GUIDED ULTRASONICS LTD.

Introduction to pipe corrosion detection using GUL guided wave technology

Created by:
Dr Chien An Chua
Regional Manager (SE Asia)

20 November 2023

GULSCREENING

GUIDED ULTRASONICS LTD.

We provide solutions to **pipe corrosion** detection, sizing and monitoring using **guided wave technology**.

Corrosion Detection


Training & Certification

Corrosion Sizing


Site Support

Corrosion Monitoring


Consultancy

Our Product Lines

GULSCANNING

Sizing corrosion accurately at pipe supports

GULSCREENING

Rapid detection of corrosion and erosion in pipes and rail.

GULMONITORING

Detection and **monitoring** of corrosion and erosion in pipes

GULSUBSEA

Detection and monitoring of corrosion and erosion in **subsea pipes**

30+

years of R&D and field experience.

GUIDED ULTRASONICS LTD. TIMELINE

1986

Result of first attempt without a full understanding of guided waves.

Source: Bartle, P. M. (1987). "Acoustic pulsing monitoring: principles operational requirements and potential," The Welding Institute, Abington, Cambridge

1992

Transducer ring, early site test (circa 1994)

1994

Dolphin Lab System developed.

1996

Method and Transduction patented by Imperial College (Alleyne & Cawley).

Disperse software released (Lowe & Pavlakovic).

1998

WavePro™ software developed based on site experience and customer feedback.

1999

Guided Ultrasonics Ltd. is formed in 1999. Malcolm Russell is elected first chairman.

2000

SE16 System launched.

2004

Rail inspection development started.

First sub-sea inspection

2005

Tube inspection tool developed and released.

2007

Wavemaker® G3 launched. Set the standard for Guided Wave Testing for almost a decade.

2008

First PIMS installed.

2010

Claw transducer for boiler tube inspection released.

2011

High Temperature rings released. Can be used on pipes at 350°C.

2012

Modular range of sub-sea rings first used.

Patented absolute calibration routine introduced (GUL).

gPIMS® Corrosion Monitoring sensors. Starts the revolution.

Unrolled Pipe Display and focusing released in WavePro™.

2014

Wavemaker® G4 launched. Introduces new advances in Guided Wave Testing.

2016

Wavemaker® G4mini launched. Lightweight and powerful.

Compact® rings launched. Lightweight, fast, efficient, and reliable.

2017

Patented Quantitative Short Range (QSR) device.

QSR1® launched. Ground-breaking technology.

2018

gPIMS® FCU launched. Autonomous Monitoring.

2020

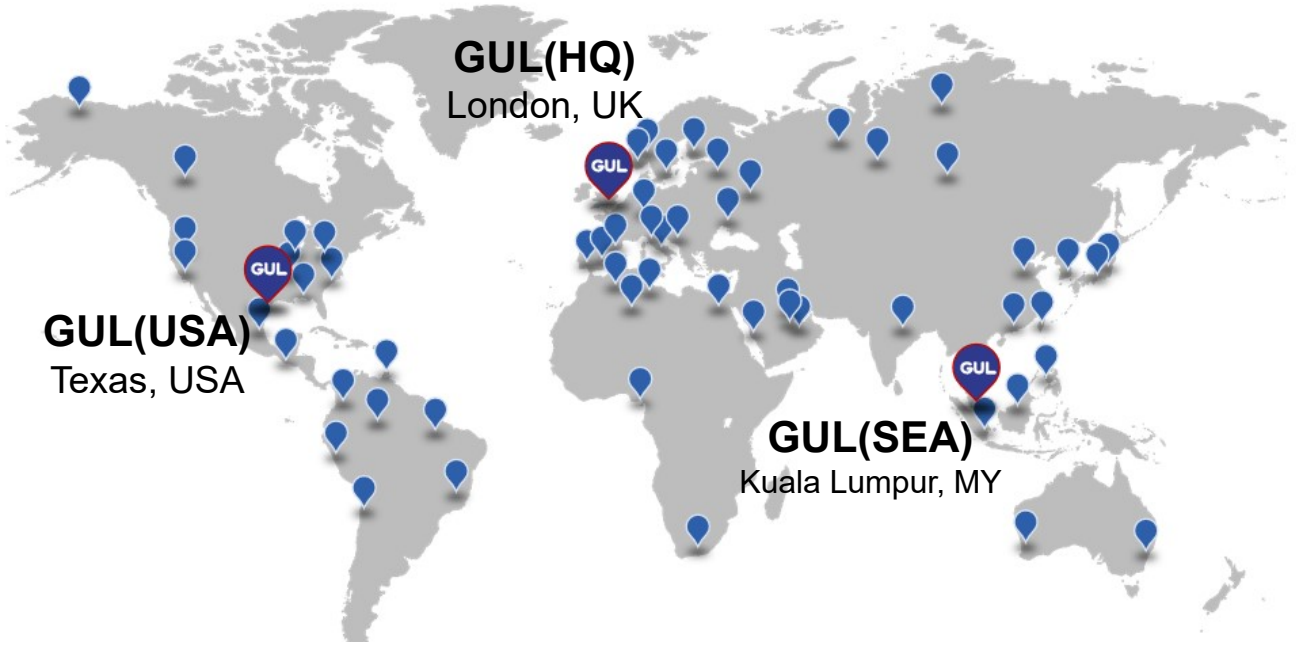
Studio Suite™ launched. From Sensor to Desktop.

2022

Launch of the QSR® Axial Scanner. Opening up more possibilities...

High Definition rings released. Improved performance for small defects.

5,500+ systems | 250+ customers | 50+ countries



Our HQ & Regional offices

GUL (HQ)

Unit 3, Brentwaters Business Park, Brentford, TW8 8HQ, United Kingdom.

GUL SE Asia

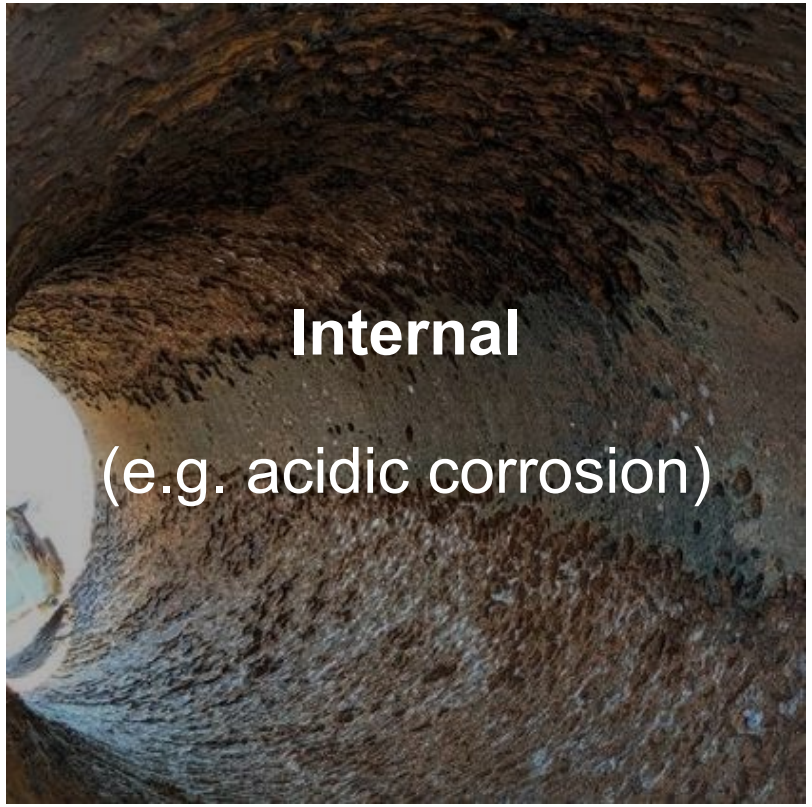
27-3, Jalan Medan Setia 1, Bukit Damansara, 50490, Kuala Lumpur, Malaysia.

GUL Americas

1416 N Sam Houston Pkwy E, Houston, TX 77032 United States of America.

Industrial Challenge

Corrosion & **erosion** creates defects that threatens the structural integrity of pipes.



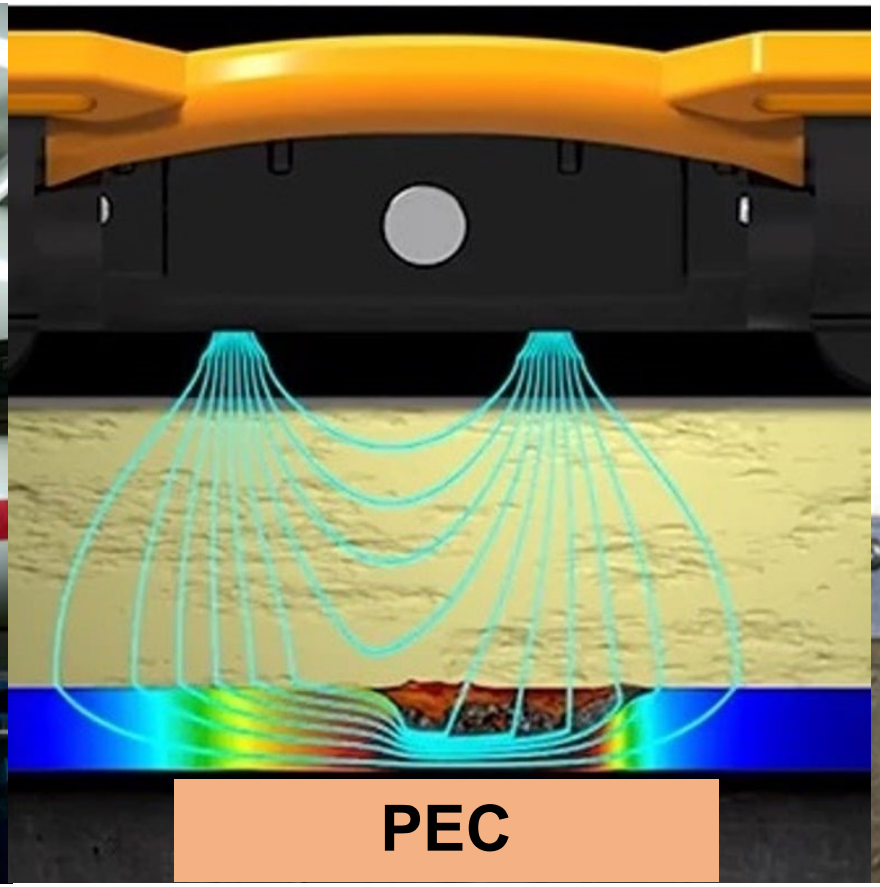
Pipe Inspection

Globally, there are **millions of kilometers of steel pipes**, and they are typically susceptible to **corrosion & erosion**.

Corrosion Sizing Tools

UT, PEC and other NDT tools are good for sizing defects

UT



PEC

Conventional NDT

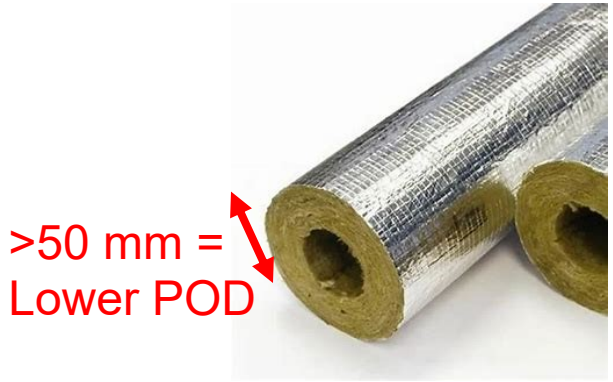
Low inspection coverage and POD

However, pipe inspection using **only UT** is challenging because:

Low POD due to low inspection coverage.

UT **requires direct access** to the inspected location.

