
IC-001 SUPPLEMENTAL READING

Internal Corrosion Field Testing

Field kits vs. lab analysis in the race against chemistry change. Companion reading for IC-001 and the Corrosion Mechanisms in Pipeline Fluids first rung of the Internal Corrosion track.

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FIELD NOTES FROM RCS

~13 MIN READ

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The silent threat beneath our feet

Beneath our feet, a network of millions of miles of pipelines serves as the circulatory system of modern industry, transporting critical resources like water, oil, and natural gas. However, this essential infrastructure faces a relentless and often invisible enemy: corrosion. This silent threat is not a static issue but a dynamic chemical battle that constantly evolves inside the pipeline. The challenge for operators is not just detecting corrosion but doing so before the evidence changes. This is the "race against chemistry change."

Successfully managing this race requires a deep understanding of the two primary diagnostic approaches for internal corrosion: rapid-response **field testing kits** and high-precision **laboratory analysis**. In this article, we'll explore the advantages of immediate field testing for pipeline fluids, particularly how it captures critical data before chemistry alters during transport to a lab. We'll focus on fluid sampling from sources like pig runs and drip blowing, where timely analysis is crucial. We'll also discuss when laboratory analysis is indispensable and how a hybrid strategy can optimize pipeline integrity.



The criticality of pipeline integrity

Pipeline integrity is paramount. A single failure due to internal corrosion can result in catastrophic environmental damage, substantial economic losses from downtime and repairs, and severe risks to public safety. Proactive corrosion control and monitoring are not optional; they are essential for responsible asset management.

The global pipeline testing and inspection services market underscores the industry's commitment to this priority, estimated to grow from USD 46.13 billion in 2023 to USD 64.27 billion by 2030. This growth reflects the increasing emphasis on preventing internal corrosion through advanced monitoring techniques, particularly in systems handling multiphase fluids where water and corrosive agents accumulate.

For corrosion technicians, the focus often lies in internal corrosion, which differs significantly from external threats. Internal corrosion arises from the pipeline's contents, making fluid sampling a frontline tool. Fluids retrieved during pig runs or drip blowing provide direct insights into the corrosive environment, allowing for targeted interventions before minor issues escalate into major failures.

The evolving challenge: why pipeline chemistry is never static

A pipeline is a contained, dynamic ecosystem where the chemical and biological composition of transported fluids is in constant flux. Temperature, pressure, and flow rates shift, altering the corrosive potential of the environment. Gases come out of solution, microbes multiply or die off, and chemical reactions occur constantly. This means a fluid sample extracted from a pipeline, whether from a pig run capturing accumulated water and debris or drip blowing to remove condensates, is a perishable snapshot. Its properties begin to change the moment it leaves the pressurized environment.

This instability demands routine monitoring, where field testing kits allow for on-site analysis, capturing the true state before these changes occur. Lab testing, though precise, risks analyzing an altered sample, which can lead to misguided decisions in internal corrosion management. For instance, in a pig run, the retrieved fluids might contain high levels of dissolved gases that drive corrosion, but delays in testing could allow those gases to escape, underestimating the risk.

The sample starts changing the moment it leaves the pipe.

Setting the stage: field kits vs. lab analysis

To deal with this evolving threat in internal corrosion, operators rely on two distinct approaches with key trade-offs. Field kits offer immediate, on-site measurements of pipeline fluids, providing a real-time glimpse into the pipeline's condition. In contrast, laboratory analysis delivers unparalleled depth and accuracy but introduces a critical time delay. The best strategy is to combine them - that's central to winning the race against chemistry change and ensuring long-term pipeline performance.

When sampling fluids from pig runs or drip blowing, field testing shines by preserving the sample's integrity right at the source. These samples may contain water and corrosive elements, making immediate analysis essential to avoid degradation during transport.

Understanding pipeline corrosion: a dynamic chemical battle

Pipeline corrosion is the gradual degradation of materials, typically metal, due to chemical or electrochemical reactions with the environment. It's a natural process that returns refined metals to their stable, oxidized state. For internal corrosion, effective control starts with understanding the mechanisms at play within the pipeline's fluids.

