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NonDestructive Evaluation for Industrial & Development Applications

Mitsubishi Heavy Industries

October, 2016

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NonDestructive Testing & Evaluation of Welds

- Overview
- Expert Based Capability
  - ASNT Based
  - Broad Range of Applications
- Methods
  - Ultrasonic Testing (UT, EMAT, PAUT)
  - Eddy Current Testing (ET)
  - Radiography (RT)
  - Computed Tomography (CT)
  - Dye Penetrant
  - Magnetic Particle
- Notes

Note: I am our CT and special engineering team leader but each technique discussed has one or more SMEs associated with it.

Overview

- We examine joints on a broad range of materials
  - Welds, brazes, glue joints
  - mm to meter size parts
  - Materials across the periodic table
  - Disjoint material types/properties
- Standard range of requirements
  - Weld/braze penetration
  - Voids, gaps, cracks, damage
  - Alignment
  - Bonding (Braze and glue)

- We maintain an expert based capability
  - Generally follow ASNT certifications
  - Maintain the capability to build UT, EC, RT and CT systems ground up.
  - Specialize in exotic applications
  - Certification and qualification as needed for non-standard applications

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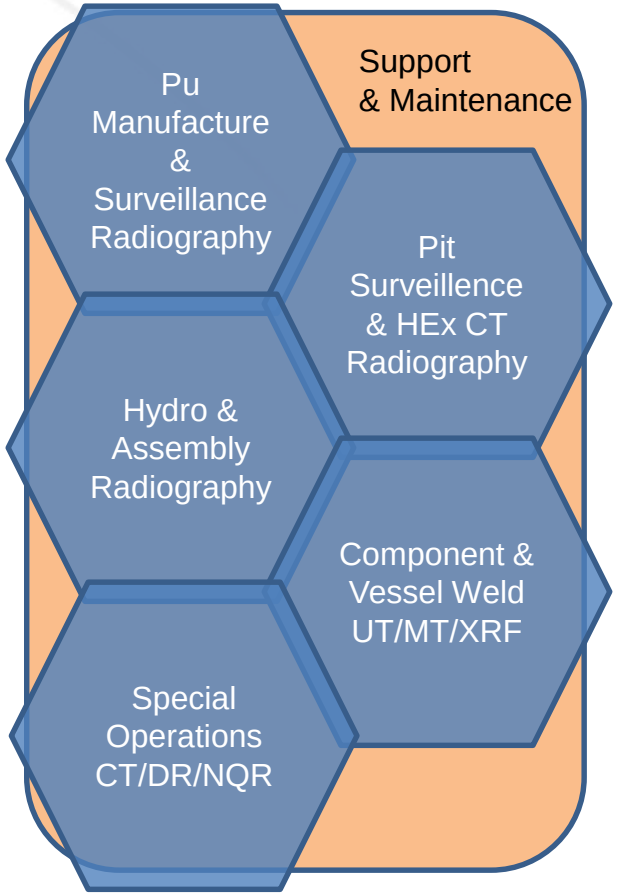
Nondestructive Testing

- Group AET-6
  within the Applied Engineering Technologies Div.
  - 6 Capability Areas integrating
    - 15 R&D Engineers & Scientists
    - 4 Technologists & Computer Systems Professionals
    - 8 Process & Sampling Technicians
    - 3 Professional Staff
    - 2 retired Scientists
  - Other LANL NDT R&D and non-traditional use of technology
    - Neutron, pRad, microCT, flash radiography, XRF, contact UT, EMAT UT, immersion UT, PAUT, IR, NQR, MRI, Simulations