Rough Surface



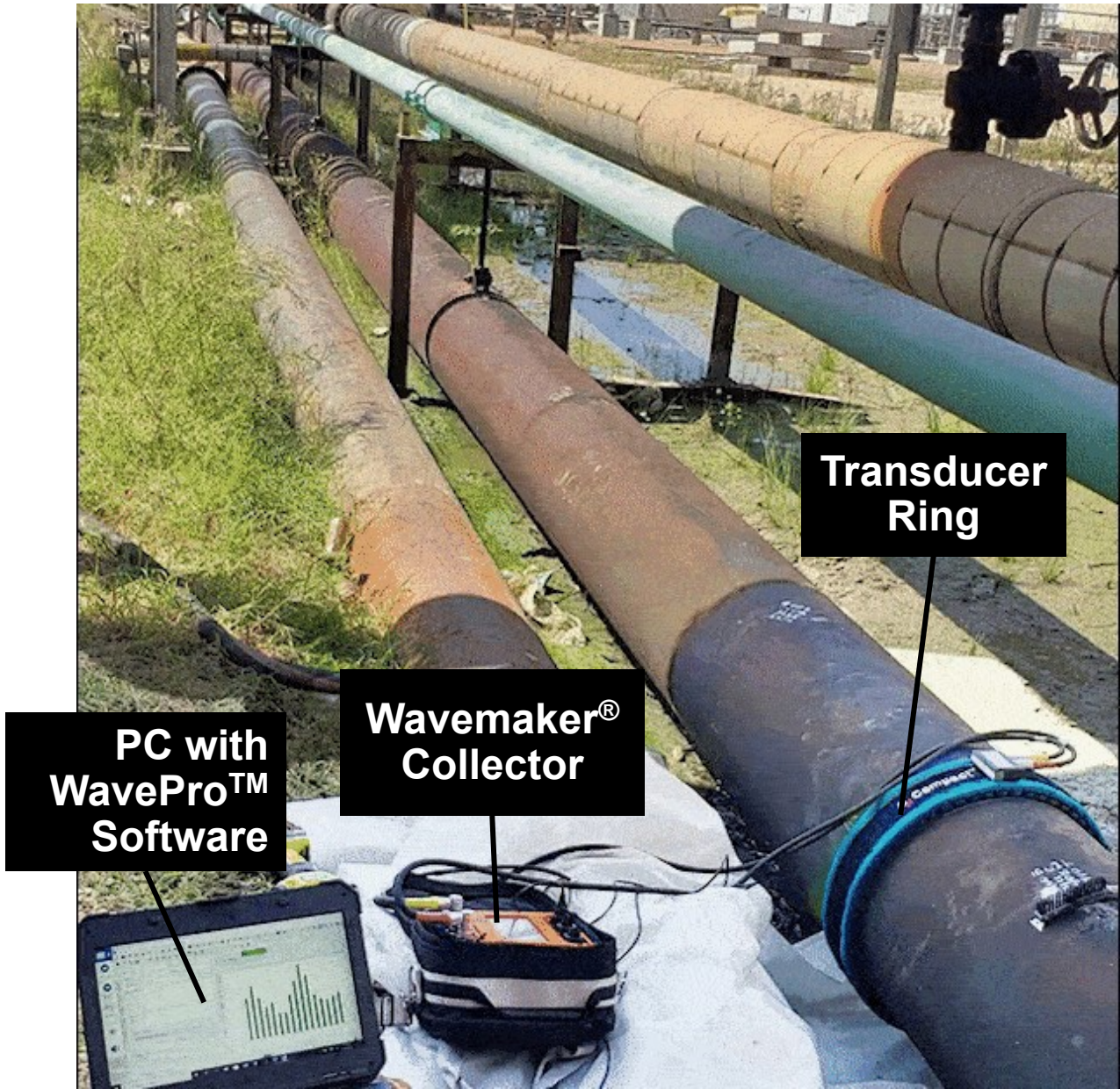
False calls can happen due to site conditions

GUL Screening

GULSCREENING

Rapid | Accurate | Reliable

Fastest and most reliable method for pipe corrosion detection



Equipment Required

Compact®

Transducer Ring

Wavemaker

G4mini

PC Laptop +

WavePro Software

How long does Screening take?

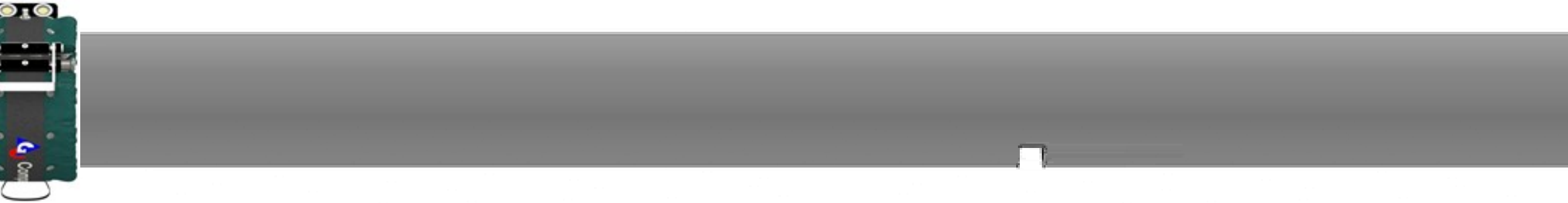
Installing the transducer ring and full data collection **as fast as 10 minutes**.

Assuming an NPS 8 pipe, 2 minutes to attach & inflate the transducer ring and perform coupling checks, and 5 minutes for notes input and data collection using the default settings.

GW travels in both directions along the pipe at the same time.

GW will reflect from defects and existing pipe features

Reflected waves are measured by the transducer ring.

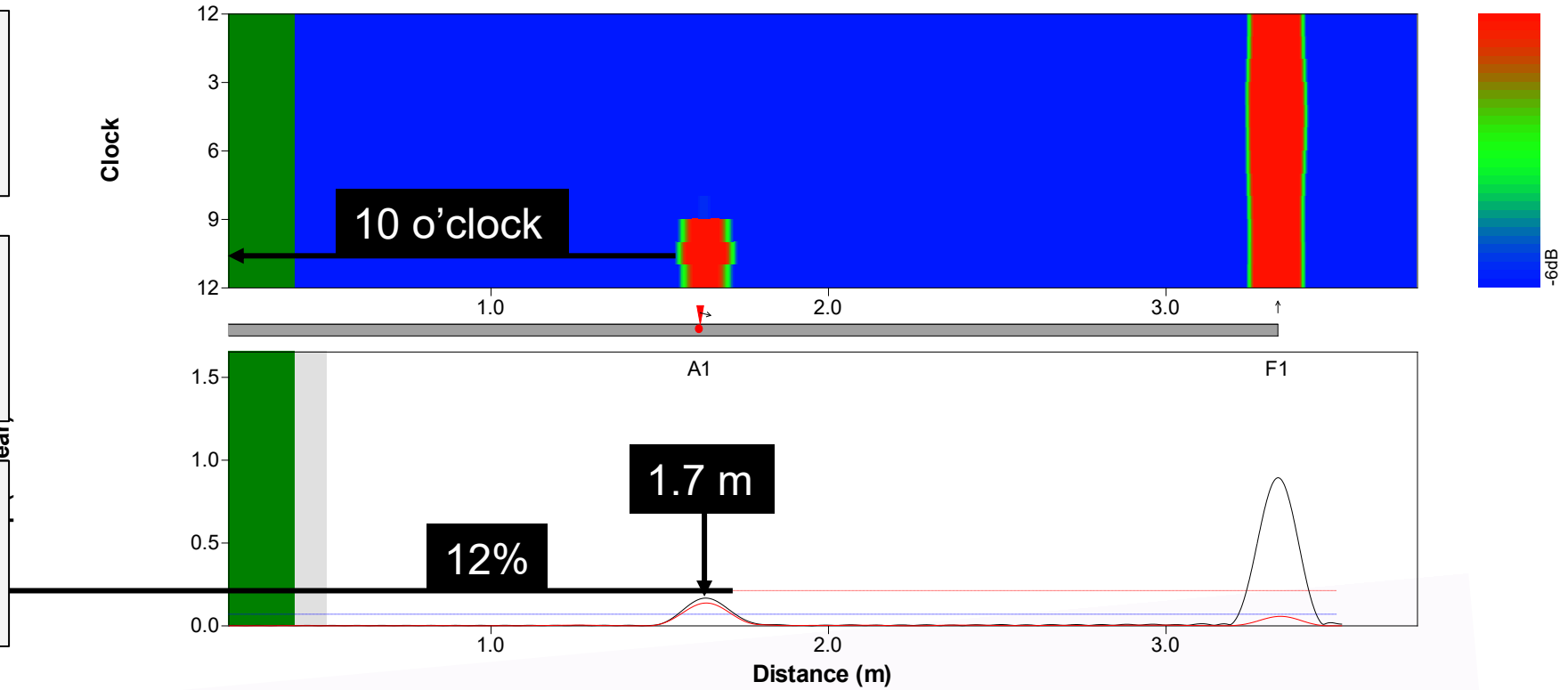


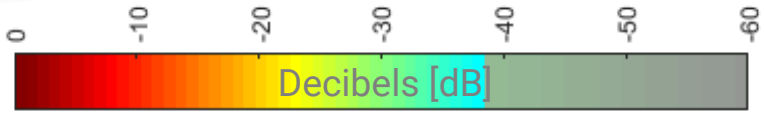
Three main results from GWT

Axial distance

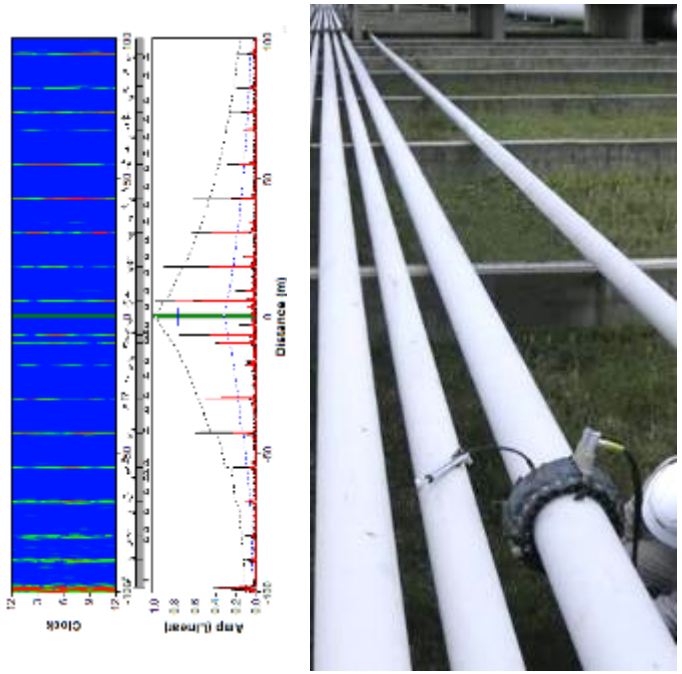
Circumferential position

Cross-sectional area change (CSC)

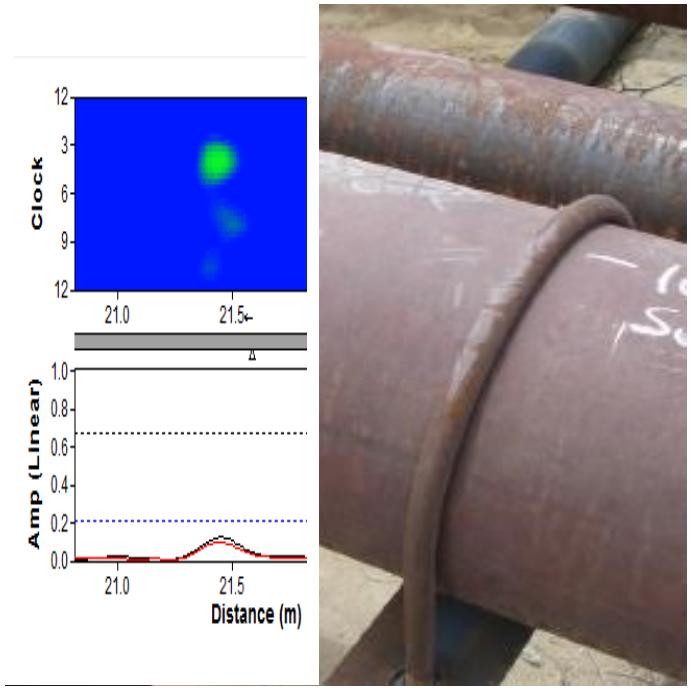




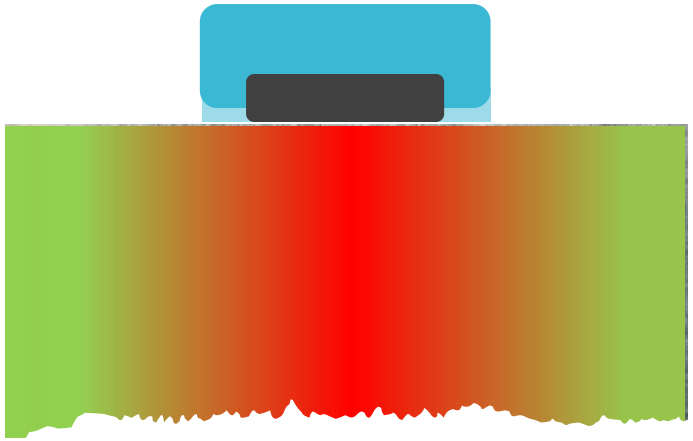
Advantage of GUL Screening



High POD with high inspection coverage.



