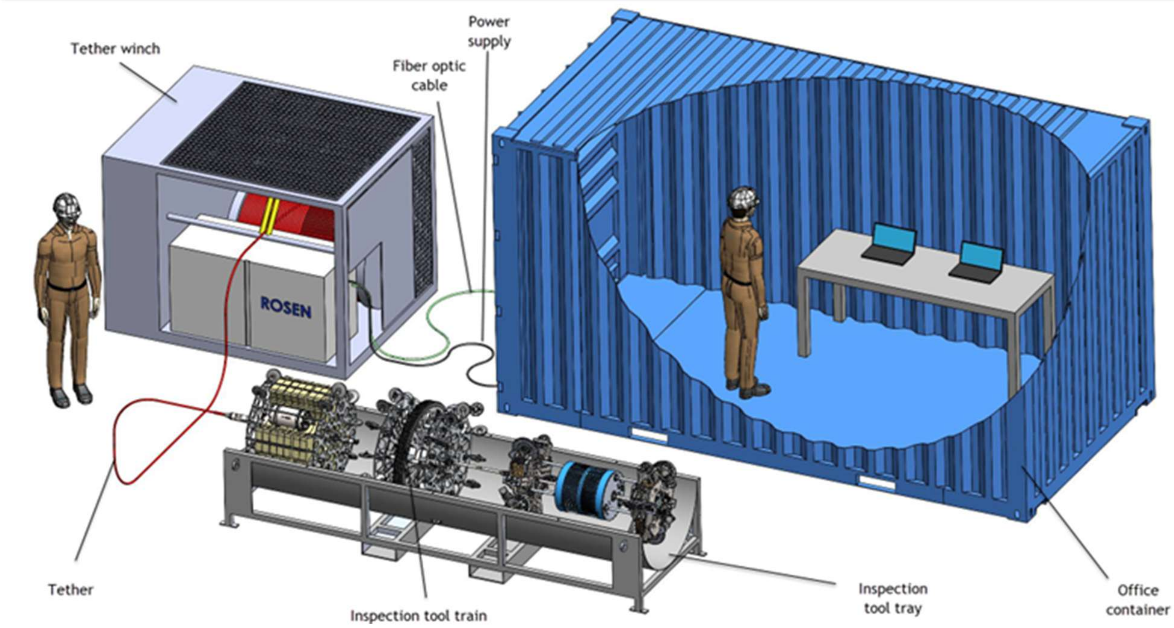
Robotic-inspection tools include the following meassurement technologies:

- RoCorr UTWM – Ultrasonic wall measurement for direct thickness evaluation and structural profiling.
- RoGeo MD – Bi-directional inline passage analysis using UT standoff echo signal for deformation detection.
- RoCD UT-A – Ultrasonic crack detection using bi-directional shear wave technology but also TOFD

(Time of Flight Diffraction) can be used for crack detection.

- RoGeo XYZ Mapping – High-resolution geolocation mapping via inertial measurement units (IMU) capturing angular and acceleration data in three axes.

Figure 8: Main components for Robotic self-propelled inspections



7. Combined Technology

Integrating Ultrasonic Wall Measurement (UTWM) with Magnetic Flux Leakage (MFL) enhances probability of detection (POD), probability of identification (POI), and sizing accuracy. Complementary technologies such as caliper and inertial mapping further improve characterization.