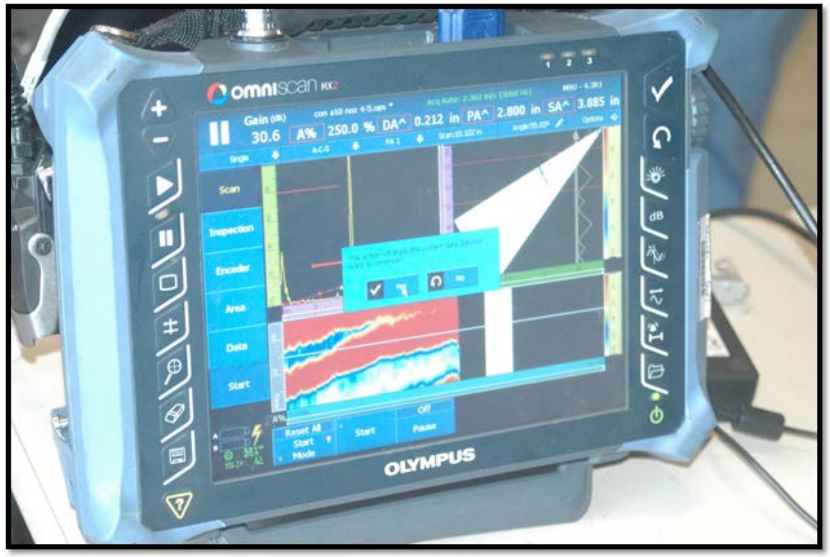
Ultrasonic Testing

- Range of parts up to several meters or larger
  - Explosive loaded vessels weld & fragment hit inspections
  - Heat sources, power supplies
  - DP components
  - Broad range of small components (immersion UT)
  - Exotic materials
- Broad Range of UT
  - Phased Array UT for plate, pipe, vessels
  - PAUT & traditional contact UT: varying complexity including contoured shoes, delay lines, tailored focal laws for part geometry;
  - Other: Through transmission, impedance, resonance, & eddy current scanning capabilities; EMAT & other specialty transducers; Immersion testing→ full waveform capture raster, rotary, squirter, contour-following, high resolution/high-frequency (≥ 50 MHz)
  - Custom built systems as needed

Ultrasonic Testing

- UT is the backbone of our weld inspection capability
- Validated against other techniques including CT, RT and destructive testing as needed.

COTS Wing Scanner



Olympus OmniScan MX2 (Phased Array)

