Honeywell

Corrosion Monitoring System (CMS) (135-00)

Materials Technology Institute

Houston, Texas

October 18, 2004

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CMS Agenda

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- Problem/Approach
  - Corrosion monitoring methods
  - CMS focus on pitting corrosion
  - Intelligent Ultrasonic Probe
- Corrosion Monitoring System Description
  - Field prototype system
  - Defect imaging
- Test Results
  - Laboratory
  - Evadale
  - Oak Ridge National Laboratory
- Future Plans/Discussion

Corrosion Monitoring Methods

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- Ultrasonic Thickness Measurement
- Weight Loss Coupons
- Electrical Resistance Probes
- Linear Polarization Resistance Probes
- Electrochemical Noise Probes
- Combinations of these methods

Corrosion Monitoring Methods

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	Pitting Information	Pitting Information On-Line	Strong Pitting Confirmation, e.g., visual	**Potential** for pit growth rate information
Ultrasonic Thickness	No	No	No	No
Weight Loss	Yes	No	Yes (Visual)	No
Electrical Resistance Probe	No	No	No	No
Linear Polarization Probe	Yes (Indication)	Yes	No	No
Electrochemical Noise Probe	Yes (Indication)	Yes	No	No
Intelligent Ultrasonic Probe	Yes	Yes	Yes (Pit Image)	Yes

Ultrasonic Guided Waves

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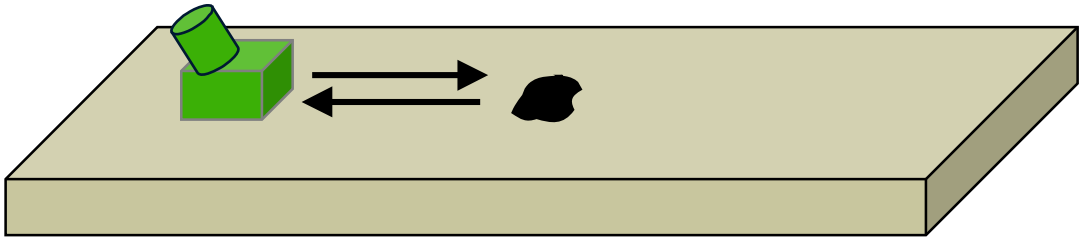
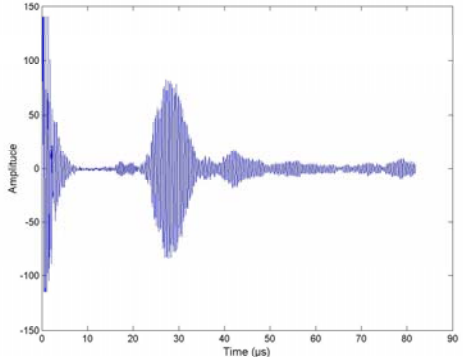
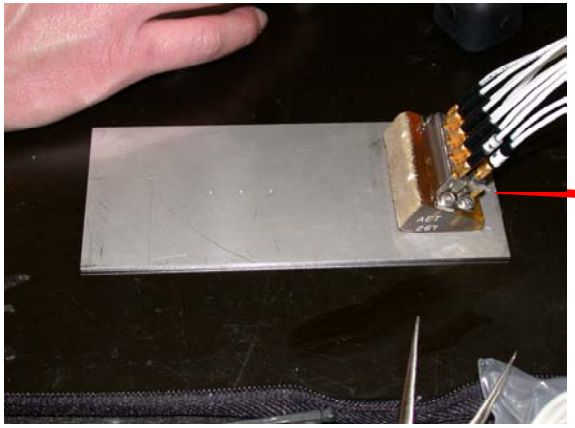
Single piezoelectric transducer

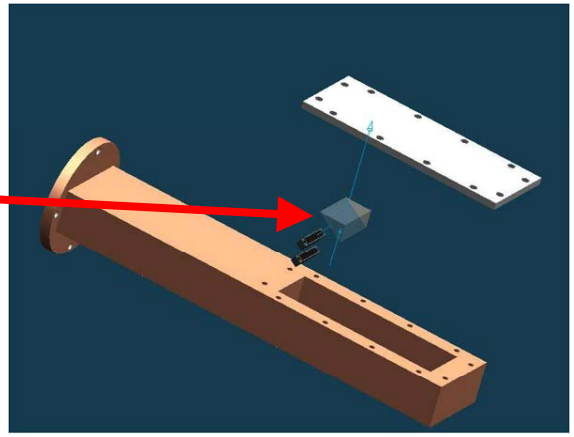


reflection from pit



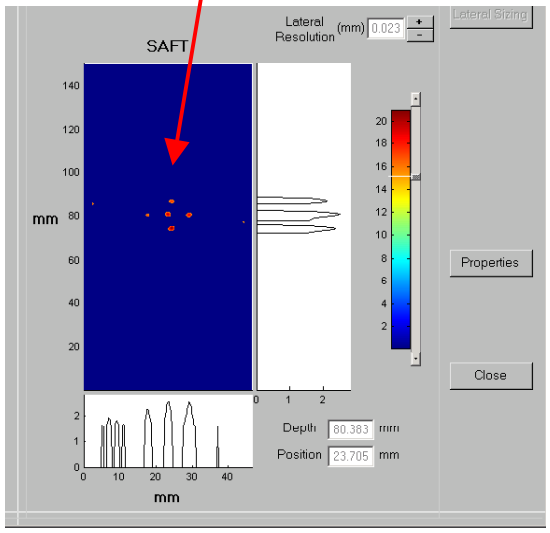
Using an array of piezoelectric transducers provides an image of the pits





Intelligent Ultrasonic Probe

Image of clustered defects



CMS Program

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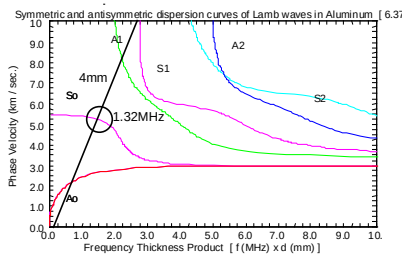
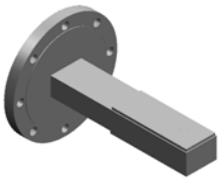
Develop and test a Corrosion Monitoring System that provides early detection of corrosion pits