Figure 9: Benefits of combining MFL-A and UTWM Inspection data

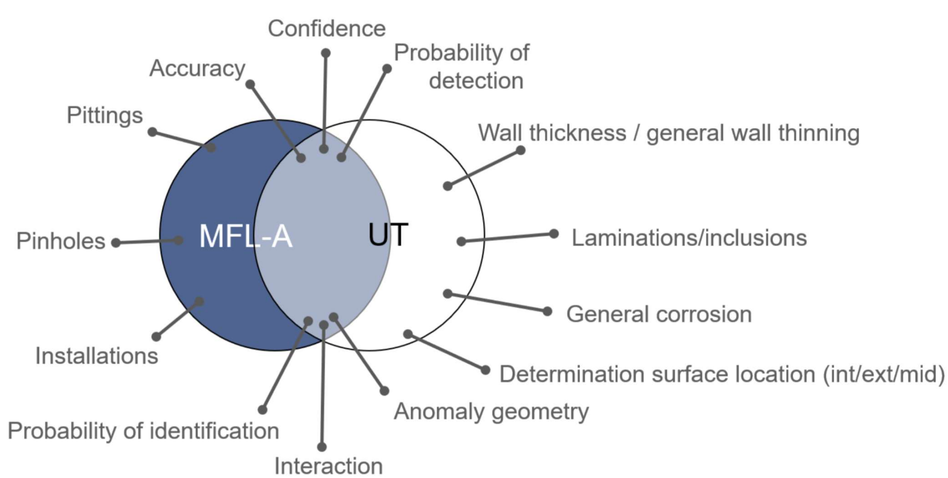
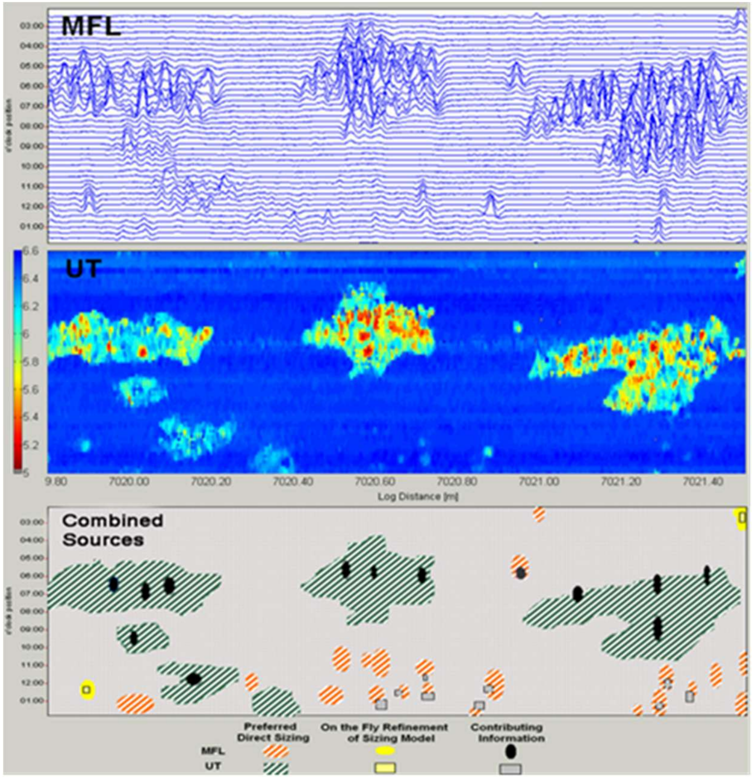


Figure 10: Combined MFL-A and UTWM data sets



8. Comprehensive integrity assessment

Ensuring the long-term reliability of tank lines requires more than isolated inspection activities; it demands a structured integrity management framework that transforms raw inspection data into actionable engineering decisions. This framework integrates advanced evaluation techniques with predictive modeling to address both current and future threats. By combining diagnostic results with engineering assessments, operators can establish a proactive maintenance strategy that aligns with recognized industry standards and regulatory requirements.

Comprehensive integrity assessment includes:

- Fitness-for-service evaluations
- Corrosion growth modeling
- Remaining life analysis
- Repair planning
- Inspection interval determination
- Cleaning schedules
- Framework alignment with recognized standards

This systematic approach enables complete threat identification and supports risk-based decision-making across the entire pipeline length, ensuring operational safety, environmental protection, and optimized lifecycle performance.

9. <u>**Case Study: 36-inch Crude-Oil Tank Line**</u>

This case study presents a comprehensive review of the in-line inspection (ILI) campaign conducted on a 36-inch crude-oil tank line that had never previously undergone internal inspection. The line, approximately 450 meters in length, forms a critical connection between storage infrastructure and the manifold system within a tank farm.

