



Applications  
Brochure

# HIGH TEMPERATURE HYDROGEN ATTACK (HTHA)

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, which offer plan views, cross-sectional diagrams, and 3D imagery, visually indicate variations in material integrity through 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 phased array ultrasonic testing (PAUT), time-of-flight diffraction (TOFD), conventional UT, full matrix capture (FMC)/total focusing method (TFM), plane wave imaging (PWI) and phase coherence imaging (PCI)
- Standard and custom probes designed in-house by our technical experts
- The most advanced software analysis in the industry
- High-resolution TFM imaging with up to 128 elements

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 AND DETECTING HTHA: ADVANCES IN ULTRASONIC INSPECTION

High temperature hydrogen attack (HTHA) occurs in environments with hydrogen and high temperatures. Early detection of this damage mechanism is crucial for preventing catastrophic failures of critical high-pressure assets. High temperatures cause hydrogen to change atomic form, forming methane bubbles in the steel, which can lead to cracks. Asset owners have started additional inspections for HTHA following unexpected component failures. Detecting and sizing the defect mechanism using conventional UT or other volumetric NDT methods is challenging due to the small nature of the indications.

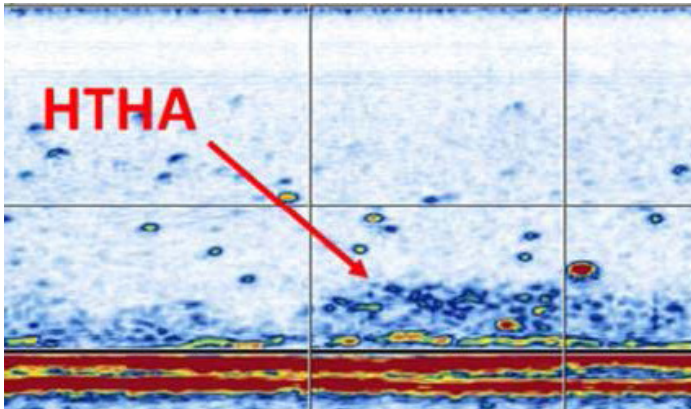


Figure 1: HTHA detected along the backwall of a component using a 2 x 64-element dual linear array (DLA) probe.

A mix of various HTHA stages often occurs simultaneously. This results in different shapes of expression, including decarburization and small voids at early stages, linked voids at intermediate stages, and crack-like damage at late stages. Due to the variation in defect shapes and the small size of early damage, HTHA poses a challenging task for ultrasonic examination.

The 2020 update to API RP 941 now incorporates more recent ultrasonic techniques such as TOFD, PAUT, and TFM. Additionally, the TULA probe, essentially ultra low angle TOFD probes, should be mentioned.

Success in detecting HTHA relies on:

- Efficient and robust inspection strategies that combine advanced ultrasonic examination techniques
- Damage specific operator training on specimens with confirmed HTHA
- Knowledge of the asset's life, particularly stress history, to avoid confusing HTHA with grain structure noise

## INSPECTION TECHNIQUES

Eddyfi Technologies offers portable PAUT systems, Mantis™, Gekko®, and TOPAZ®, which provide all ultrasonic techniques recommended by the American Petroleum Institute (API) in one box, enabling inspectors to deploy the test methods with full capability.

### PHASED ARRAY ULTRASONIC TESTING

PAUT provides an image of the inspected region, in addition to traditional A-scans, allowing for a more intuitive interpretation of the results. Due to weak ultrasonic responses in the early stage of HTHA damage, sensitivity settings will be much higher than those typically used for generic weld inspections. Therefore, larger aperture (more elements) PAUT probes are required; it is recommended to use a minimum of 64 elements. The frequency needs to be high enough to offer sufficient sensitivity to HTHA but also compatible with the range of thicknesses of the assets. Typical frequencies are 10 MHz for the thinnest components (<30mm) and no lower than 5 MHz for the thickest ones (>75mm).