Inspect **inaccessible** locations



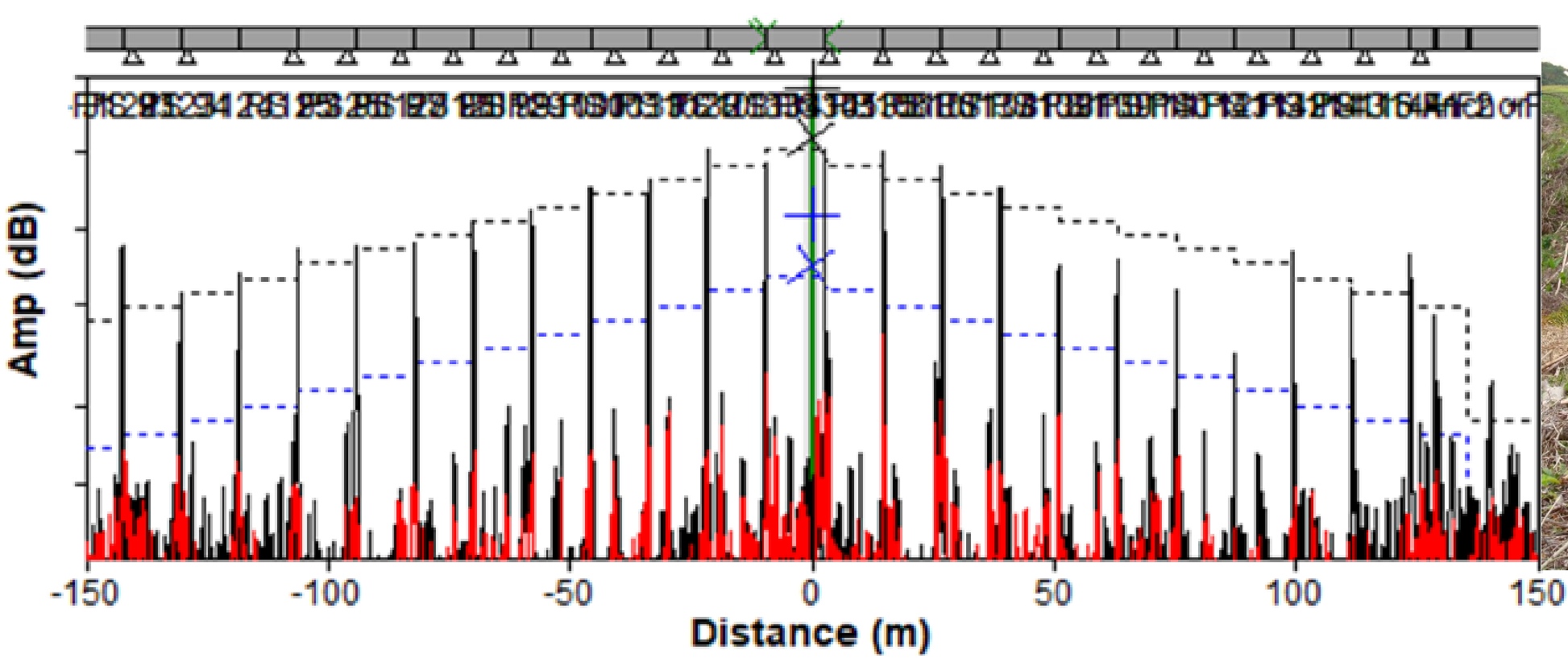
Reduced false calls; low sensitivity to rough surfaces

Limitations of GWT

- **Does not measure wall loss** directly
- Relatively **low sensitivity to axial cracks**
- Attenuation (e.g. coatings, soil) can reduce range
- Bends and large fittings can limit test range

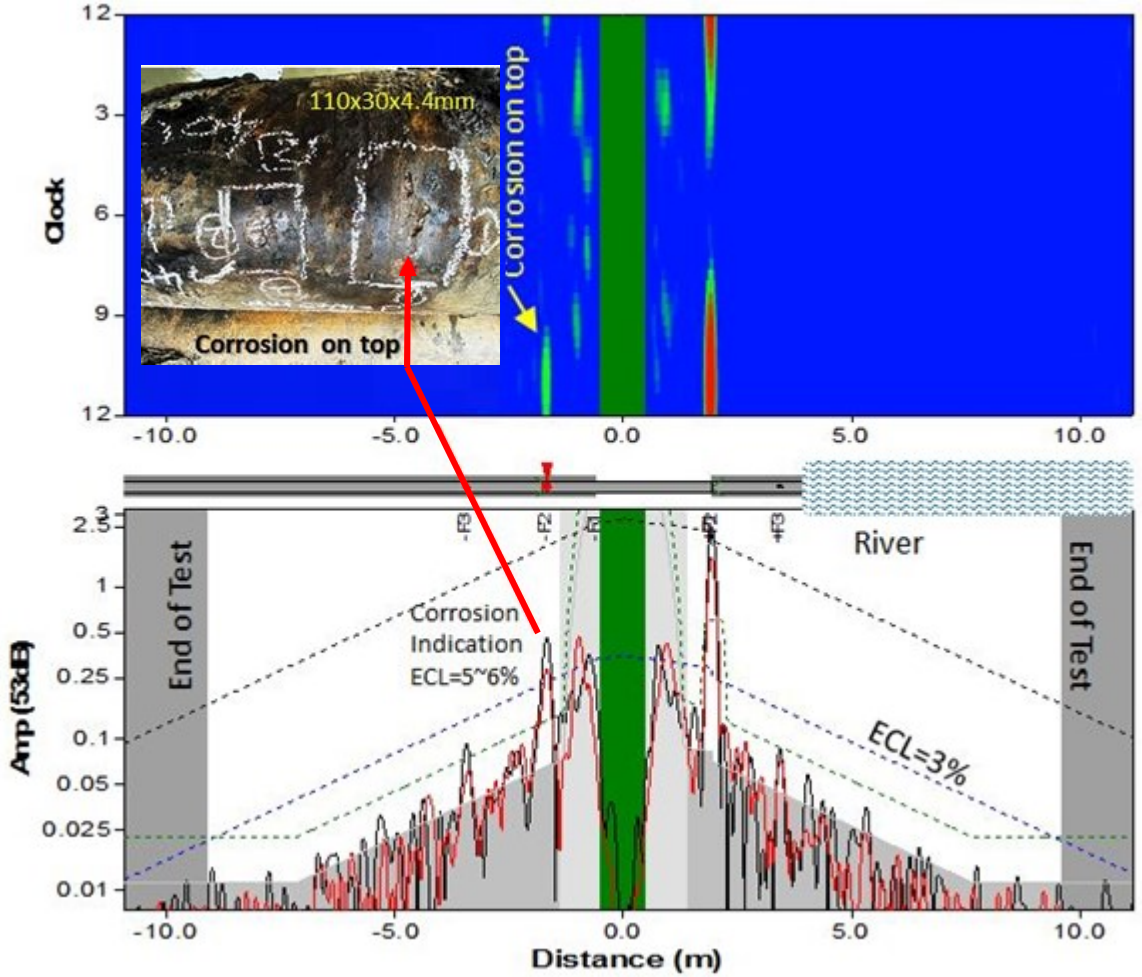
Example #1: Above Ground Transport Pipeline

A total of **300 meters** of pipe was inspected from a **single test location**.



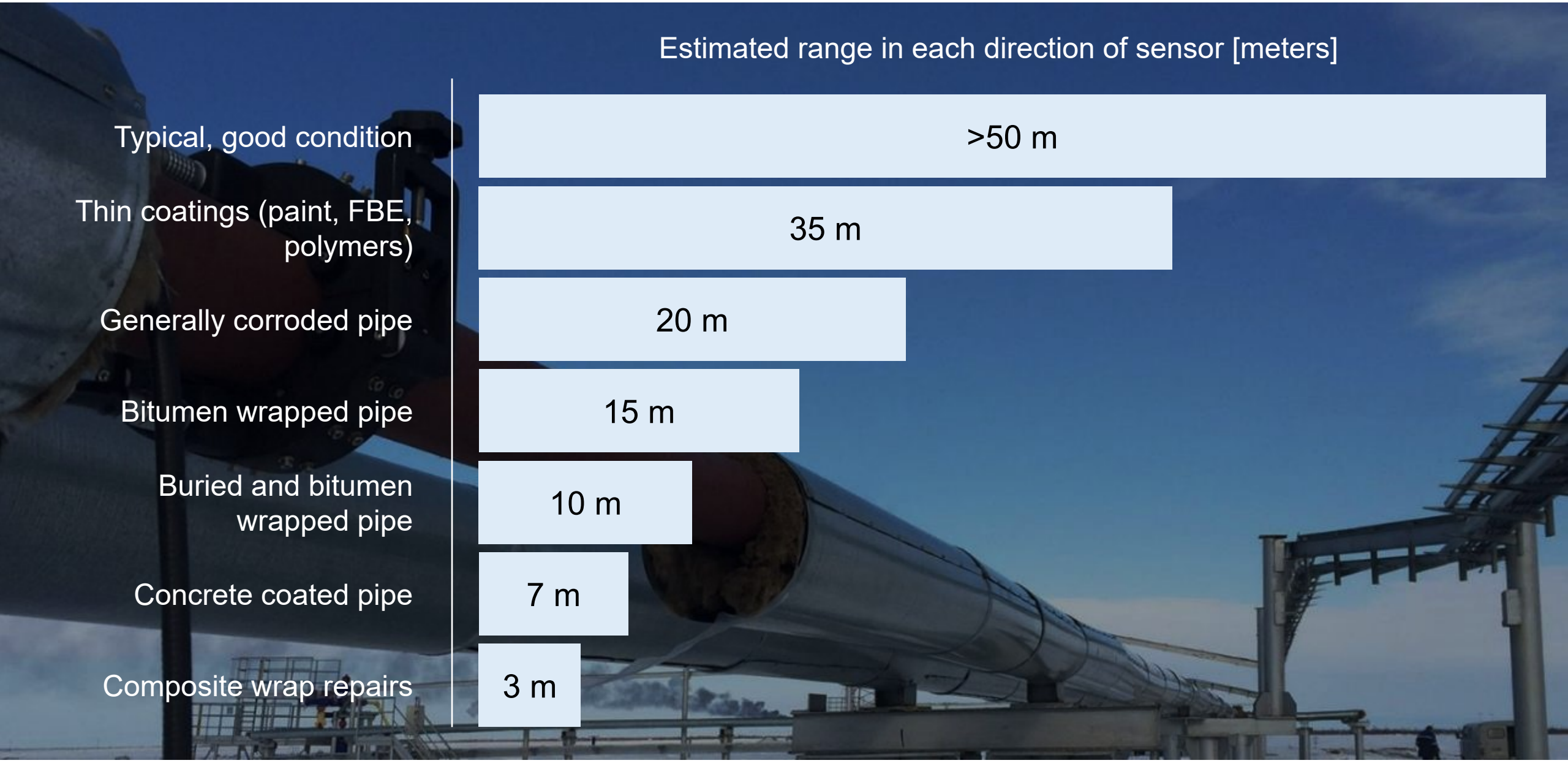
Example #2: Buried Pipes

A total of **18 meters** of pipe was inspected from a **single test location**.



Source: TMQC (https://www.linkedin.com/in/ping-hung-robert-lee-4a588021/detail/recent-activity/shares/)

GUL Screening Inspection Range



Inspection Range Reference: ASTM E2775-16

E2775 – 16

TABLE X1.1 Typical Attenuation Rates and Average Test Range in Each Direction for Different Test Pipe Configurations

Test Condition	Typical Attenuation	Typical Range of Test
Clean, Straight Pipe	-0.15 to -0.5dB/m (-0.046 to -0.17dB/ft)	50–200 m (164–656 ft)
Clean, Wool Insulated	-0.17 to -0.75dB/m (-0.052 to -0.23 dB/ft)	40–175 m (131–574 ft)
Insignificant/Minor Corrosion	-0.5 to -1.5 dB/m (-0.152 to -0.457dB/ft)	20–50 m (65.6–164 ft)
Significant Corrosion	-1 to -2 dB/m (-0.305 to -0.61dB/ft)	15–30 m (49.2–98.4 ft)
Kevlar Wrapped	-0.15 to -1 dB/m (-0.046 to -0.305dB/ft)	30–200 m (98.4–656 ft)
Spun Epoxy Coating	-0.75 to -1 dB/m (-0.23 to -0.305dB/ft)	30–50 m (98.4–164 ft)
Well Packed Earth	-1 to -2 dB/m (-0.305 to -0.61dB/ft)	15–30 m (49.2–98.4 ft)
Thin (<2.5mm), Hard Bitumen Tape	-1.25 to -6 dB/m (-0.381 to -1.83dB/ft)	5–25 m (16.4–82 ft)
Thick (>2.5mm), Soft Bitumen Tape	-4 to -16 dB/m (-1.22 to -4.88dB/ft)	2–8 m (6.56–26.24 ft)
Well Bonded Concrete Wall	-16 to -32 dB/m (-4.88 to 9.76dB/ft)	1–2 m (3.28–6.56 ft)
Grout Lined Pipe	-1 to -3 dB/m (-0.305 to 0.91dB/ft)	10–30 m (32.8–98.4 ft)
Loosely Bonded Concrete Wall	-4 to -16 dB/m (-1.22 to -4.88dB/ft)	2–8 m (6.56–26.24 ft)

