FG RFEC Technique for Thick Multilayer Aircraft Structures Inspection

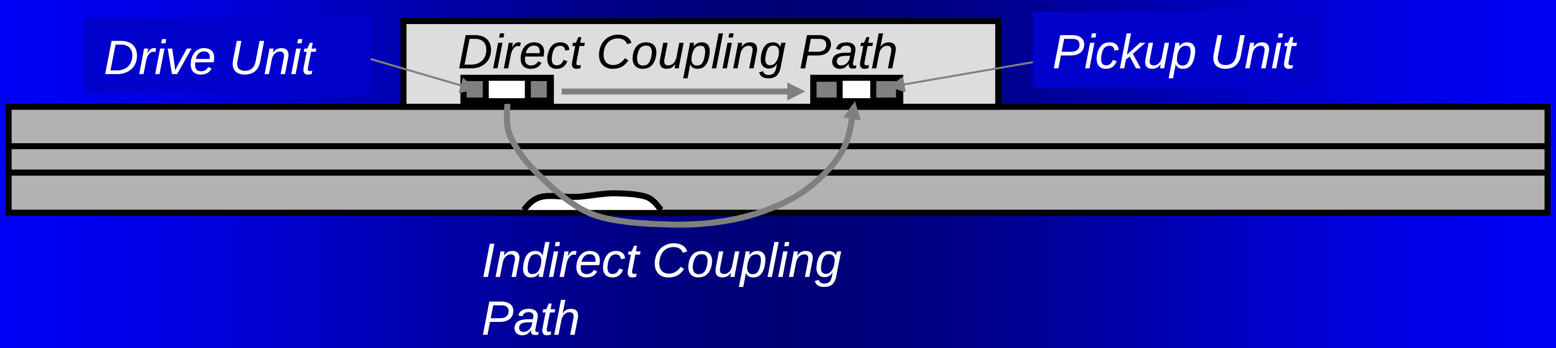
Part I Corrosion Detection

Yushi Sun
Innovative Materials Testing Technologies, Inc.
3141 W. Torreys Peak Drive
Superior, CO 80027
Tel: 303 554 8000
Fax: 303 554 8001
Email. Suny@imtt-usa.com

Contents

Introduction

FG RFEC Probe
A Solution for Deep Penetration



The probe blocks the direct coupling path. The energy released from the drive unit is forced to go along the indirect coupling path.

Therefore, the entire signal received by the pickup unit has passed the wall twice and carries the whole information about the wall condition.

Part 1 Introduction

Super Sensitive Eddy Current Instrument SSEC II

- Modification of conventional EC instrument; capable of working with FG RFEC probes as well as conventional EC probes
- Higher sensitivity and larger gain to work with the extremely weak signal from an RFEC probe
- Fully computerized system capable of on the spot automatic control, signal processing and pattern recognition
- Light, small and portable

Part I – Deeply hidden corrosion detection

Topic 1 Raster scan using a sliding probe

<u>Probe RF4 V.3</u>

- Detecting 0.040” corrosion under 0.603” aluminum layers
- Detecting 0.006” corrosion under 0.367” aluminum layers

<u>Probe RF2 V.3</u>

- Detecting 0.006” corrosion under 0.157” aluminum layers
- Detecting 0.004” corrosion on backside of a 0.125” thick aluminum layer

Topic 2 Calibration for corrosion depth and location in structure thickness

Topic 3 Corrosion shape estimation

Topic 1 Raster Scan Using a Sliding Probe

A. Photos of FG RFEC Sliding Probes for Crack Detection

RF4 V.3

Footprint: 0.85” x 2.15”
Coil Center-to-Center Distance, CCD = 1.15”

RF2 V.3

Footprint: 0.3” x 0.62”
Coil Center-to-Center Distance, CCD = 0.3”

Topic 1 – Raster scan using a sliding probe

Example 1:

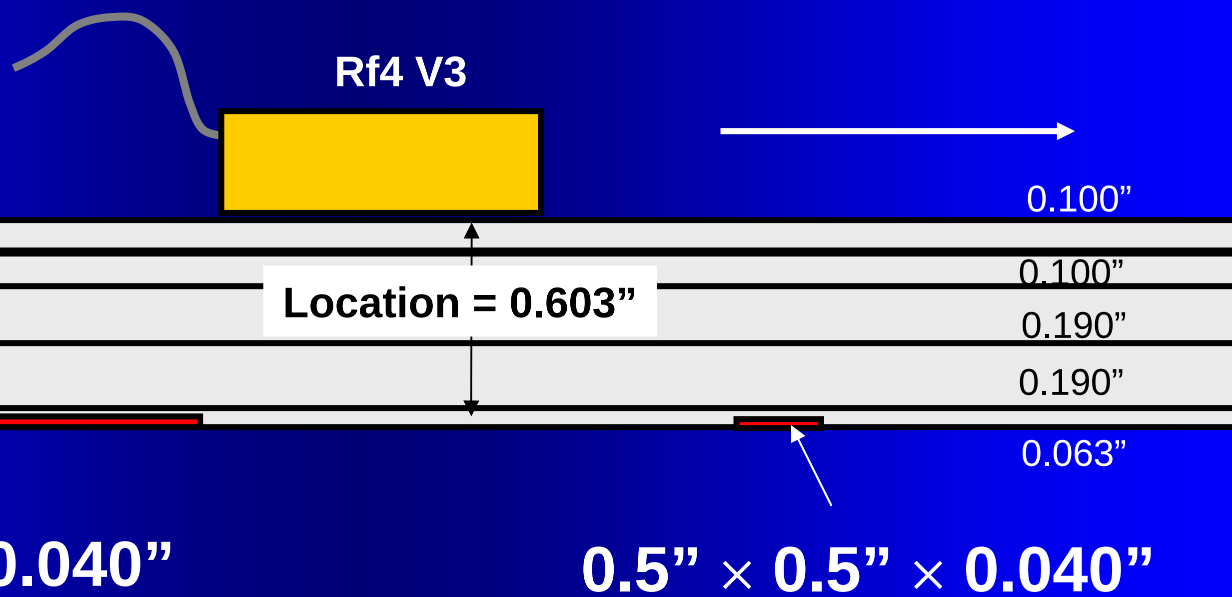
5 Layer 2024 T3 Aluminum Specimen

0.1” + 0.1” + 0.19” +0.19” + 0.063”

Total Thickness = 0.643”

Corrosion on Bottom of 5th Layer

Location = 0.603”

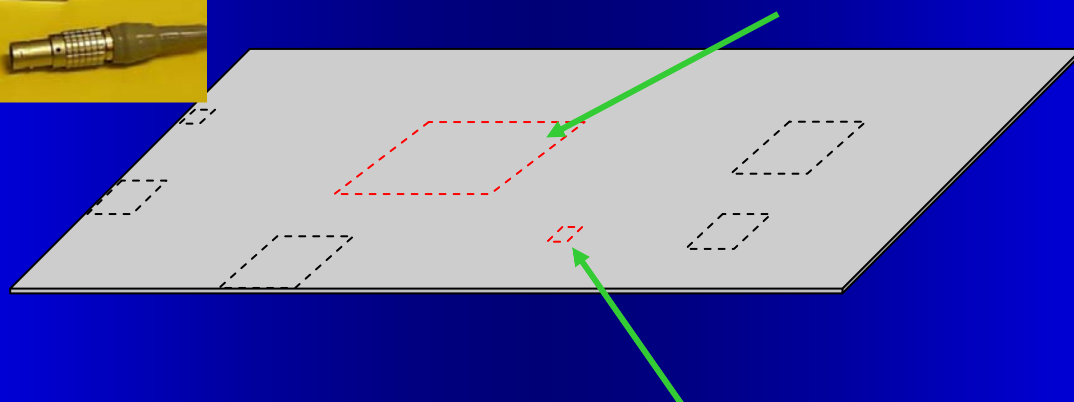


Example 1

Corrosion Sample – the 5th Layer

0.063” thick aluminum, chemical thinning on the bottom side

3.0” × 3.0” × 0.040"