Eddyfi Technologies provides a range of standard PAUT probes compatible with HTHA inspection and has also designed a series of PAUT probes tailored to maximize sensitivity not only for the phased array technique but also for TFM and PCI.

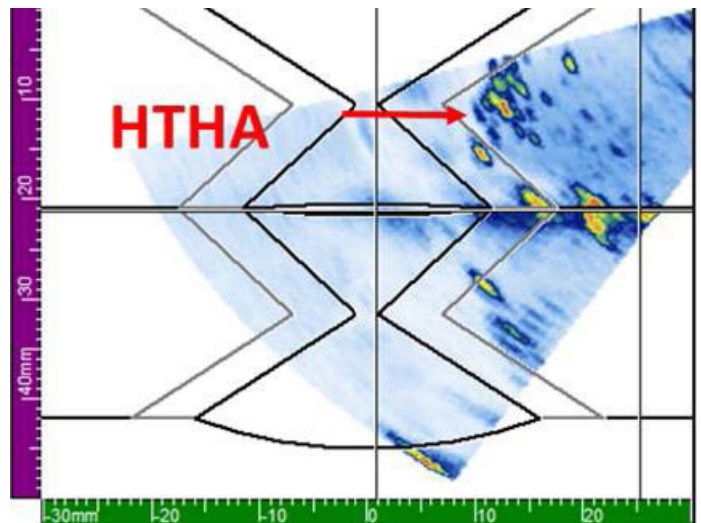


Figure 2: Image of a focused sectorial scan, providing a clear image of the area damaged by HTHA.



Figure 3: DLA probe (2 x 64-element) designed for pitch-catch inspections & linear array (64-element) with curved active elements provides a small focal beam (~1mm) along both the active and passive planes.

## FAST SCREENING TOOLS: TOFD AND TULA

TOFD is used as a fast screening tool before indications are confirmed by other techniques. The technique is sensitive to small diffractors such as the microcracks encountered during the HTHA mechanism. Increased grain noise (short indications) and clustering in A-Scan signals are indicative of early-stage HTHA.

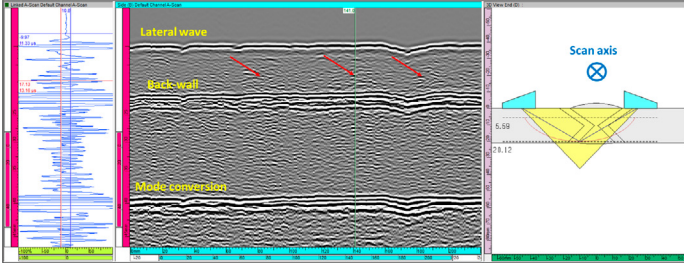


Figure 4: TOFD scan highlighting clustering in A-scan signals, which are indicative for early stage HTHA.

Probe selection depends on material type and wall thickness; for thinner components up to 25mm (1in), 10 MHz, Ø 3mm (0.12in) probes are very suitable. Thicker components might require the use of lower frequencies such as 7.5 and 5 MHz.

TULA™ is a conventional dual-crystal probe at 10 MHz with a roof angle that determines the depth of natural focus. Various TULA probes with specific focal depths are required to optimize detection throughout a range of thicknesses. They are available for normal incidence and inspection of the base material and with an angled beam to detect HTHA in the weld HAZ region.



Figure 5: TULA probes. Image courtesy of GB Inspections Systems Ltd.

## TFM/PCI

The advantage of PAUT paired with TOFD/TULA is further complemented by the additional use of TFM for the most comprehensive assessment possible. Inspectors can benefit from live interpretation of TFM frames and make assessments that ultimately help improve operations, reduce human and environmental risks by monitoring HTHA damage. The PAUT probes described are designed to be used interchangeably with PAUT or TFM/PCI, providing improved resolution along the passive plane for all techniques.