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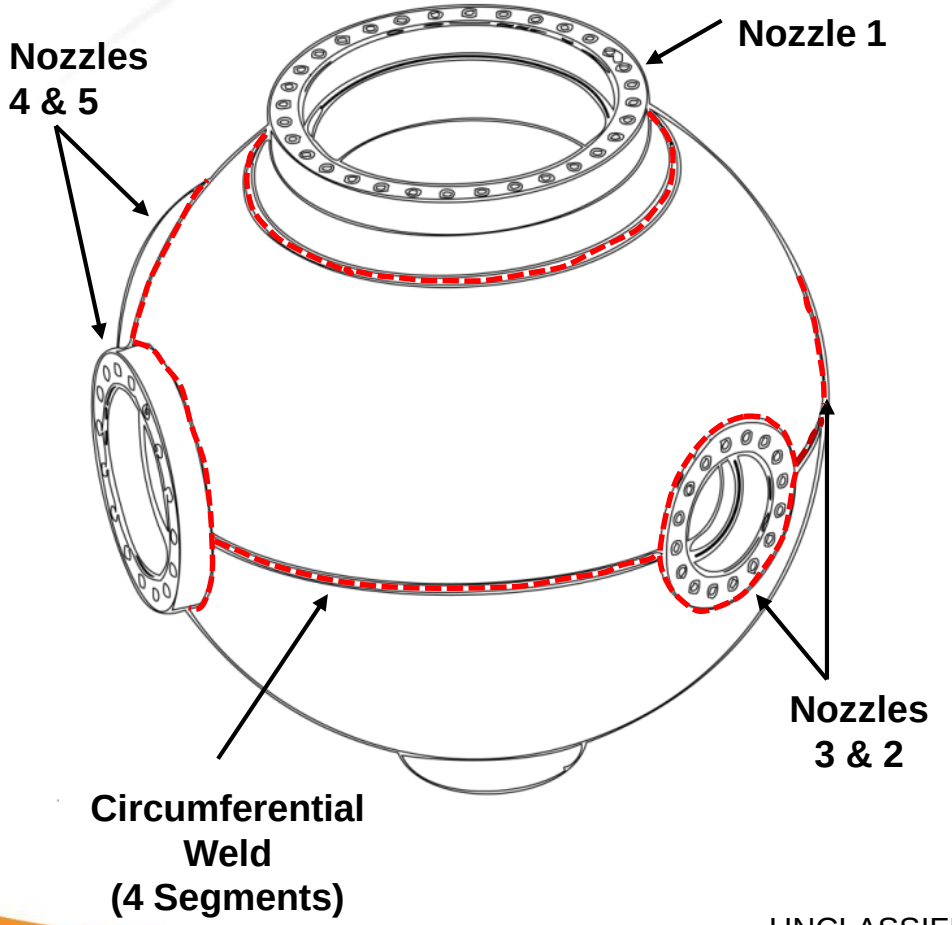
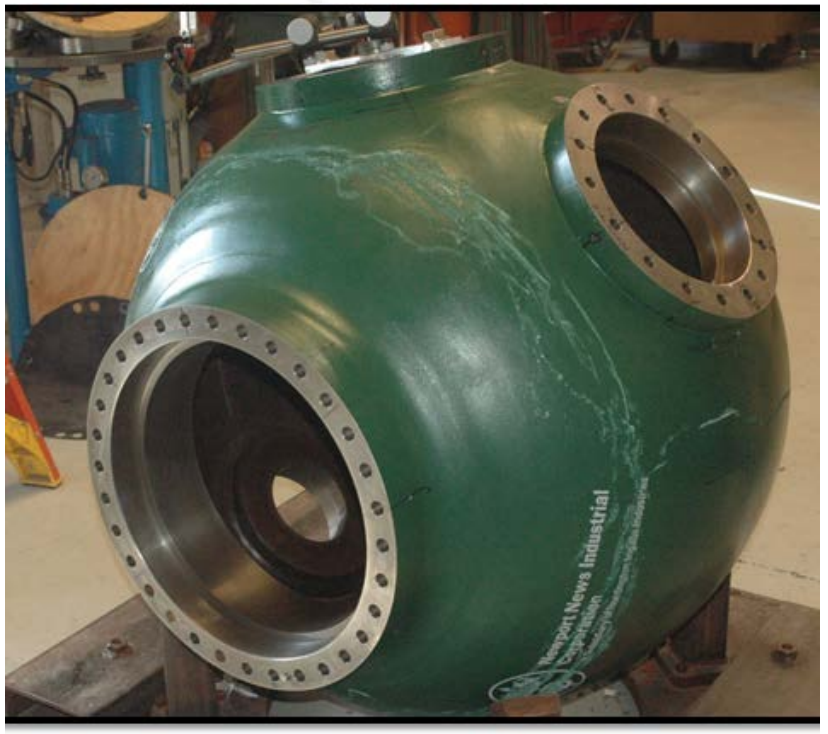
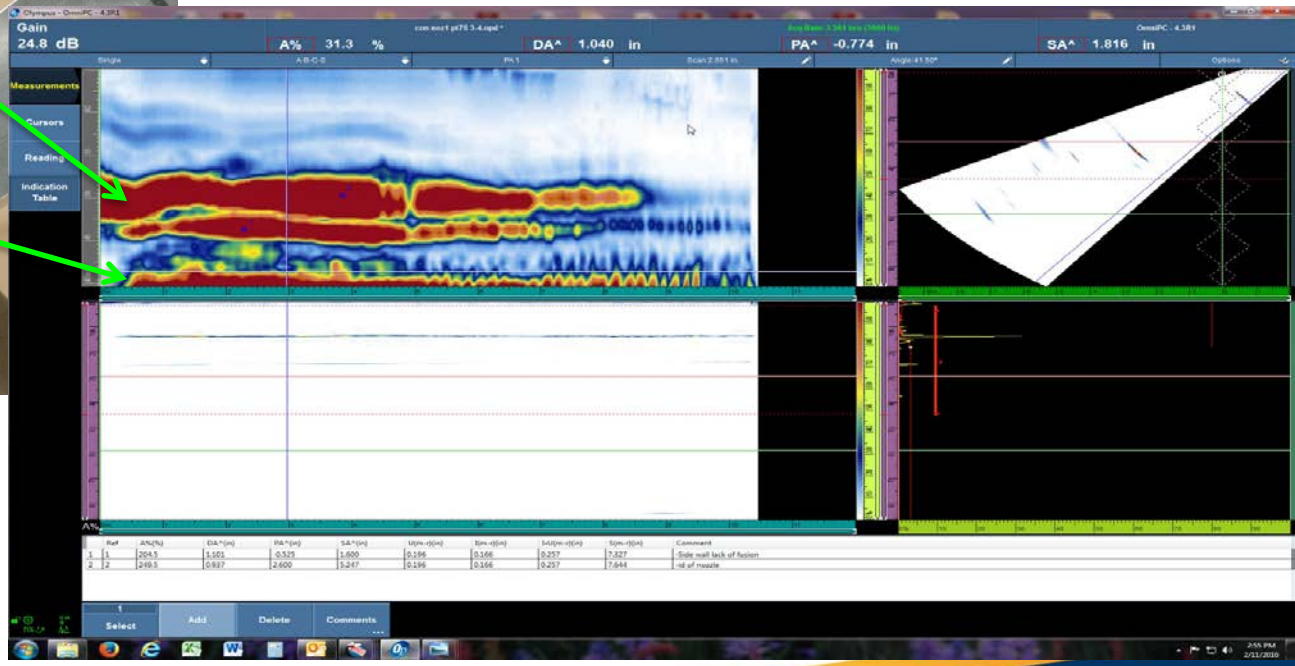
Ultrasonic Testing Example: Confinement Vessel





