


Applications
Brochure

# HYDROGEN-INDUCED CRACKING (HIC)

## The phased array ultrasonic solution that keeps you on ahead of the curve.

Discover the all-inclusive package delivering actionable data.

### THE BEYOND CURRENT SOLUTION

Eddyfi Technologies offers a wide array of innovative phased array ultrasonic testing (PAUT) inspection solutions, which use non-intrusive techniques primarily on a test component's external surface. These solutions provide plan view, cross-sectional, and 3D imagery, visually indicating material integrity variations in easily interpretable graphics.

- One-stop shop solutions driven by technical expertise
- Streamlined workflow for setup, acquisition, and reporting
- Full support for ultrasonic testing (UT) methods including PAUT, time-of-flight diffraction (TOFD), conventional UT, full matrix capture (FMC)/total focusing method (TFM), plane wave imaging (PWI) and phase coherance imaging (PCI)
- Standard and custom probes designed in-house by our technical experts
- High-resolution TFM imaging

**At Eddyfi Technologies, our advanced technical experts lead the way in guiding you with dedicated packages for both industry-typical and niche inspection applications. We deliver highly optimized solution kits driven by our market-leading instruments, packed with software features that enhance efficiency and user experience.**

## UNDERSTANDING THE THREAT

In process environments containing wet hydrogen sulfide ($H_2S$), commonly referred to as sour service, assets have the potential for exposure to several damage mechanisms, which can result in catastrophic failure. These damage mechanisms generally affect carbon and low-alloy steels, particularly in the oil and gas industry, although $H_2S$ can also be present in other process environments. Failure to detect or monitor these damage mechanisms can lead to loss of containment and loss of life.

The most common wet $H_2S$ damage mechanisms are hydrogen induced cracking (HIC), stress oriented hydrogen cracking (SOHIC), sulfide stress cracking (SSC), and hydrogen blistering.

The $H_2S$ and $H_2O$ contained in crude oil interact with the iron (Fe) of the steel wall releasing hydrogen (H) into oil stream. The hydrogen diffuses into the steel and comes together to form molecular hydrogen at discontinuities. Over time, more and more hydrogen becomes trapped building up pressure and therefore stress in the steel leading to local failure.

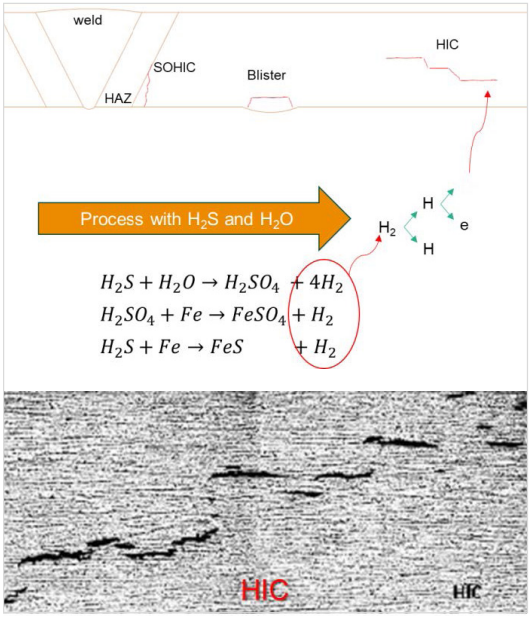


**Figure 1:** Example of associated flaws.

High stresses cause laminations that are usually parallel to the wall surface, leading to more hydrogen entering and increased pressure.

- Stresses cause cracks which tend to join laminations together. This is known as HIC or stepwise cracking.
- If the lamination occurs near the surface, we end up with a blister rising from the steel surface.
- SOHIC appears as arrays of cracks stacked on top of each other resulting in a through-thickness crack around the heat affected zones (HAZ).
- SSC is a form of hydrogen embrittlement that occurs in high-strength steels and in localized hard zones in weldment of susceptible materials such as HAZ.

