



hotsensei®

# “Ultrasonic inspection at elevated temperatures”

Tim Stevenson



## Who we are

Established 2011

Commercialised new piezo and ultrasonic technology

UK Based – HQ, Huddersfield, West Yorkshire, UK

Developer and Manufacturer of **Piezoceramics, Sensors and Solutions** from raw material to turn-key system.

Wide range of sensing applications

- Corrosion/erosion monitoring
- EV brake wear sensing
- Molten lead level sensing
- Flare gas metering
- Steam flow meters
- Gas turbine vibration sensing
- NDT

**Manufacturer and supplier of ultrasonic solutions for extreme environments**



Raw Materials



Ceramics components



Sensors & Deployment systems

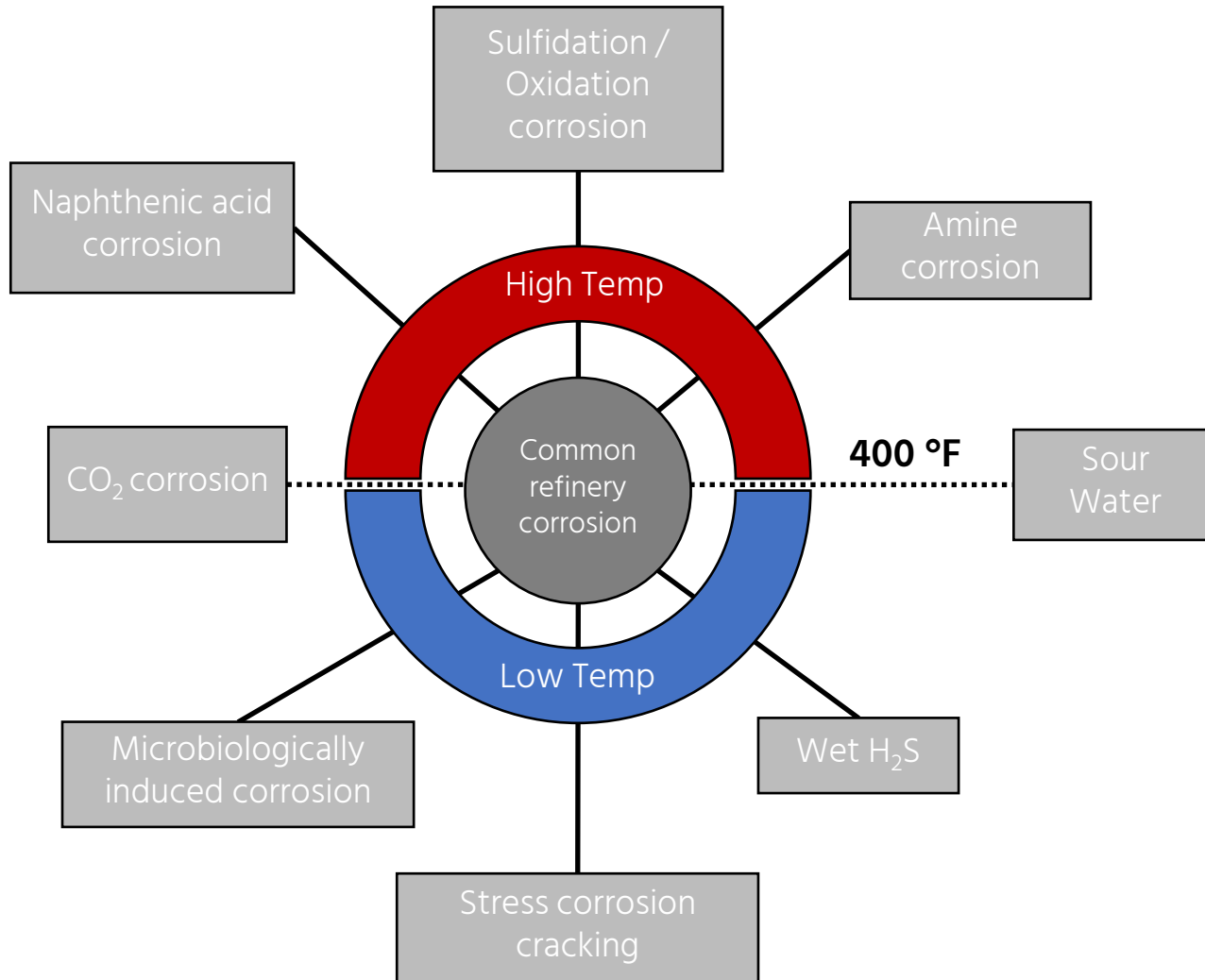


System integration



Development & Test capability

# Corrosion and integrity assessment



| Damage mechanism          | Appearance        |
|---------------------------|-------------------|
| Sulfidation               | Uniform thinning  |
| Amine corrosion           |                   |
| Oxidation                 |                   |
| Sour water corrosion      |                   |
| Naphthenic acid corrosion |                   |
| Condensate corrosion      | Pitting/ grooving |
| Acid corrosion (HF, HS)   |                   |



## An example - Sulfidation Corrosion

### Mechanism

- Most prevalent mechanism in oil refining industry
- All crude oil feeds contain naturally occurring sulfur compounds (incl  $\text{H}_2\text{S}$ )
- Uniform wall thinning, forming FeS sulfide semi-passive layer at  $>260^\circ\text{C}$  /  $500^\circ\text{F}$
- Localised thinning can occur from high-velocity flow / erosion of passive layer
- Affects heaters, boilers, cokers, distillation units, FCCs and can lead to catastrophic rupture – rather than leaks.
- Increased silicon content steel is more resilient and now standard, however most plant precedes these ASME standards.

### Mitigation: Detection and Monitoring

- 2012 Richmond Refinery overhauled the recommended practices for prevention and inspection.
- **API (RP 571, 2020) now require identification of carbon steel hydrocarbon circuits that contain low Si content at risk**
  - 100% inspection to determine areas of accelerated corrosion
  - Where found – continuous monitoring is recommended



**hotsensei**® | Powered by **ionix**

### Extreme Environments

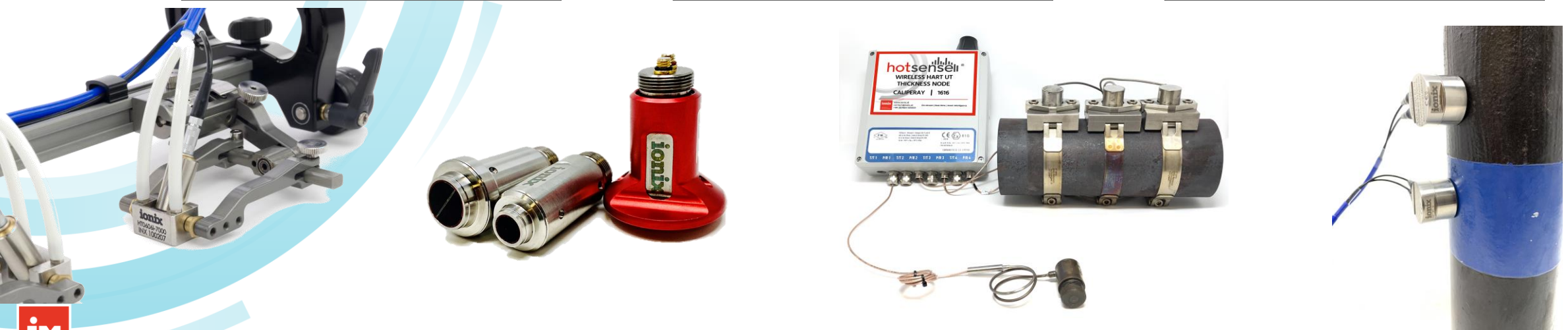
Ultrasonic platform for use in **extreme environments** including high temperature, explosive atmospheres, radiation and shock

### High Temperature

Continuous high temperature operation and **excellent stability** from -200°C to +580°C.