Phase Array UT Example: Confinement Vessel



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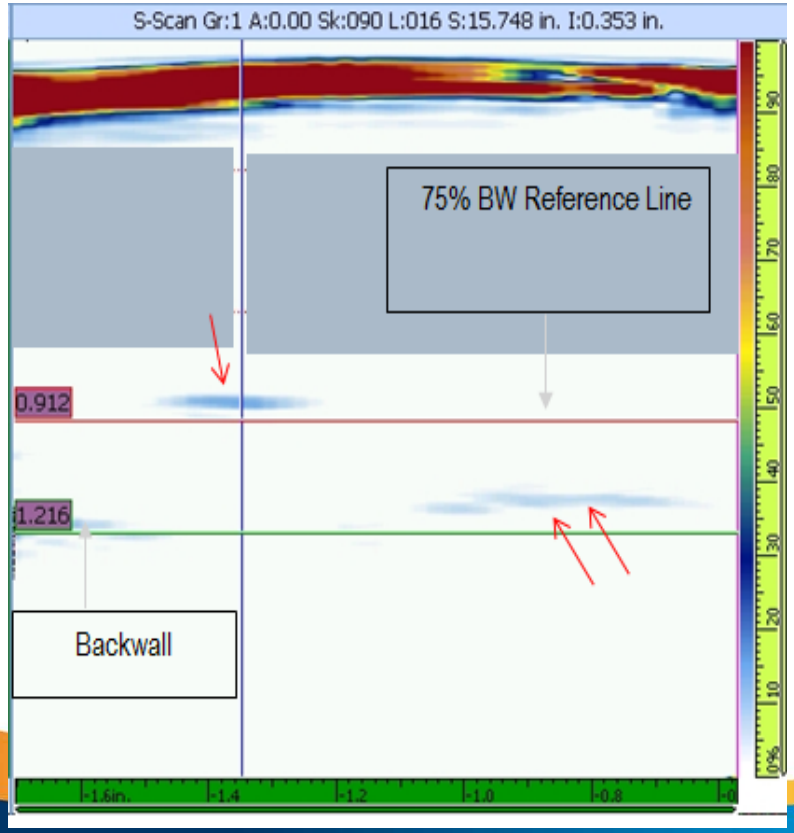
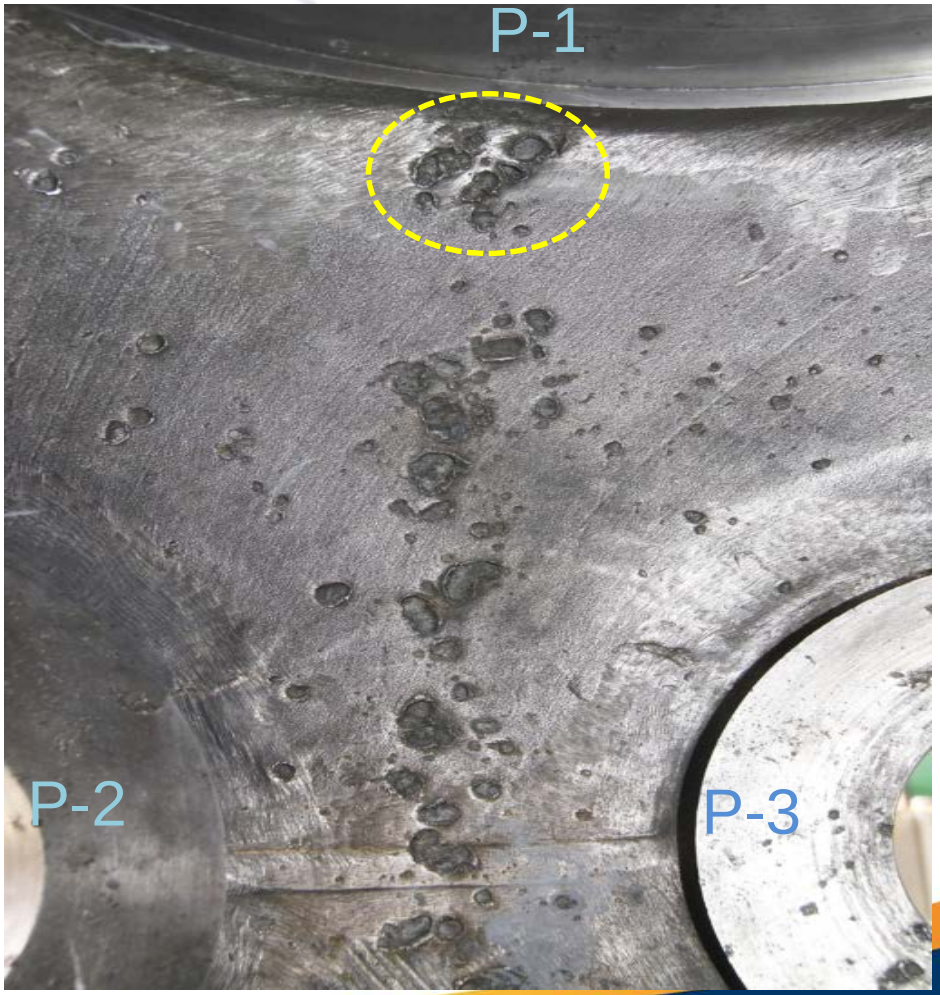
Ultrasonic Testing Example:
Confinement Vessel Strike Evaluation