Transducer rings for a wide range of applications

Inflatable Rings

Compact Rings

EFC Inflatable Rings

HT Inflatable Rings

HD Inflatable Rings

Solid Rings

LITE Solid Rings

HT Solid Rings

HD Solid Rings

Claw Transducers

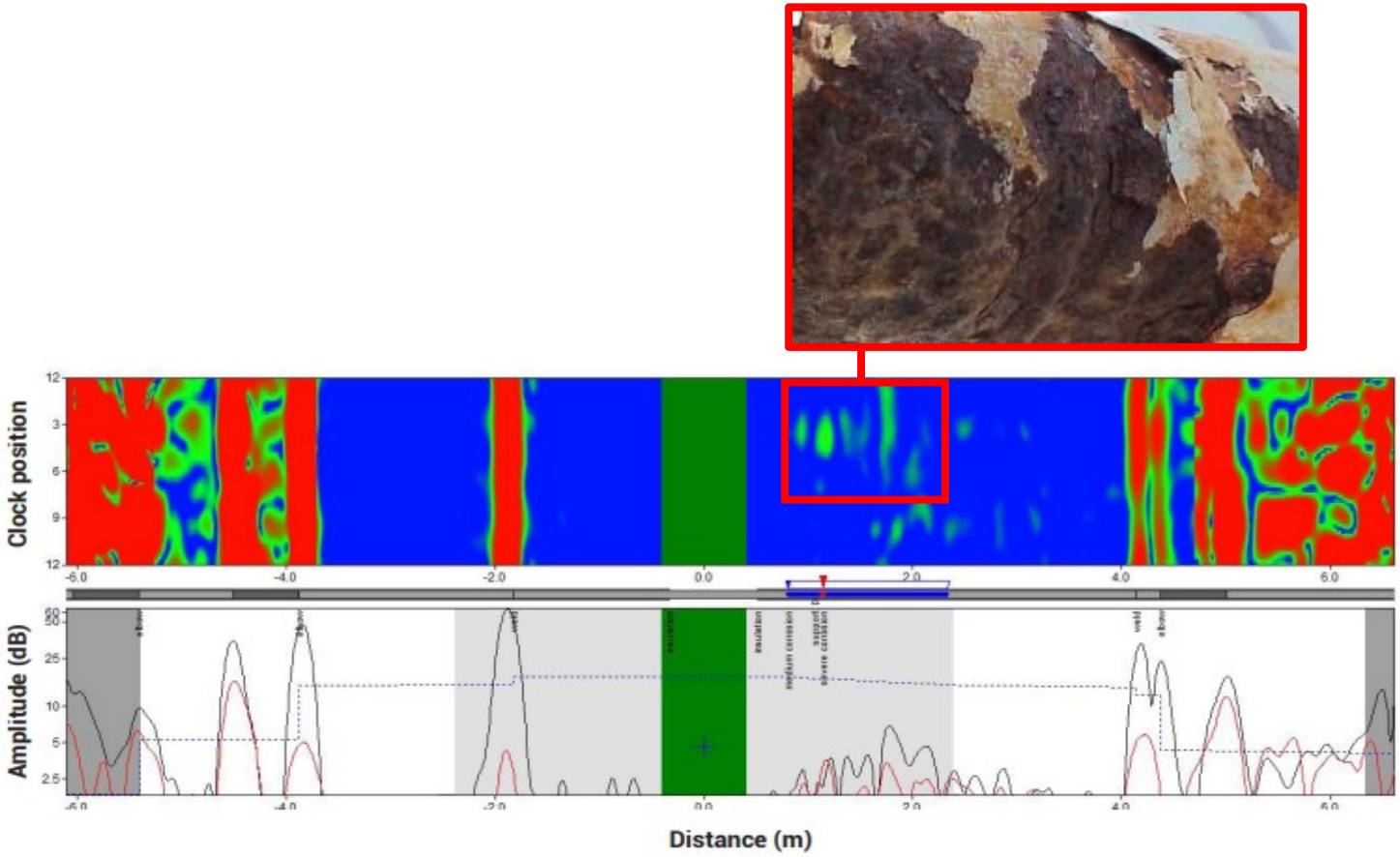
Claw

Low Profile Rings

Low Profile (Slinky) Rings

Case Study: Corrosion Under Insulation

https://www.guided-ultrasonics.com/corrosion-under-insulation/



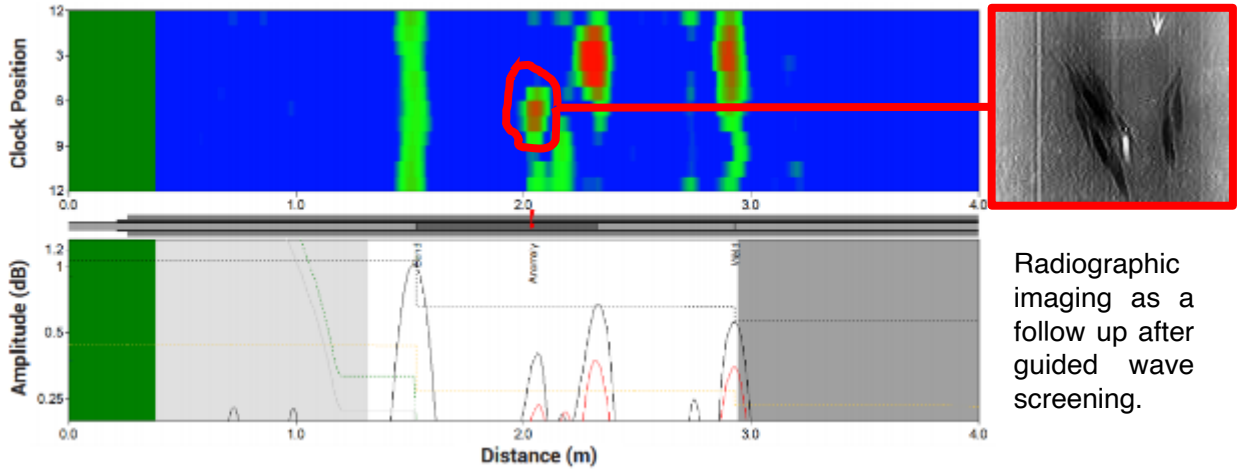
Inspect long insulated pipes for corrosion; only partial removal of insulation.

Case Study: Pipe Erosion at Elbows

https://www.guided-ultrasonics.com/elbows/

Detect erosion damage

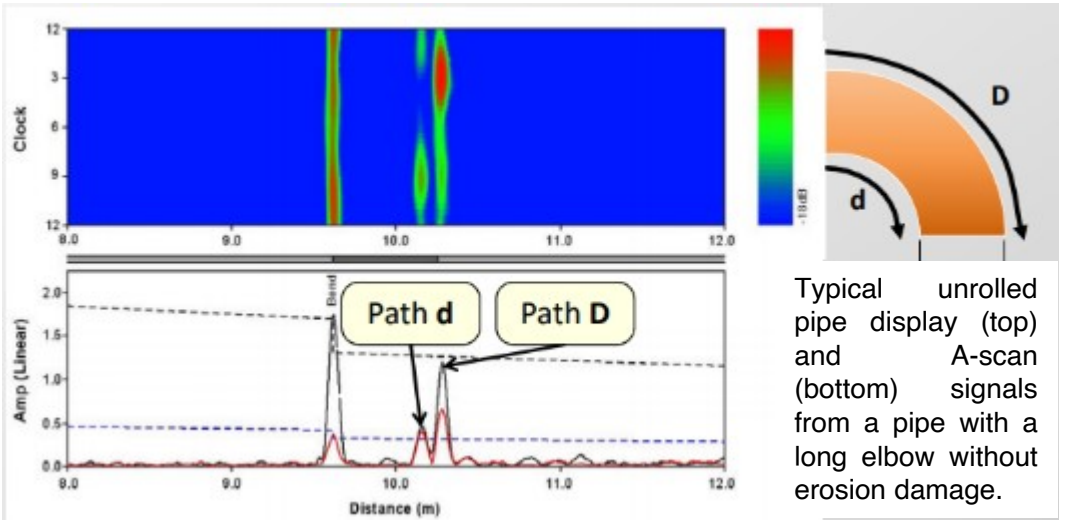
Damaged Elbow



Radiographic imaging as a follow up after guided wave screening.

Unrolled pipe display (top) and A-scan (bottom) from guided wave (GW) screening using GUL equipment collected from site; the erosion damage has been labelled by the GW operator at axial distance of approximately 2 meters.

Elbow in typically good condition



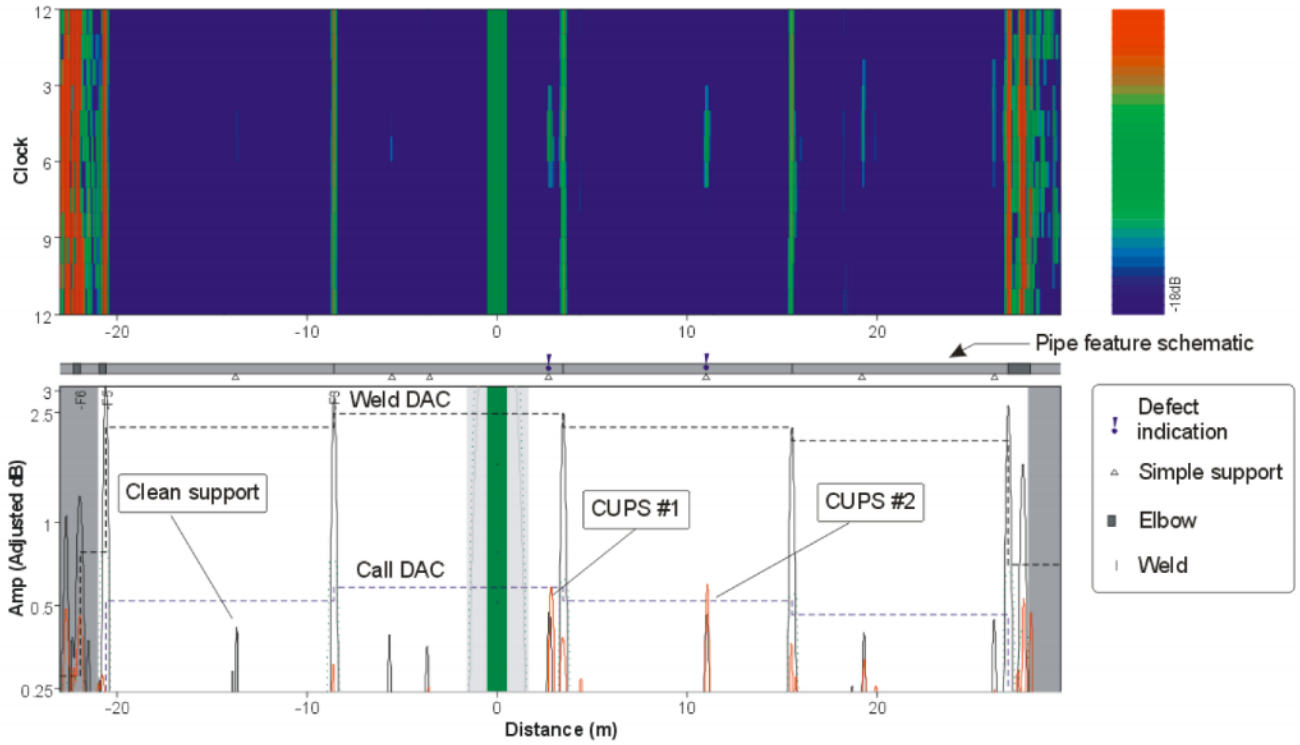
Typical unrolled pipe display (top) and A-scan (bottom) signals from a pipe with a long elbow without erosion damage.

Case Study: CUPS Detection & Sizing

- NPS 10 – Jet fuel line with CUPS
- Detection and sizing of CUPS needed

✓ GUL Screening successfully **detected** CUPS

Photo of GUL Screening equipment on pipeline.

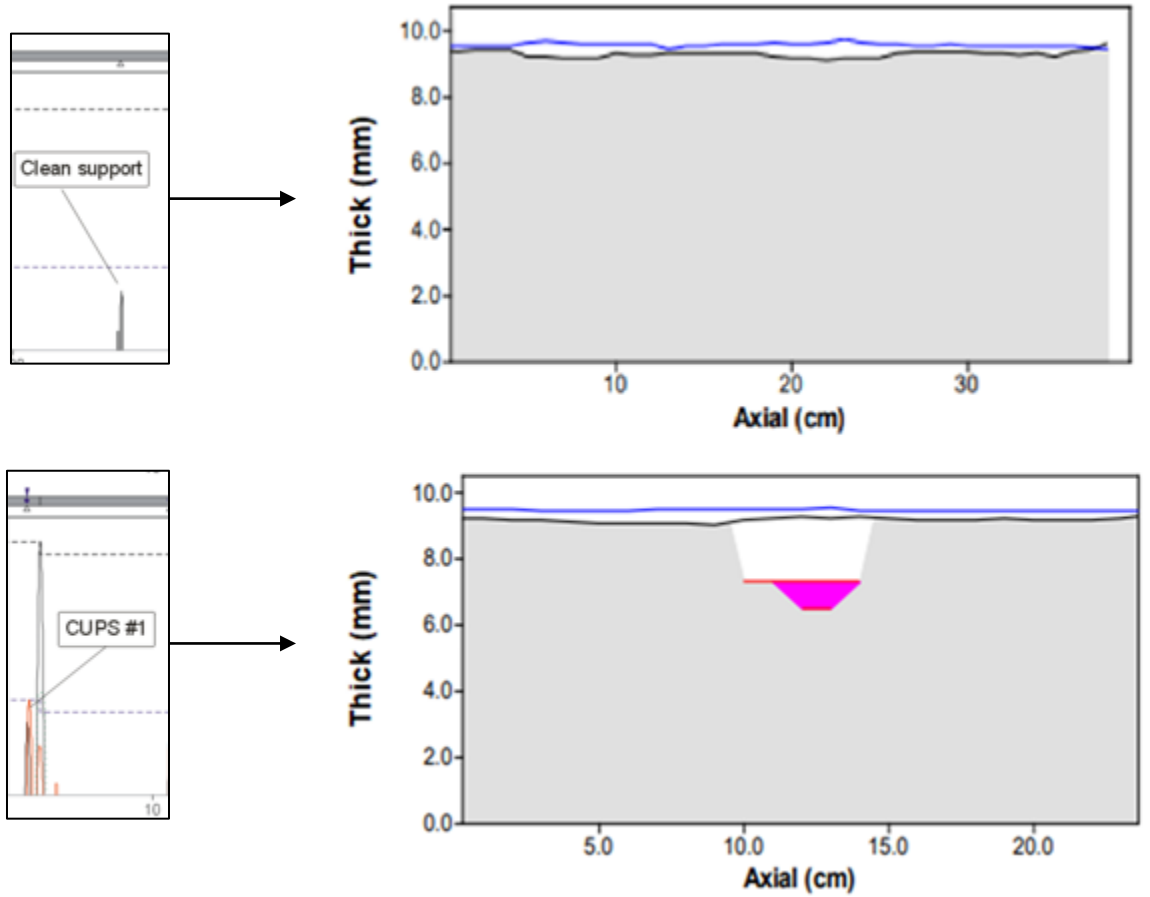


Unrolled pipe display (top) and A-scan (bottom) results.