### Continuous Monitoring

Enabling **continuous monitoring** of critical assets and processes on-stream, and in real time



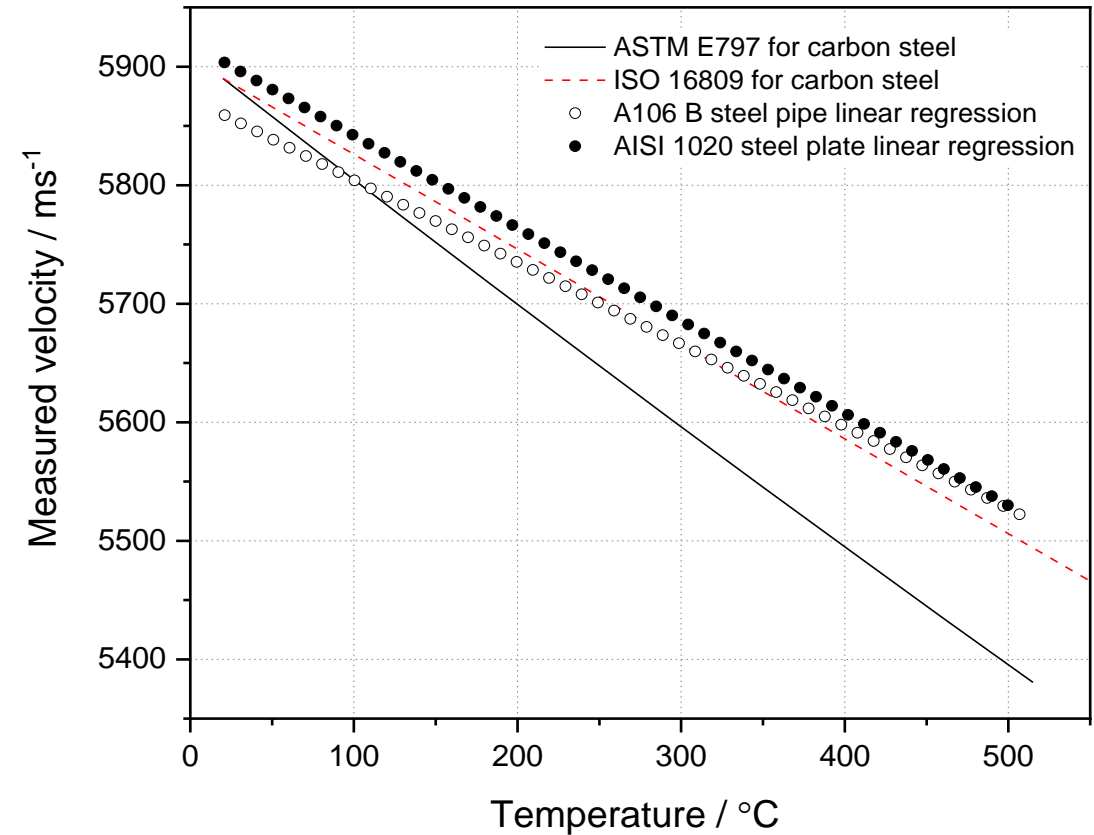
Ionix made equipment available to all the HOIS participants.

- HotSense UT probes - 5 MHz, 8 and 12 mm dia.
- HotSense TOFD sets - 5 MHz, 6 mm dia.