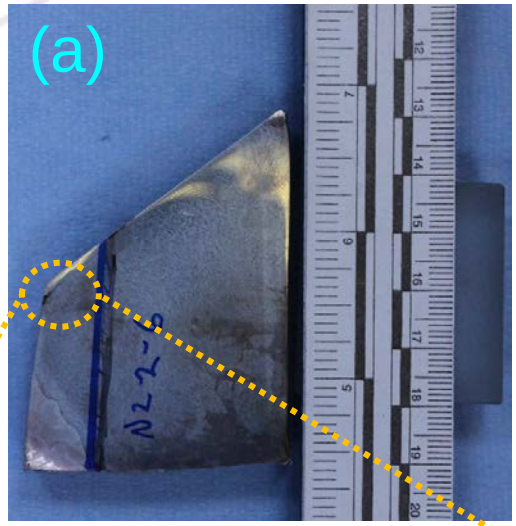
- Remaining wall thickness
- Base metal damage
- Fitness-for-Duty Evaluation

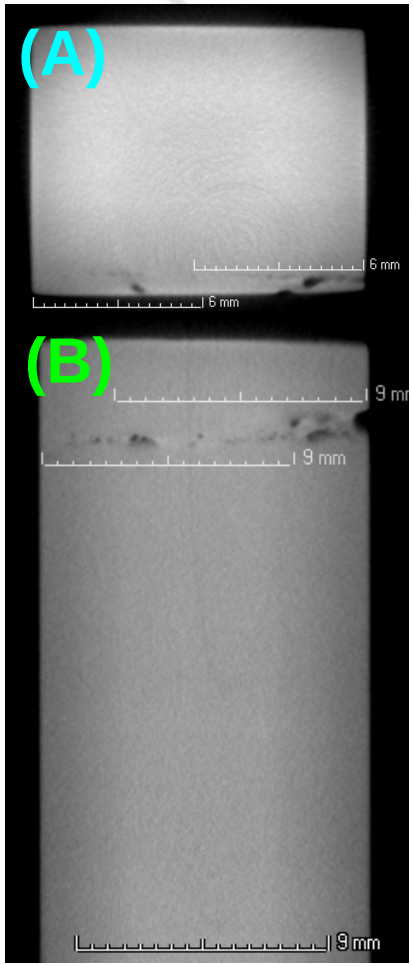


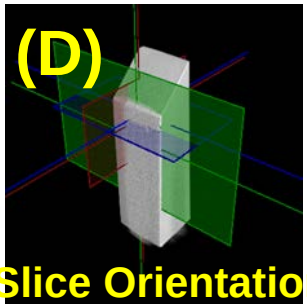


Ultrasonic Testing - Verification

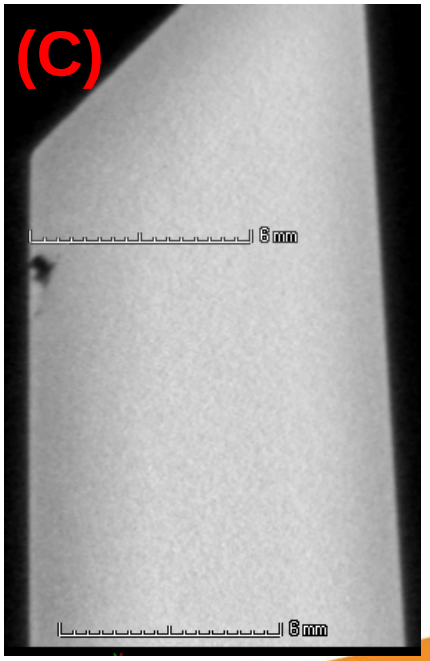
Weld section, micrograph and CT scans of the section showing defects for comparison to UT







