

Inspection of Steel Vessels with Cladding Overlay, using MWM-Array Technology

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Technical Approach

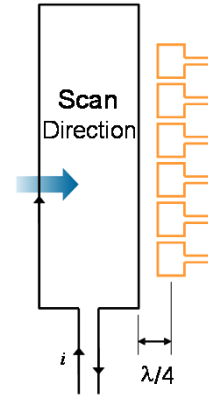
- **Goal: Detect hydrogen blisters in weld overlay clad vessels**
 - Detect substrate cracks
- **Equipment:** 8200 GridStation[®] Electronics
- **Software:** GridStation autonomous data analysis
- Preliminary demonstration and mock up performed in Waltham, MA, USA
- Inspection performed in Saudi Arabia, during 8 day period (April 2014) on four large vessel units
- Scans performed of over 50% of the internal clad surface



Technology Overview

1. Sensors: flexible eddy current arrays

- Paradigm shift in sensor design (first priority is predictable response based on physics-based modeling)



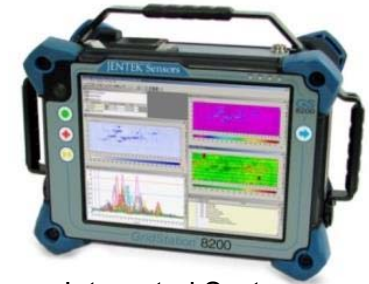
2. Next Generation Electronics

- 10x signal-to-noise improvement
- Very low frequencies (deep penetration)
- Crack detection through up to 0.5 inches of material
- Reduced drift

Nonintegrated System



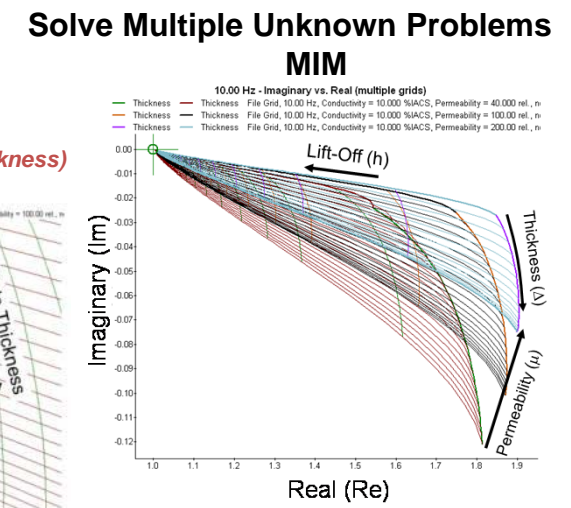
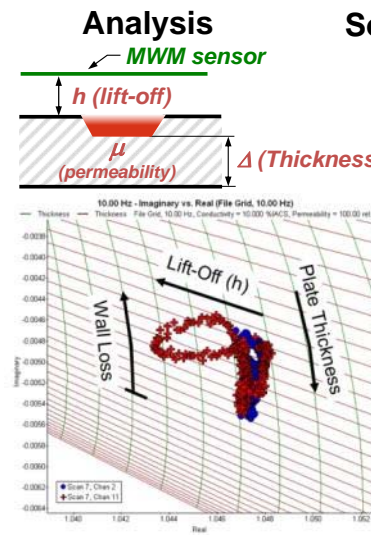
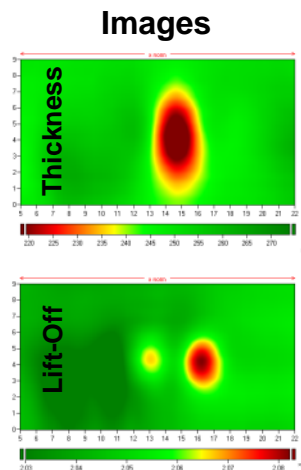
Probe Electronics Units (PEU)