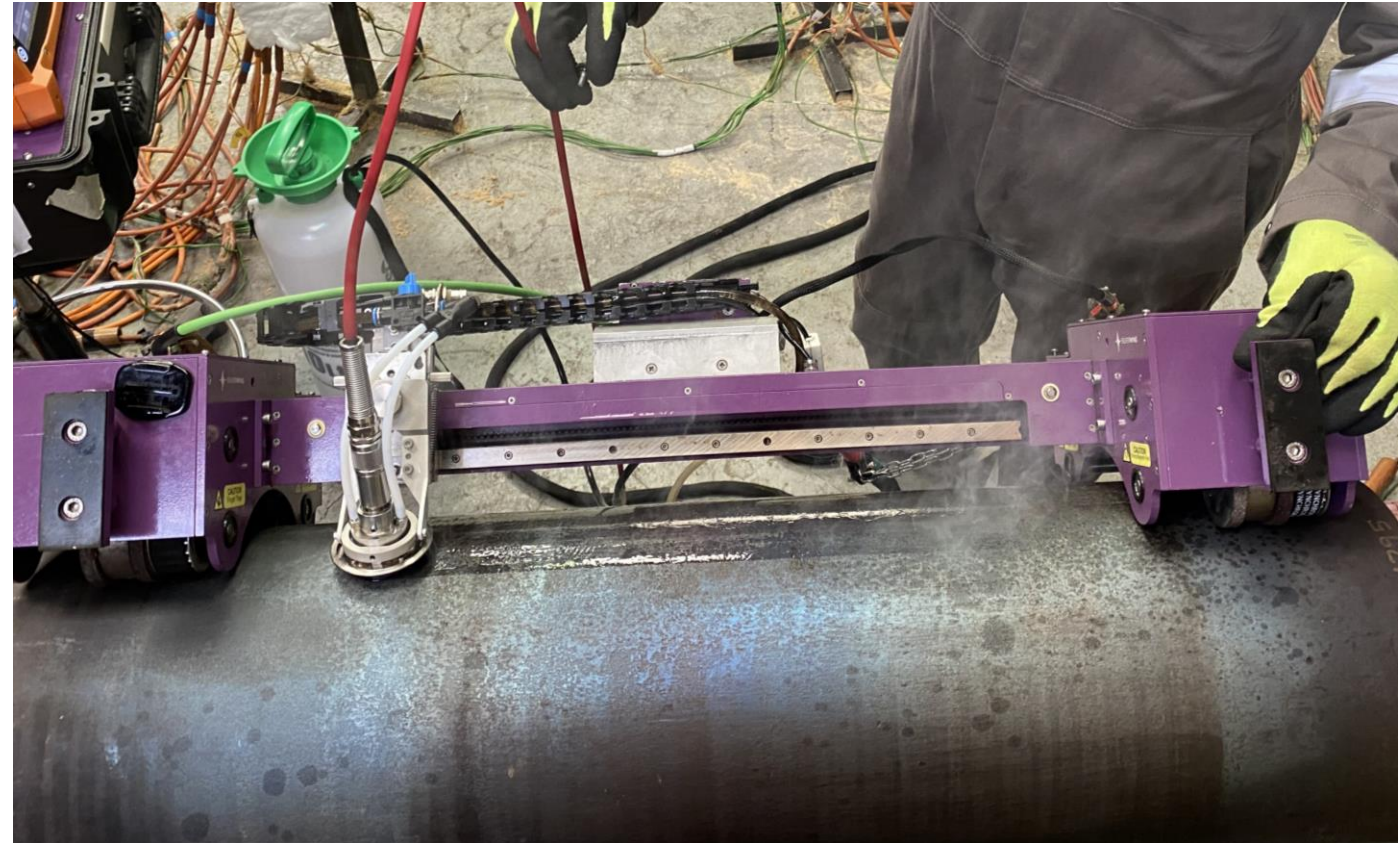
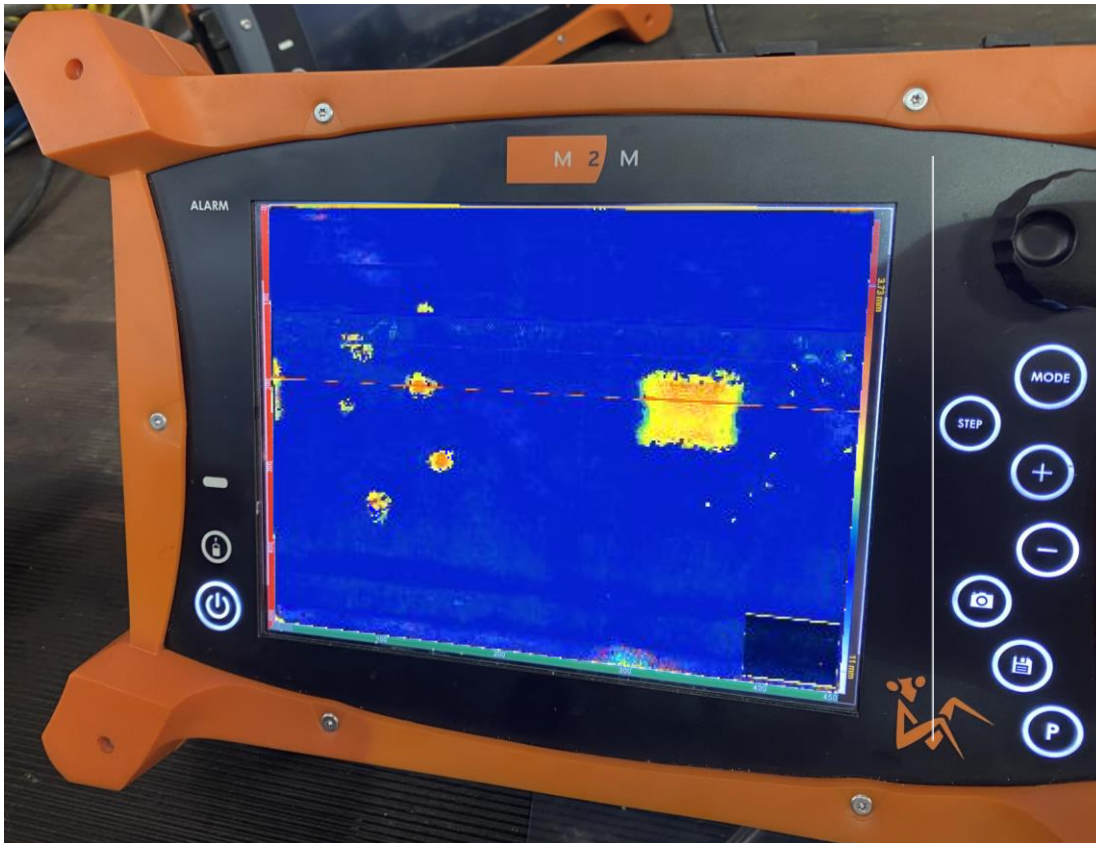
Users included;

- EddyFi
- Bilfinger
- Oceaneering

We provided speed of sound as a function of temperature data to HOIS, and temperature correction curves to the users.