- Select frequency and mode for ultrasonic guided Lamb waves

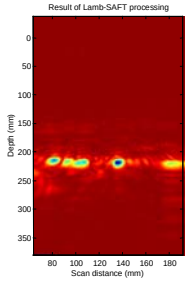


- Design and fabricate processing hardware/software

- Design and fabrication of transducer array and ultrasonic probe



- SAFT (Synthetic Aperture Focusing Technique) algorithm development for pit imaging



- Field testing

CMS Field Prototype System

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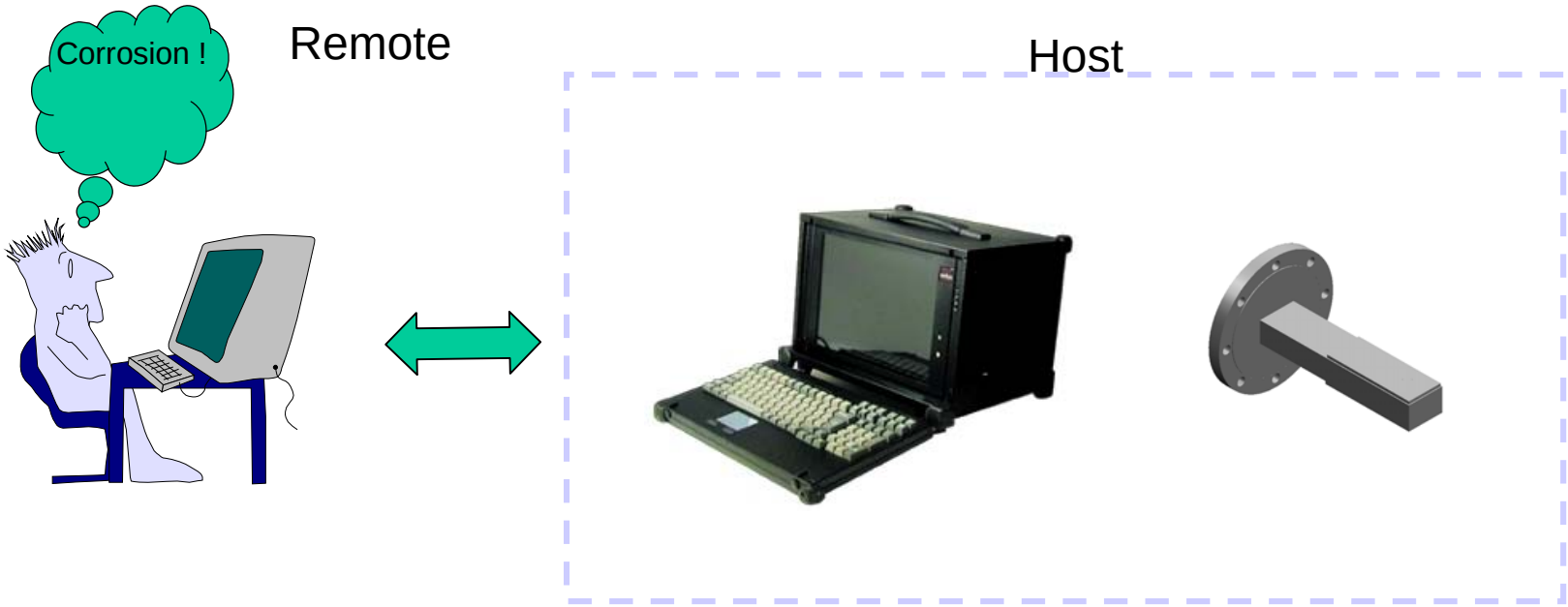

- The CMS remote computer connects to the host computer via internet

- The remote computer automatically downloads the array data and can remotely set system parameters

- The remote computer analyzes the data using our SAFT algorithms and provides an image of the defects

SAFT Imaging of Defects

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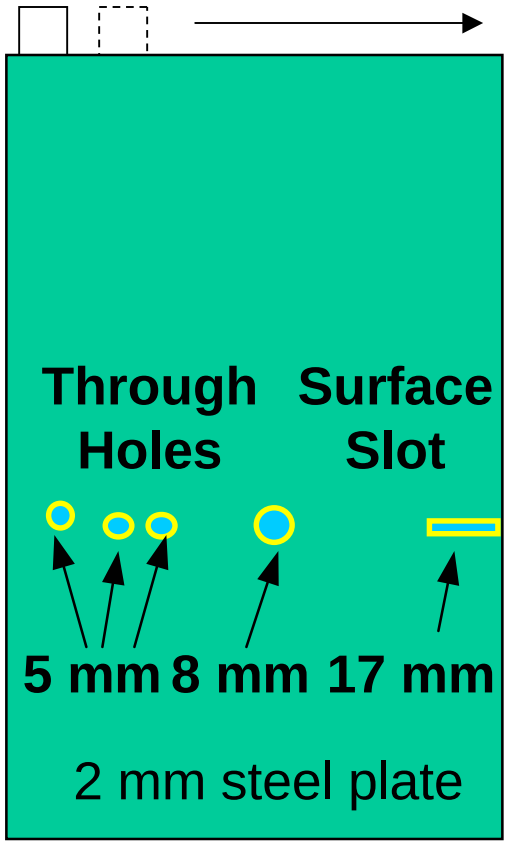
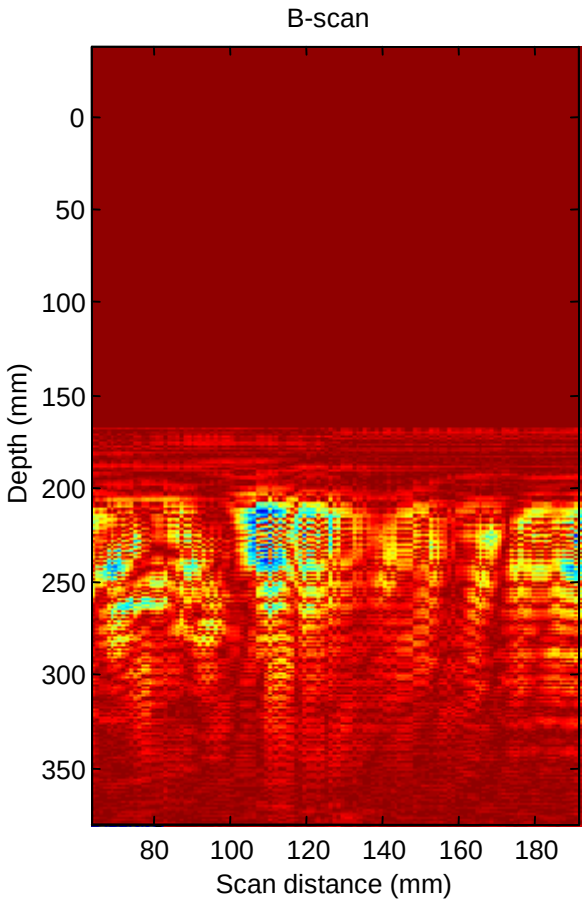
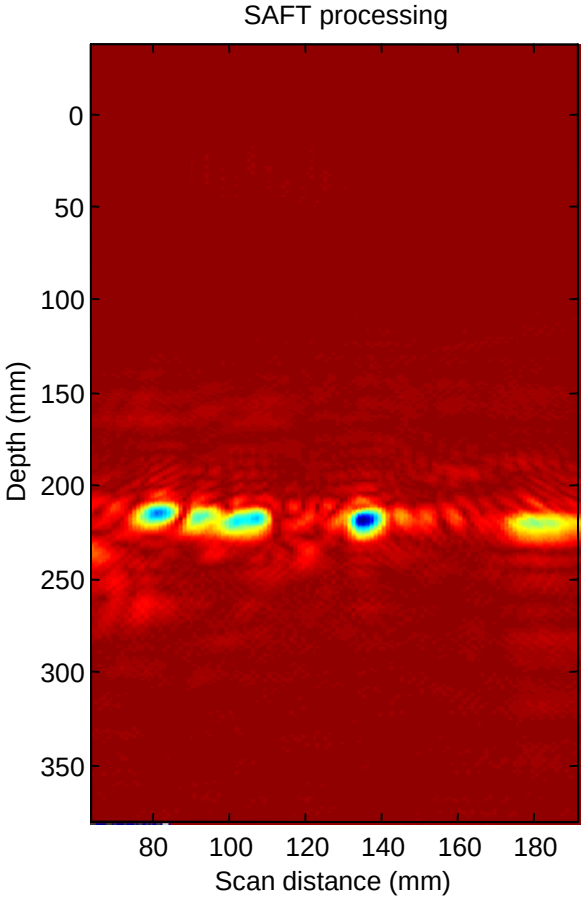