# INSPECTION TECHNIQUES

**Eddyfi Technologies offers portable PAUT systems, Mantis™ and Cypher®, which provide all ultrasonic techniques in one box, enabling inspectors to deploy the test methods with full capability.**

## FAST SCREENING TOOLS: TOFD

Time-of-flight diffraction (TOFD) is used as a fast screening tool before indications are confirmed by other techniques. TOFD is mostly used for fast screening of welds to determine the presence of HIC/SOHIC but it can also be used for the base material.

**Advantages:**

- Less dependent on defect orientation
- Digital record of the examination
- Accurate through-wall sizing

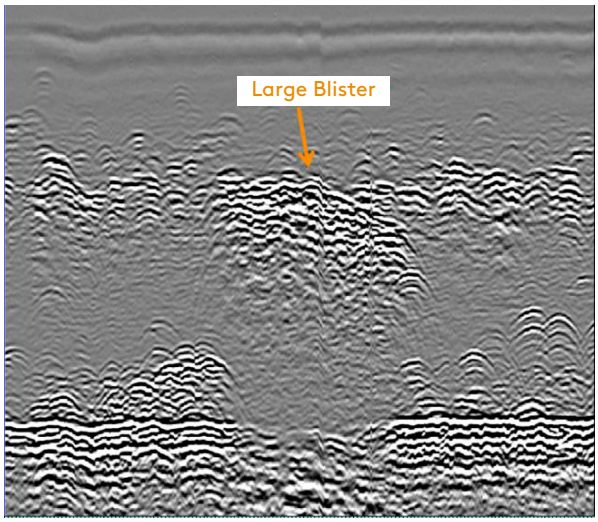


**Figure 2:** TOFD scan displaying large blisters. Image courtesy of Aker Solutions.

## TOTAL FOCUSING METHOD

TFM/FMC is a process that involves two steps. The acquisition part, FMC, consists of firing the elements one by one and recording the data on all receivers each time. This leads to a large beam spread, which becomes more sensitive to connections between laminations. This is very important in the context of wet $H_2S$, where both morphologies, HIC and blistering, differ significantly in terms of favorability to a 0-degree intersecting beam. TFM focuses the acoustic energy everywhere within a region of interest (ROI) defined by the operator, providing optimum spatial resolution along the active plane. Eddyfi Technologies' PAUT instruments also offer PWI capability, which is essentially a sectorial scan using the full aperture of the array (64 elements here) combined with TFM reconstruction. The advantage is a gain in productivity and more sensitivity as we fire all the elements rather than one at a time.

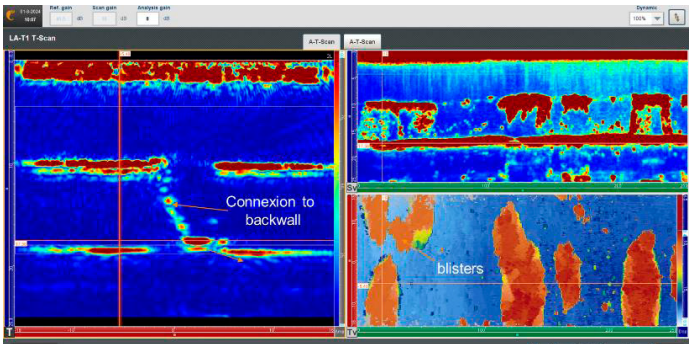


**Figure 3:** Visible connection between the HIC damage, blister and the backwall (ID).

Explore the following blog for further details on how to better detect $H_2S$ damage.

## INSPECTION SOLUTIONS

**Examinations using manually encoded, semi-encoded, or fully motorized (automated) scanners provide 100% coverage of the component, data storage for asset monitoring throughout its lifetime, and offline analysis of the data, contributing to the inspection reliability for this challenging industry problem. Tailor your requirements with our variety of alternative scanners available.**

### SEMI-AUTOMATED SOLUTION

The PaintBrush2 delivers the versatility and performance required for challenging HIC inspections. Its ergonomic design makes it easy to map targeted areas using Dual Linear Array or Linear Array probes. Supporting PAUT, TFM, and PWI techniques, it provides reliable, high-resolution results across complex geometries.