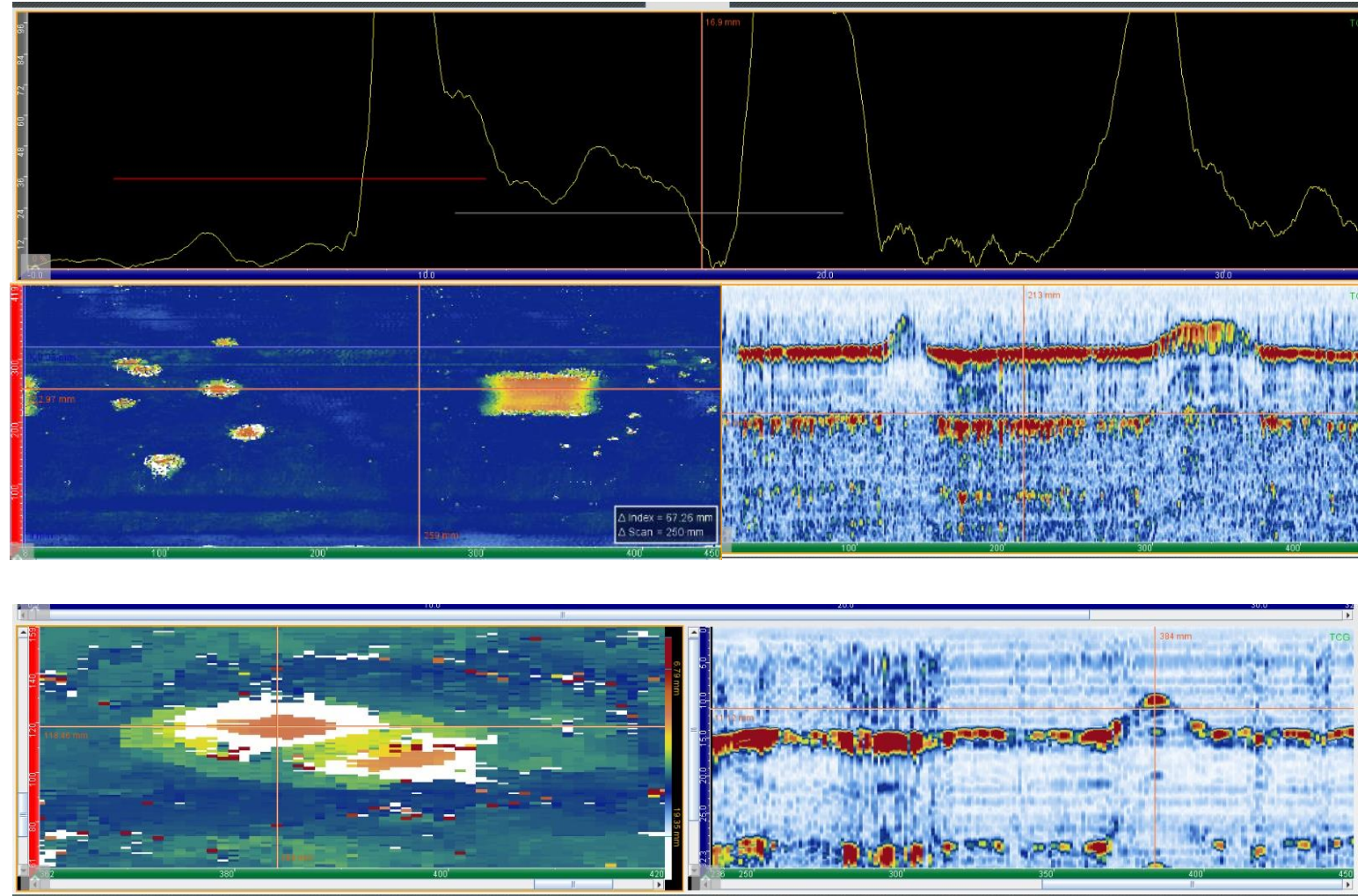
## Corrosion mapping, HOIS 2021



Corrosion mapping at  $>400^{\circ}\text{F}$

## Corrosion mapping, HOIS 2021

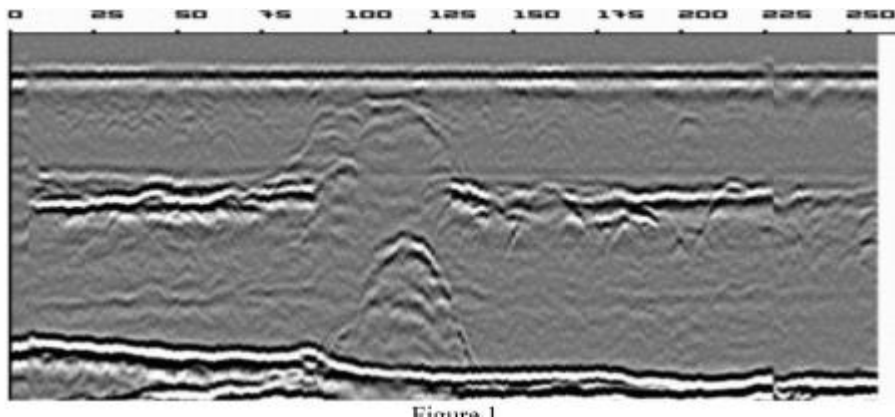
- Good POD for pits and larger defects even at elevated temperature
- Pit clusters (>2:1 height to width) were detected by tip indication only
- TCG applied to suppress noise at elevated temperature
- Rapid setup with no cooling
- Slower scans than PAUT, but commensurate with cost



## Angle beam inspection, HOIS 2022

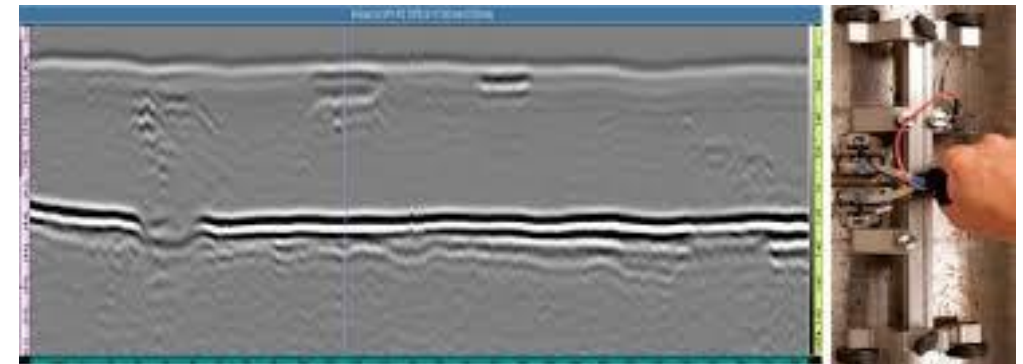
### Weld root corrosion

- Common damage mechanism downstream
- TOFD is an effective measurement covering weld body and HAZ with wide beam spread
- Compatible with API 579 and other standards for FFS assessment of in-service defects
- Limited high-temperature options

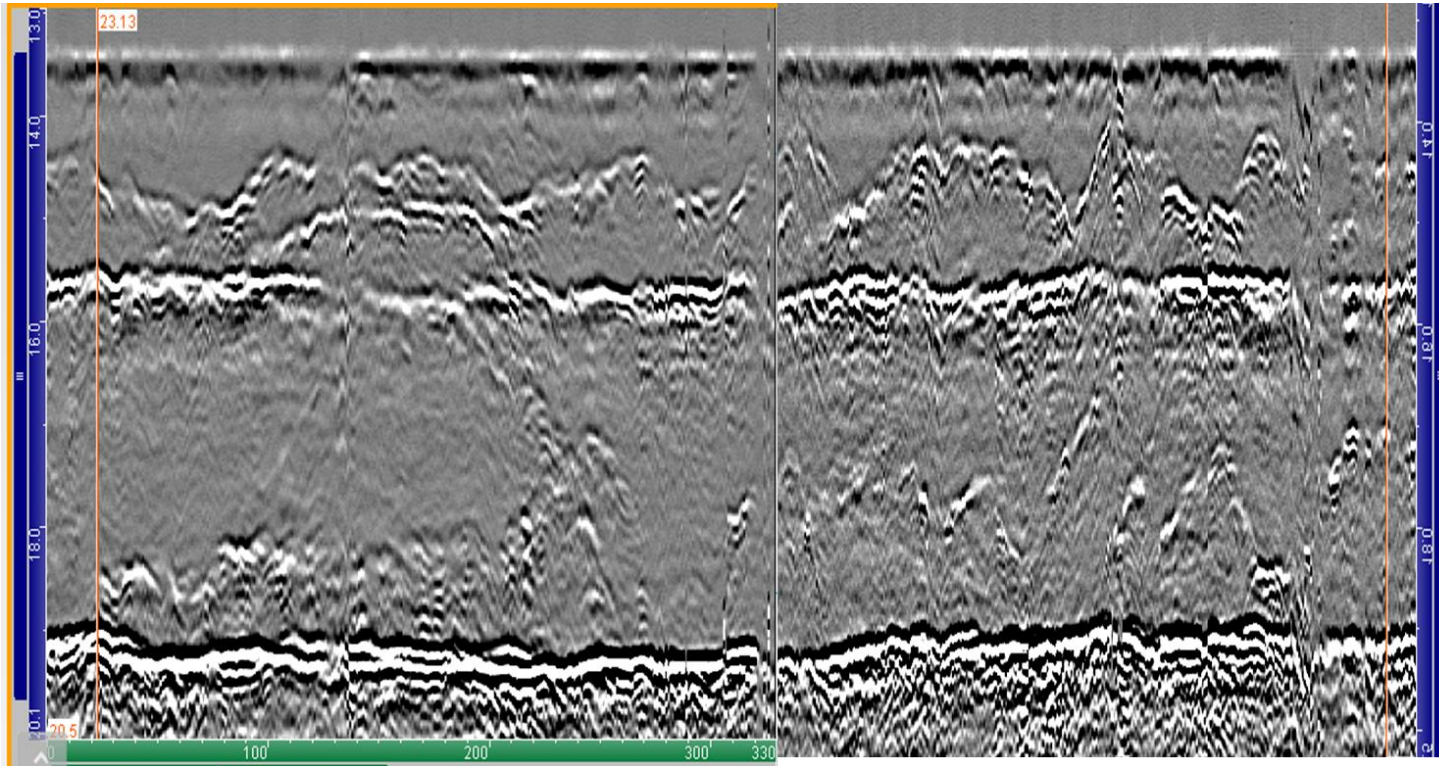


### Crack/defect inspection

- TOFD carries the highest POD for NDT methods
- Becoming more popular in tandem with PAUT
- Accurate sizing of defects (in steel >6 mm thick)
- Limited high-temperature options
- Angle variation with temperature needs to be compensated
- Wall thickness of HT components often thicker