Case Study: CUPS Detection & Sizing

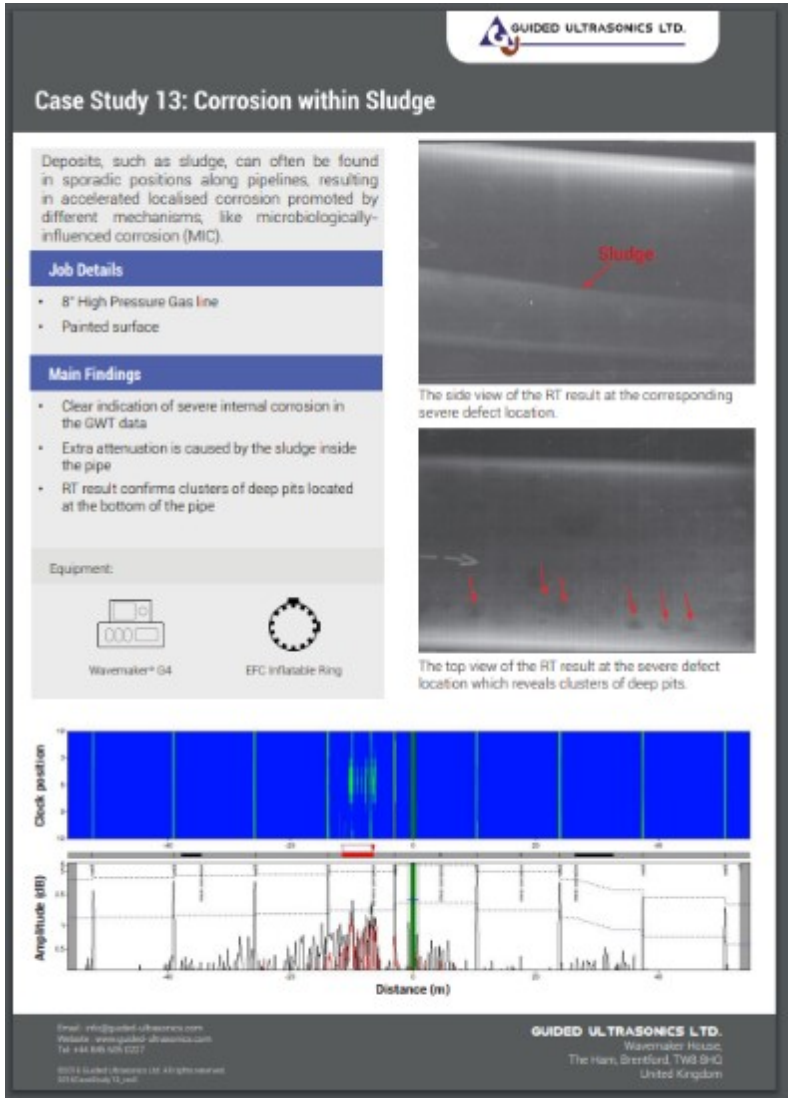
✓ GUL Scanning successfully **size** CUPS for FFS assessment.

Photo of GUL Scanning equipment on pipeline.



QSR1® measurement data showing the remaining wall thickness at locations labelled as Clean support and at CUPS#1 from GUL Screening results.

Case Study: Pitting corrosion under Sludge



https://www.guided-ultrasonics.com/sludge/

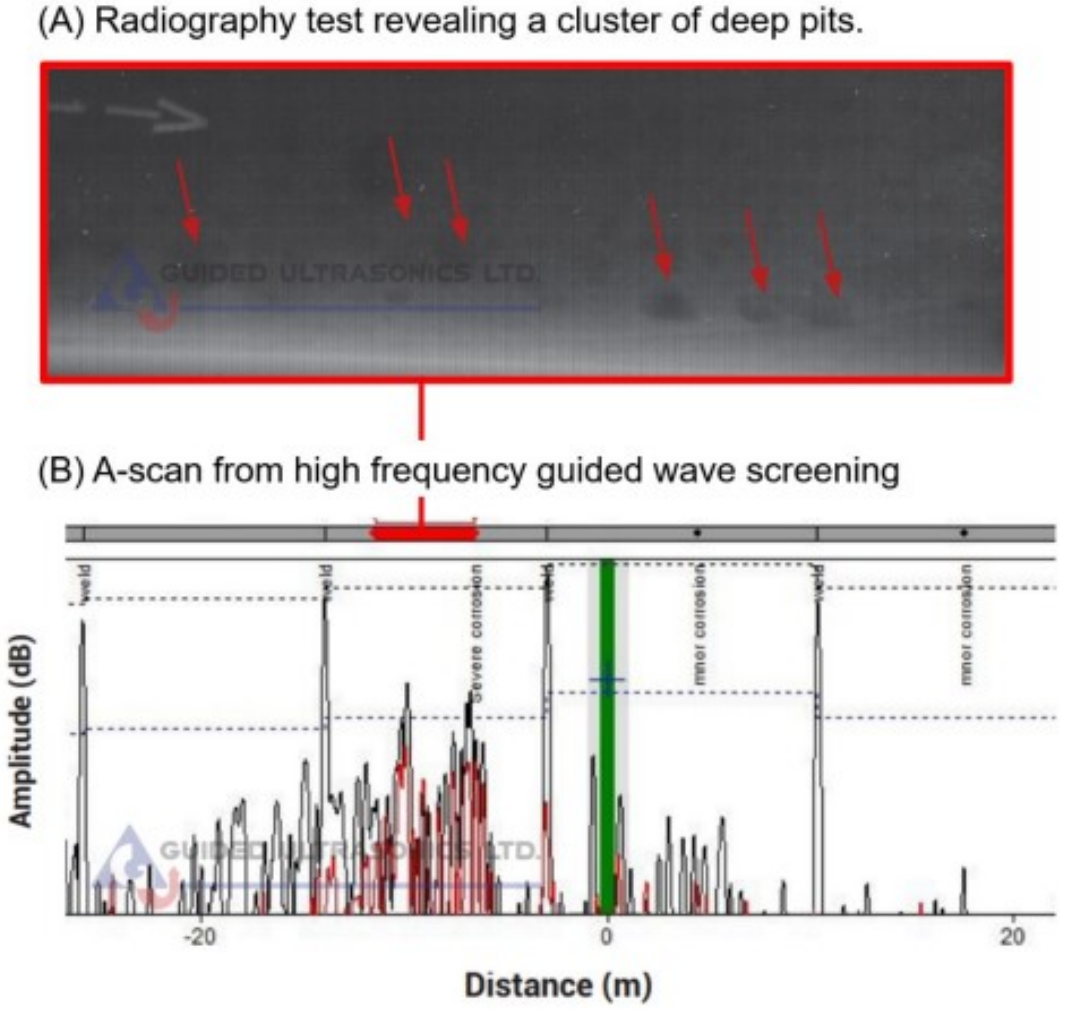
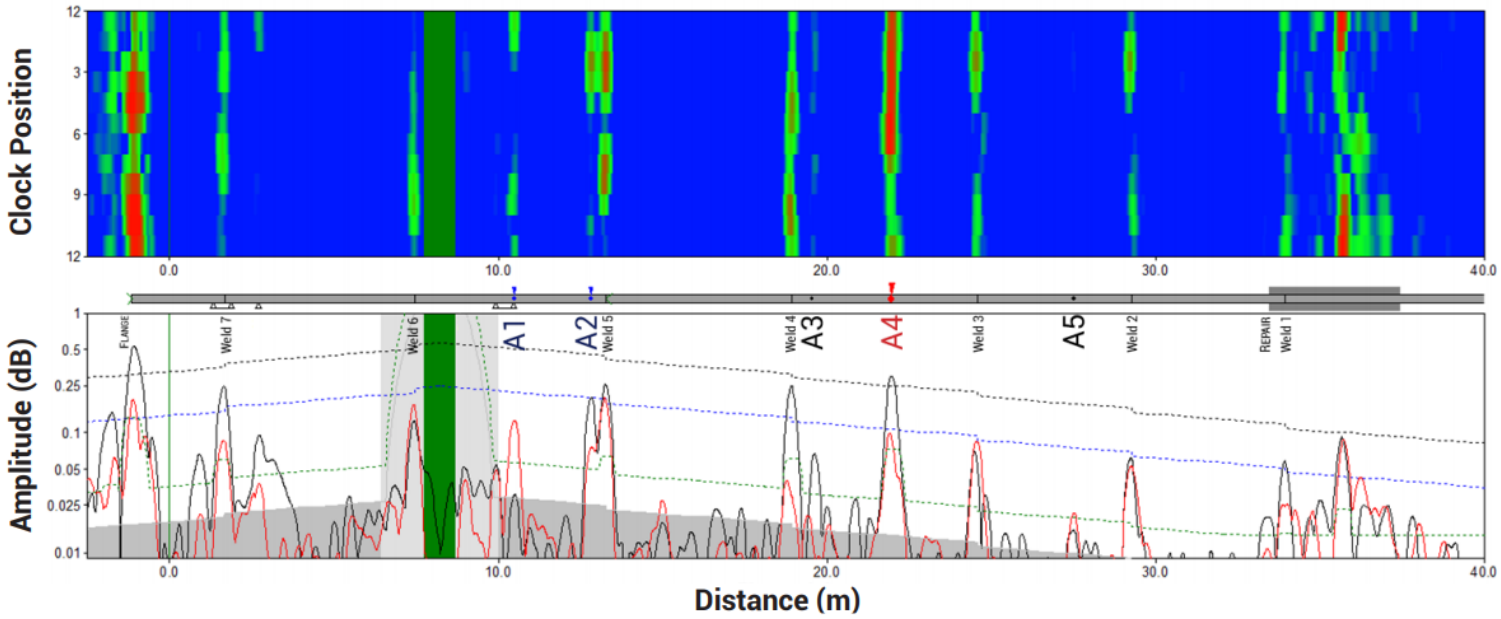


Figure 7: (A) Radiography results revealing a cluster of deep corrosion pits as a follow up from (B) the A-scan results from a high frequency guided wave screening test.

Case Study: Caisson

A total of **40 meters** of pipe was inspected.



Indication	GWT Location [m]	GWT CSA [%]	UT Location [m]	UT CSA [%]	Comments
A1	10.49	8	9.95 - 10.5	13.8	Defect at support.
A2	12.82	10	12.82	7.1	Internal wall loss.
A3	19.54	5	19.58	4.03	Internal wall loss.
A4	21.97	27	21.88	21.88	Primary reason for UT prove-up.
A5	27.50	2.1	27.49	2.15	Sum of multiple defects in close proximity.

https://www.guided-ultrasonics.com/wp-content/uploads/2017/01/2016CaseStudy18_rev0.pdf