The basics of corrosion: electrochemical processes at play

Most internal pipeline corrosion is electrochemical, requiring four components: an anode (where metal dissolves), a cathode (where reduction occurs), a metallic path (the pipe wall), and an electrolyte (often water in the fluids). Electrons flow from anode to cathode through the pipe, while ions complete the circuit in the electrolyte, leading to metal loss at the anode. This is particularly prevalent in carbon steel pipelines handling fluids with dissolved salts, acids, or gases.

Common types of pipeline corrosion

Internal corrosion types vary based on the fluids' composition:

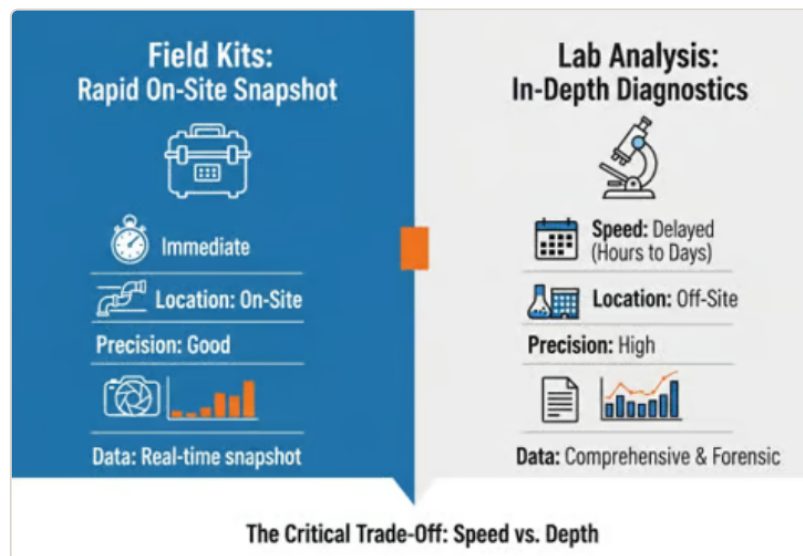
- **Sweet corrosion** - caused by CO_2 and water forming carbonic acid, highly corrosive to carbon steel. Common in fluids from gas pipelines where CO_2 accumulates.
- **Sour corrosion** - involves H_2S , leading to sulfide-related cracking and metal loss. Often detected in sour gas fluids from drip blowing.
- **Microbially influenced corrosion (MIC)** - microorganisms like sulfate-reducing bacteria (SRB) or acid-producing bacteria (APB) create localized corrosive environments, thriving in stagnant fluids collected during pig runs.

MIC can account for up to 40% of internal pipeline failures, highlighting the need for rapid microbial assessment in fluid samples.

The role of the environment: water, oil, gases, and solids

The internal pipeline environment drives corrosion, with water in fluids acting as the primary electrolyte. Dissolved gases like CO_2 , H_2S , and oxygen amplify corrosivity.

While this article focuses on fluids, it's worth noting that gases, hydrocarbons, suspended solids, and sludges retrieved alongside fluids can create corrosion sites, leading to localized attacks. These mixed samples require careful separation to prioritize fluid analysis for immediate threats.



The race against chemistry change

The core challenge in testing pipeline fluids for internal corrosion is that the in-pipe environment differs vastly from a sample bottle analyzed hours or days later. This "race against chemistry change" highlights the strengths of field kits over delayed lab testing for volatile parameters in fluids from pig runs or drip blowing.

What constitutes "chemistry change" in a pipeline fluid sample?

Changes start immediately upon sampling:

- **Degassing** - gases like CO_2 and H_2S escape, altering pH and removing or changing corrosive agents.
- **Oxidation** - atmospheric oxygen alters dissolved metals like iron, skewing corrosion indicators.
- **Microbial activity** - bacteria die or multiply, distorting MIC assessments in water samples.
- **Temperature shift** - can cause mineral precipitation, changing fluid chemistry.

These transformations can render lab results misleading if not mitigated, especially for fluids that are inherently unstable after removal.