## HT weld inspection, HOIS 2021





**"100% inspection, 100% of the time"**

Case Studies

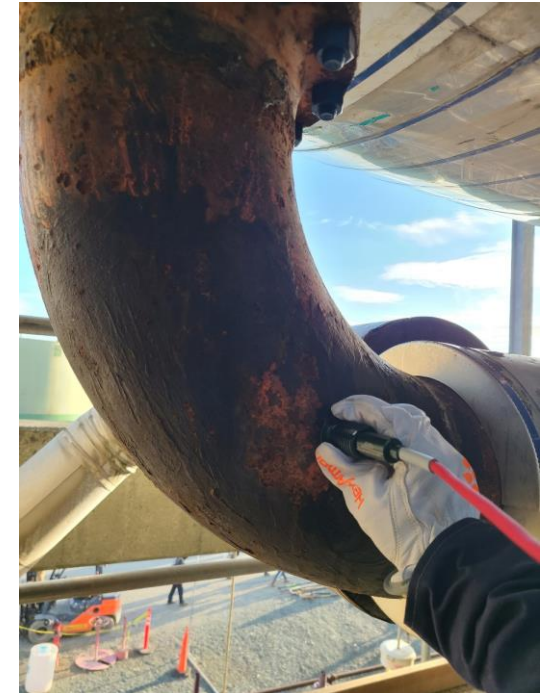
## “In-service remaining wall thickness”

### The Challenge

- Corrosion surveys are routinely carried out on critical refinery components such as pipework and pressure vessels that operate at high-temperatures ( ~700 F)
- The remaining wall thickness is used to establish a fitness for service
- Measurements are often scheduled during a shutdown when the components are cool, which results in lost productivity.
- Many operators are seeking on-stream corrosion surveys to reduce or remove the need to shutdown.

### Solution

- 5 MHz dual UT transducers, capable of continuous operation up to 762 F allow inspection personnel to perform UT wall thickness surveys whilst the asset is operational.
- By allowing the transducer to reach the surface temperature with no duty cycle, reduces delay drift, and allows more time to undertake quality surveys in between calibrations.
- Accurate measurements achieved with velocity compensation



## "On-stream corrosion survey of US refinery"

### Challenge

- Remaining wall thickness data was required on refinery components, including hydrocracker
- Surface temperature range up to 371 °C / 700 °F continuously
- Time consuming inspections with conventional probes with duty cycling and calibration
- Lack of repeatable measurements giving conservative values for fitness for service

### Solution

- HotSense transducers replaced traditional, incumbent transducers, reducing duty cycling to achieve repeatable results
- Enabled on-stream inspection of components not previously accessible, such as hydrocracker
- Each transducer out-performed previous units completing at least 2X the number of measurements before needing re-surfacing.
- Manufactured to international standards allowed immediate use, traceability and compliance with existing UT procedures and ASNT qualifications.



## “High temperature sulfidation”

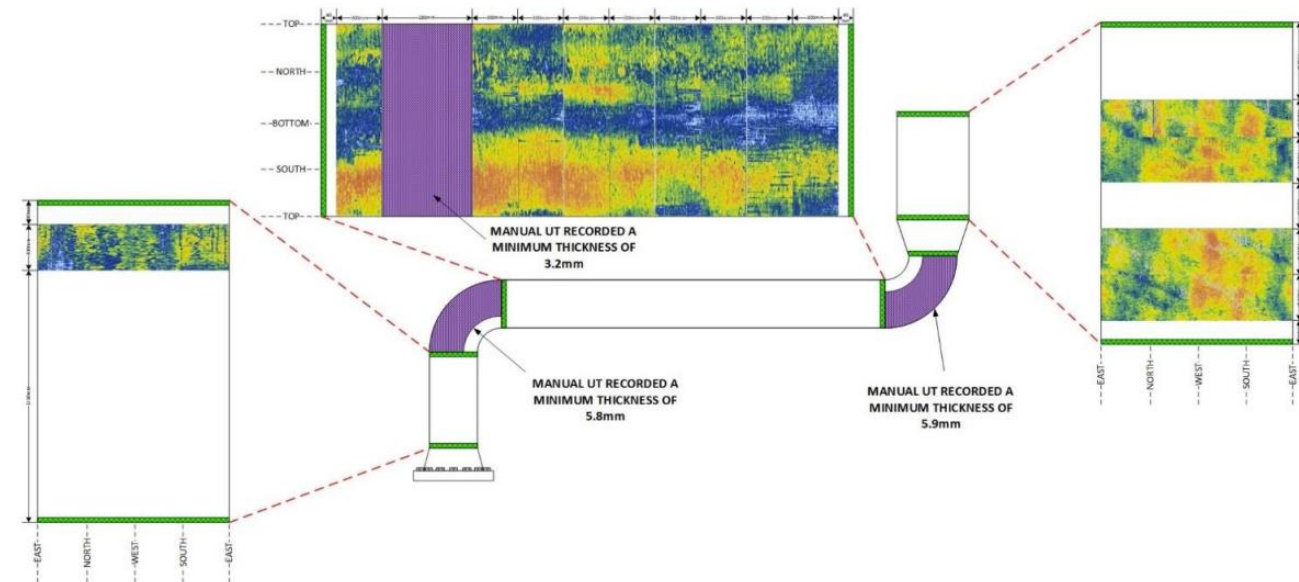
### The Challenge

- Remaining wall thickness required for an in-service 5 m refinery piping circuit operating at 500 °F at risk of sulfidation
- 6” – 8” NPS carbon steel piping
- Aim to determine areas of accelerated thinning by means of UT corrosion mapping (C-scan)



### Solution

- 5 MHz dual UT transducer deployed with a magnetic crawler and UT set allows immediate implementation.
- Wall thickness maps on the designated circuits were undertaken with no additional training or setup
- Measurements were collected without cooling, shutdown or isolation of the circuit
- Temperature compensation allowed for accurate, repeatable data



## “High temperature non-intrusive inspection (NII) of pressure vessel”

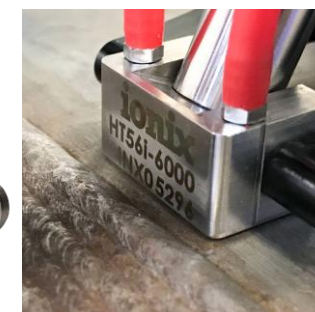
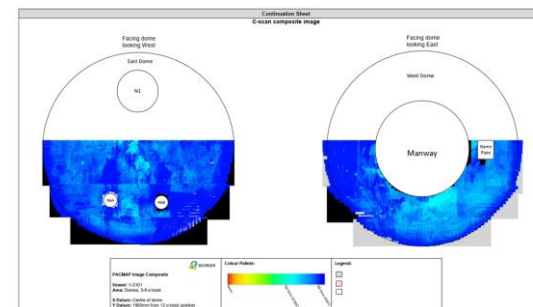
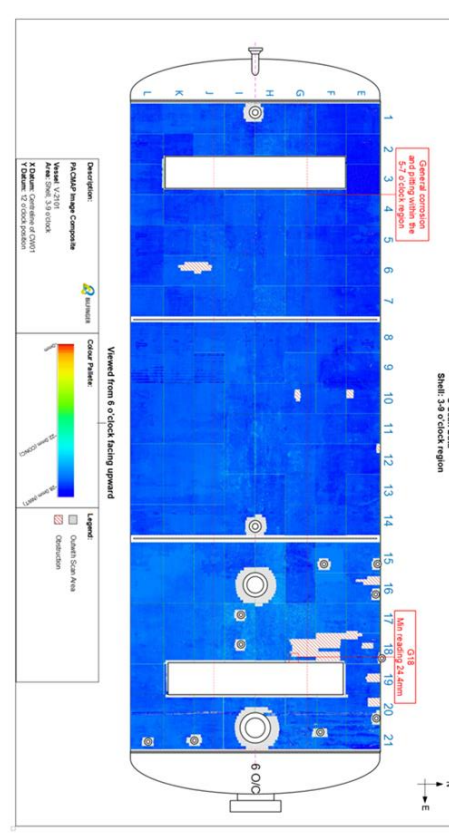
### The Challenge