TFM/PCI focuses the acoustic energy everywhere within a region of interest (ROI) defined by the operator, providing optimum spatial resolution along the active plane. Both Gekko and TOPAZ 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.

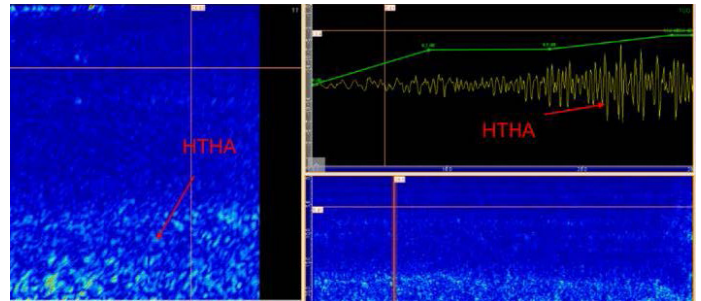


Figure 6: T-scan, D-scan and A-scan showing stage two HTHA.

A newer technique, similar to TFM but based on phase information, has emerged: PCI. PCI is sensitive to small diffractors that tend to radiate energy in all directions, such as the microcracks encountered with HTHA. By combining PCI reconstruction with dedicated probes and PWI, it is possible to detect HTHA with relatively good sensitivity.

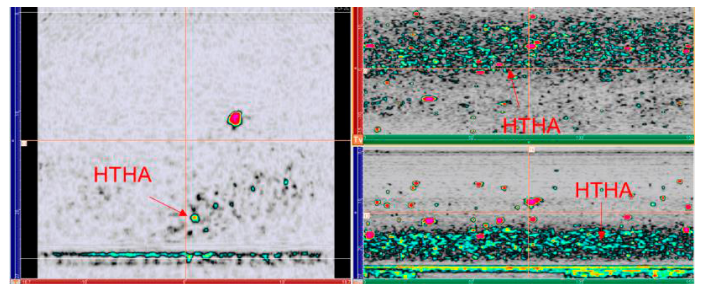


Figure 7: Detection of HTHA damage while providing better productivity at the same time utilizing PCI obtained from PWI.

## INSPECTION SOLUTIONS

Encoded 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 - contact for more information.

### SEMI-AUTOMATED SOLUTION

The handheld **NDT Sweeper** is a highly versatile semi-automated 2D encoded scanner which can virtually replace multiple specialized scanners due to its ability to perform corrosion mapping and weld inspections.

- From 100mm (4in) OD to flat
- 2D mapping – dual encoder
- Omni-wheels
- Versatile
- Integrated braking system
- Lightweight



Figure 8: Semi-automated NDT Sweeper for corrosion and weld inspections.

### 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
- Max speed 250mm(9.8in)/sec
- Elevated temperatures up to 150°C (302°F)
- Versatile

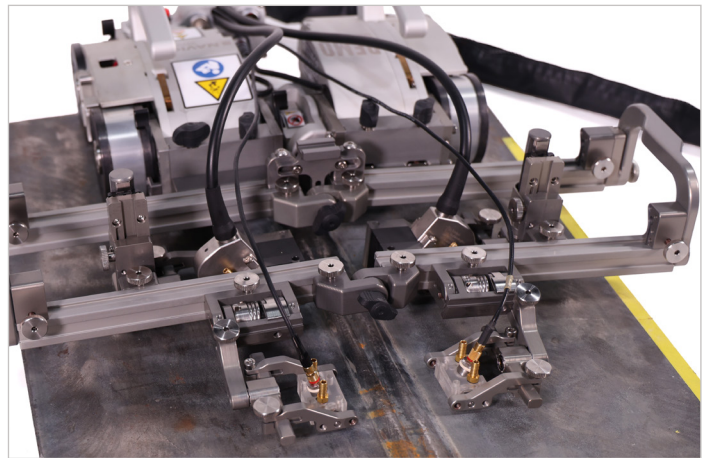


Figure 9 and 10: Automated crawler for corrosion and weld inspection. Handles removable.