Slice Orientation



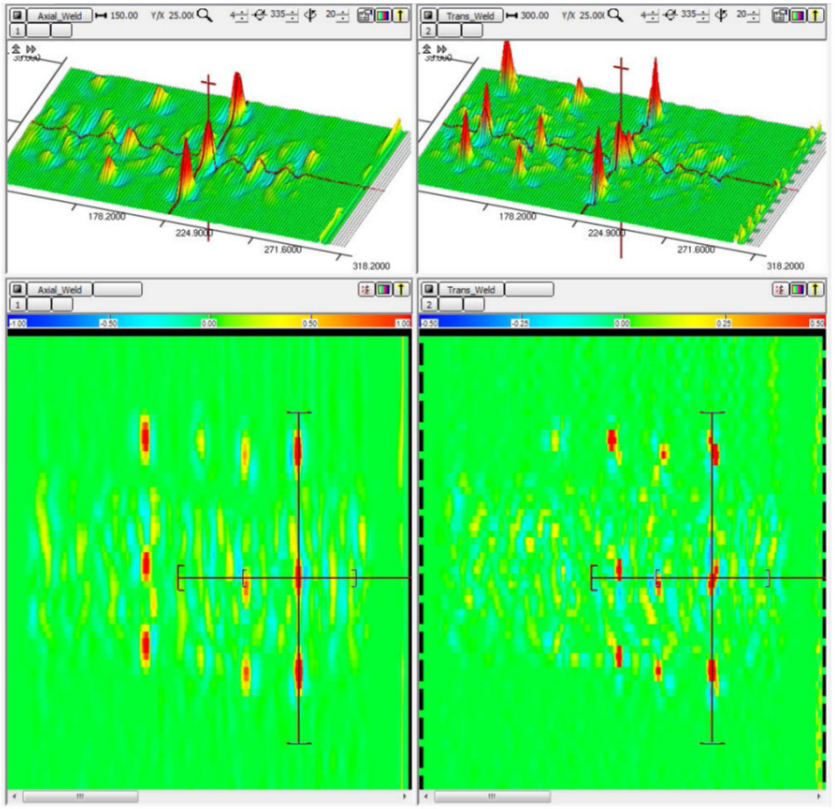
Eddy Current Testing (ET)

- Commercially available Eddyfi and Olympus systems
- Older custom built systems

Ectane 2 Eddy Scope

SS Weld Example with indications

Magnifi Software

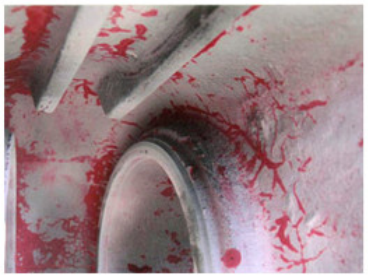


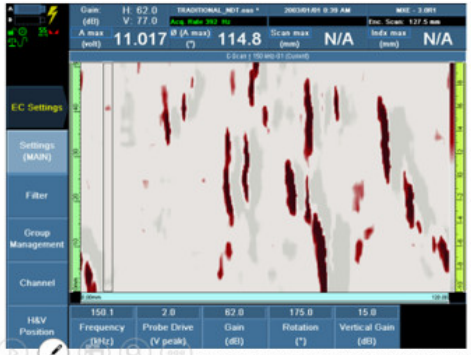
Eddy Current

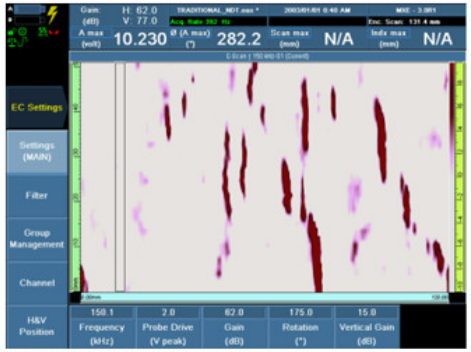
Traditional Dye Penetrant Vs Eddy Current Array