- Performing NII on a pressure vessel operating at 350 °F in accordance with HOIS-GP-103 ( Recommended practice for NII of pressure vessels )
- Check required that wall thickness is within allowable pressure limits using UT corrosion mapping & TOFD
- Dims: 25 m x 6 m x 25 mm WT ( 82' x 20' x 1" WT)

### The Solution

- **Ionix HS582i** HT UT transducers
- **Ionix HotSense™** TOFD probes/wedges
- **JIREH SKOOT – HT** Automated crawler

Utilizing the latest specialized HT equipment from Ionix and Jireh that was part of the HOIS project, a comprehensive NII was able to be conducted in-service *without* the need for vessel cooling, shutdown, or isolation. Temperature compensation allowed for accurate, repeatable data, accompanied by a comprehensive composite C-map overview.



## “In-service flare stack inspection”

### The Challenge

- Significant corrosion in stacks and flares can occur due to acidic compounds with moisture in the presence of heat.
- Due to inaccessibility, they are challenging to inspect
- The transitional region from carbon to stainless steel can promote accelerated wall loss, with surface temperatures of ~215 °F

### The Solution

- The Voliro-T aerial platform was fitted with a UT payload with HS5122i HT capable transducer & couplant.
- The stack is now accessible in any orientation, at up to 200 points per hour, whilst the asset is in service and no loss of productivity.
- Live A-scan, auto peak detection was adopted for fast, reliable wall thickness data at elevated temperatures.



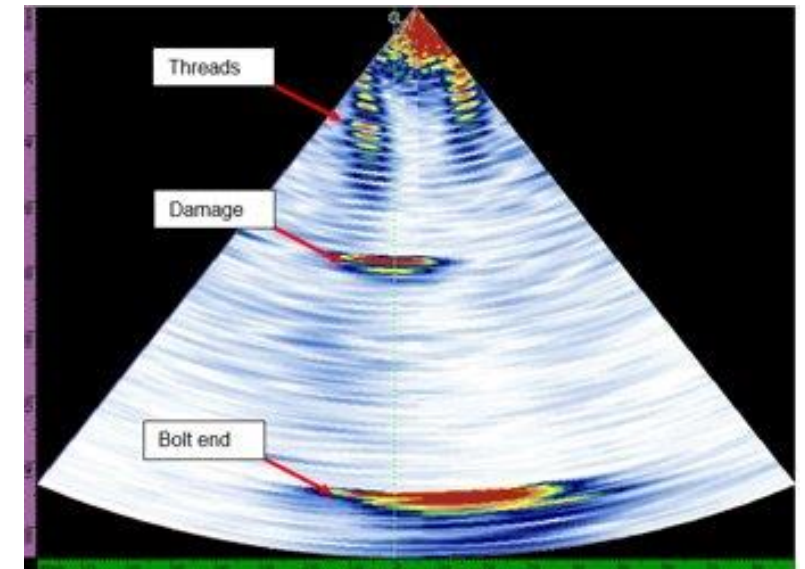
## “High-temperature bolt inspection”

### The Challenge

- Repair of gate valve steam leaks required injection of sealant and clamping
- Injection can only take place when the bolt conditions are verified safe
- The valve cannot be isolated, and the bolts exhibit a surface temperature of ~400 °F continuously in service.

### The Solution

- 5 MHz, 16 element linear PAUT probes were used to generate compression waves around a sweep angle at 0 degrees without a wedge.
- Phased array imaging allowed assessment of each bolt to assess damage
- Damaged bolts that were identified and assessed against the location of the bolt and position of damage relative to aligning with the leak path



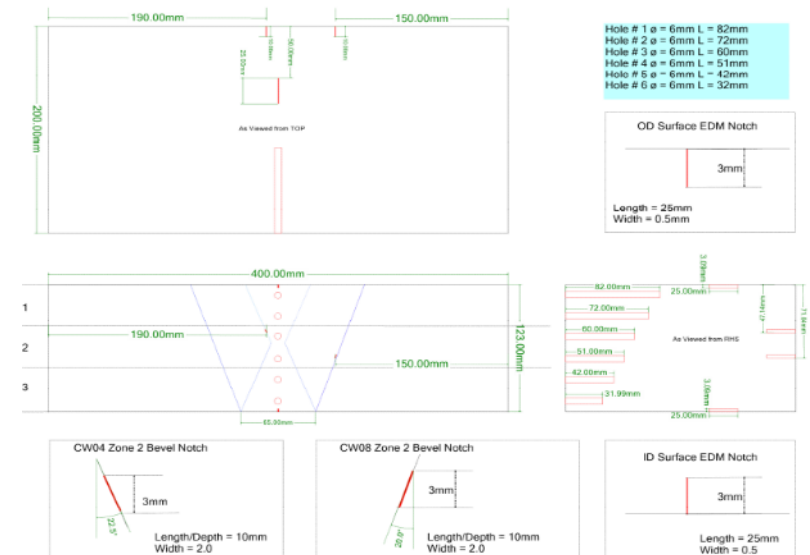
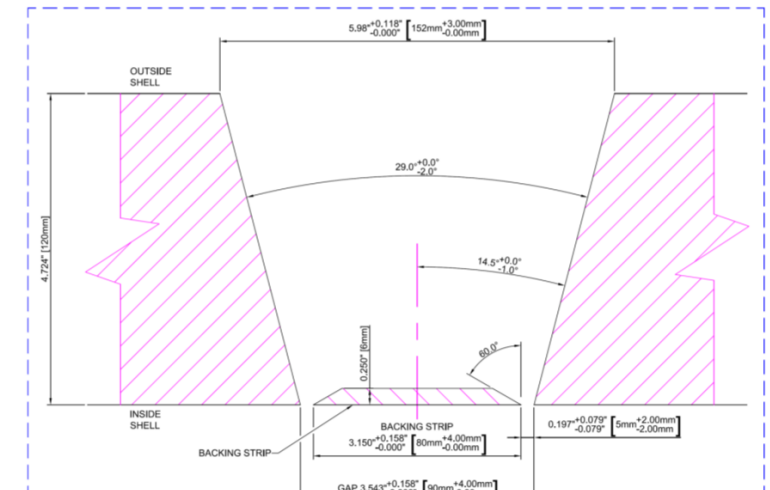
## “Ammonia converter inspection for repair”

### The Challenge

- Major & multiple cracks were detected on a shell to shell circumferential weld on an ammonia converter.
- The cracking was ID connected and 50% of the through wall thickness
- A repair campaign for a custom weld required TOFD examination at 66% partial and 100% fill at 400 °F pre-heat.