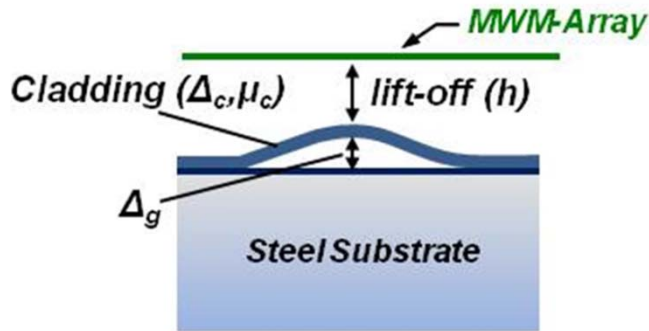
Integrated System

3. GridStation Software using Hyperlattices®

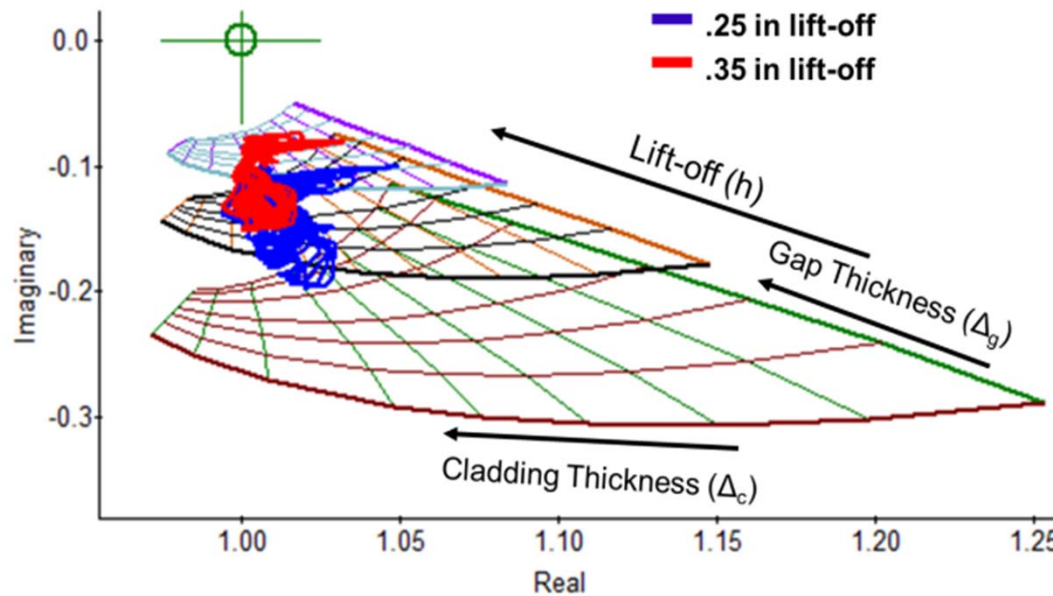
- Rapid, autonomous data analysis
Performs multivariate inverse method (MIM) using precomputed databases
 - Defect Images
 - Performance Diagnostics
 - Noise Suppression