OLYMPUS

“Traditional” ECA Displays







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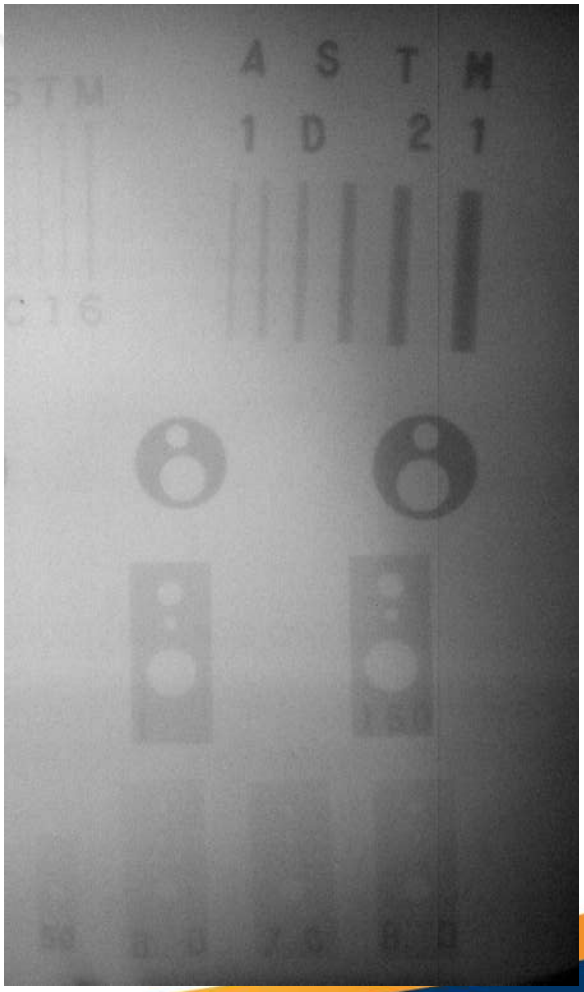
2D X-Ray (RT/DR/CR)

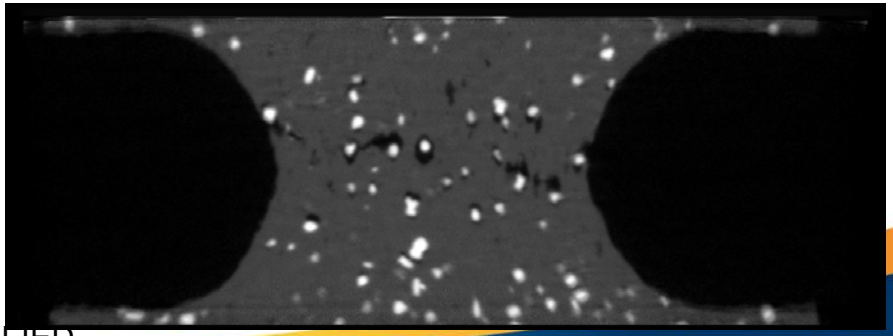
- Voids, alignment, gaps and cracking
- Does not show closed gaps/cracks
- Extensive personnel expertise
- Range of detectors
  - Film, Storage Phosphor (CR)
  - aSi Flat panels
  - Camera scintillator systems (custom)
- X-Ray sources from 35kV to 20 MV
  - ~10 Micro-focus x-ray cabinets
  - Multiple 450, 320 bay based systems
  - 950kV and 6MV Varian Linacs
  - Microtron (6-20MV) and 6MV Portacs
- Portable Golden and Betatron sources