B-scan



SAFT Image



Laboratory Test Results

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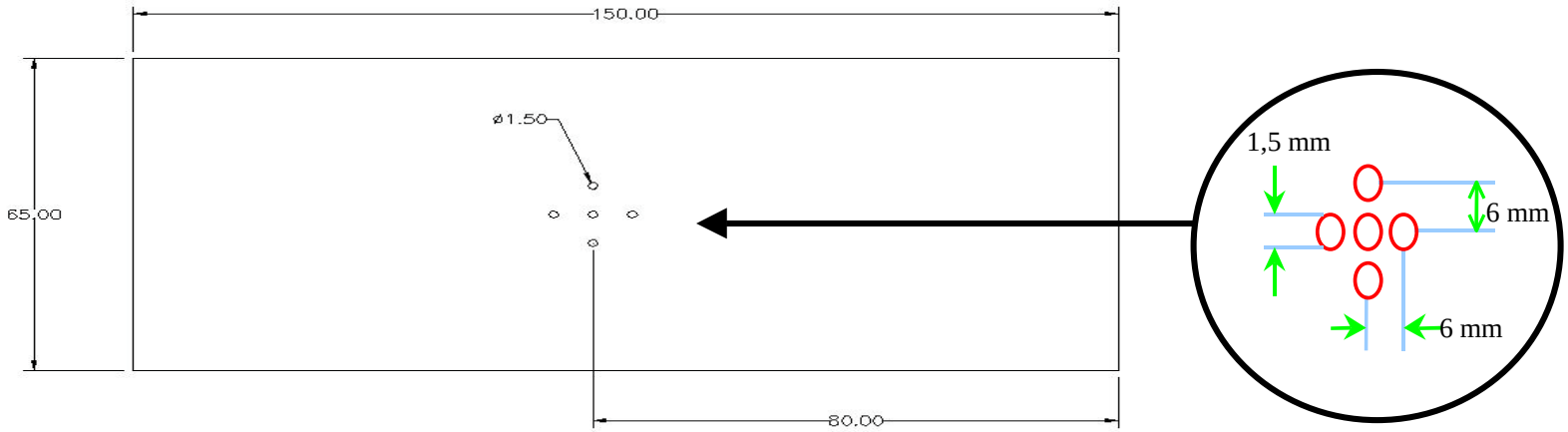
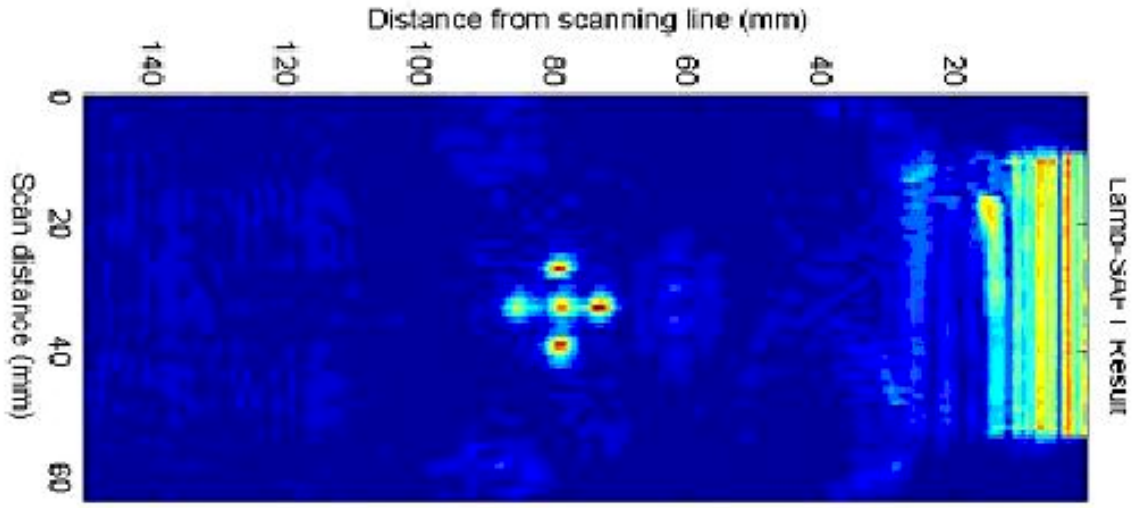
SS304 plate with **five simulated pits** (plate thickness =1.895 mm, pit depth = 1mm)