Inverse Method: 4-Unknown HyperLattice Databases



1. Lift-Off
2. Cladding Permeability
3. Cladding Thickness
4. Gap thickness

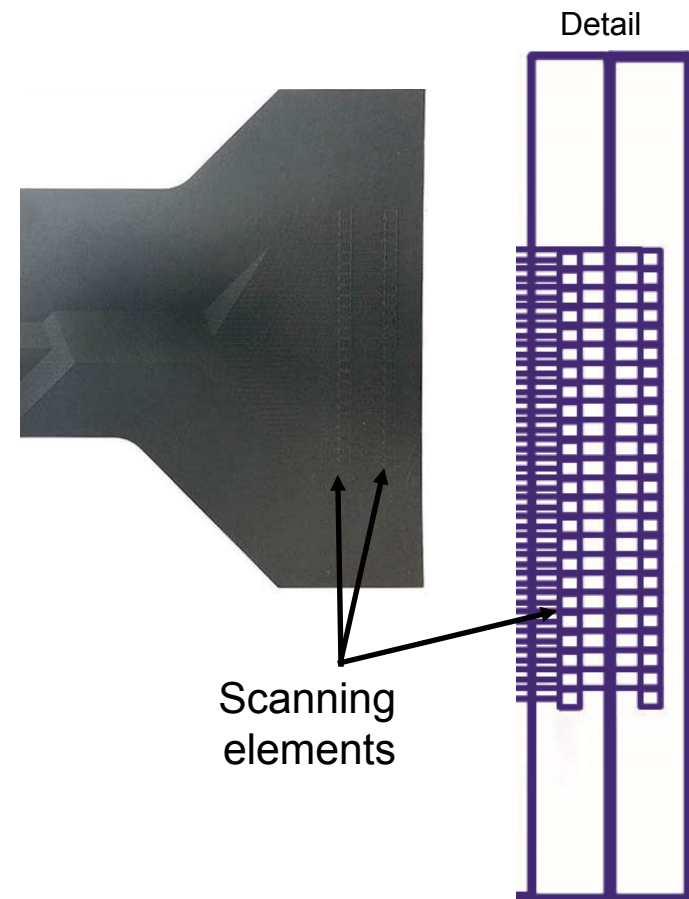


Vessel Scanner: Manual