### Solution

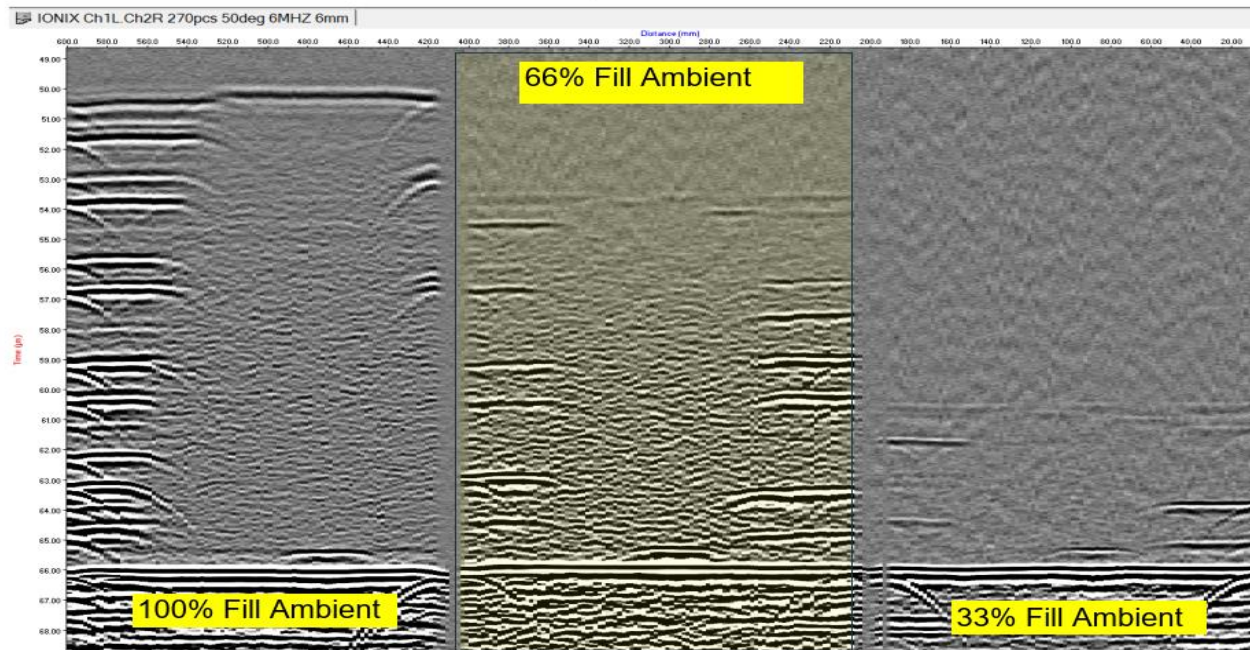
- Validation blocks were prepared and welded to determine the custom weld and the UT technique.
- 5 MHz 50 deg TOFD was effective in detecting defects within 1.5” of the ID surface.
- All 6 defects were detected at 100% fill.
- Repairs were executed without the need to cool down and cycle pre-heating.



## “Ammonia converter inspection for repair”

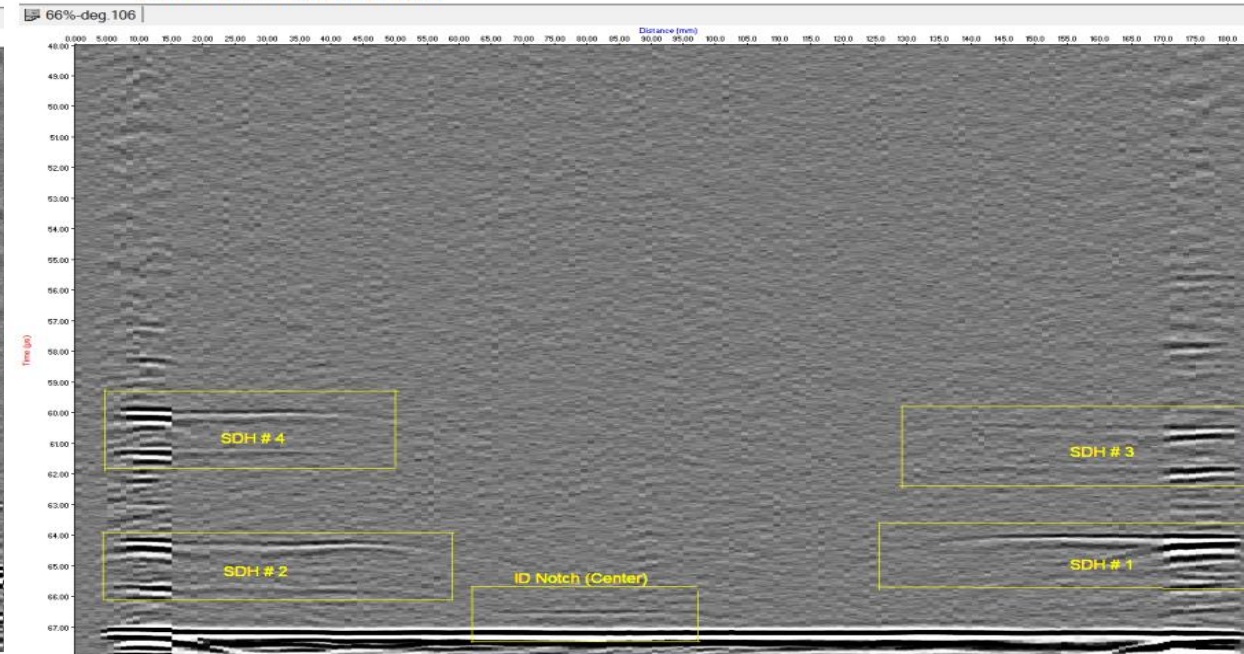
### 66% Fill Validation Scans using IONIX 50Deg TOFD probes