The pipeline exhibited several challenging characteristics. Wall thickness varied between 9.5 mm and 12.7 mm, and certain sections were internally coated with epoxy approximately 2–4 mm thick. The route incorporated multiple 1.5D/90° bends, back-to-back configurations, and unbarred full-bore offtakes, features that significantly increase negotiability demands on inspection tools. These conditions, coupled with the absence of permanent launchers or receivers, required the design and installation of temporary enabling infrastructure to facilitate safe and controlled tool passage.

The inspection scope was jointly defined by the operator and ROSEN after evaluating all available information. It comprised pre-ILI cleaning, a high-resolution bi-directional MFL inspection using RoCorr MFL-A technology, and a tethered robotic UTWM and geometry survey. Based on the assessment, the expected corrosion mechanism was general wall thinning with the potential presence of pitting, and the internal coating added further complexity. Accordingly, both parties agreed to deploy the two technologies in combination to ensure comprehensive coverage of the anticipated threat spectrum.

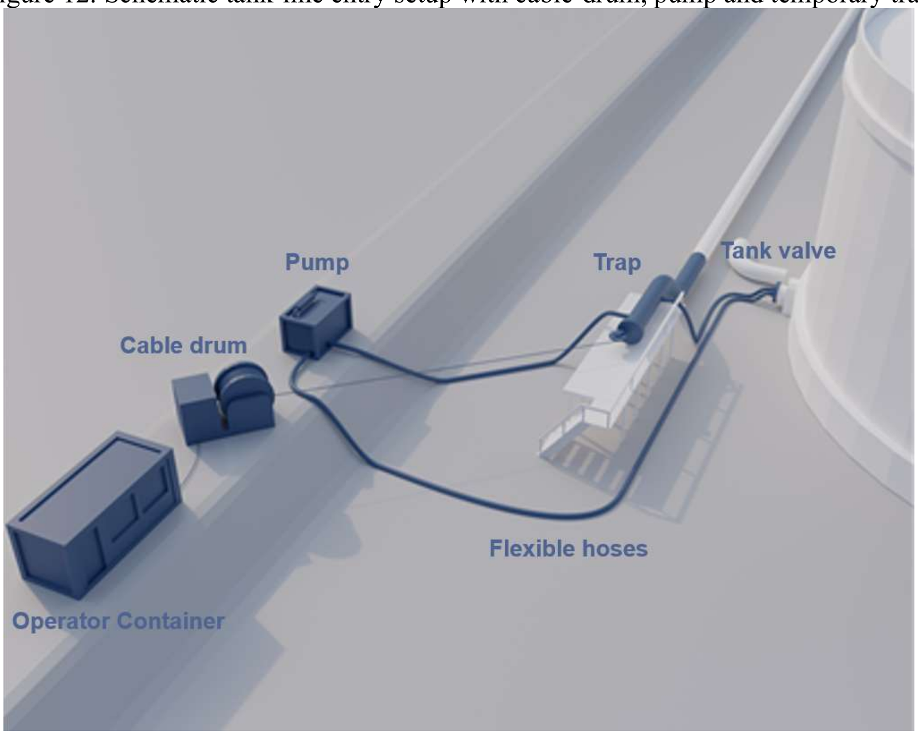
To achieve these objectives, a turnkey solution was implemented encompassing all enabling works and operational planning. This included a pump spread laydown plan, supply of a crude-oil-capable centrifugal pump rated for approximately 1200 m³/h at 12 bar, and temporary piping to establish controlled flow paths between the tank, pump, and trap.

Figure 11: Centrifugal Pump

Additional components such as bends, crossovers, and valves were integrated to optimize hydraulic performance and ensure operational flexibility. All equipment underwent Factory Acceptance Testing (FAT) prior to mobilization, and detailed method statements governed each phase of the campaign, from tool launch and tracking to controlled approach near the manifold and retrieval.