Manual Scanning Cart and Sensor

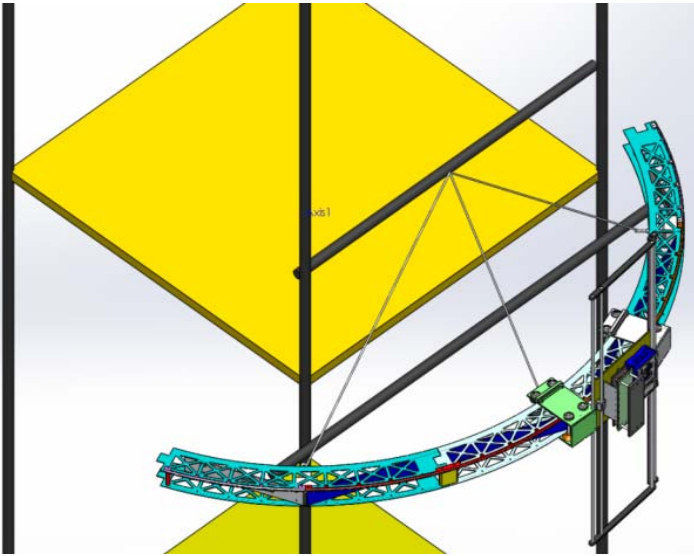


Flexible Array Sensor FA216

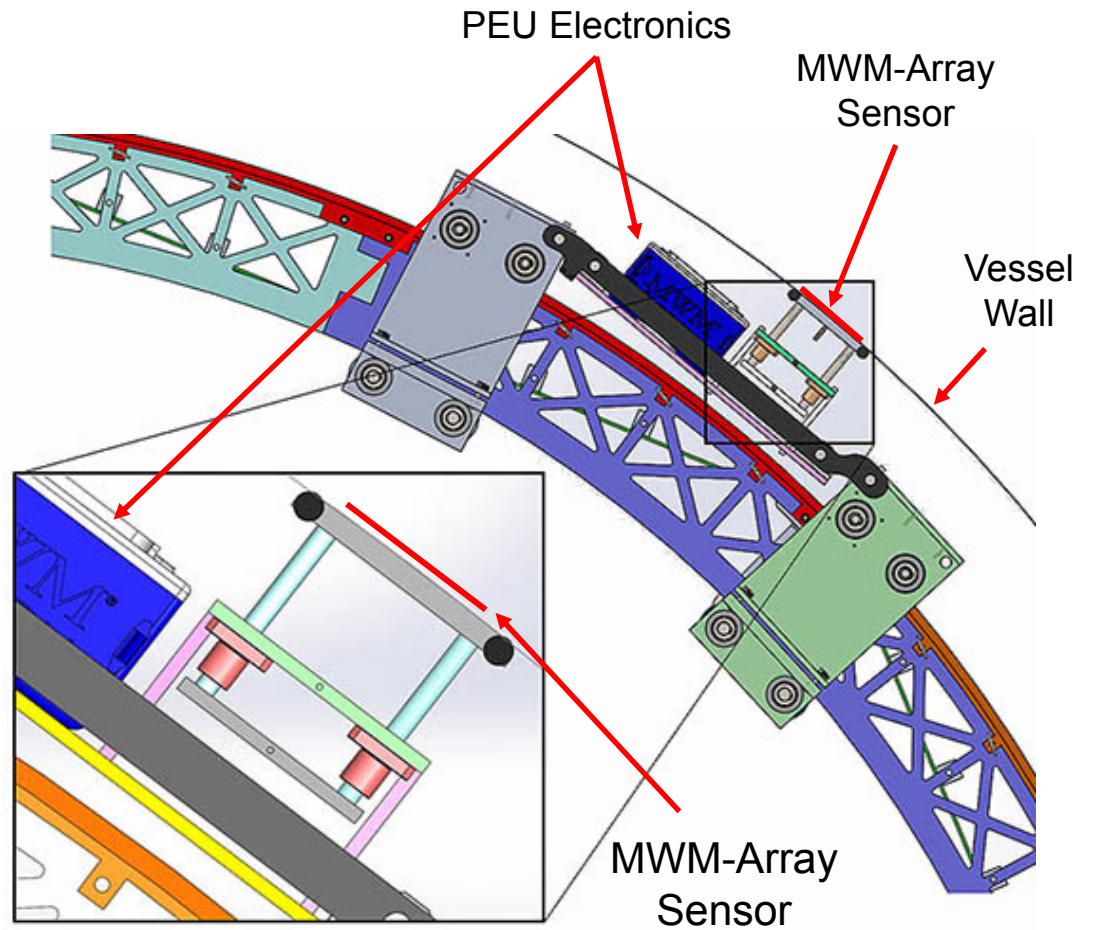
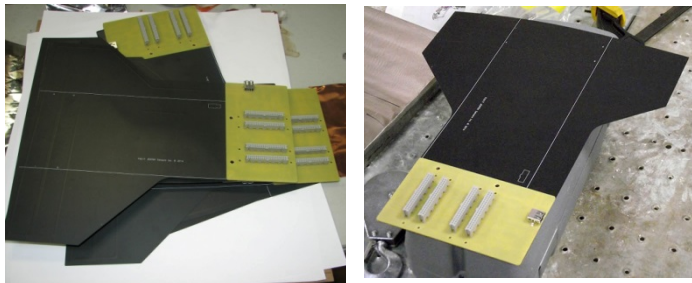