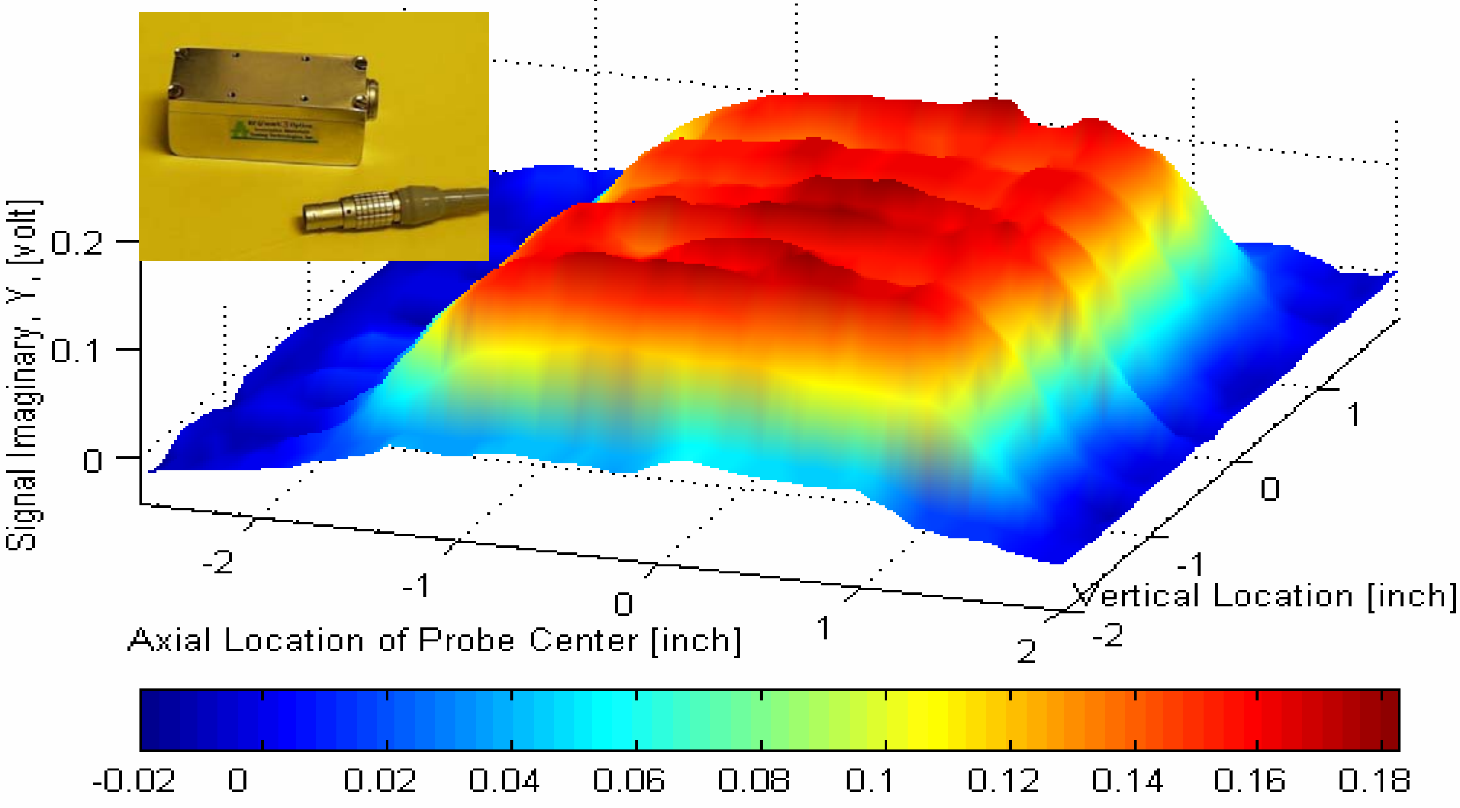


0.5” × 0.5” × 0.040"