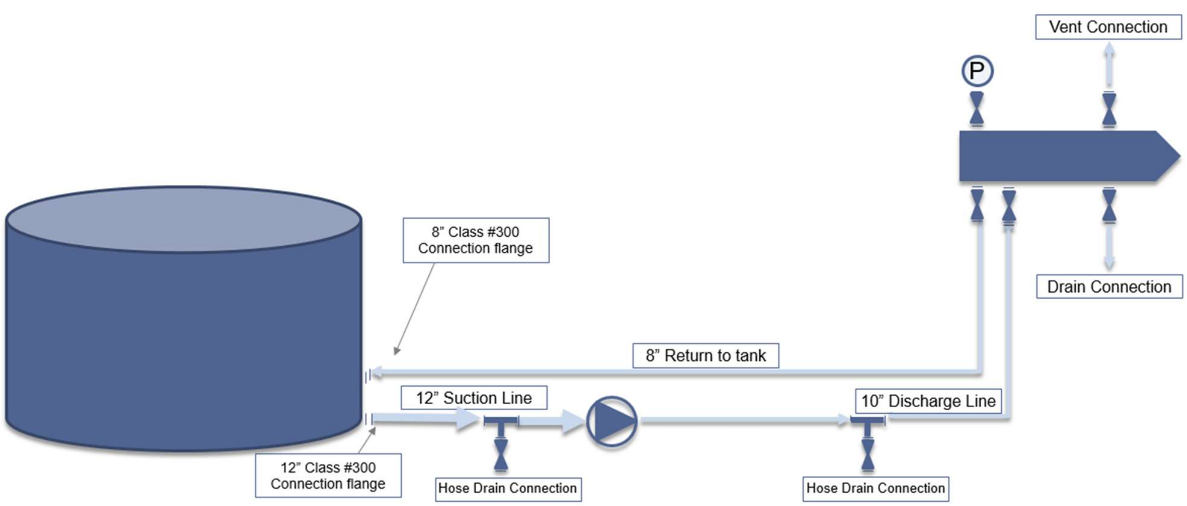
Enabling works commenced with the removal of a 90° bend and adjacent spool piece near the tank valve to create a suitable entry point. In its place, a goose-neck assembly incorporating a temporary trap, comprising a neck, reducer, and oversize barrel, was installed at the high point of the line. This configuration provided a secure staging area for tool insertion and minimized air entrainment.

Figure 12: Schematic tank-line entry setup with cable-drum, pump and temporary trap



Cleaning operations were executed in two phases using reversed cleaning pigs (RCPs). Phase 1 employed a low-aggressive RCP to loosen deposits and characterize fouling levels, confirming passage through critical geometric features. Debris collected during this phase aligned with expectations for a line subject to intermittent flow and lacking recent maintenance. Phase 2 utilized a medium-aggressive RCP to extract residual material and condition the internal surface for high-resolution inspection. The reversed design of these pigs ensured that debris was transported back to the entry point, thereby preventing accumulation near the manifold and mitigating the risk of hydraulic blockage.

Figure 13 : General temporary piping setup tank - pump - trap - tank



Following successful cleaning, a compact, high-resolution RoCorr MFL-A tool was deployed in bi-directional mode. Pump control targeted a conservative velocity of approximately 0.3 m/s, with a design safe negotiability through tight-radius and back-to-back bends. Continuous tracking confirmed tool progression 100m, 50m and 10m before the manifold and verified controlled approach to the manifold, where the tool was parked short just 2m before the manifold. By changing the flow-direction and use of the booster pumps, the tool got pumped back towards the starting point and retrieved.

Figure 14: Pictures RCP Cleanings Pigs after the Run

Figure 15: Picture Tandem 36" MFL-A tool after the run

Figure 16: ROSEN Field Engineers operating the pump for RCP runs (left) and ROSEN Inspector monitoring inspection progress of tethered UTWM inspection (right)

The final inspection phase involved a tethered, self-propelled robotic tool equipped with UTWM and geometry measurement capabilities. The system's modular design allowed integration of multiple sensor carriers, delivering comprehensive data on wall thickness, internal diameter variations, and geometric anomalies. Real-time data transmission via the umbilical enabled immediate evaluation in the control room, allowing operators to flag indications and initiate targeted re-spot inspection during the same run. The umbilical also served as a safety line, while the winch system ensured controlled payout and retrieval, maintaining operational integrity throughout the campaign.