### PHASED ARRAY PROBES AND WEDGES

We offer a wide range of in-house standard and technique-specific linear array probes and wedges for inspecting HTHA. Need something specific? [Contact](#) our team for customized probe and wedge options. Wedges with a flat footprint are suggested in the recommended kits below. However, contoured wedges, such as AOD and COD, are recommended for piping and can be manufactured upon request.

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



Figure 11: A11, A12 and TOFD probes.

# ORDERING INFORMATION

## HTHA T < 30mm (1.2in) - Screening Kit

ITEM	DESCRIPTION
MANTIS-16:64PR	MANTIS™16:64PR UTPA&TOFD – Multigroup – PRF 12kHz – 2 axis – Plate & Pipe + CAD – 128GB SSD, easy-latch adaptor, 1 batt. PS&AC adaptor, WiFi dongle, manual, rugged case. Incl. perpetual embedded CAPTURE™GO software for data acquisition and analysis.
TOFD10-3-ST1-LEMO00	TOFD Piezo Composite Transducer, 10MHz, 3mm crystal diameter, ST1 casing, Lemo00 connector
WEDGE-TOFD-60LW-ST1-IHC	TOFD wedge for ST1 type TOFD probe - 60-degree LW nominal angle in carbon steel - Irrigation channels (Dual Ports) and probe holder fixtures.
TULA-B	TOFD Ultra Low Angle (Focus 10mm) 10MHz
TULA-C	TOFD Ultra Low Angle (Focus 25mm) 10MHz
TOFD-CBL-LEMO00toLEMO00-PAIR-5M	TOFD Cable - Lemo00 to Lemo00 connectors - Pair - 5m length
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.
COUPLANT-GLYCERIN-90ML	Couplant, liquid. Blue color. No air bubble. Quantity: 90ml - bottle.
SCAN-MANUAL-PUMP-4MM	Manual water pump - 7.9 L.
SCAN-IRRIG-KIT-4MM	(4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners

## HTHA T < 30mm (1.2in) - Assesment Kit

ITEM	DESCRIPTION
GEKKO-64:128PR-TFM128	GEKKO® 64:128PR with real-time TFM128. Comes with 256GB SSD, easy-latch adaptor, 2 batt., PS&AC adaptor, WiFi dongle, manual, rugged case. Includes perpetual embedded CAPTURE™GO software for data acquisition and analysis.
CAPTURE-PRO	CAPTURE™ PRO software, perpetual license. Setup creation, advanced 3D data analysis and reporting capabilities.
10L64-A12-38.4X10-2.5-IPEX	64-element linear array probe - 10MHz - Active aperture of 38.4mm x 10 mm - Pitch: 0.6mm - Elevation: 10 mm - A12 casing - 2.5m cable - IPEX connector
WSA12-0L-FLAT-20mm	Standard wedge for A12 phased array probe - Designed for linear scanning at 0 degree using LW - 0deg LW nominal angle - 20mm delay
WSA12-55S-FLAT-IHC	Standard wedge for A12 phased array probe - Designed for azimuthal scanning from 40 to 70 degree using SW - 55deg SW nominal angle - Irrigation, probe holder fixtures & carbides
WSA12-IHC-RING	IHC Ring for A12 wedges, ported wedge ring with wear pins
5L64-AL-TFM-19.2X15-3-IPEX-DF15	64-element linear array probe - 5MHz - Active aperture of 19.2mm x 15mm - Pitch: 0.3mm - Elevation: 15mm - AL-TFM casing - 3m cable - IPEX connector - Focalized at 15mm
WSAL-55S-FLAT-IHC	Dedicated wedge for AL-type phased array probe - Designed for sectorial scanning from 40 to 70 degree using Longitudinal waves - 55-degree SW nominal angle - Irrigation channels and probe holder fixtures and carbide wear pins
10DL64-DLA-TFM-24X5-2.5-IPEX	64-element dual linear array probe - 10MHz - Active aperture of 24mm x 5mm - Pitch : 0.375mm - Elevation: 5mm - DLA-TFM casing - 2.5m cable - IPEX connector
SCAN-ACC-DLA-SHOE-4IR-41MM	Probe holder for small aperture (24mm x 5mm) 1D-Linear Transmit-Receive Phased array probe (Side-by-Side configuration) – 4x Irrigation Port – Compatible with corrosion probes CS casing
SCAN-ODI-1PA-LE	ODI scanner - 1 probe - LEMO 16 Encoder connector - Cable length 2.5 m - Max Clamp Width: 55 mm - Encoder Resolution: 16.0 counts/mm
SCAN-MANUAL-PUMP-4MM	Manual water pump - 7.9 L.
SCAN-IRRIG-KIT-4MM	(4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners

NOTE: Minimum required / Recommended Instrument listed, alternatives are available.

\*\*TULA is a trademark of GB Inspections Systems Ltd.

## ORDERING INFORMATION

### HTHA 30mm (1.2in) ≤ T < 75mm (3in) - Screening Kit

ITEM	DESCRIPTION
MANTIS-16:64PR	MANTIS™16:64PR UTPA&TOFD – Multigroup – PRF 12kHz – 2 axis – Plate & Pipe + CAD – 128GB SSD, easy-latch adaptor, 1 batt. PS&AC adaptor, WiFi dongle, manual, rugged case. Incl. perpetual embedded CAPTURE™GO software for data acquisition and analysis.
TOFD7.5-6-ST1-LEMO00	TOFD Piezo Composite Transducer, 7.5MHz, 6mm crystal diameter, ST1 casing, Lemo00 connector
WEDGE-TOFD-60LW-ST1-IHC	TOFD wedge for ST1 type TOFD probe - 60-degree LW nominal angle in carbon steel - Irrigation channels (Dual Ports) and probe holder fixtures.
WEDGE-TOFD-45LW-ST1-IHC	TOFD wedge for ST1 type TOFD probe - 45-degree LW nominal angle in carbon steel - Irrigation channels (Dual Ports) and probe holder fixtures.
TULA-A	TOFD Ultra Low Angle (0° roof angle) 10MHz
TOFD-CBL-LEMO00toLEMO00-PAIR-5M	TOFD Cable - Lemo00 to Lemo00 connectors - Pair - 5m length
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.
COUPLANT-GLYCERIN-90ML	Couplant, liquid. Blue color. No air bubble. Quantity: 90ml - bottle.
SCAN-MANUAL-PUMP-4MM	Manual water pump - 7.9 L.
SCAN-IRRIG-KIT-4MM	(4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners

### HTHA 30mm (1.2in) ≤ T < 75mm (3in) - Assessment Kit

ITEM	DESCRIPTION
GEKKO-64:128PR-TFM64	GEKKO® 64:128PR with real-time TFM64. Comes with 256GB SSD, easy-latch adaptor, 2 batt., PS&AC adaptor, WiFi dongle, manual, rugged case. Includes perpetual embedded CAPTURE™GO software for data acquisition and analysis.
CAPTURE-PRO	CAPTURE™ PRO software, perpetual license. Setup creation, advanced 3D data analysis and reporting capabilities.
10L64-A12-38.4X10-2.5-IPEX	64-element linear array probe - 10MHz - Active aperture of 38.4mm x 10 mm - Pitch: 0.6mm - Elevation: 10 mm - A12 casing - 2.5m cable - IPEX connector
WSA12-0L-FLAT-20mm	Standard wedge for A12 phased array probe - Designed for linear scanning at 0 degree using LW - 0deg LW nominal angle - 20mm delay
WSA12-55S-FLAT-IHC	Standard wedge for A12 phased array probe - Designed for azimuthal scanning from 40 to 70 degree using SW - 55deg SW nominal angle - Irrigation, probe holder fixtures & carbides
WSA12-IHC-RING	IHC Ring for A12 wedges, ported wedge ring with wear pins
5L64-AL-TFM-19.2X15-3-IPEX-DF50	64-element linear array probe - 5MHz - Active aperture of 19.2mm x 15mm - Pitch: 0.3mm - Elevation: 15mm - AL-TFM casing - 3m cable - IPEX connector - Focalized at 50mm
WSAL-55S-FLAT-IHC	Dedicated wedge for AL-type phased array probe - Designed for sectorial scanning from 40 to 70 degree using Longitudinal waves - 55-degree SW nominal angle - Irrigation channels and probe holder fixtures and carbide wear pins
SCAN-ODI-1PA-LE	ODI scanner - 1 probe - LEMO 16 Encoder connector - Cable length 2.5 m - Max Clamp Width: 55 mm - Encoder Resolution: 16.0 counts/mm
SCAN-MANUAL-PUMP-4MM	Manual water pump - 7.9 L.
SCAN-IRRIG-KIT-4MM	(4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners

NOTE: Minimum required / Recommended Instrument listed, alternatives are available.

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# ORDERING INFORMATION

## HTHA T ≥ 75mm (3in) - Screening Kit

ITEM	DESCRIPTION
MANTIS-16:64PR	MANTIS™16:64PR UTPA&TOFD – Multigroup – PRF 12kHz – 2 axis – Plate & Pipe + CAD – 128GB SSD, easy-latch adaptor, 1 batt. PS&AC adaptor, WiFi dongle, manual, rugged case. Incl. perpetual embedded CAPTURE™GO software for data acquisition and analysis.
TULA-A	TOFD Ultra Low Angle (0° roof angle) 10MHz
SCAN-ODI-1PA-LE	ODI scanner - 1 probe - LEMO 16 Encoder connector - Cable length 2.5 m - Max Clamp Width: 55 mm - Encoder Resolution: 16.0 counts/mm
SCAN-MANUAL-PUMP-4MM	Manual water pump - 7.9 L.
SCAN-IRRIG-KIT-4MM	(4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners

## HTHA T ≥ 75mm (3in) - Assessment Kit

ITEM	DESCRIPTION
GEKKO-64:128PR-TFM64	GEKKO® 64:128PR with real-time TFM64. Comes with 256GB SSD, easy-latch adaptor, 2 batt., PS&AC adaptor, WiFi dongle, manual, rugged case. Includes perpetual embedded CAPTURE™GO software for data acquisition and analysis.
CAPTURE-PRO	CAPTURE™ PRO software, perpetual license. Setup creation, advanced 3D data analysis and reporting capabilities.
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
WSA12-0L-FLAT-20mm	Standard wedge for A12 phased array probe - Designed for linear scanning at 0 degree using LW - 0deg LW nominal angle - 20mm delay
WSA12-55S-FLAT-IHC	Standard wedge for A12 phased array probe - Designed for azimuthal scanning from 40 to 70 degree using SW - 55deg SW nominal angle - Irrigation, probe holder fixtures & carbides
WSA12-IHC-RING	IHC Ring for A12 wedges, ported wedge ring with wear pins
SCAN-ODI-1PA-LE	ODI scanner - 1 probe - LEMO 16 Encoder connector - Cable length 2.5 m - Max Clamp Width: 55 mm - Encoder Resolution: 16.0 counts/mm
SCAN-MANUAL-PUMP-4MM	Manual water pump - 7.9 L.
SCAN-IRRIG-KIT-4MM	(4mm-ID) Irrigation Kit - Fits ROTIX, STIX and LYNCS scanners

NOTE: Minimum required/Recommended Instrument listed, alternatives are available.

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# ORDERING INFORMATION

## 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. North American power cord.

\*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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