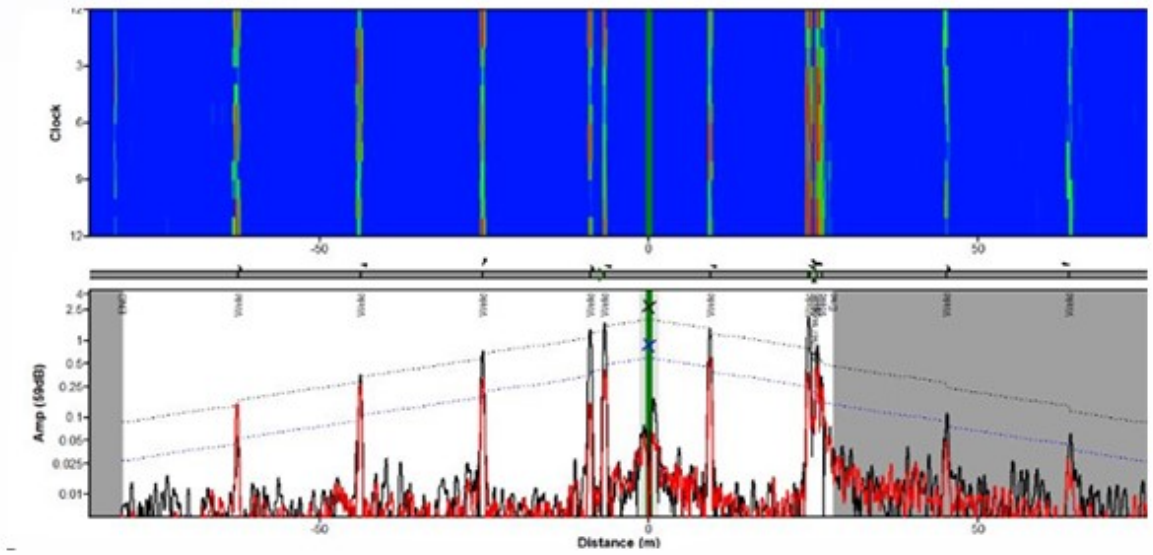
Case Study: High temperature pipes

HT transducer rings

measures **reliable** & **accurate**

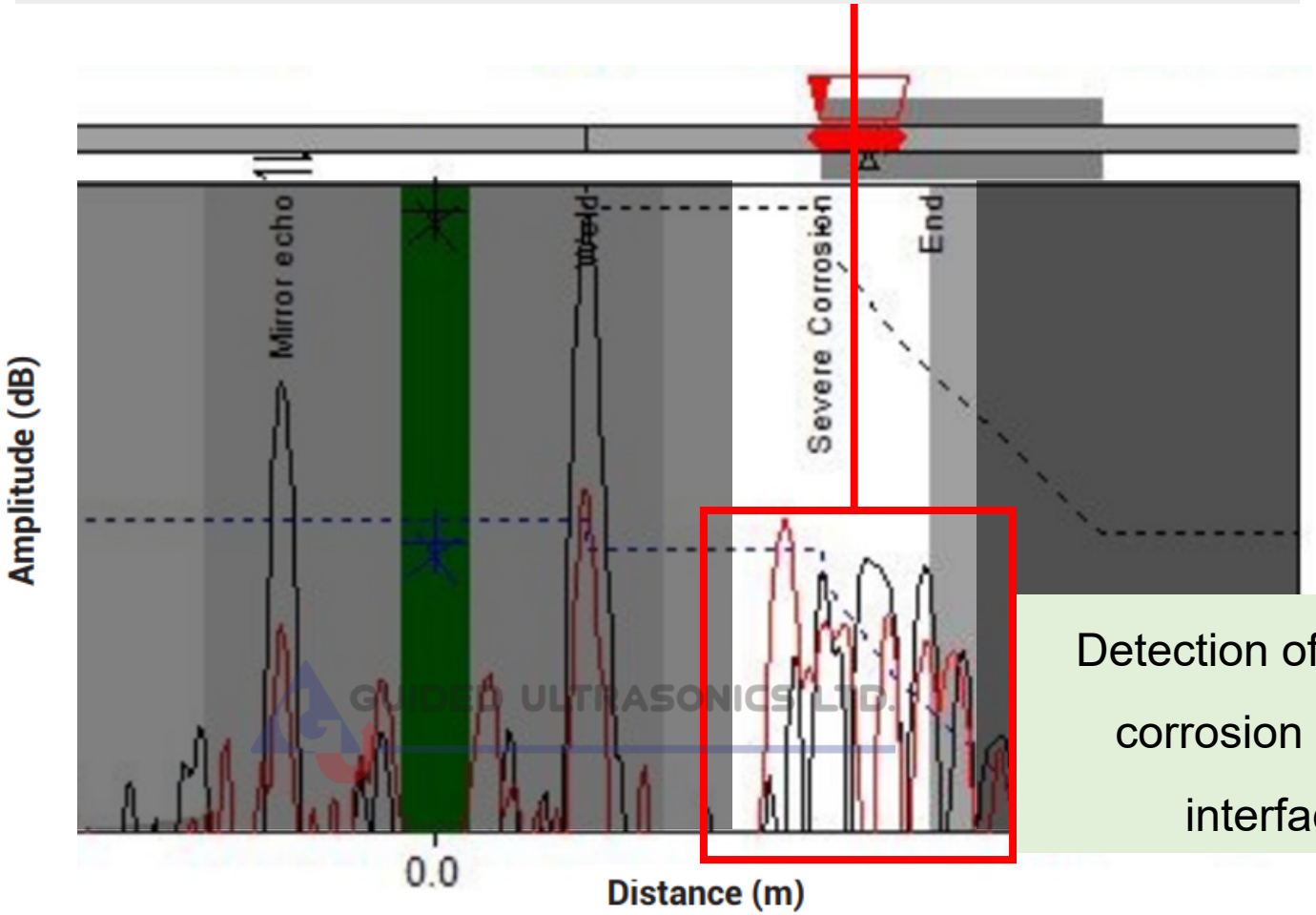
GWT results;

for pipes up to **350°C**.



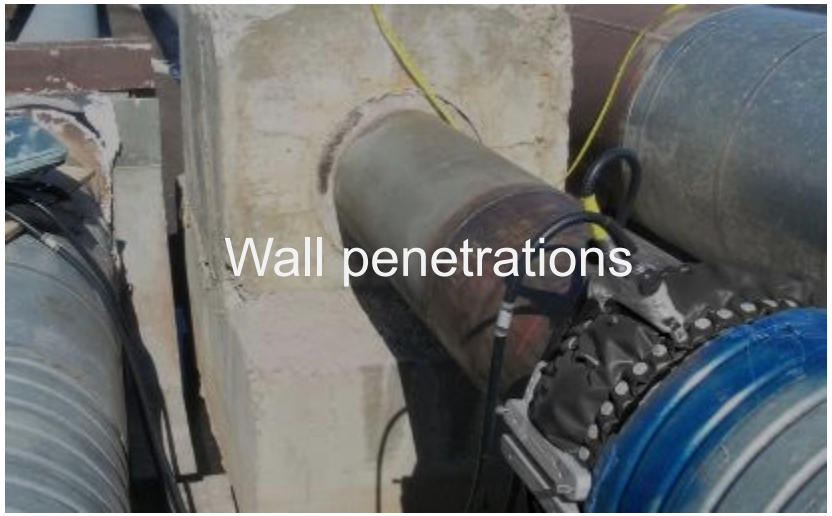
Case Study: Concrete Anchor Support

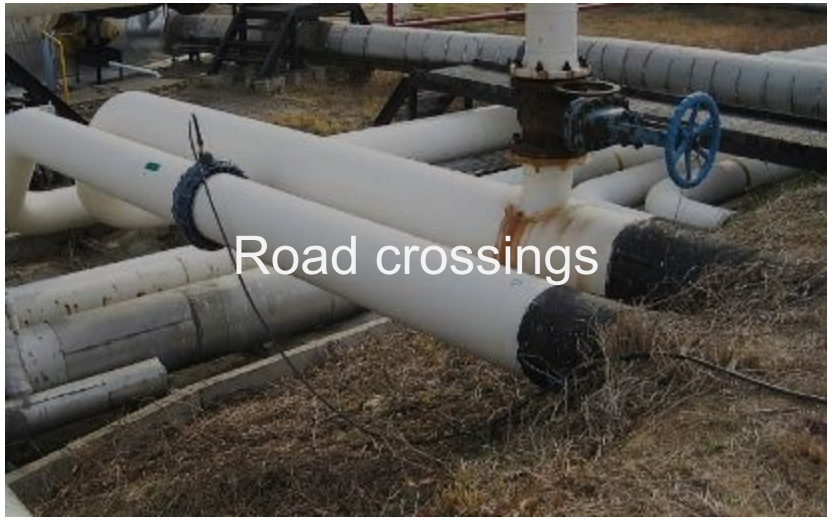
- Severe corrosion detected at the concrete-air interface of the concrete anchor support.

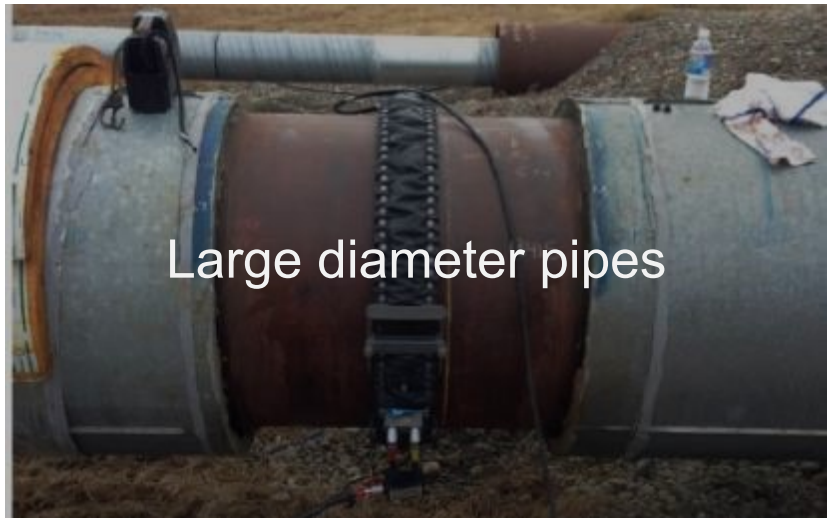


Detection of severe corrosion at the interface

And Many More Applications





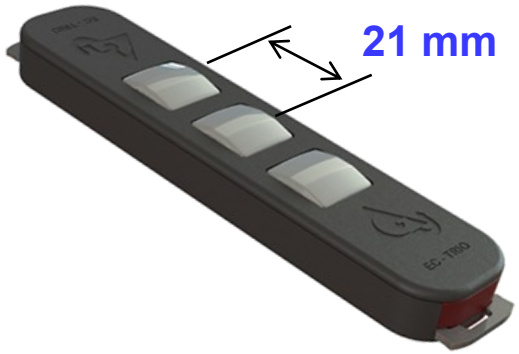


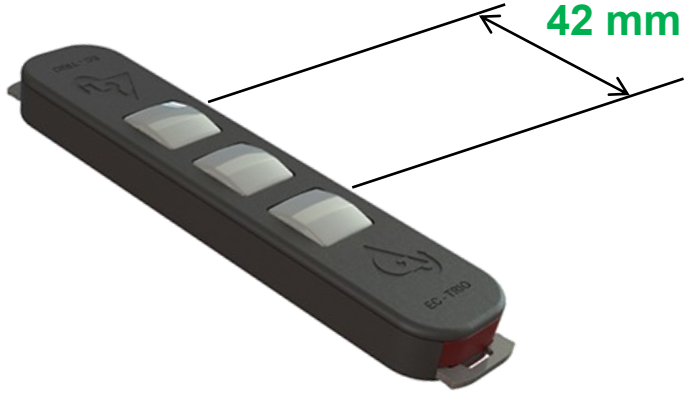
Faster inspection work using Compact™ ring

Installing the transducer ring and full data collection **as fast as 10 minutes**.

Assuming an NPS 8 pipe, 2 minutes to attach & inflate the transducer ring and perform coupling checks, and 5 minutes for notes input and data collection using the default settings.

Fastest way to inspect at ultra wide frequency range





Why is GUL better? (Transducer Ring)

Our transducer rings are **rigorously tested** for **common site conditions**:

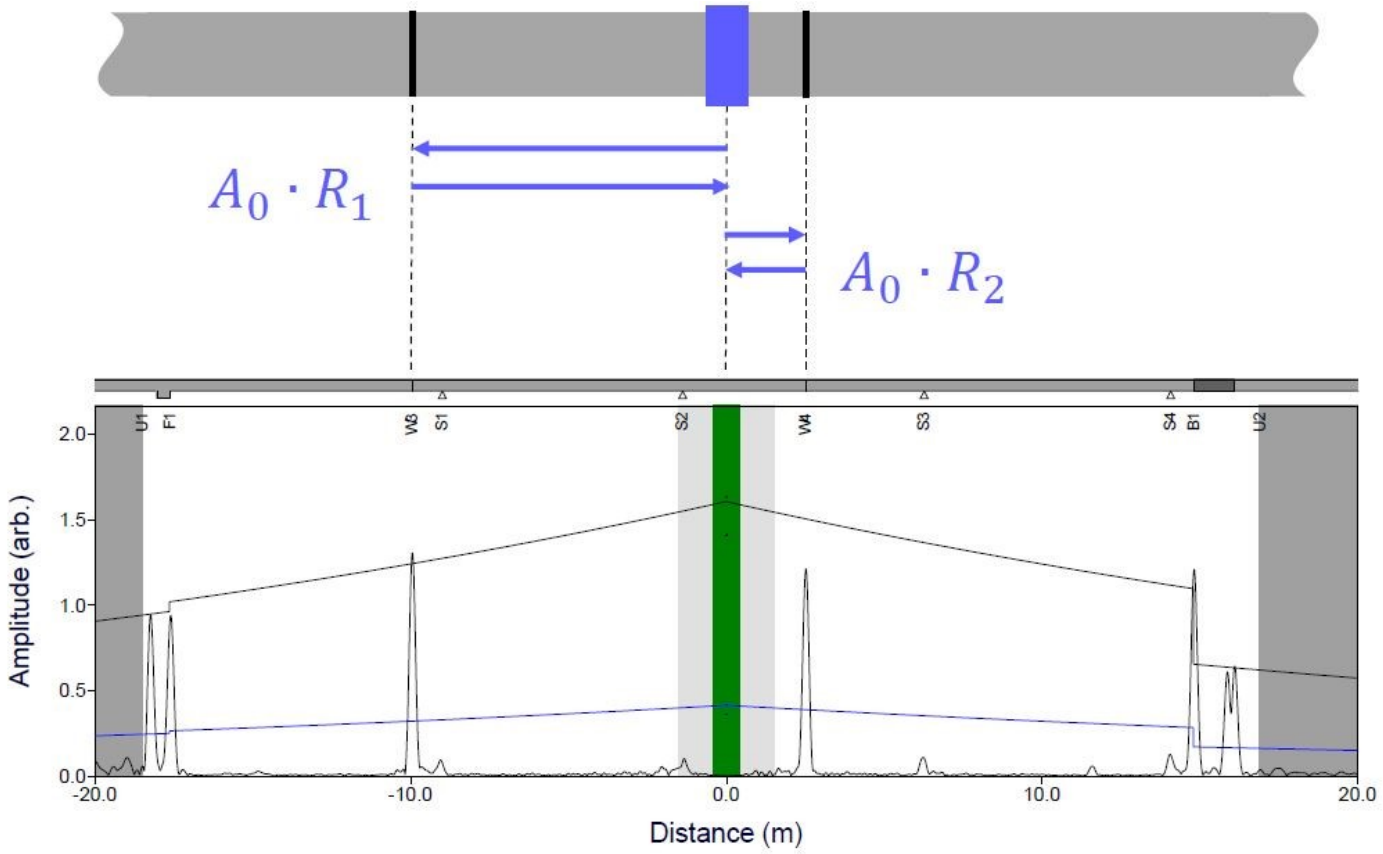
Direct Rain

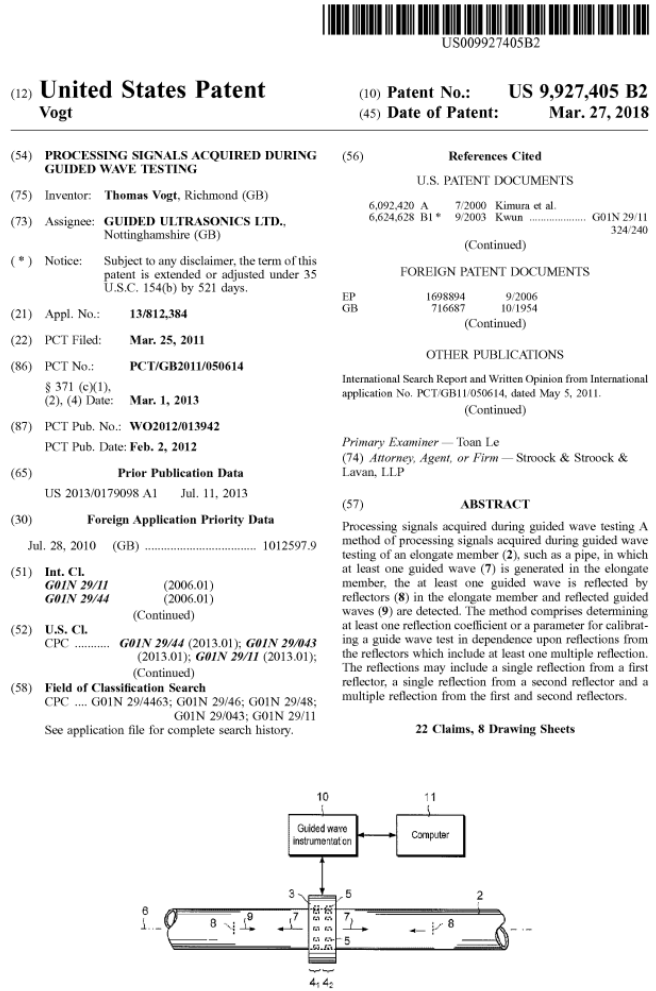
Particulate Ingress

Forced Moisture

What is Absolute Calibration?