#### 50/50° Wedge Combination Scans Including 3 Blocks at each welded fill Level at Ambient temperature



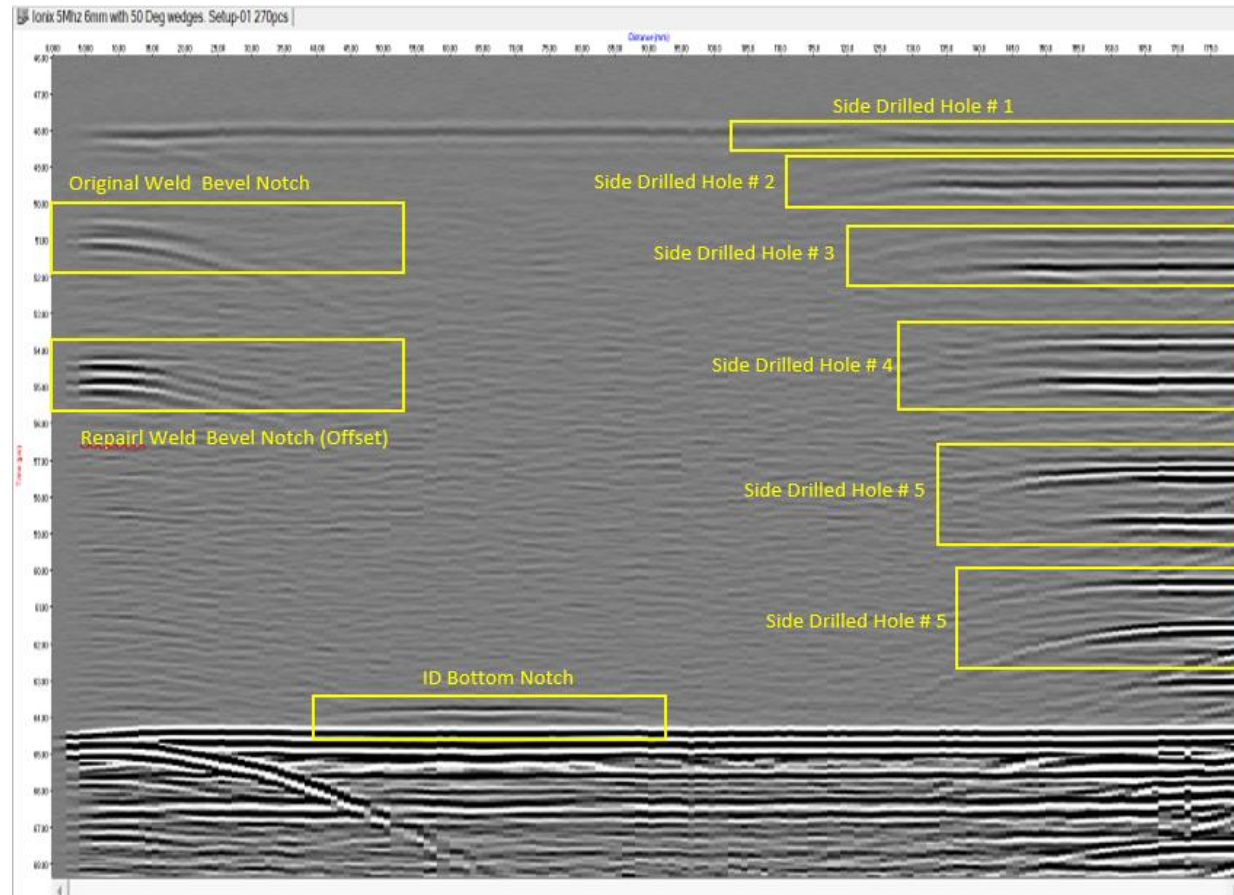
#### 50/50° Wedge Combination Scans of Block 68036 (66% fill) at Elevated temperature 190°C (374°F)

##### Center Position Scan



## “Ammonia converter inspection for repair”

### 100% Fill Validation Scans using IONIX 50Deg TOFD probes



## “Intrinsically safe tank inspection”

### The Challenge

- Petrochemical, gas and oil refinery plant is often operating in hazardous locations with potentially explosive atmospheres and at elevated temperatures
- A hot work permit is routinely required to access Ex zones, and requires the plant to be cooled or isolated for measurement

### The Solution

- Intrinsically safe gauge and transducers that are capable of operation up to 580 °F continuously, in Zone 0 / Class 1 Div 1 locations.
- The gauge integrated auto-zero and temperature compensation functions in line with HOIS-G-054 recommend practice, for accurate reporting



## **“Intrinsically safe tank inspection”**

### **The Challenge**

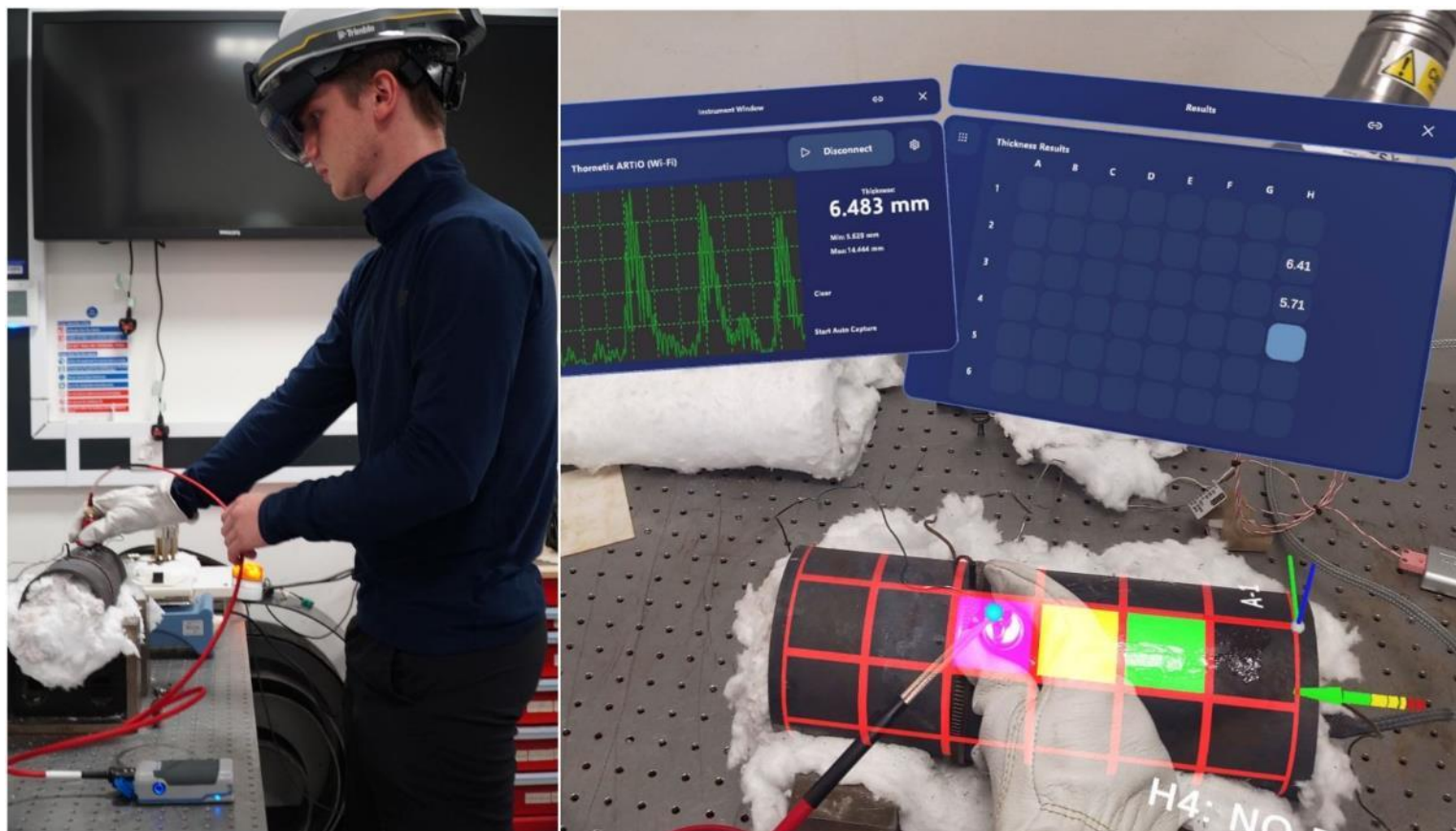
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## “Augmented reality inspection at elevated temperature”



# hotsensei®

Delivering on stream, real-time, asset intelligence

## Integrated by



## Trusted by



## Relied on by