Laboratory Test Results

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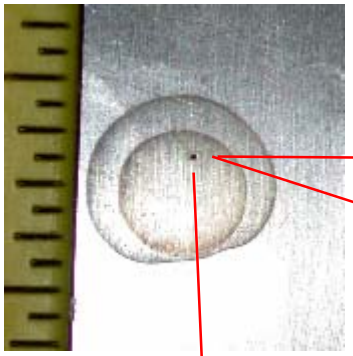
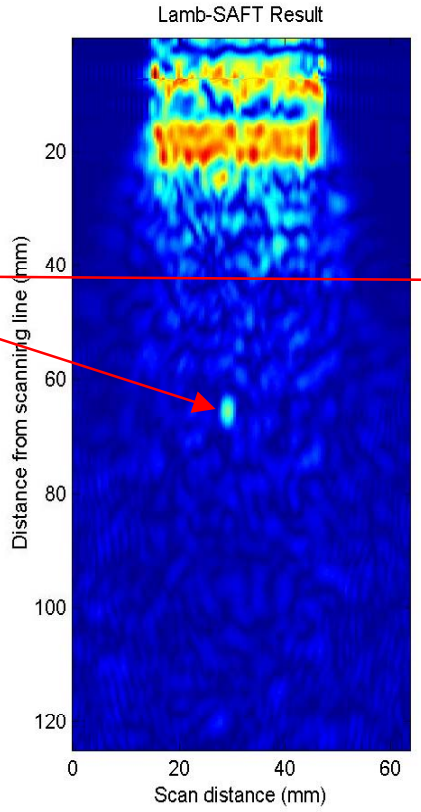
SS304 **real corrosion pit**

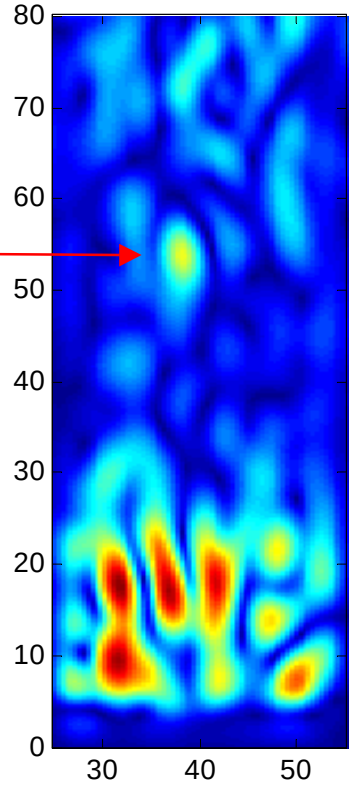


~ .25mm

Manual scan



Array scan



Laboratory Test Results

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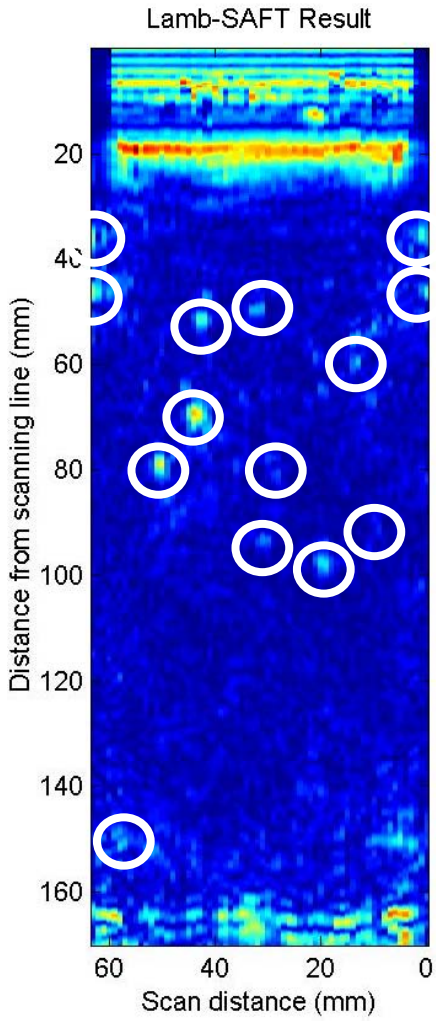
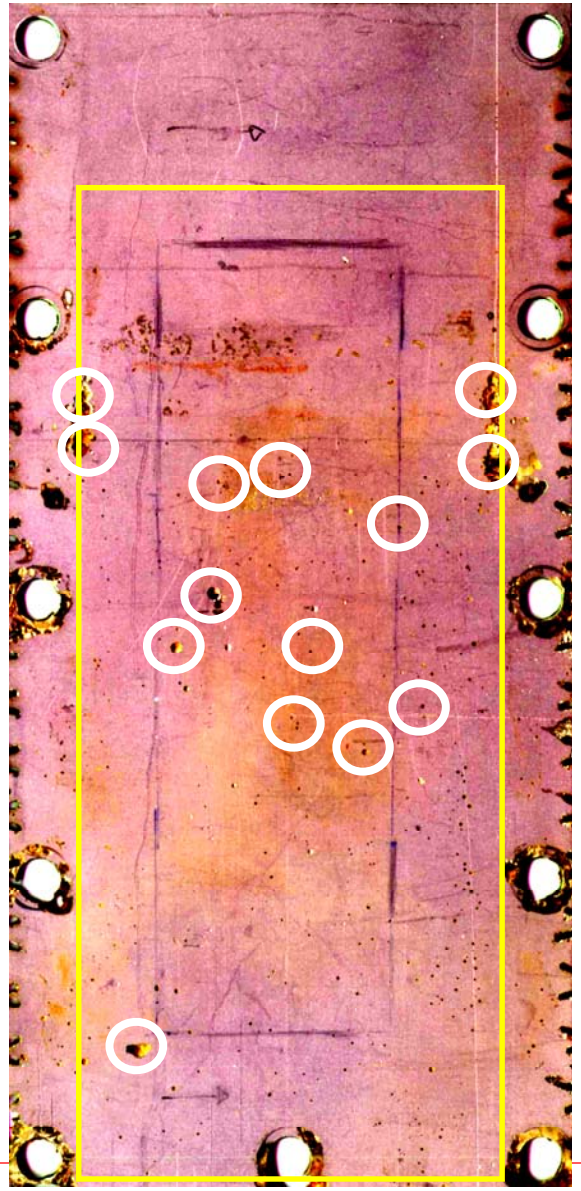
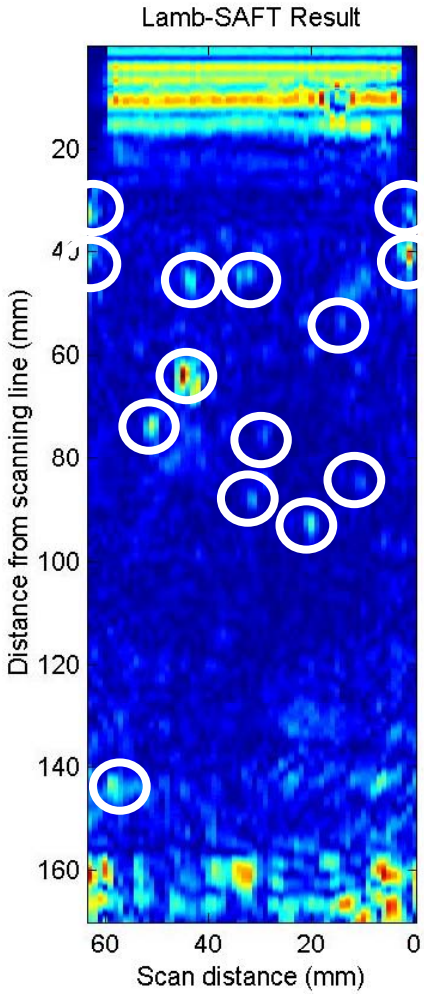
SS304 **real pits**







