Guided Wave Testing (GWT)

Use of guided wave testing for the detection and monitoring of corrosion under insulation

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This presentation

• Brief history of GWT
• How it works
• How good is it at identifying CUI
• Monitoring
• New build considerations
• Limitations
• Procedures and training
• Other GWT applications
• Future developments
GWT History

• Lamb waves identified in the 1930’s
• Research projects in the 1990’s “Link and Thermie” programs
• Development of “dispersion curves”
• Required faster portable computers
• First commercial equipment available 1999
• Mid 2000’s Subsea, focussing, c-scan display, rail, permanently installed etc.
• 3 GWT systems developed Wavemaker (GUL) Teletest (Pi), MSS (SWRI)
Guided Wave Testing Standards

- ASTM – 2011
- BSI – 9690 parts 1 & 2
- TUV certification: GUL GWT procedure certified under EN standard 14748
- NACE TG 410 – 2012/13
- ASME Article 18 – 2012/13

Need for harmonization between the different standards.

Standards within integrated ‘system’ including legal requirements, codes and best industrial practices...
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Principle

Standard UT

Guided Waves

Metal structure

Transducer Ring

Inspected Area

Inspected area
Reflection from a Feature
(such as corrosion)

When the guided wave hits a change in cross section (or impedance), it reflects back toward the transducer
Dispersion curves

- **Longitudinal L(0,2)**
- **Torsional T(0,1)**
- **F(1,2)**
- **F(1,3)**

**Legend**
- **Black** = axi-symmetric modes
- **Red** = non-axi-symmetric modes
- **Blue** = other modes that are not used by the system

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Corrosion is indicated by large red component.
Guided Waves (Focusing) C-Scan display
At every change in cross section there is a reflection of the guided waves

- Amplitude depends on cross sectional area change

The dark grey section represents the cross-sectional area
Distribution of Loss

- The percentage loss given by the ECL
  - could be concentrated in a narrow portion of the pipe (e.g. a critical deep defect)
  - could be equally distributed around the circumference (e.g. a shallow wall loss)
The ratio of Red to Black depends on the circumferential extent of the feature.

When the feature does not extend very far around the circumference, RED = BLACK.

When the feature extends significantly around the circumference, RED << BLACK.

Circumferential Extent (percent)
Axi-Symmetry
Displayed as black and red lines

- BLACK lines represent axi-symmetric waves
  - Uniform around the circumference
- RED lines represent non-axi-symmetric waves
  - Varies around the circumference
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Why Guided Waves?

• 100% volumetric coverage
• Rapid screening
• In Service inspection
• Permanent record
• Significantly reduced access costs

Think of costs for:
scaffolding, removing insulation, digging, operating underwater
Rapid screening

- Very good at confirming clean pipe
- Acts as filter: point out areas where more attention is needed
- Everyone knows about health screening
In-service inspection

• Temperature performances
  – from -40°C to 180°C
  – the extremes of this range will require modified procedures

• Product
  – low viscosity fluid does not affect torsional mode
  – frequency range enables good performances in case of viscous fluid

• Pump noise, product flow
  – signal/noise can be improved using predefined software procedures
  – In some cases (isolated) testing is not feasible
Managing pipe inspection

Pipeline operators need to deal with kilometres of pipelines (each site)
How do operators manage the inspection now?
What capabilities are offered by Guided Waves?
GWT and other complementary methods

• Prove up using other NDT methods (UT, RT, Leak detection, etc…)

• Use with RBI can be very powerful
Touch point corrosion – 8” Sch 40

Weld DAC 14%
Call DAC 4%
Touch point corrosion patch with pitting
Touch point corrosion – 12” Sch 40

Pitting touch point corrosion at 6 o’clock position of pipe

Weld DAC 20%
Call DAC 3%
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100% Volumetric coverage

What is the probability of finding a defect using UT spot check compared to Guided Waves?
What is the probability of finding a defect using UT spot check compared to Guided Waves?

