Semi Automated Corrosion Mapping using Phased Array Ultrasonics

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Presentation Content

- Industry Survey
- Understanding Damage Mechanisms & Applications
- Considerations applicable to Corrosion Mapping
- Introduction to Corrosion Mapping with Phased Array Ultrasonics
- Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection & Mapping
Industry Survey: Corrosion Mapping

The survey included:
• Major oil companies.
• Providers of inspection services
• Equipment manufactures and
• Individuals that perform Fitness for Service Calculations.

Twenty four companies and more than 70 people were included in the survey. Cumulative experience of the individuals surveyed exceeded 600 years of corrosion mapping experience. Most of the information gathered occurred during meetings with numerous key personnel that are directly involved with corrosion mapping services.

Fossil fuel process industry owner operators confirmed the current and increasing need for corrosion mapping. The driving force for corrosion mapping is the world demand for fuel. Safety, asset integrity assurance, contractual delivery of product, insurance requirements, compliance with government regulations and internal directives contribute to the utilization of corrosion mapping services.

Process facilities are required to remain on-line to meet the increasing fuel demands. Continuous operation of the equipment requires thorough integrity assessment using inspection techniques that can be applied while the equipment is in service. Wall thickness reduction due to corrosion and erosion are two of the greatest detriments that compromise containment of process.
Summary of Industry Survey

**Included:**
- Major Oil Companies
- Inspection Service Providers
- Engineering Companies perform FFS Calculations

**Tallies:**
- 24 companies, 7 countries
- >70 People including management, inspectors and equipment designers
- >600 years of experience in corrosion detection and mapping

**Common Problems:**
- Accurately Determine Corrosion Rate
- Repeatability of AUT Scans
- Differentiate between mid wall anomalies and ID connected wall loss
- Qualified Personnel
- Lack of Industry Standard for Corrosion Mapping
Why Perform Corrosion Mapping?

• Safety
  Current Condition of Equipment?

• Economics
  Reduced: Downtime, Vessel Entry.

• Determine Corrosion Rate

• Determine Remaining Life
  How long will it operate at current process exposure
  Replacement planning
  Selection of material for replacement
Examples of Corrosion

- ID & OD Corrosion
- Preferential Weld Corrosion
- Microbiological Induced Corrosion
- Isolated Corrosion Pits
Mid-Wall Anomalies

- Wet $H_2S$ Blistering
- Laminations

Figure 1: Pictures of blisters and step-wise cracking due to HIC
Applications for Corrosion Mapping

- Tanks, Atmospheric and Pressurized
- Flare Lines
- Knock Out Drums
- Heater Exchanger Shells and Channel Sections
- Columns, Trays and down-comers
- Boots on Horizontal Drums
- Clad Vessels
- Nozzles
- Raised Face Flanges
- Piping, flow impingement, injection points, material changes
- Corrosion Under Insulation
- Pressure Vessel Saddle Supports
Considerations Applicable to Corrosion Mapping:

Automated UT, Corrosion Mapping

Raster Scanning

Index Direction

.375 Diameter

.187”

Effective Beam
Considerations Applicable to Corrosion Mapping:

**Data Point Density**

- **Low Density**
- **High Density**
Considerations Applicable to Corrosion Mapping: Variable Data Point Density

6 FBHs, .100” Deep

0.040” x 0.040” / 1mm x 1mm

0.080” x 0.040” / 2mm x 1mm

0.160” x 0.040” / 4mm x 1mm

0.640” x 0.040” / 16mm x 1mm

0.800” x 0.040” / 20mm x 1mm

0.960” x 0.040” / 24mm x 1mm
Considerations Applicable to Corrosion Mapping:

Critical Information

• Inspection Criteria
  – What size anomaly to be detected
  – Nominal Wall thickness
  – Data point density

• Surface Preparation
  – Painted
  – Grit Blasted
  – Rusted

• Equipment Information
  – Material of construction
  – Manufacturing process
  – Surface Temperature

• Damage Mechanisms
  – Process info = Type of Corrosion
  – Historical Information
  – Where to Inspect

• Deliverables
  – Content
  – Electronic or Hard Copy
  – How soon
**Basic Principles:**

- Phased Array Probes are composed of multiple piezoelectric elements
- Pulsing and receiving of the elements are computer controlled
- Linear Scan
Introduction to Corrosion Mapping with Phased Array Ultrasonics:

Multiple Beam Configurations

- Focused
- Non Focused
- Angle Beam
- Sectorial

Phased Array Transducer
Phased Array Probe

- 7.5 MHz, 64 element
- 60 mm coverage (2.36 in)
- 1mm Pitch (.039” x .039”)
- Scan speed of 100 mm/s (4 in/s) 1mm x 1mm Data Point Density
- Near surface resolution 1.6 mm (.063in)
- Primary use linear scan at 0°
Introduction to Corrosion Mapping with Phased Array Ultrasonics:

Large Effective Beam

Conventional Pitch Catch

Phased Array 64 element

.187"

2.36"

12 Times more coverage with phased array probe.
Introduction to Corrosion Mapping with Phased Array Ultrasonics:

Three Techniques for PA Compression Wave

Contact:
- Pitch Catch & Pulse Echo

Wheel Probe:
- Pulse Echo

Bubbler:
- Pulse Echo
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

Calibration and Performance Demonstration

- Calibration
- Performance Demonstration
- Flat Bottom Holes
- Images via Excel
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

Semi Automated Phased Array for Corrosion Mapping
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

Scan Views:
“A” “B” “C” Scans Simultaneously
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

Scan Map

• View of areas scanned

• Precise measurements for repeat scans

• Location (s) of anomalies for monitoring

• Repair plans
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

**Heat Exchanger Shell Scan**

Four square feet of surface area inspected in 2.5 minutes with .080” (2mm) x .040” (1mm) data point density.
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

Scan Map
Applying Phased Array Ultrasonics for Corrosion and Mid Wall Anomaly Detection and Mapping:

Example “C” Scan Image

Wall Loss below T Min in scan 3 at BDC.
Scan Position is 32”L X 55”C Reference from TDC & Flange to Shell Weld.
Conclusion

Positive Attributes of Phased Array Ultrasonics used for Corrosion Mapping: “TOP 3”

• Safety

  Thorough and accurate assessment of remaining wall thickness compliments certainty of equipment integrity.

  Personnel Injuries  Ignition Sources

  Impact Damage from Scanners Falling

• Corrosion Rate

  High Data Point Density improves probability of detecting wall loss therefore enhances accuracy of engineering calculations.

  Wide effective beam optimizes repeatability of subsequent scans and comparison of wall loss shape and size.

• Detection and Characterization

  Differentiate between mid wall anomalies and ID connected wall loss.
Questions and Discussion

Contact Information:

Mark Carte
Olympus NDT
12569 Gulf Freeway
Houston Texas 77346
Office: 281 922 9300
Cell 1: 832 633 0283
Cell 2: 281 744 3022
Mark.Carte@OlympusNDT.com