Specimen provided by CNDE

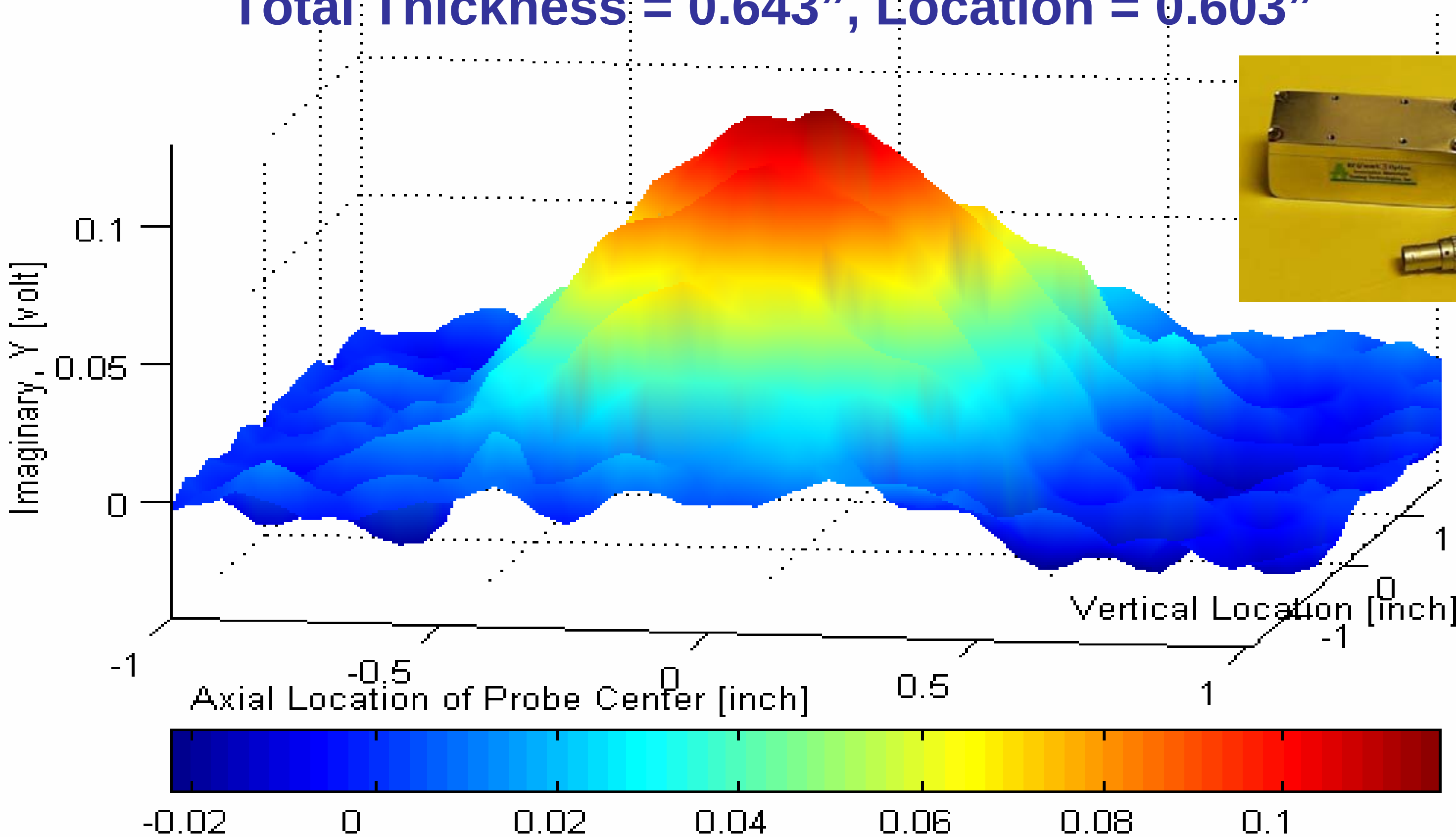
Test Result - Example1.1

3” × 3” × 0.040” 5th Layer Bottom Side Corrosion, f=200Hz
Total Thickness = 0.643”, Location = 0.603”



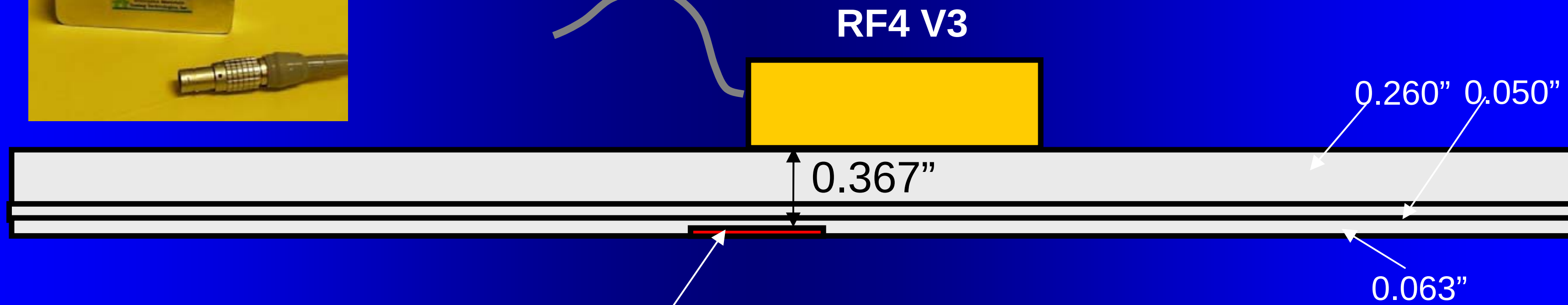
Test Result - Example1.2

0.5” × 0.5” × 0.040” 5th Layer Bottom Side Corrosion, f=200Hz
Total Thickness = 0.643”, Location = 0.603”



Example 2

3 Layer 2024 T3 Aluminum Specimen
0.26” + 0.05” + 0.063”
Total Thickness = 0.373”
Corrosion on Bottom of 3rd Layer
Location = 0.367”