Vessel Scanner: Automated

Vessel Mock-Up



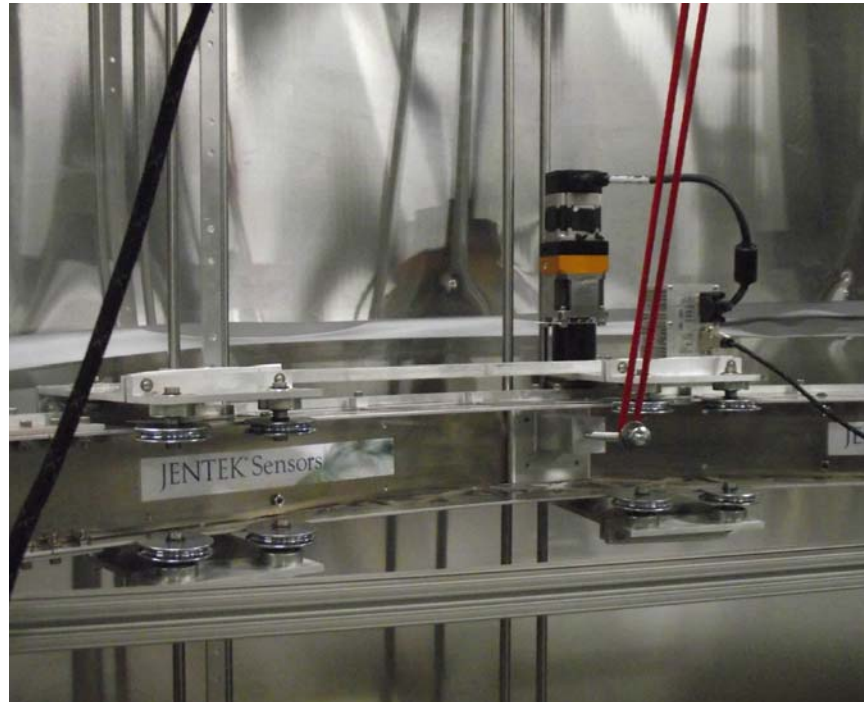
MWM-Array Sensors



Test Set Up, JENTEK Sensors, Waltham, MA

Scanner supports, scanner rail and mount