A GUL patented method to **rapidly & accurately calibrate the DAC curves** (Patent US 9927405).





US009927405B2

(12) **United States Patent**
Vogt

(10) **Patent No.: US 9,927,405 B2**
(45) **Date of Patent: Mar. 27, 2018**

(54) **PROCESSING SIGNALS ACQUIRED DURING GUIDED WAVE TESTING**

(75) Inventor: **Thomas Vogt**, Richmond (GB)

(73) Assignee: **GUIDED ULTRASONICS LTD.**, Nottinghamshire (GB)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 521 days.

(21) Appl. No.: **13/812,384**

(22) PCT Filed: **Mar. 25, 2011**

(86) PCT No.: **PCT/GB2011/050614**
§ 371 (c)(1),
(2), (4) Date: **Mar. 1, 2013**

(87) PCT Pub. No.: **WO2012/013942**
PCT Pub. Date: **Feb. 2, 2012**

(65) **Prior Publication Data**
US 2013/0179098 A1 Jul. 11, 2013

(30) **Foreign Application Priority Data**
Jul. 28, 2010 (GB) 1012597.9

(51) **Int. Cl.**
G01N 29/11 (2006.01)
G01N 29/44 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01N 29/44*** (2013.01); ***G01N 29/043*** (2013.01); ***G01N 29/11*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G01N 29/4463; G01N 29/46; G01N 29/48; G01N 29/043; G01N 29/11
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,092,420 A 7/2000 Kimura et al.
6,624,628 B1 * 9/2003 Kwun G01N 29/11 324/240
(Continued)

FOREIGN PATENT DOCUMENTS

EP 1698894 9/2006
GB 716687 10/1954
(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion from International application No. PCT/GB11/050614, dated May 5, 2011.
(Continued)

Primary Examiner — Toan Le
(74) *Attorney, Agent, or Firm* — Stroock & Stroock & Lavan, LLP

(57) **ABSTRACT**

Processing signals acquired during guided wave testing A method of processing signals acquired during guided wave testing of an elongate member (**2**), such as a pipe, in which at least one guided wave (**7**) is generated in the elongate member, the at least one guided wave is reflected by reflectors (**8**) in the elongate member and reflected guided waves (**9**) are detected. The method comprises determining at least one reflection coefficient or a parameter for calibrating a guide wave test in dependence upon reflections from the reflectors which include at least one multiple reflection. The reflections may include a single reflection from a first reflector, a single reflection from a second reflector and a multiple reflection from the first and second reflectors.

22 Claims, 8 Drawing Sheets

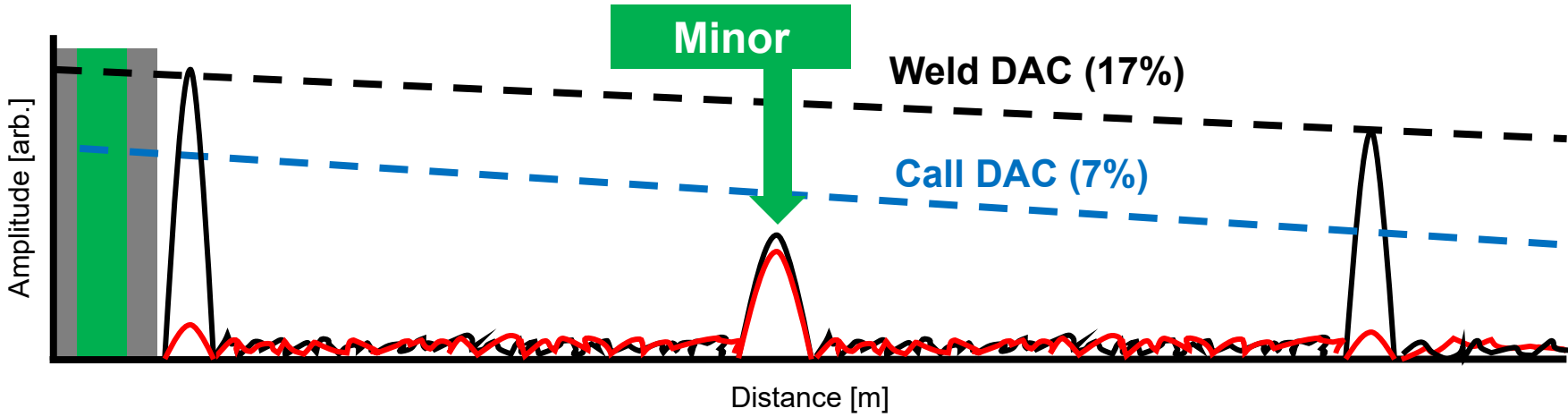
With Absolute Calibration…

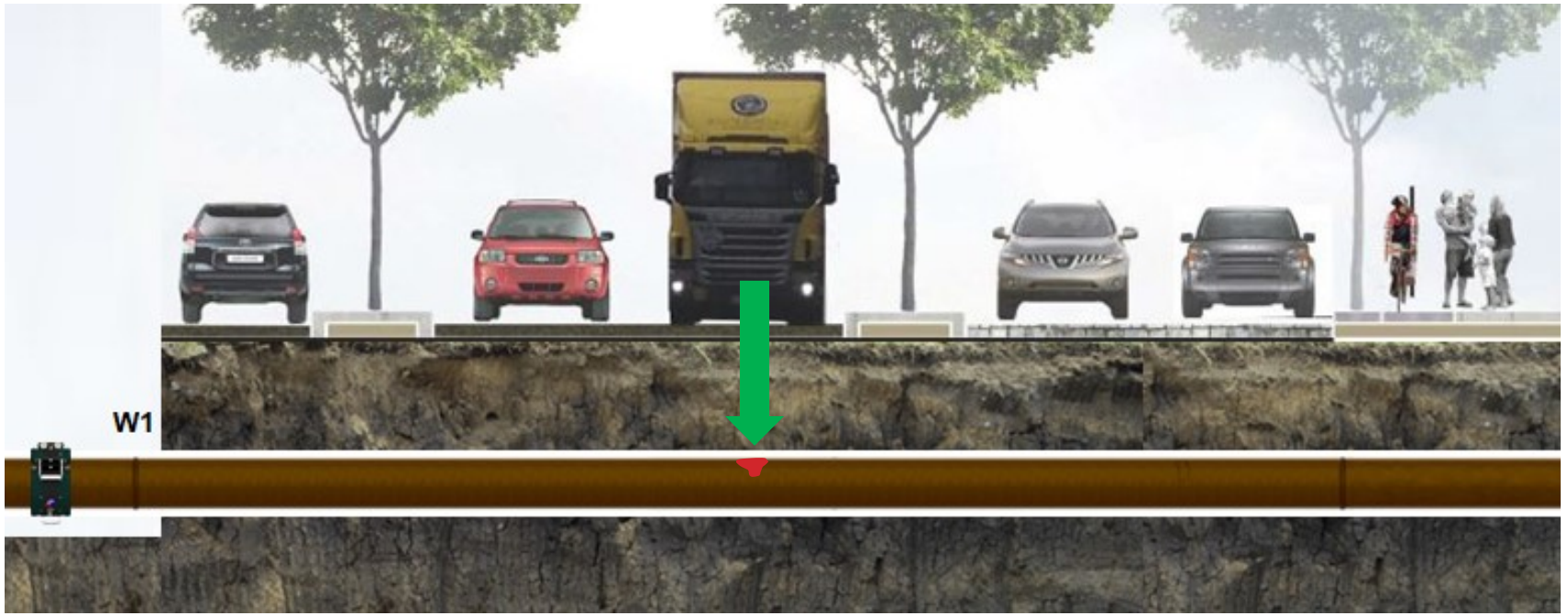
With AbsCal

WavePro calculates the true weld DAC to be **17% CSC**.

The detected indication is **correctly classified as a Minor**.

Frequent GWT inspection performed to estimate defect growth rate.





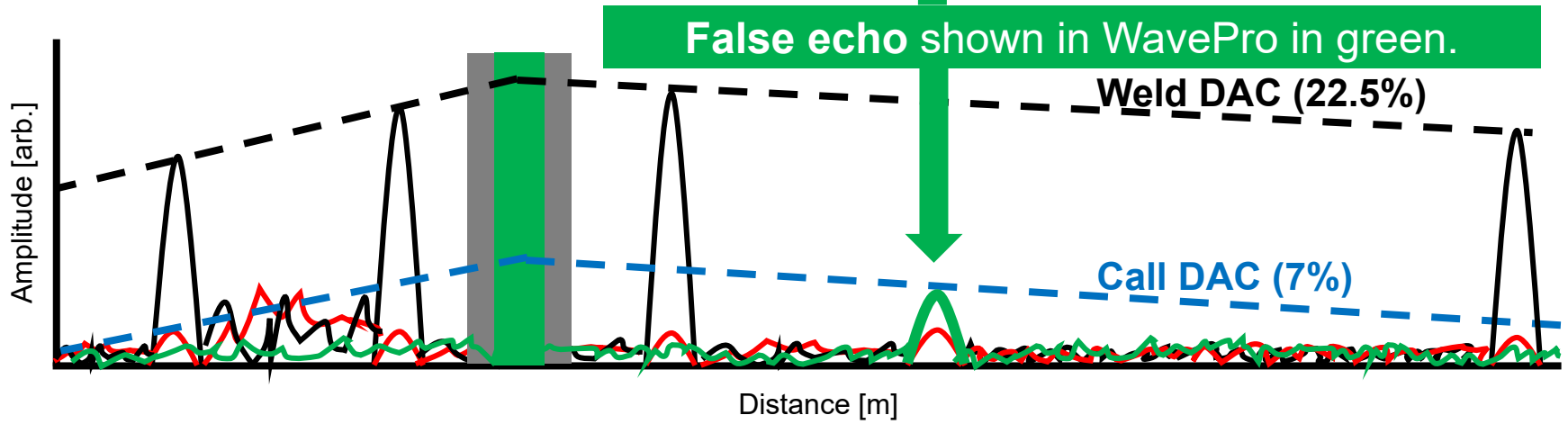
With Simulated Reverberation

With SimRev

The inspector is having a **bad day** and **missed a false echo.**

He uses **Simulated Reverberation feature** in WavePro software.

The software identifies reverb false echo in **green**. **No false calls were then made**.