Why dynamic chemistry is a game-changer for corrosion testing

This instability means delayed testing risks analyzing artifacts, leading to incorrect diagnoses and ineffective treatments. Field testing captures the transient state accurately, making it ideal for routine monitoring of internal corrosion via fluid samples. For example, a sample from a pig run showing elevated dissolved H_2S on-site might not show nearly the same result (or zero) back at the lab.

Field corrosion testing kits: rapid insights at the front line

Field testing kits are engineered to win the race against chemistry change, allowing technicians to test fluids directly at the sampling point before degradation. This is particularly valuable for internal corrosion monitoring, where fluids from pig runs or drip blowing provide windows into the pipeline's health.

Advantages of field kits: speed, accessibility, and cost-effectiveness

Field kits can provide some immediate results. They're usable in remote locations, cost-effective for frequent testing, and support trend analysis. For internal corrosion, field testing preserves sample integrity by measuring parameters like pH, dissolved gases, and microbial activity on-site, preventing changes from degassing or oxidation that could occur on the way to a lab.

Common types of field kits for pipeline fluid corrosion testing

A well-equipped program for fluid sampling includes:

- Testing for the presence of water
- Temperature and pH meters or strips
- Titration and colorimetric kits for quantifying dissolved CO₂, H₂S, sulfide in water phases
- Total alkalinity
- Manganese concentration
- Microbiological kits like serial dilution bottles or ATP/AMP assays to estimate SRB and/or APB presence, essential for MIC in stagnant fluids
- Stain tubes for immediate gas detection, such as CO₂ (ASTM D4984-06), H₂S (ASTM D4810-06), and water vapor (ASTM D4888-06), providing semi-quantitative results via color change

These tools are portable and user-friendly, tailored for the demands of field operations.

Limitations of field kits in the face of changing chemistry

Despite advantages, field kits have lower precision and higher detection limits than lab instruments. They're limited in test range and susceptible to user error or environmental interference, such as heavy odorants. For complex internal corrosion issues, they serve as screening tools, necessitating lab confirmation.



Laboratory corrosion analysis: the quest for precision and depth

For in-depth insights into pipeline fluids, lab analysis provides controlled, sophisticated testing unattainable in the field.

Advantages of lab analysis: accuracy, detail, and robust QA/QC

Labs measure to parts-per-billion levels, offering comprehensive profiles of fluids' water, deposits, and corrosion products. This detail is essential for further analysis, specific microbial identification, or validating remediation. Strict QA/QC ensures reliable, defensible data, crucial for regulatory compliance in internal corrosion programs.

Key laboratory techniques for pipeline fluid corrosion

Techniques for fluid samples include:

- Ion chromatography (IC) for anions like chloride and sulfate, which exacerbate corrosivity
- Inductively coupled plasma (ICP-OES) for dissolved metals, indicating active corrosion

- Gas chromatography (GC) for hydrocarbon and gas compositions
- Internal corrosion coupon analysis (a related but entirely different topic for another article)
- Surface analysis via scanning electron microscopy / energy dispersive spectroscopy (SEM/EDS), X-ray diffraction (XRD), and profilometry for corrosion products
- Water chemistry analysis for pH, alkalinity, hardness, dissolved or suspended solids, moisture or solids %, etc.

These methods provide the "why" behind field observations.

Challenges and considerations for lab analysis

Time delays exacerbate chemistry changes in fluids, requiring preservation (e.g., refrigeration, stabilizers) and rapid transport. Higher costs limit use to targeted diagnostics, making field testing the preferred first step for routine fluid sampling.

The core conflict: field kits vs. lab analysis

Balancing speed, accuracy, depth, and cost is crucial for internal corrosion management through fluid testing.

Accuracy vs. speed: making the trade-off

Field kits prioritize speed, offering directional insights from fresh fluids; labs provide precision but later.

Diagnostic depth vs. screening capability

Field tests screen anomalies; labs diagnose root causes.

The impact of chemistry change on test validity

Field minimizes impacts by instant measurement; labs manage through protocols, but volatiles in fluids are at risk.