Example:
10” pipe, 12m length with 2 simple supports

Per test:
Standard UT = 0.027% area coverage
Guided Wave ~ 100% area coverage
Monitoring using GWT - Advantages

- Greatly improved sensitivity Normal testing ~ 1% to 5%
- Monitoring in the order of 10 times better as you are detecting changes
- Data from all tests can be stored for setting up same test parameters and also for comparison
- Can use removable or permanently installed transducers
- Data collection after base can be done by “data collectors”
GW monitoring sensitivity

Simple visual estimate of change – slow and sometimes difficult method of interpreting GWT data differences.
Riser monitoring results

2008 Result

2009 Result

2010 Result
Riser GW monitoring results: The automatically processed comparisons

The yellow trace is the reflection coefficient calculated from the 2010 reading using the calibration curves. The black trace is the difference between the 2010 and baseline readings.
Monitoring using GWT – Potential problems

The accuracy of comparing results must take into account the following:

– Unique transducer identification
– Ring position (for removable rings)
– Calibration
– Pipe temperature difference
– Transducer coupling (permanent attachment)
– Test parameters must be the same
– Ideally the software should calculate the change
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Using GWT – New build considerations

• Design for monitoring points especially when using permanently installed transducers
• For example sub sea and road crossings can be installed and take base line readings
• Design coatings etc to maximise range (avoid thick bitumastic coatings)
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Dead zone

• Cannot test region of pipes close to the ring location
• Dead zone extending over 0.5m from ring (depends on test configuration)
Range

- 5-150 meters in each direction depending on local conditions
- Factors affecting range
  - Geometry
  - General pipe conditions
  - Material inside pipe
  - Attenuative surface coating
Difficult geometry

• Only test through one bend in each direction

• Defects at branches cannot be found reliably

• Flanges and Ts represent the end of the test
Type of defect

- More difficult
  - Single isolated pit
  - Axial cracks
  - Small pits in welds

- Easier
  - A cluster of pits
  - Circumferential cracks
  - Large cracks in welds
  - CORROSION I/E - EROSION
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GWT Procedures

• Procedures need to be developed for:
  – Different applications
  – Permanent ring attachment and base test
  – Data collection from permanent rings
  – Comparison of monitoring data
  – Data management
GWT operator training and certification

- The success of GWT is very operator dependant so good training/certification is crucial
- Some applications are more difficult
- The main manufacturers have different approach to training/certification
- PCN agreed by all GWT equipment suppliers available this year
- CSWIP only available for Teletest
Information management

• Managing information from NDT inspection is major issue.

• With Guided Waves each result contains in one file information on tens of meters of pipe.

• New development will enable asset integrity packages linking exact positioning of pipe features and defects (plotted on Google Earth for example)
Guided Waves (C-Scan)

Unrolled pipe view

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Interpretation - Frequency scanning

- Time saving when collecting data
- Takes away responsibility from the inspector to choose best frequencies on site
- More information available which was not visible before when collecting single frequencies
- Extremely important in applications where the feature response is frequency dependent
- Helps distinguishing different features (e.g. defects from supports)
- POD
Typical performance on bare straight pipe (20 years old in good conditions)

- 100 meters range on each side
- Amplitude detection 1% Cross section
- Concentration of defect (approximate)
- Angle definition of defect +/-22 degrees

Factors reducing range discussed below
Applications

• Rapid, full coverage screening of pipes
• Especially cost effective in difficult to access locations
  – Pipe racks
  – Corrosion under insulation
  – Road crossings
  – Wall penetrations
  – Rope access
  – Road crossing
  – Buried pipes
• Can reliably detect general metal loss
Effect of Pipe Contents

- **Gases - no effect**
- **Liquids**
  - Almost no effect on the torsional mode
  - Affects the longitudinal mode when the pipe is fully filled
- **Sludge**
  - Heavy viscous deposits in the pipe attenuate the signal and reduce the test range
  - Can be similar effect to bitumen wrapping
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Future developments

• Auto monitoring hardware and software
• Asset integrity packages linking exact positioning of pipe features and defects (plotted on Google Earth for example)
• Improved buried pipe capability
• Absolute calibration
Other GWT applications

- Tube testing boilers/heat exchangers
- Sub sea (diver and ROV deployed
- Rail
- Tubular structures
- Lampposts
G-Scan Rail Screening System
Conclusions

• GWT is a very versatile inspection tool
• Needs to be used with complementary NDT methods
• Can save considerable access costs
• More accurate when used in monitoring mode
• Has data record of all tests
Questions

PQS
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