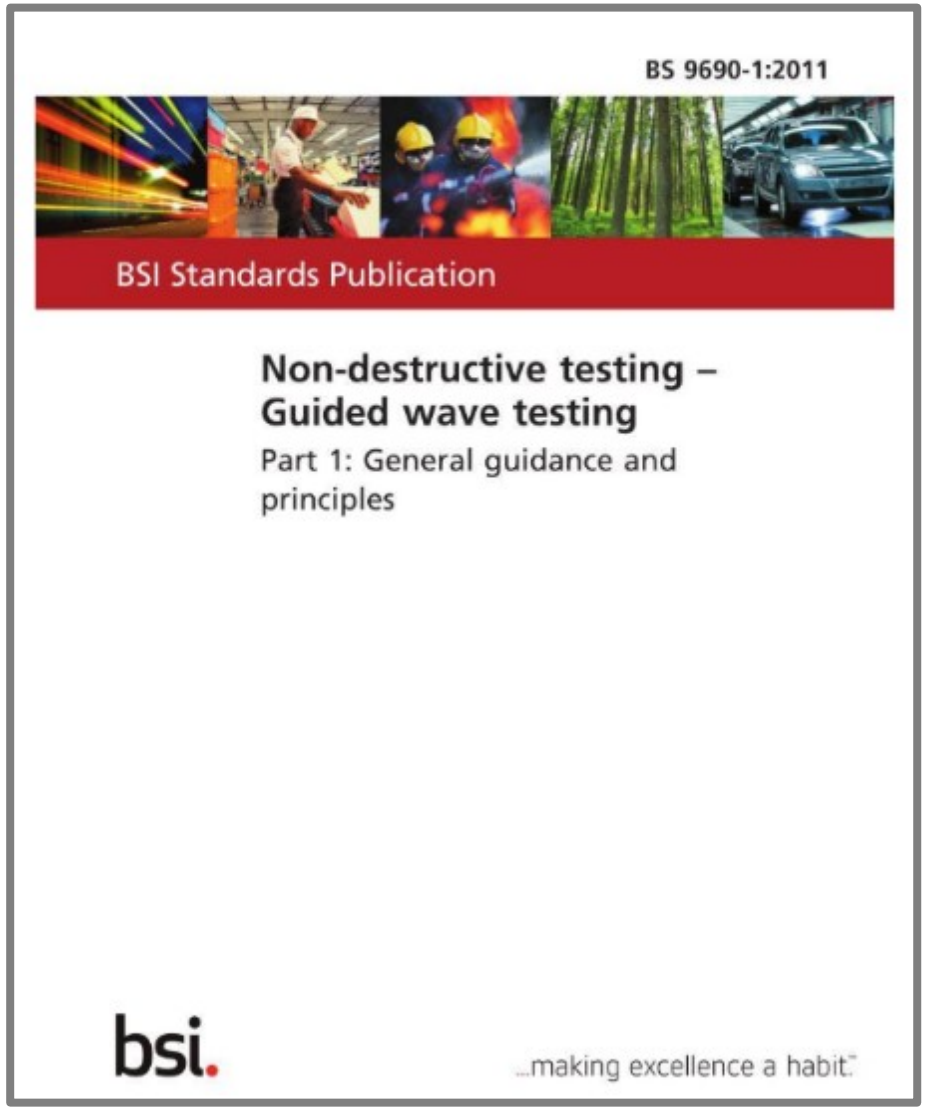
Codes & Standards

BS 9690:2011
Non-destructive testing – Guided Wave Testing

ASTM : E2775 -2011
Standard Practice for Guided Wave Testing of Above Ground Steel Pipework Using Piezoelectric Effect Transduction

ISO/DIS 18211.2
Non-destructive testing – Long range inspection above ground pipelines and plant piping using guided wave testing with axial propagation

ASME : Article 18
Guided Wave Testing Method for Basic Piping

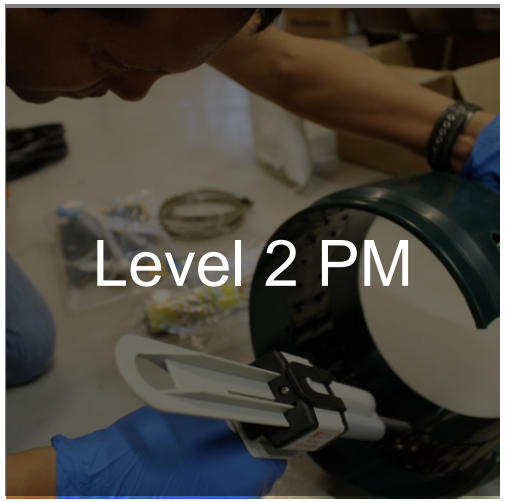


Track Record – GUL Screening

Client	Location	Industry	Description	Year
SGS	Peru	Inspection	EFC Rings	2020
Acuren Inspection	USA	Inspection	Wavemaker G4mini, EFC Rings	2020
PetroChina	China	Oil Company	Wavemaker G4mini	2019
Arise Global	Egypt	Inspection	Wavemaker G4mini, EFC Rings	2019
Iris NDT	USA	Inspection	Upgrade from G3 to G4mini	2019
Stork	Kuwait	Inspection	Wavemaker G4mini, EFC Rings	2019
Oceaneering	Algeria	Inspection	Wavemaker G4mini, Compact Rings	2019
Stanley	South Africa	Heavy Machinery	Wavemaker G4mini, EFC Rings	2019
Mistras	Netherlands	Inspection	Wavemaker G4mini, Compact Rings	2019
POSCO	Korea	Steel	Wavemaker G4mini, Compact Rings	2019
SINOPEC	China	Oil Company	gPIMS	2019

and many more…

GUL Training Courses

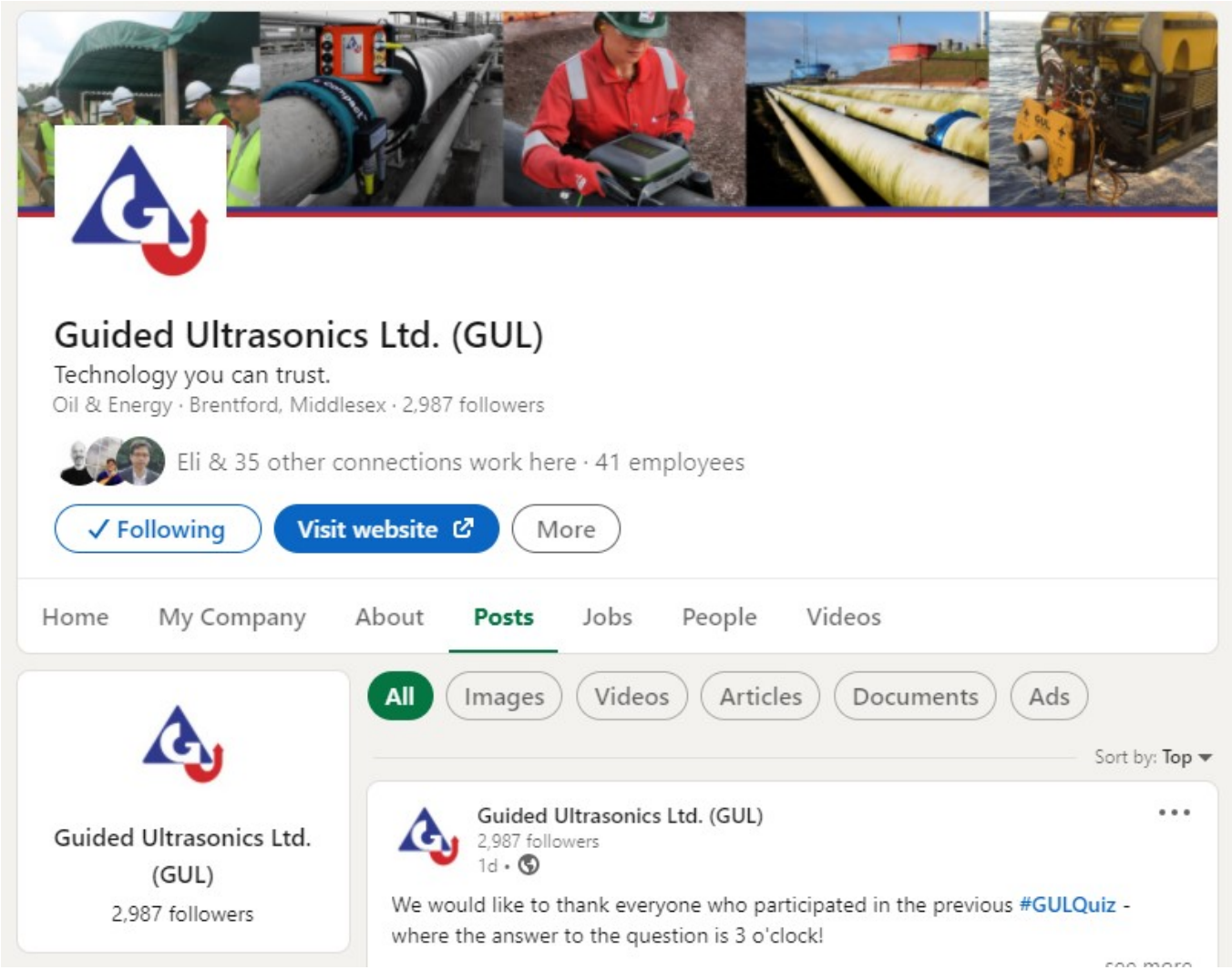
	Level 1 P	Level 2 XB	Level 2 SP	Level 2 PM
Courses				
Applications	**Straight Pipes**	**Road Crossing & Buried Pipes**	**Supports & Process Pipes**	**Pipeline Monitoring**
Description	Suitable for NDT inspectors new to the field of guided wave testing (GWT)	Advanced application specific training course for the inspection of road crossings and buried pipes.	Advanced application specific training course for the inspection of supports and processing pipework	Advanced application specific training course for the installation of the gPIMS® corrosion monitoring system.
Course Content	• Level 1 Guided Wave theory • Introduction to Wavemaker system • Introduction to WavePro™ software • Selection of test parameters • Basic Data Interpretation • Basic Reporting	• Advanced Data Interpretation • Advanced Data Collection Protocols • GWT of Buried Pipes • GWT of Pipes under Road Crossings • Pitch & Catch Configuration • Combining Transducer Rings	• Advanced Equipment Configuration • Advanced Data Collection • Advanced Calibration • Inspection of Supports • Inspection of Welds & Pipe Fittings • Detailed review of Level 1 work	• Introduction gPIMS® • Guided Wave Monitoring • Installation of gPIMS® • Practical Session

For more information:
http://www.guided-ultrasonics.com/training/

LinkedIn

Follow us on LinkedIn:

https://www.linkedin.com/company/guided-ultrasonics

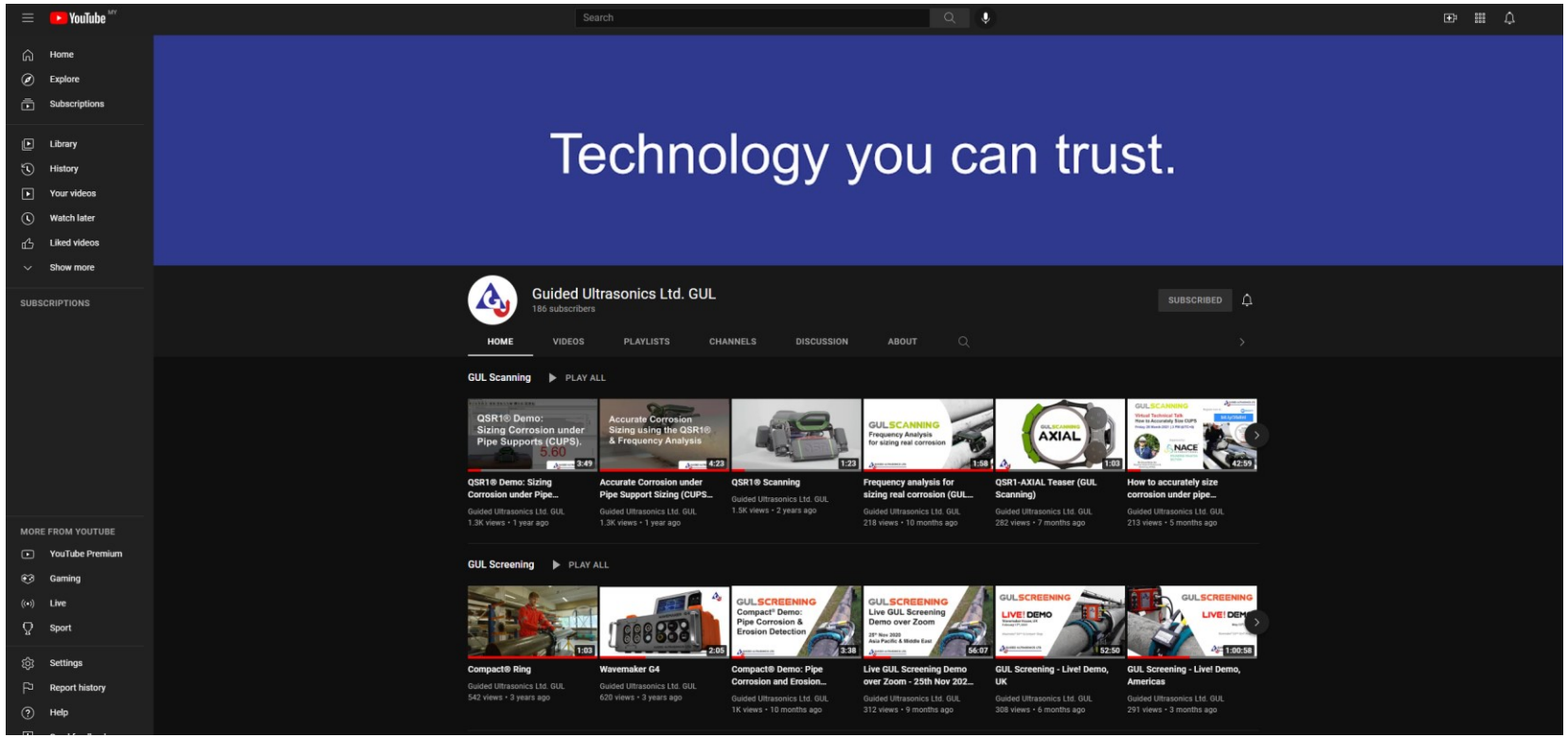


GUL Screening Videos (YouTube)

YouTube

Subscribe to channel:

https://www.youtube.com/channel/UCGT2S7kF5kHONCuwHLtthkA



	Demo Videos	URL
1	GUL **Screening – Compact Ring Demo**	https://youtu.be/FJcMACGDpWc
2	GUL **Scanning – QSR1 Demo**	https://youtu.be/T9B1Lh7eBgA

Screening FAQ Page

https://www.guided-ultrasonics.com/inspection/screening/faq/

GUIDED ULTRASONICS LTD.

Products Training GUL Services Technology Company News Search...

GUL FAQ

Frequently Asked Questions

Welcome to our Frequently Asked Questions (FAQs) page. Here you will find answers to the questions we get asked the most about GUL technology.If you have a question that is not addressed here, please let us know using our Contact Form.

Screening – FAQs

Scanning – FAQs

Monitoring – FAQs

Technology you can trust.

GUIDED ULTRASONICS LTD.