on vessel mock-up

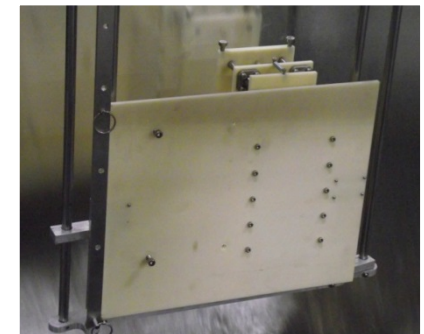
System



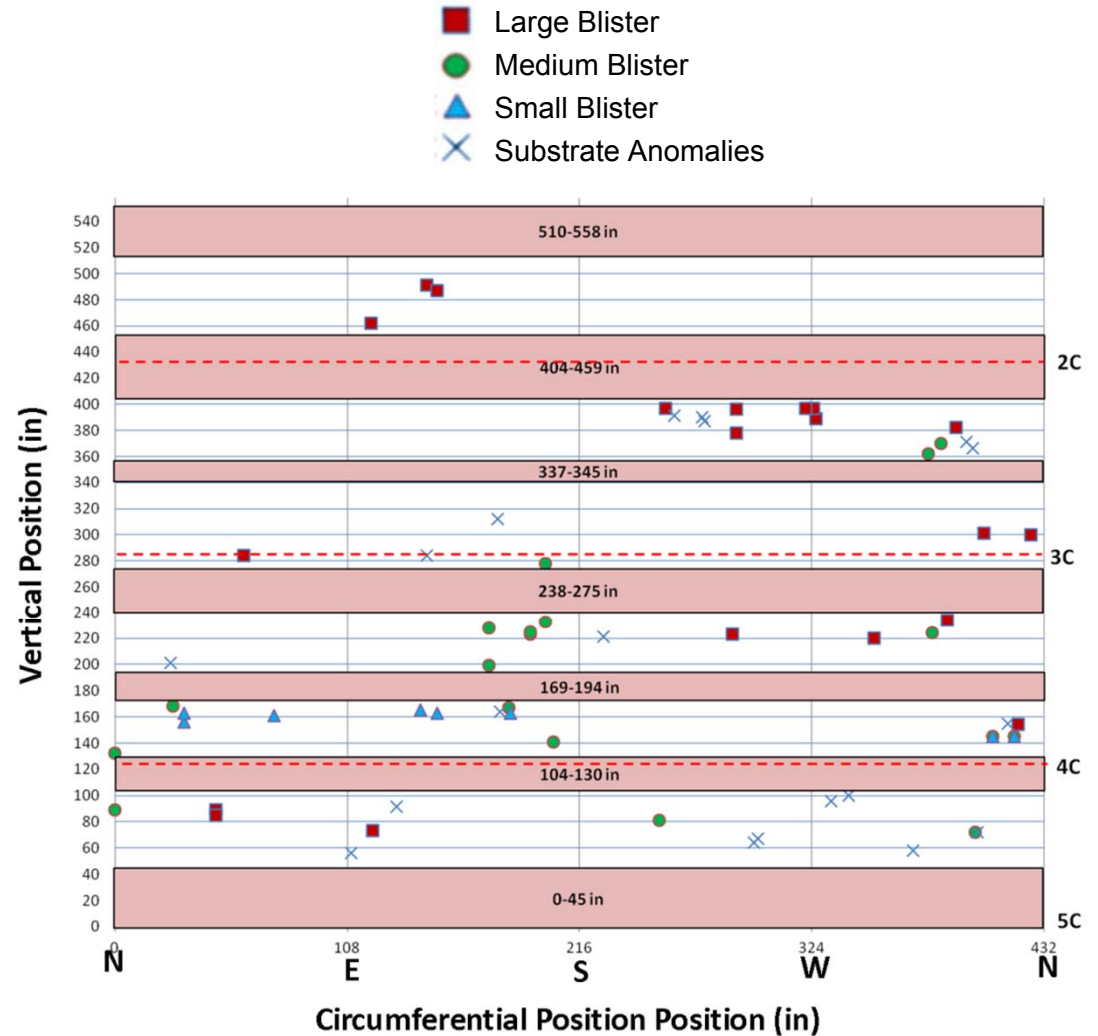
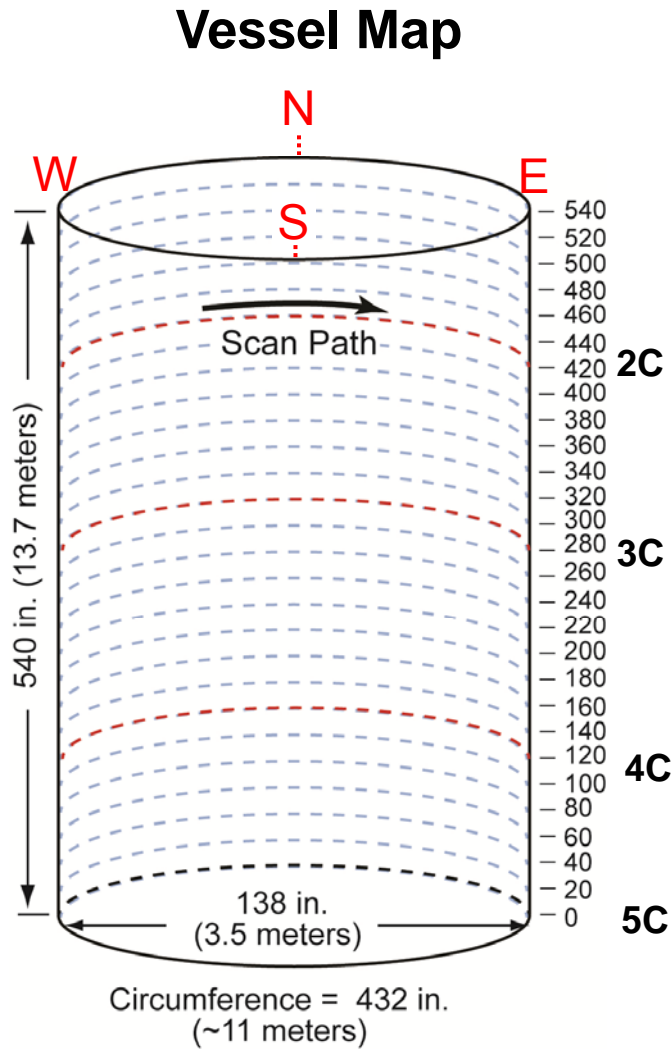
Scanner rail