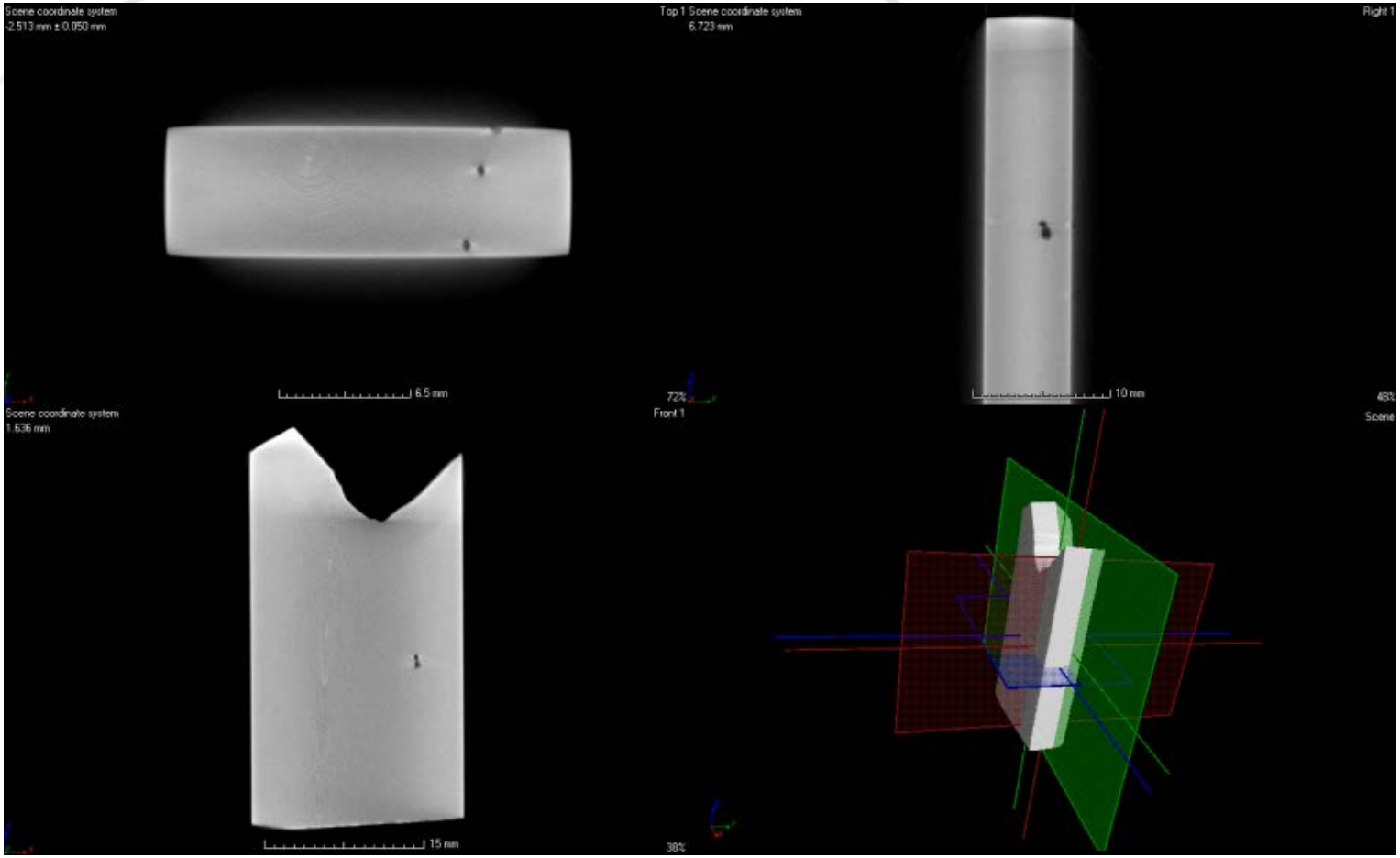
3D X-Ray (CT)

- Voids, alignment, gaps and cracking
- Does not show closed gaps/cracks
- Replacing some RT
- Same source selection as RT plus synchrotron and neutron support
- Primarily aSi panels or camera/scintillator systems
- Significant computing infrastructure
- Home grown reconstruction code

X-ray graded collimator setup at the Microtron for CT (above) and a Cu/W alloy synchrotron CT slice (below)



3D X-Ray (CT)



CT of a weld sub-section showing voids for validation of UT results

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Dye Penetrant & Magnetic Particle

- Standard ASNT certification
- Cracks and other surface defects
- Commercially available systems
  - Exotic and hazardous materials

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Notes

- Large range of available techniques with SME expertise
  - Routine use of multiple techniques
  - Ability to build a new, qualified, NDT procedure ground up
- Very large range of x-ray source energy
  - Experience with > 100 g/cm^2 radiography and CT
  - Field radiography up 6MeV
  - Neutron, proton for unique problems
- Experience with exotic material NDT (broad range of elements, hazards, disjoint material properties)
- Access to all of LANL resources (materials, simulation, destructive testing, etc)
- Not competitive when a solution is commercially available

Questions

Abstract: NonDestructive Evaluation for Industrial & Development Applications

(for Mitsubishi Oil and Gas – October, 2016)

Provide overview of weld inspection for Non-Destructive Testing at LANL. This includes radiography (RT/DR/CR/CT for x-ray & neutron sources), ultrasonic testing (UT/PAUT), dye penetrant inspection (PT), eddy current inspection (ET) and magnetic particle testing (MT). Facilities and capabilities for weld inspection will be summarized with examples.