Evaluation Tests

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- **MeadWestvaco Evadale, Texas**
  - April 16, 2003 - July 30, 2003
- **Oak Ridge National Laboratory (ORNL)**
  - October 7, 2003 - December 30, 2003
  - April 28, 2004 - May 5, 2004

Evadale Test Results

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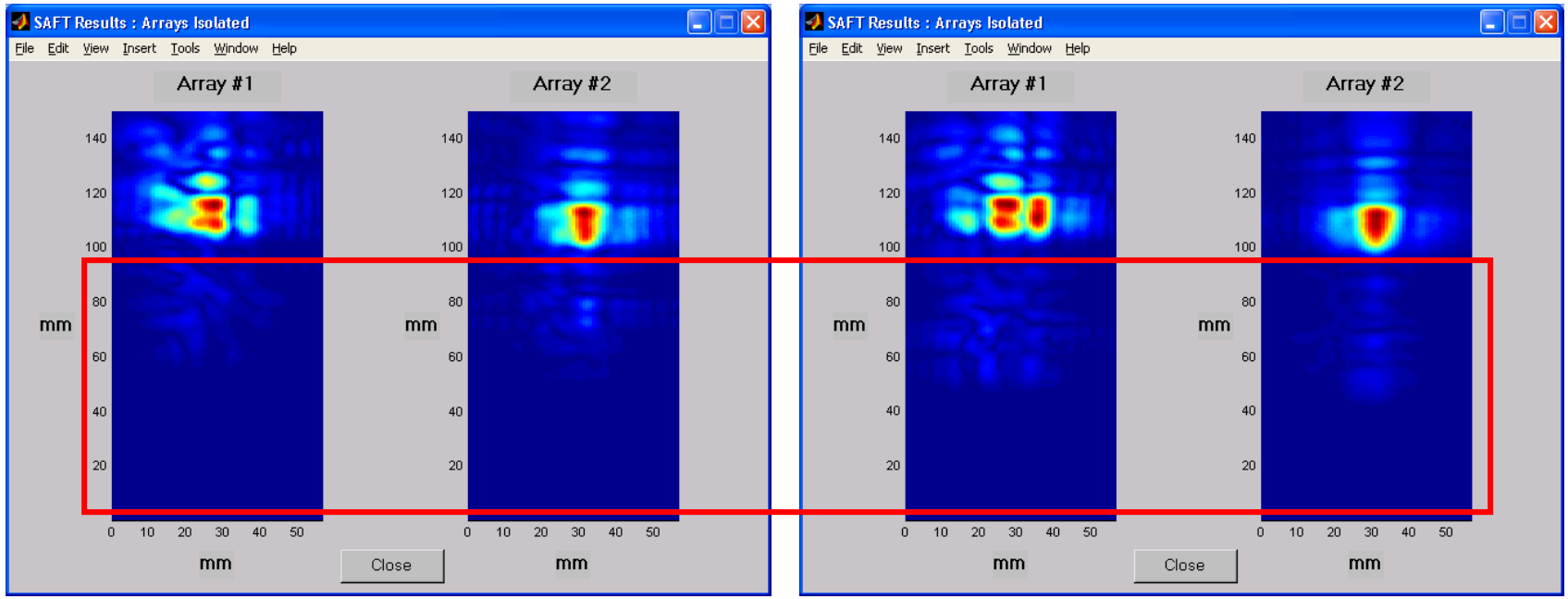
06-18-2003

07-23-2003



- Pitting did not occur during our Evadale tests
- Our sensors confirmed this result

Evadale Test Results

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IUP had no discernible pitting corrosion after 106 days of exposure