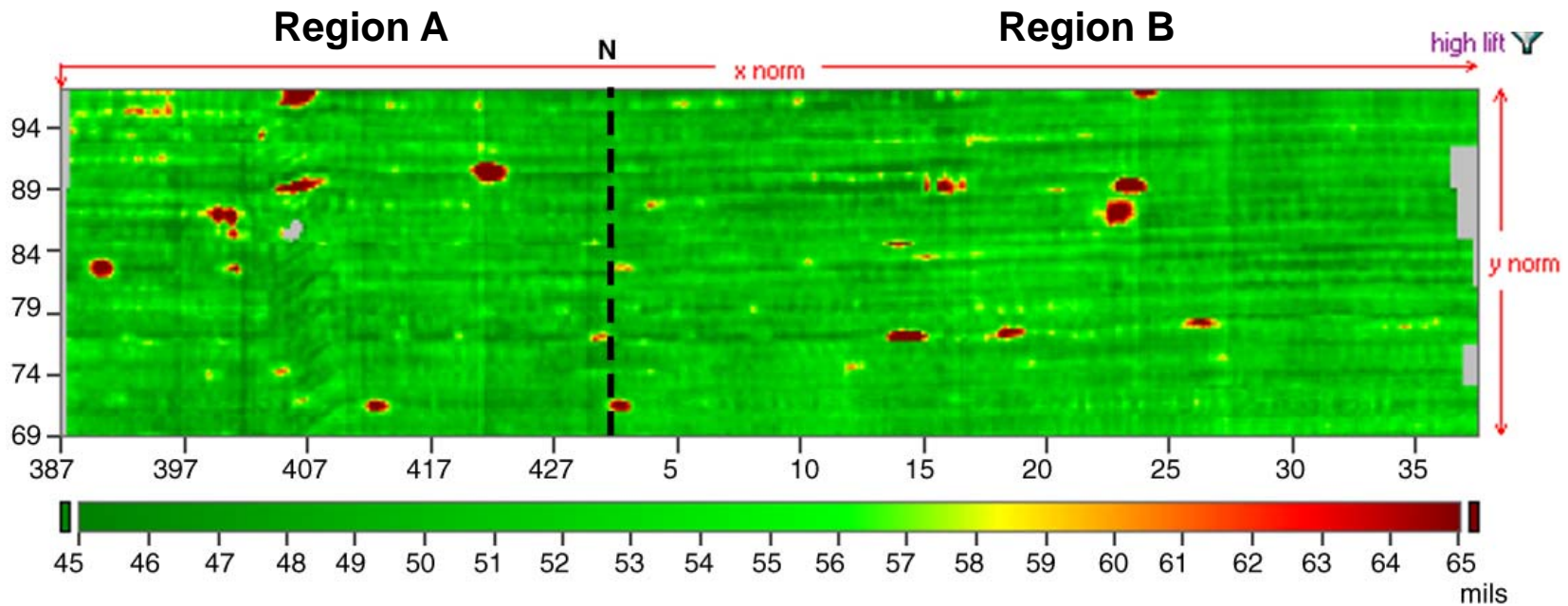
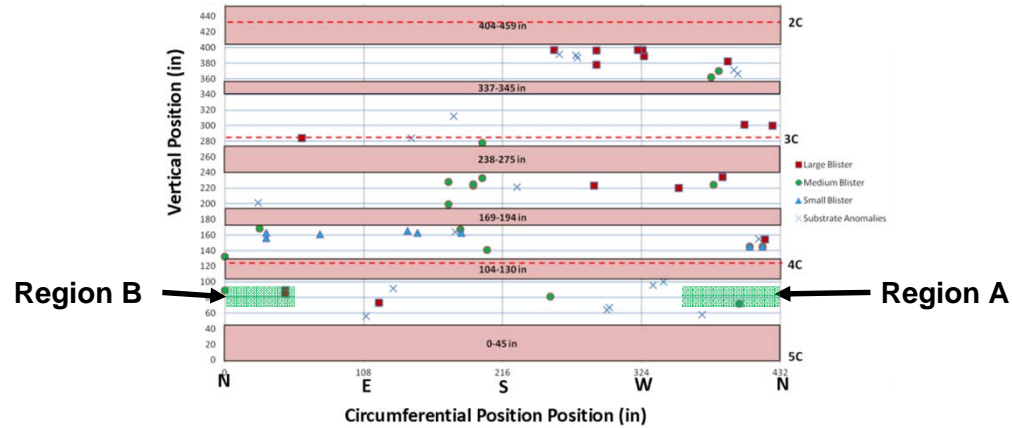
Scanner mount
for sensors



