

Application Note

On-Stream Ultrasonic Phased-Array Corrosion Mapping

Highlights:

- Advanced corrosion mapping using Ultrasonic Phased Array (PAUT) and HotSense HeatMaster solutions
- Continuous and reliable inspection of high-temperature assets while in operation.
- Enhanced safety and efficiency with minimal downtime.

The Challenge:

Ultrasonic testing (UT) for wall thickness measurement is a cornerstone of Non-Destructive Testing (NDT), frequently employed to assess corrosion damage across various industries. Traditionally, this has involved conventional UT methods, such as spot readings with dual element transducers or C-scan mapping via encoded raster arms. The adoption of Ultrasonic Phased Array (PAUT) has further improved efficiency by increasing aperture, covering larger areas per scan and providing greater detection probability for complex flaws and detailed damage morphology, especially when advanced data techniques like Total Focussing Method (TFM) are used.

These inspections are commonplace in sectors ranging from Aerospace and Civil Engineering to critical infrastructure in Energy, where power generation and the extraction and refining of oil and gas equipment operates at elevated temperatures above 80 °C (176 °F). Such environments exceed the limits of standard PAUT transducers and their coupling wedges, which are typically constructed using composite materials sensitive to thermal expansion and degradation.

Historically, high-temperature assets have been inspected during planned shutdowns, incurring costly production losses and potentially aggravating corrosion due to heat cycling. For example, below, in Figure 1, steam condensate erosion during cold starts can result in significant wall loss, compared to assets maintained at high operating temperatures (base loaded).

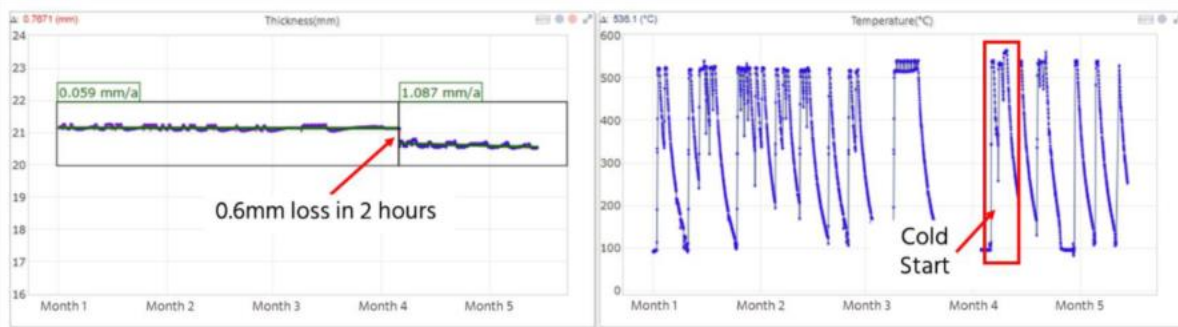


Figure 1: Data captured from installed HotSense UT sensors on a steam line showing accelerated wall loss of 0.6 mm (~3% of remaining wall) over a 2 hours caused by the conditions of a re-start from cold.

With growing efficiency demands and technological advancements, there is an increasing trend to inspect assets whilst on-stream. Development of on-stream procedures and processes, and deployment of modern UT equipment, and such as the Ionix HotSense UT range, now allow for accurate and repeatable wall thickness measurements at continuous temperatures up to 350 °C (662 °F), compatible with commercial pumpable couplants and automated high-temperature scanners from leading providers enabling operators to undertake on-stream inspections safely, accurately and reliably.

High-temperature assets are subject to a range of corrosion damage mechanisms. The most prevalent corrosion mechanism downstream is sulfidation where sulphur in hydrocarbons react with iron >260 °C, and more broadly flow-assisted corrosion is found across energy assets. For more complex damage and flaws, such as pitting, blistering, stress corrosion cracking (SCC), hydrogen induced corrosion (HIC) and high-temperature hydrogen attack (HTHA), a high-resolution, high probability of detection is required, where advanced phased array techniques such as TFM are best suited.

However, PAUT remains fundamentally limited for high-temperature service due to its reliance on composite transducer construction. The use of epoxies, necessary for structural integrity and damping, leads to swelling, misalignment, and eventual failure at elevated temperatures. Attempts to mitigate these issues with high-temperature epoxies or fillers have yielded only



marginal improvements and often introduce new drawbacks, such as increased susceptibility to water absorption and increased cross-talk.

Conventional workarounds, such as duty cycling probes or deploying and discarding multiple transducers, either negate the advantages of PAUT or become prohibitively expensive and time-consuming. Thus, solving the challenge of high-temperature PAUT (HT-PAUT) is essential to unlock the full benefits of on-stream corrosion inspection.

The Solution

Ionix presents a new solution for HT-PAUT: **the HotSense™ HeatMaster actively cooled wedge**.