Cost-effectiveness: initial savings vs. long-term reliability

Field kits enable frequent, low-cost monitoring; labs offer long-term savings by preventing failures via accurate diagnostics.

Aspect	Field Testing	Laboratory Testing
Speed of Results	Immediate, on-site	Delayed by transport
Sample Integrity for Fluids	Preserves volatiles like dissolved gases	Risk of degassing or microbial shifts
Analytical Scope	Basic parameters for screening	Full chemistry and advanced microbiology
Precision/Sensitivity	Lower, suitable for trends	High, quantitative for root causes
Cost per Sample	Lower, ideal for routine	Higher, for in-depth
Operational Impact	Quick adjustments	Strategic planning and compliance

Methodology and applications of field testing for fluid sampling

Field testing is foundational for internal corrosion monitoring via fluids, providing on-site analysis to capture immediate conditions before changes.

Sampling techniques and protocols for fluids

Effective testing starts with strategic fluid collection. Focus on sources like pig runs (capturing accumulated water and corrosives) and drip blowing (removing fluids from low points).

- **Sample types** - prioritize liquids for chemistry and microbes; collect associated gases or solids if present but analyze fluids first.
- **Equipment** - use clean, inert containers; purge lines to avoid contamination; keep sensitive samples cool.
- **Integrity measures** - documentation like location and current conditions; perform immediate tests to lock in data.

Frequency is risk-based: monthly for high-risk wet gas systems, quarterly otherwise, or post-operational upsets. Regulations like PHMSA 49 CFR Part 192 and industry standards mandate timely monitoring, especially in high-consequence areas.

On-site analytical methods for fluid parameters

Target change-sensitive parameters in fluids:

- **Presence of water** - typically water-finding paper or paste.
- **pH measurement** - use portable meters, test kits, or strips. For liquids, immerse directly; calibrate to ensure accuracy.
- **Alkalinity testing** - field strips or titration kits.
- **Dissolved gases (CO₂, H₂S)** - colorimetric testing kits; ensure directions are followed exactly.
- **Metals** - colorimetric for iron/manganese.
- **Solids in fluids** - filters or visuals to detect deposits and additional testing.

These provide immediate insights.

Microbiological field testing in fluids

Rapid assessment is vital, as MIC thrives in fluids:

- Culture-based: dilution kits for SRB/APB, incubated 14-28 days.
- Enzyme-based: ATP luminometry for total activity, APS reductase for SRB.
- Swabs if biofilms present in fluid samples.

High counts may prompt a remedial plan.

Integrating corrosion coupons and probes with fluid testing

While this article is fluid-focused, corrosion coupons (weight-loss analysis after 3-6 months) and probes (electrical resistance or linear polarization resistance for real-time rates) can be installed at (or near) sampling points to collect direct data. This topic will be discussed in an upcoming article.

Best practices and quality assurance

To maximize reliability, use standardized protocols for sampling, testing, and documentation. Ensure technician qualification / training, and chain-of-custody to maintain integrity for lab analysis. Emphasize sterile technique, safety, and accurate kit use. Record all details for traceability.

Conclusion: informed decisions in an ever-changing environment

The fight against internal pipeline corrosion, particularly through fluid sampling, occurs on a shifting chemical landscape. Field kits deliver immediate intelligence from pig runs and drip blowing, while lab analysis provides forensic depth. A hybrid approach transforms data into actionable narratives for safety and environmental protection.

FROM RCS

Roberts Corrosion Services, LLC

Established in 2011, Roberts Corrosion Services, LLC delivers comprehensive, turn-key cathodic protection and corrosion control solutions nationwide. Our end-to-end expertise encompasses design and inspection, installation and repair, surveys and remedial work. We provide drilling services for deep anode installations and a full laboratory for analysis of samples and corrosion coupons, as well as custom CP rectifier manufacturing.

While our initial focus was on the Appalachian Basin area, we complete field work all over the US. We are a licensed contractor in many states and can complete a wide range of services.

Our biggest strength is in our flexibility for our clients. Solutions and results.

Let us know how we can help.