Remote unit sustained considerable corrosion damage

ORNL Test Results

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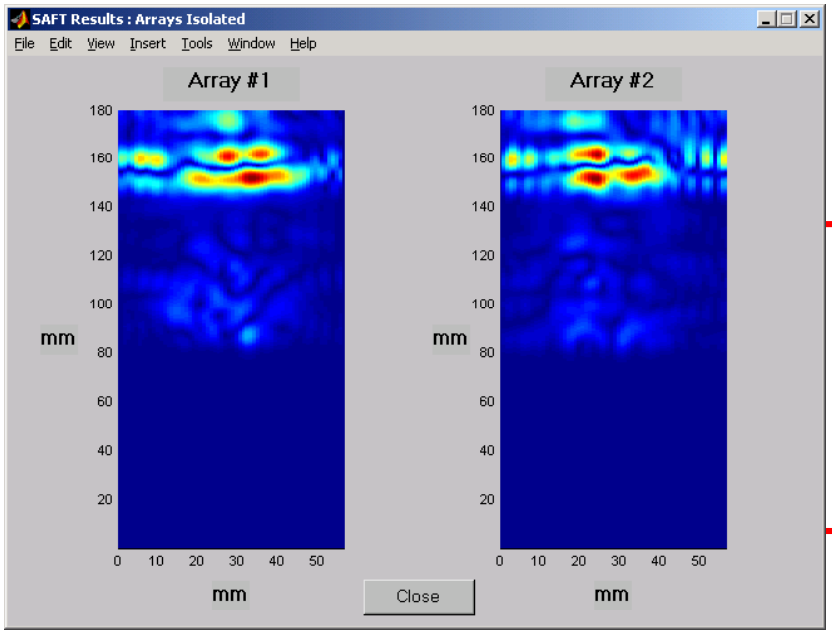
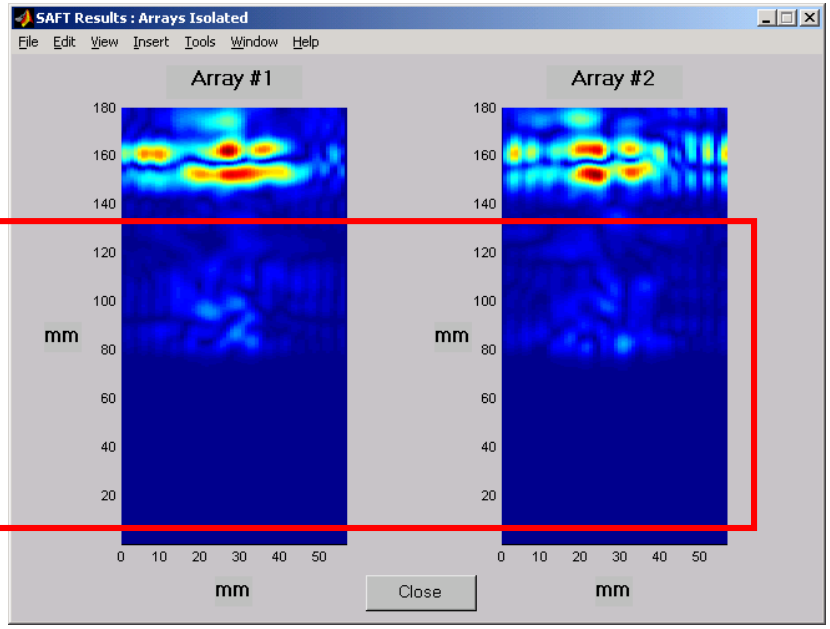
10-20-2003



10-30-2003



- No pitting
- Confirmed by sensor

ORNL Test Results

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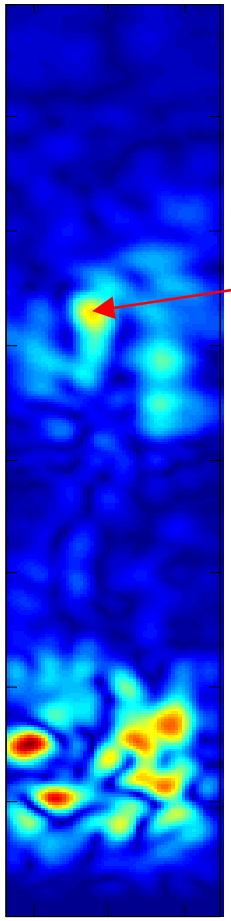
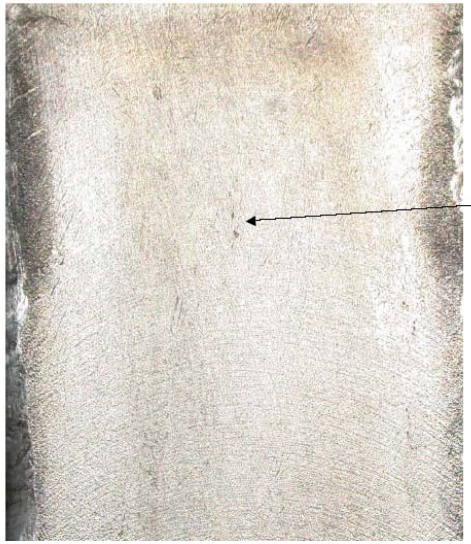
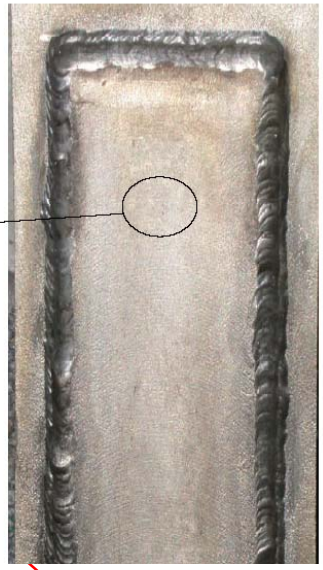
First pit formation!

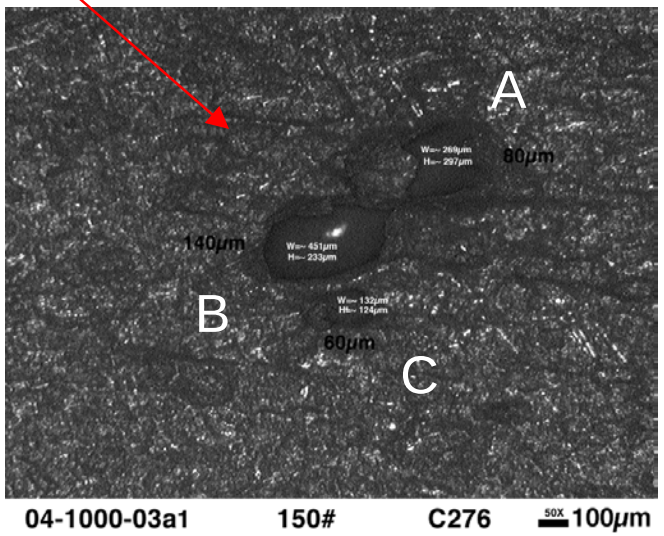






From SEM at ORNL

	Width	Height	Depth
A	.269mm	.297mm	.08mm
B	.451mm	.233mm	.14mm
C	.133mm	.124mm	.06mm