The HeatMaster system enables inspectors to use their existing PAUT transducers by integrating them onto a compact, actively cooled 0-degree wedge. This solution supports continuous inspection from -55 °C up to over 250 °C, making on-stream PAUT more accessible and cost-effective. The wedge combines an engineering polymer with a metal cooling frame, compatible with high-temperature scanner cooling systems or standalone chillers, maintaining the transducer array below 75 °C (note: maximum operating temperature is transducer manufacturer dependent).

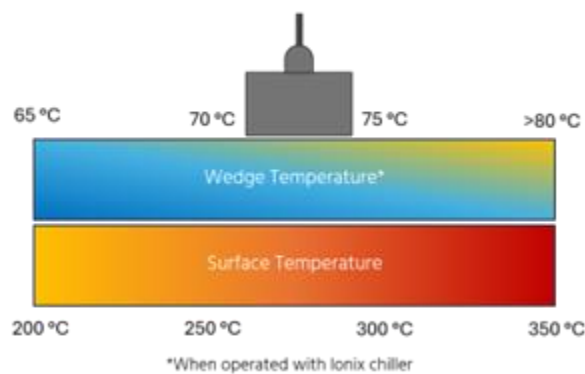


Figure 2: Continuous temperature chart for the HotSense HeatMaster

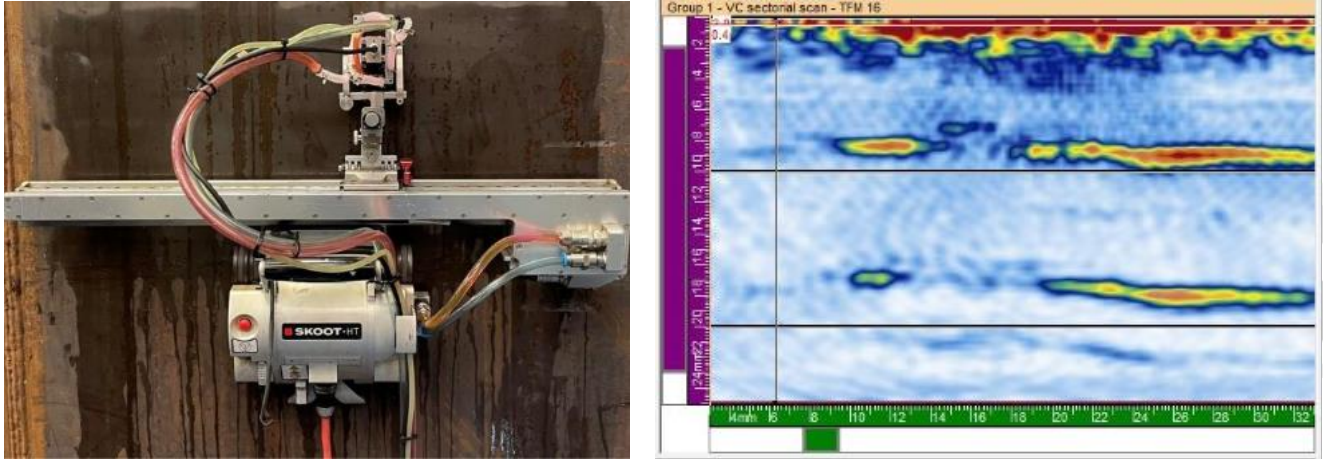


Figure 3:

- **Left:** HotSense™ HeatMaster deployed on the Jireh Skoot HT for corrosion mapping at surface temperature of 200 °C.
- **Right:** TFM Sectorial Scan data captured from the EddyFi Cypher showing internal wall loss profile from corrosion.

Designed for flexibility, the HeatMaster wedge supports various commercial linear array formats (16, 32, and 64 elements) and is available in multiple sizes and profiles to accommodate diverse asset geometries, such as pipes, vessels, and flat surfaces. Its reusable and replaceable wedges ensure low operational costs and adaptability for a wide range of corrosion scanning tasks.

Using a zero-degree wedge interface allows for continuous, calibrated zero-gate measurements, unaffected by temperature-induced velocity changes, thereby facilitating simple, accurate, and repeatable wall thickness assessments with standard training and procedures. Quick velocity calibration enables inspectors to set up and begin data collection efficiently, with modern equipment allowing remote inspection of hot assets for enhanced safety using Phased Array (PA) and Total Focussing Method (TFM).



The Benefits:

- Enables on-stream corrosion inspection without shutdowns, reducing downtime and production losses.
- Supports safe, remote operation for inspectors, minimising exposure to hazardous conditions
- Delivers accurate, repeatable wall thickness measurements across a wide range of temperatures
- Flexible, cost-effective solution adaptable to various asset types and geometries
- Facilitates real-time fitness for service assessments, aiding asset reliability and lifecycle management