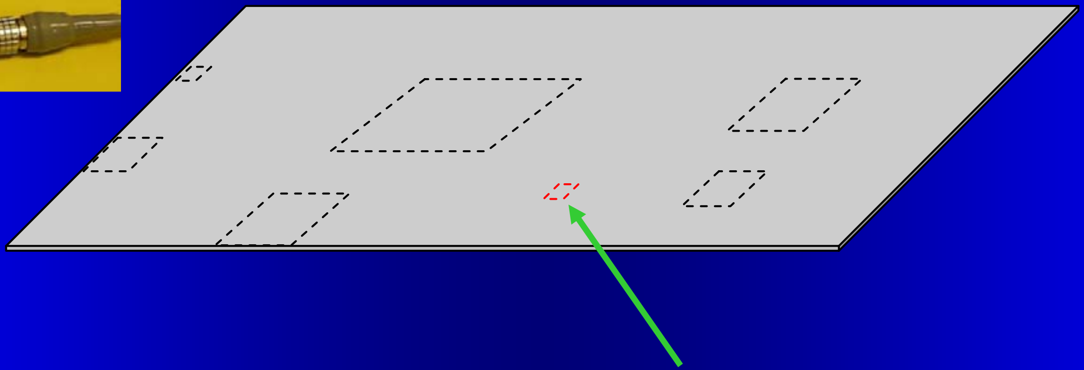
0.5” × 0.5” × 0.006” corrosion

Part I – Deeply hidden corrosion detection

Example 2

Corrosion Sample – the 5th Layer

0.063” thick aluminum, chemical thinning on the bottom side

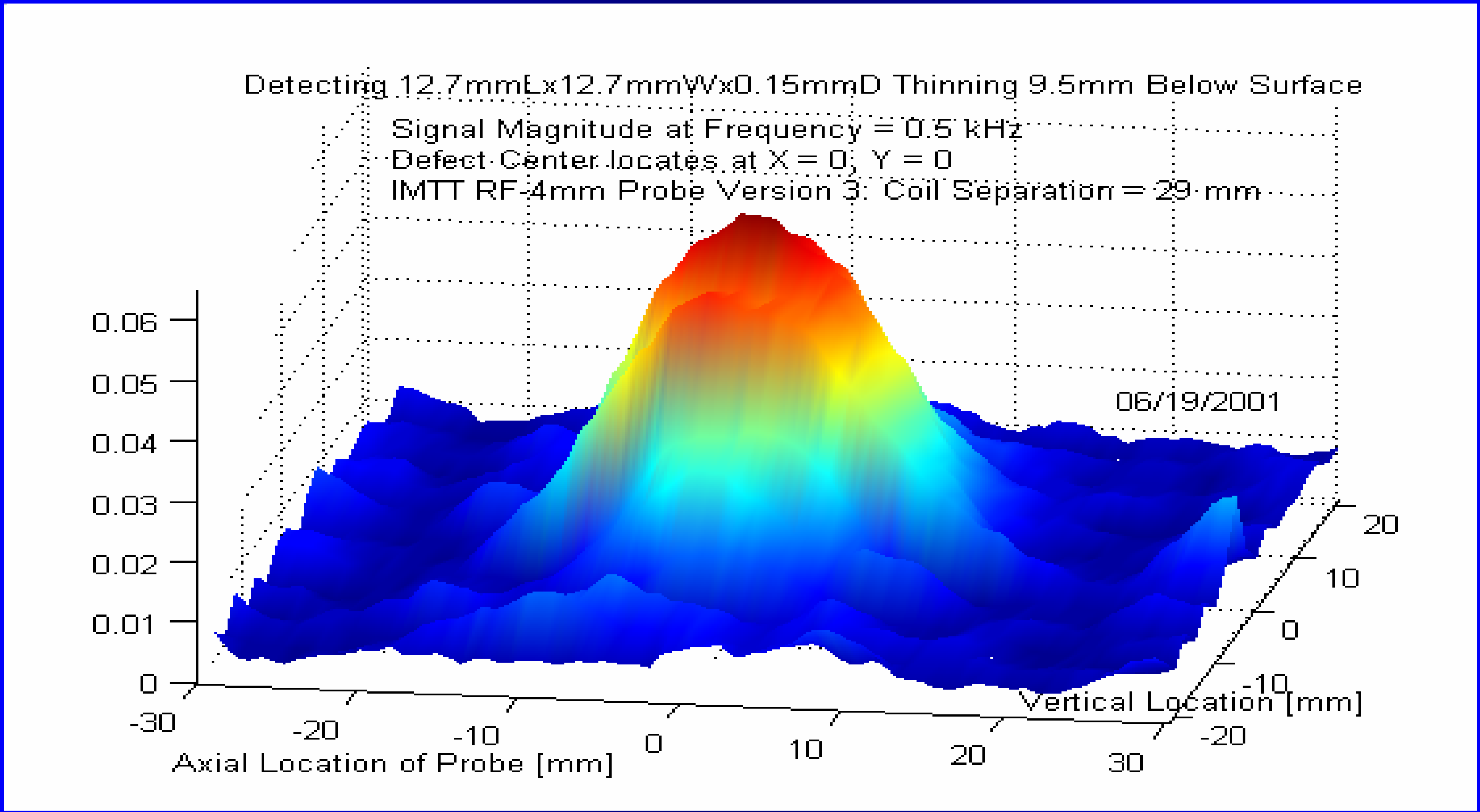


0.5” × 0.5” × 0.006"