- Versatile applications: General corrosion, composites, HTHA, HIC
- Extensive temperature range: -35°C to 150°C / -31°F to 302°F
- Diameter range: from 100 mm (4 in) pipes to large elbows
- Broad probe compatibility: Dual Linear Array, A11 (0L), A12 (0L), NW1
- Freedom from grid constraints for fast and flexible 2D mapping



**Figure 4:** PaintBrush2.

### AUTOMATED SOLUTION

The automated, robust, field-proven NAV2 robotic scanner has been successfully deployed on various assets such as storage tanks, pressure vessels, pipelines, and other critical infrastructure.

- From 75mm (3in) OD to flat
- Ultra low profile
- Battery operated and remote controlled
- Integrated piloting capability when paired with cypher
- Max speed 250mm (9.8in)/sec
- Elevated temperatures up to 150°C (302°F)
- Versatile

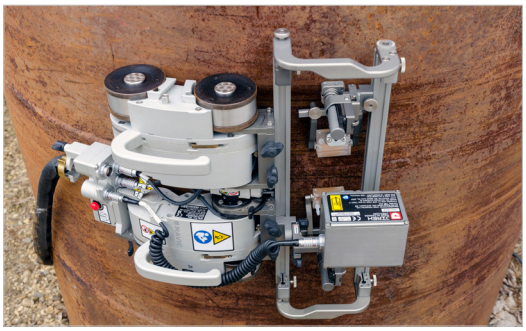



**Figure 5 and 6:** Automated crawler for corrosion and weld Inspection. Handles removable.

### PHASED ARRAY PROBES AND WEDGES

We offer a wide range of in-house standard and technique-specific linear array probes and wedges for inspecting $H_2S$ damage. Need something specific? Contact our team for customized probe and wedge options. While flat-footprint wedges are suggested in the recommended kits below, we can also manufacture AOD and COD contoured wedges upon request, especially for piping applications.

Discover a new era of precision with Eddyfi Technologies' high-quality NDT probes and transducers: View PAUT Probe Catalog