ORNL Test Results

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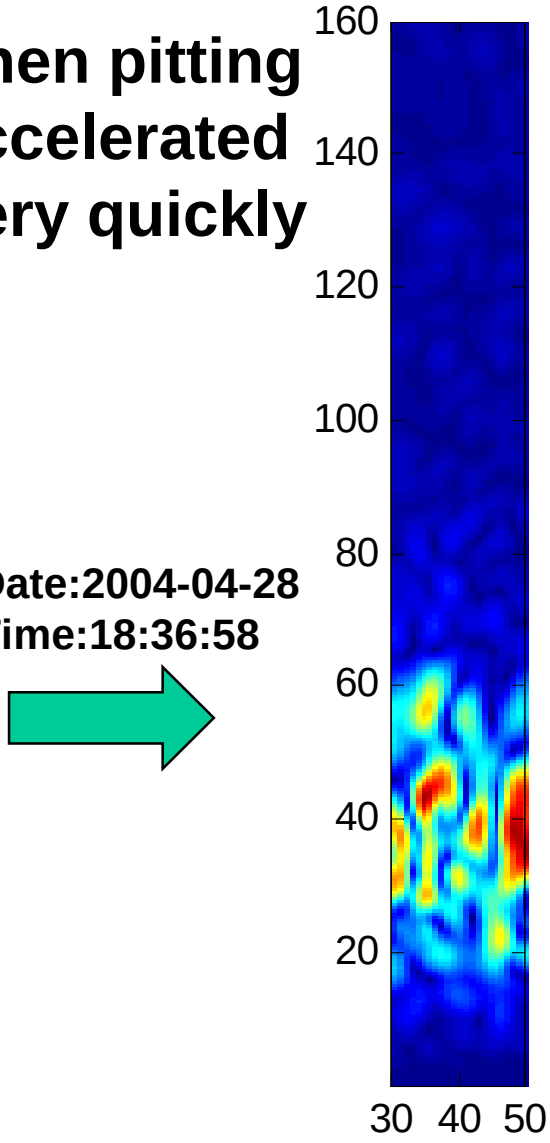
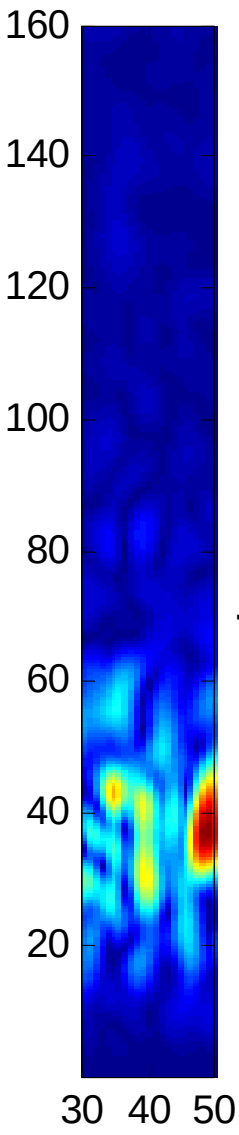
Then pitting accelerated very quickly