Specimen provided by CNDE

Test Results - Example 3

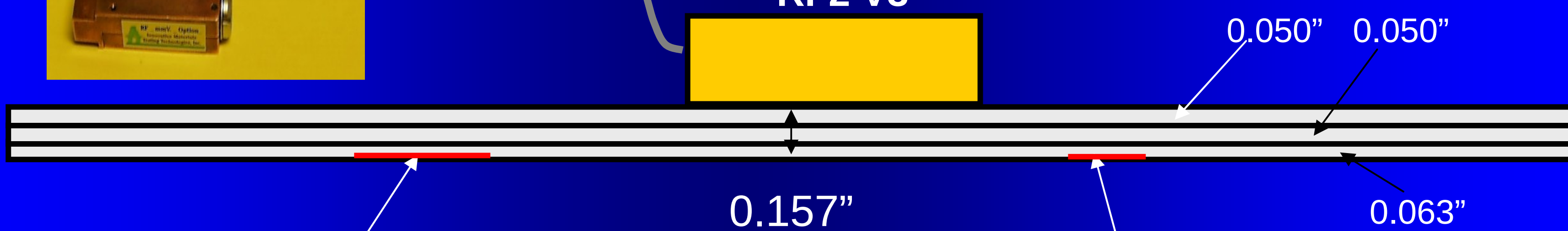
0.5” × 0.5” × 0.006” 3rd Layer Bottom Side Corrosion, f=500Hz
Total Thickness = 0.373”, Location = 0.367”



Part I – Deeply hidden corrosion detection

Example 3

3 Layer 2024 T3 Specimen
0.05” + 0.05” + 0.063”
Total Thickness = 0.163”
Corrosion on Bottom of 3rd Layer
Location = 0.157”



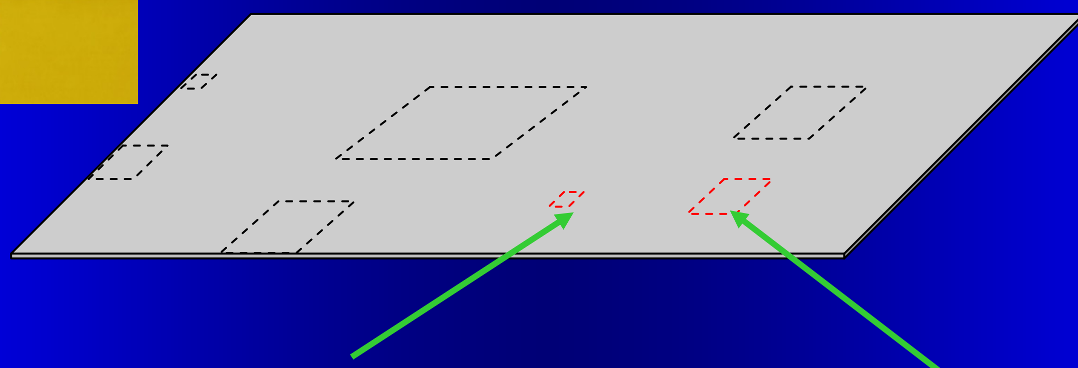
1.0” × 1.0” × 0.006”

0.5” × 0.5” × 0.006”