Figure 17: 36“ UTWM tool as tool data sheet image

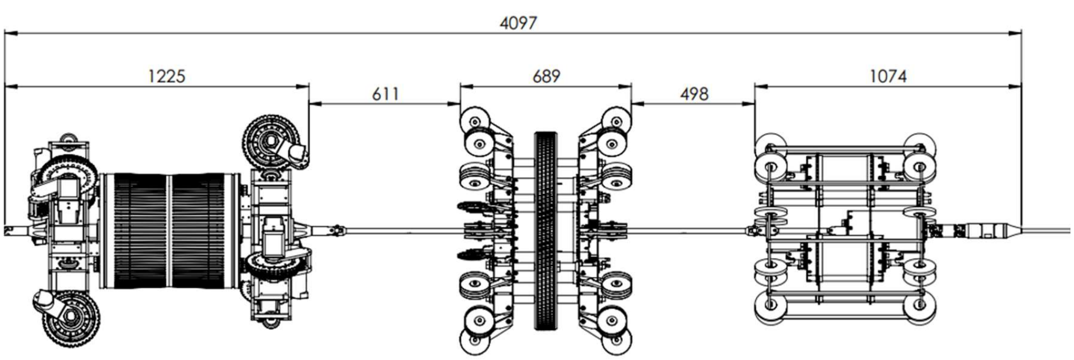
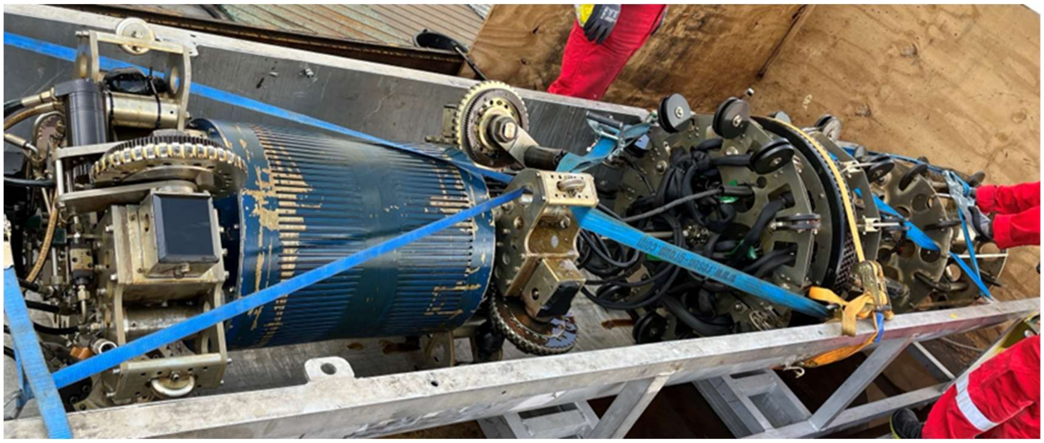


Figure 18: 36“ UTWM tool in loading tray



Data evaluation combined MFL and UTWM results to enhance detection confidence and sizing accuracy. MFL provided broad coverage for internal and external metal-loss features, while UTWM delivered direct wall-thickness measurements, resolving depth and morphology with high precision. Geometry data supplemented these findings by confirming negotiability margins and identifying localized ovalities. The combined dataset revealed minor bottom-of-the-line corrosion features consistent with water and sediment accumulation at the invert. These anomalies were classified as non-critical, supporting a strategy of monitoring rather than immediate repair. The comprehensive dataset now serves as a baseline for corrosion-growth modeling and fitness-for-purpose assessments, informing future inspection intervals and maintenance planning.

Several lessons emerged from this campaign. Progressive cleaning proved essential for mitigating debris-related risks and preserving coating integrity. Bi-directional free-swimming tools demonstrated reliable passage through complex geometries when supported by appropriately sized pumps and conservative hydraulic parameters. Robotic UTWM technology added deterministic control and real-time data visibility, enabling adaptive decision-making and reducing the need for repeat mobilizations. Finally, the integration of complementary measurement technologies, MFL and UTWM significantly improved probability of detection and identification, reinforcing the value of multi-modal inspection strategies in challenging environments.