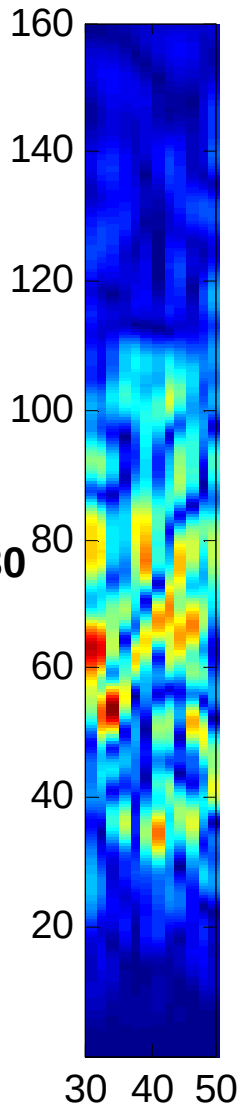
Date:2004-04-28
Time:18:36:58



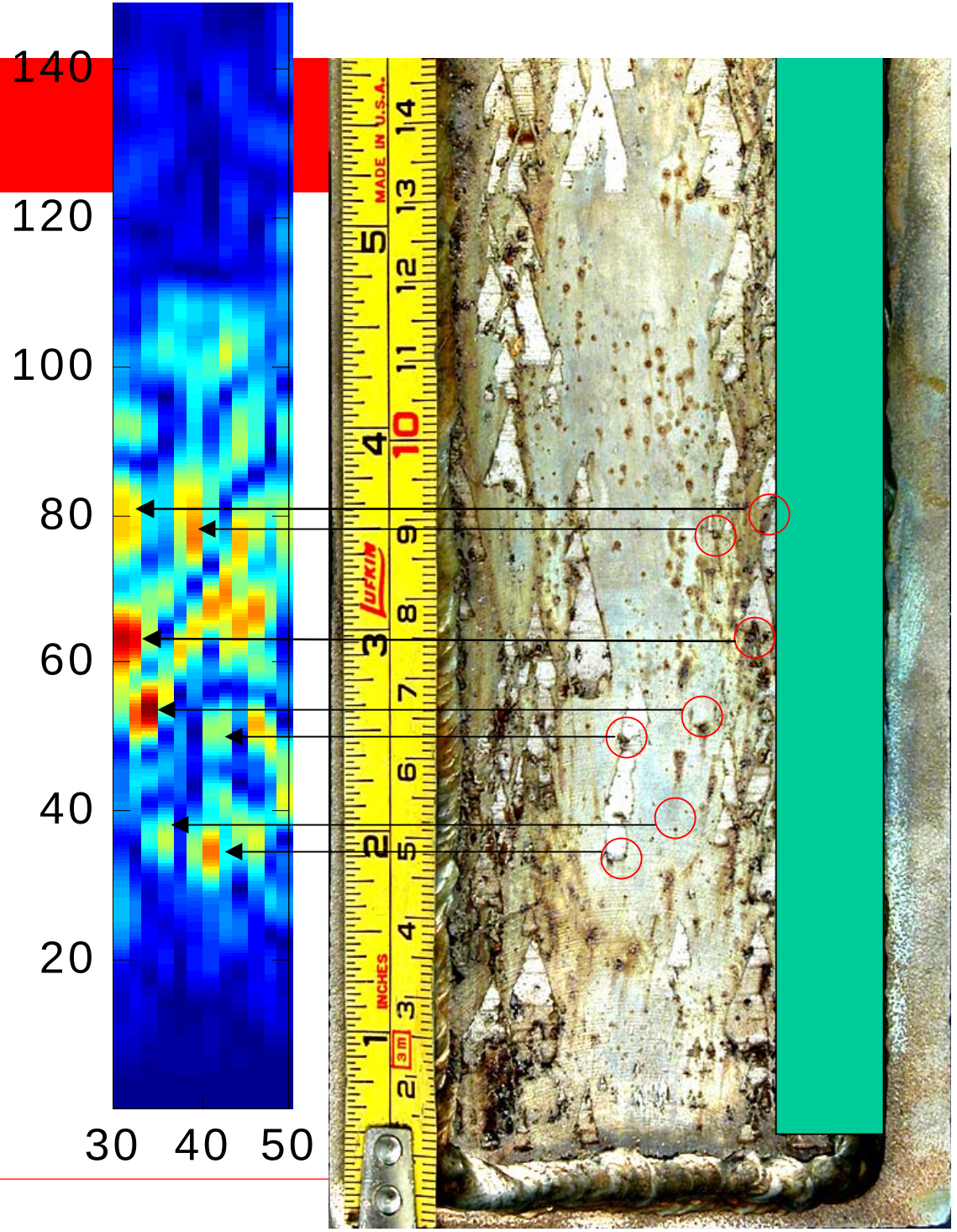
Date:2004-04-29
Time:22:23:01



Date:2004-04-30
Time:21:00:34

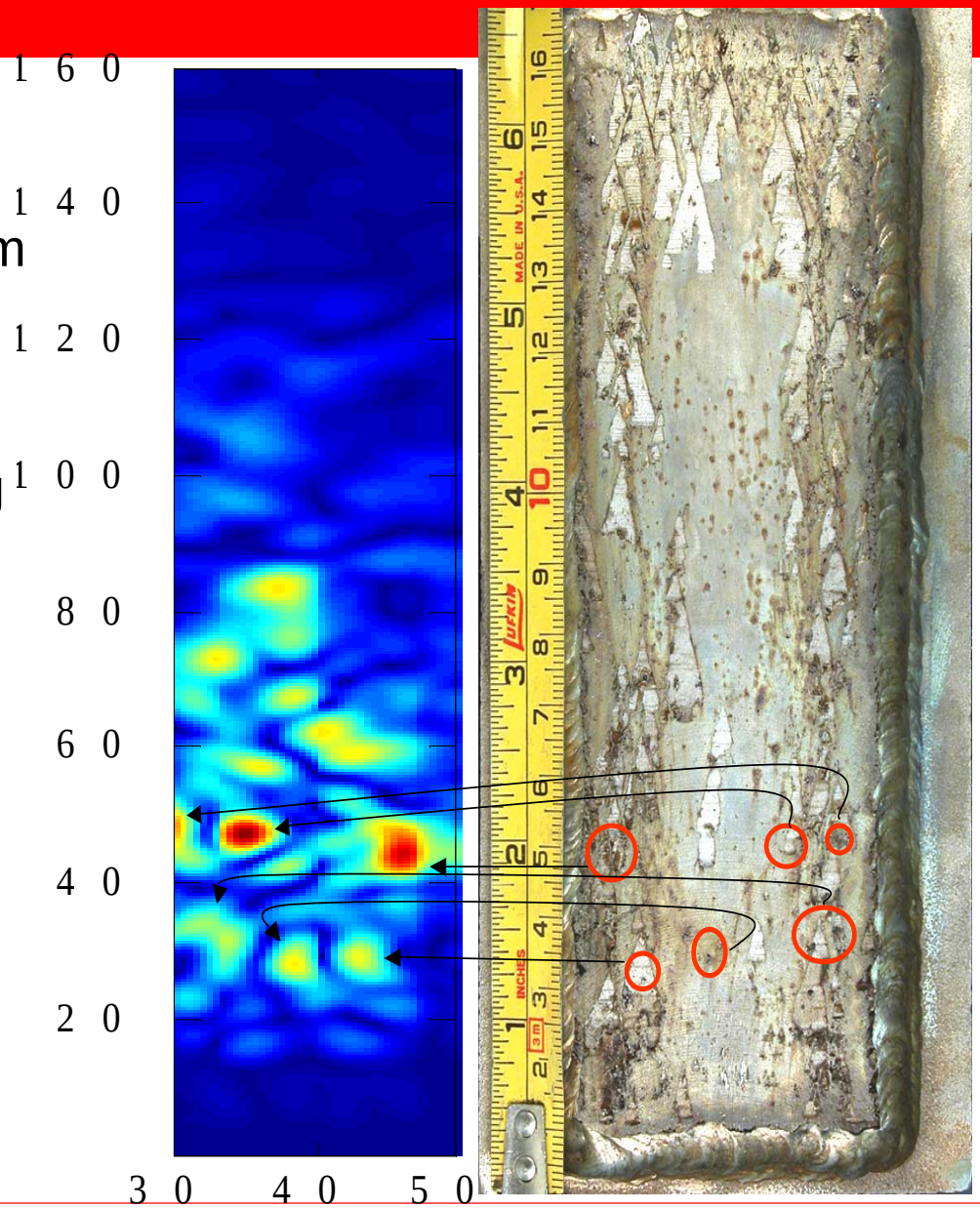


Date:2004-04-30
Time:21:00:34

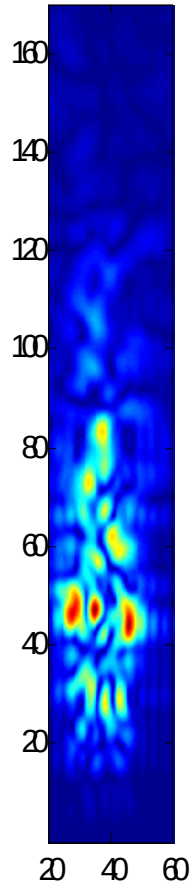


- Probe picture taken after data was collected
- Don't have a one-to-one correspondence between SAFT image and probe picture
- A few pits and the corresponding image are indicated

- Recent data from the ORNL probe
- A few pits and the corresponding image are indicated



Date:2004-05-03
Time:17:54:00



Current Status

- Positive identification of pit initiation and growth
- Capability to detect small pits with millimeter and sub millimeter dimensionalities

Future Vision

- Automated pit detection and growth rate estimate
- Crevice corrosion and SCC detection capability could be added to IUP
- Transducer array mounted directly on monitored asset

Future Work Needed

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- More testing of IUP in industrial plants
- Automating pit detection and estimating pit growth rate
  - Initial project currently being completed
  - New project scheduled to start
- Adding crevice and SCC capability to IUP
- Mounting transducer array on asset
  - Possible project next year