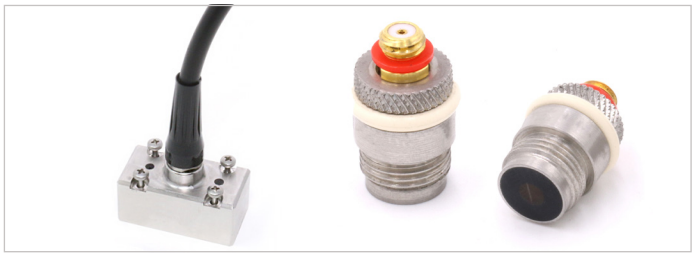

**Figure 7:** A12 and TOFD probes.

# ORDERING INFORMATION

| TYPE | ITEM | DESCRIPTION |
|---|---|---|
| | **Solution kit is compatible with the following instruments: Cypher®, Emerald, Panther™** | |
| Linear array probe | 5L64-A12-38.4X10-2.5-IPEX | 64-element linear array probe – 5MHz - Active aperture of 38.4mm x 10mm - Pitch: 0.60mm - Elevation: 10mm - A12 casing - 2.5m cable - IPEX connector |
| | WSA11-A12-0L-FLAT-20mm-IHC | Standard wedge for A11 and A12 phased array probe - Nominal angle of 0deg LW - Flat-20mm delay - Integral Irrigation. Scanner Holes & Carbide |
| TOFD probe | TOFD5-6-ST1-LEMO00 | TOFD Piezo Composite Transducer, 5MHz, 6mm crystal diameter, ST1 casing, Lemo00 connector – (2 QTY required) |
| | Wedge-ToFD-60LW-ST1-IHC | TOFD wedge for ST1 type TOFD probe - 60-degree LW nominal angle in carbon steel - Irrigation channels and probe holder fixtures – (2 QTY required) |
| | TOFD-CBL-LEMO00toLEMO00-PAIR-5M | Coaxial cables for TOFD - LEMO00 male to LEMO00 male - 5 meters long - Includes one double cable |
| Scanner | SCAN-PAINTBRUSH2-5M-LE | PaintBrush2 – Magnetic Corrosion scanner - fitted with a 5M LEMO16 encoder plug. For flat or curved surfaces (4'' or bigger in diameter). Kit includes tools for scanner maintenance and transport box |
| | SCAN-SPARE-PB2-A11-A12-FORK | Fork set for PaintBrush2 to allow use of A11 and A12 probes. Compatible with wedge - WSA11-A12-0L-FLAT-20mm-IHC. |
| | SCAN-ODI-2TOFD-LE | ODI II scanner - ToFD - 2 probes - LEMO 16 Encoder connector - Cable length 2.5 m - Max Wedge Width: 45 mm - Encoder Resolution: 16.0 counts/mm - Pivot button 5mm. |
| Accessories | COUPLANT-GLYCERIN-90ML | Couplant, liquid. Blue color. No air bubble. Quantity: 90ml - bottle |
| | SCAN-MANUAL-PUMP-7.9L | Manual water pump - 7.9 L - Compatible with SCAN-IRRIG-KIT-4MM & SCAN-IRRIG-KIT-6MM. Supplied as a Pump only. STIX, ROTIX and MICROBE scanners supplied with Irrigation. |
| | SCAN-IRRIG-KIT-4MM | (4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners |

*NOTE: DE15 encoder cable and ZPAC probe connectors also available. Various options for TOFD to be deployed with.

## High Temperature PaintBrush2 Kit

| ITEM | DESCRIPTION |
|---|---|
| SCAN-PAINTBRUSH2-HT-KIT-5M-LE | PaintBrush2 Elevated Temp Kit – Magnetic Corrosion scanner - 5M LEMO16 encoder plug, For flat or curved surfaces (4'' or bigger in diameter). Kit includes 5DL32-PB2-48x5-5-IPEX-HT-RD probe, tools for scanner maintenance and transport box |
| SCAN-MANUAL-PUMP-7.9L | Manual water pump - 7.9 L - Compatible with SCAN-IRRIG-KIT-4MM & SCAN-IRRIG-KIT-6MM. Supplied as a Pump only. STIX, ROTIX and MICROBE scanners supplied with Irrigation |
| SCAN-HT-SLEEVE-5M | 5M high temperature zipper cable management sleeve. Surface temperature rating -55C (-67F) to 180C (356F) |

NOTE: Rated to 150C up to 25 minutes, duty cycling.

## Automated

| ITEM | DESCRIPTION |
|---|---|
| NAV2-SYSTEM-15M* | Automated, battery operated and remotely controlled crawler system – Includes base crawler, control box, 2 x batteries, umbilical, irrigation, cable management, joystick plus accessories. For diameters 3"+. |
| AUTO-WELD-KIT-2TP-STD** | Standard kit for Weld Inspection. Includes: Pivot frame – 20cm (9.8in), 4 x Toolposts compatible with NAVIC2. |
| AUTO-RASTER-ARM-300MM | Motorized raster arm for Navic2 system - 300mm option – Predominately for zero degree |
| AUTO-SPARE-HEAVYDUTY-TP-W | Heavy duty vertical probe holder - wide, designed to carry larger probes on the raster arm, such as the Aqualock cart or Linear Array Probes such as A12 with IHC Ring. Supplied with 8mm pins. |
| NAV2-WELD-OPT-GUIDE | Battery powered optical guide for weld Inspection |
| SCAN-MOTORIZED-PUMP-* | The motorized couplant pump is a powered pumping unit used for supplying couplant fluid to the scanning surface. Output: 690 kPa (100 psi), 3.8 L/min (1.0 GPM). Max fluid viscosity 100 cSt. FCC, ISED, CE and UKCA Certified. NA/EU/UK Plug options. |

*Available in 5m (16.4ft)/15m (49.2ft)/30m (98.4ft) Lengths - Add Medium temperature kit for surface temperatures above 50°C (122°F).
**Other variants available - recommended to add SCAN-PIVOT-BTN-KIT

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