This case study underscores the feasibility and effectiveness of advanced inspection methodologies for tank lines previously deemed inaccessible. By combining engineering rigor, structured execution, and state-of-the-art diagnostic technologies, operators can achieve high-confidence integrity assessments, comply with regulatory standards such as POF 100 and API 1163, and transition from reactive maintenance to proactive, risk-based asset management. The approach demonstrated here provides a replicable model for similar installations worldwide, ensuring operational safety, environmental protection, and optimized lifecycle performance.

10. <u>Conclusion:</u>

Tank lines historically considered unpiggable can now be inspected with high confidence through a structured program integrating progressive cleaning, bi-directional free-swimming tools, and tethered robotic in-line inspection tools. Combining these approaches offers significant advantages, addressing the unique operational and geometric constraints of tank-farm infrastructure while ensuring comprehensive integrity coverage.

Effective execution begins with collaborative planning to define inspection scope and integrity objectives, minimizing operational disruption. Determining the most suitable entry point for the inspection campaign is critical to maximize efficiency and outcome. For turnkey solutions, the methodology encompasses complete system delivery, including traps, pumps, temporary piping, valves, offtakes, and crossovers. All phases, from procurement through installation and commissioning, are managed under a unified framework, enabling seamless integration, reducing interface complexity, and streamlining project delivery.

Technology selection plays a central role in this process. While MFL-A technology is ideal for detecting pitting corrosion and circumferentially oriented defects, UTWM captures general wall thinning more reliably. Depending on the expected defect mechanisms, either technology, or a combination of both, should be selected. In this case, the corrosion mechanism was expected to be general wall thinning potentially coinciding with pitting corrosion, and the presence of internal coating further increased the complexity. Therefore, ROSEN and the operator agreed to deploy both technologies in combination, ensuring full coverage of the anticipated threat spectrum.

Complementary systems, including caliper tools and inertial mapping (IMU), capture deformation and positional information, creating a complete integrity dataset. Combined modalities enhance detection probability, improve sizing accuracy, and support robust decision-making.

Integrated data evaluation transforms raw measurements into actionable intelligence. Correlating MFL indications with UTWM thickness profiles reduces uncertainty, clarifies feature morphology, and strengthens classification confidence. This evaluation underpins fitness-for-purpose assessments, corrosion-growth modeling, and remaining-life calculations, enabling risk-based intervention planning rather than assumption-driven decisions.

The case study validates this methodology. Progressive cleaning eliminated debris without manifold accumulation, mitigating hydraulic risk and preserving coating integrity. Bi-directional free-swimming tools negotiated complex bends at controlled velocities, while robotic UTWM provided deterministic movement and real-time data visibility for immediate spot-check assessments. Combined datasets confirmed minor bottom-of-the-line corrosion features, allowing a monitoring strategy rather than immediate repair, optimizing cost without compromising safety.

For operators, the roadmap is clear: select propulsion mode based on hydraulic feasibility, free-swimming where flow can be established, robotic where it cannot; implement progressive cleaning to stabilize conditions; deploy combined technologies for comprehensive coverage; and embed results within an integrity framework including fitness-for-purpose evaluations, corrosion-growth assessments, remaining-life analysis, repair planning, and interval setting. Aligning these processes with recognized standards ensures traceability and regulatory compliance.

This integrated approach shifts tank-line integrity management from reactive interventions to proactive, risk-based stewardship. Leveraging advanced diagnostics and structured workflows enables extended asset life, reduced unplanned outages, and measurable lifecycle benefits, delivering operational reliability and environmental protection.

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12. Curriculum Vitae

Franz Bruening works as a Principal Technical Solutions Specialist for challenging in-line inspection services at the ROSEN office in Lingen, Germany.
After studying Mechanical Engineering at the Fachhochschule Ostfriesland in Emden, Germany, he joined ROSEN in 1997. He has nearly 30 years of experience in pipeline inspection services and has served in roles including Field Engineer, Project Manager, Head of Field Operations, and Technical Solutions Specialist. He currently works as Principal Technical Solutions Specialist at ROSEN Group, specializing in complex "unpiggable" pipeline inspection projects, supporting clients through solution development, planning, and safe delivery of high-quality integrity data.