Map of Reported Blister Locations

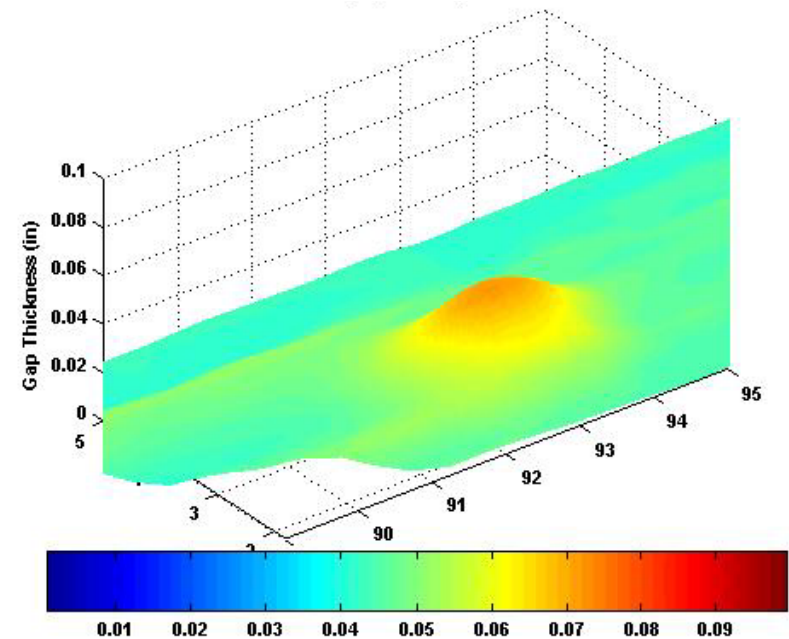
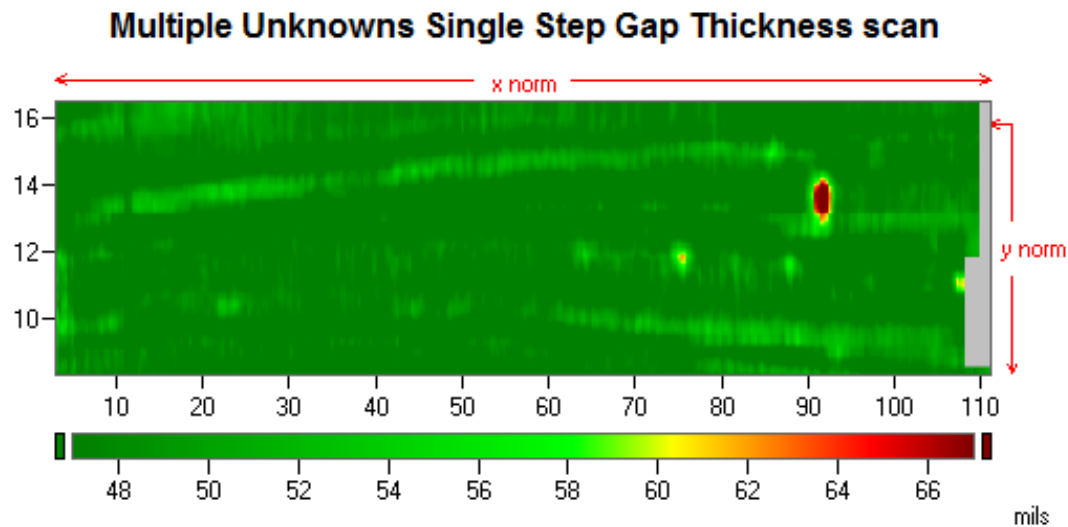


Example Gap Thickness C-Scan



Gap Thickness C-Scan and 3-D Plot

Corresponding 3D plot localized around the location of a blister



Summary

- Program **goal** was to demonstrate imaging and **characterization of blister volume** using MWM-Array sensor technology
- A successful **first service for inspection** for hydrogen blisters in weld overlay clad vessels was completed at a major facility in Saudi Arabia
- Hydrogen blisters were **successfully mapped** and **digitally registered**
- **Suspect cracks** in the steel substrate below the cladding were also **identified**