Example 3

Corrosion Sample – the 3rd Layer

0.063” thick aluminum, chemical thinning on the bottom side



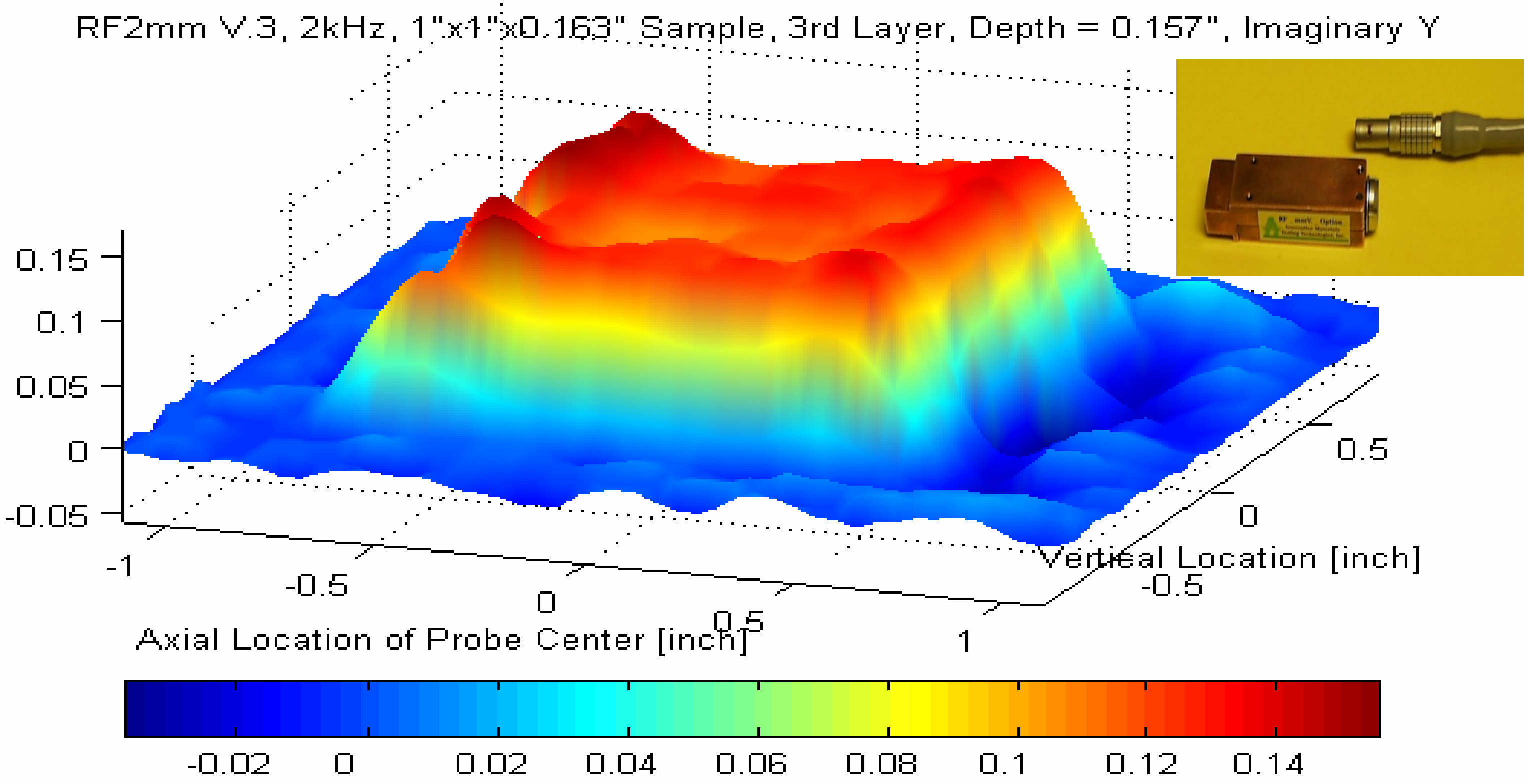
0.5” × 0.5” × 0.006"   1.0” × 1.0” × 0.006"

Specimen provided by CNDE

Test Result - Example 3.1

1” × 1” × 0.006” 3rd Layer Bottom Side Corrosion, f=2.0 kHz

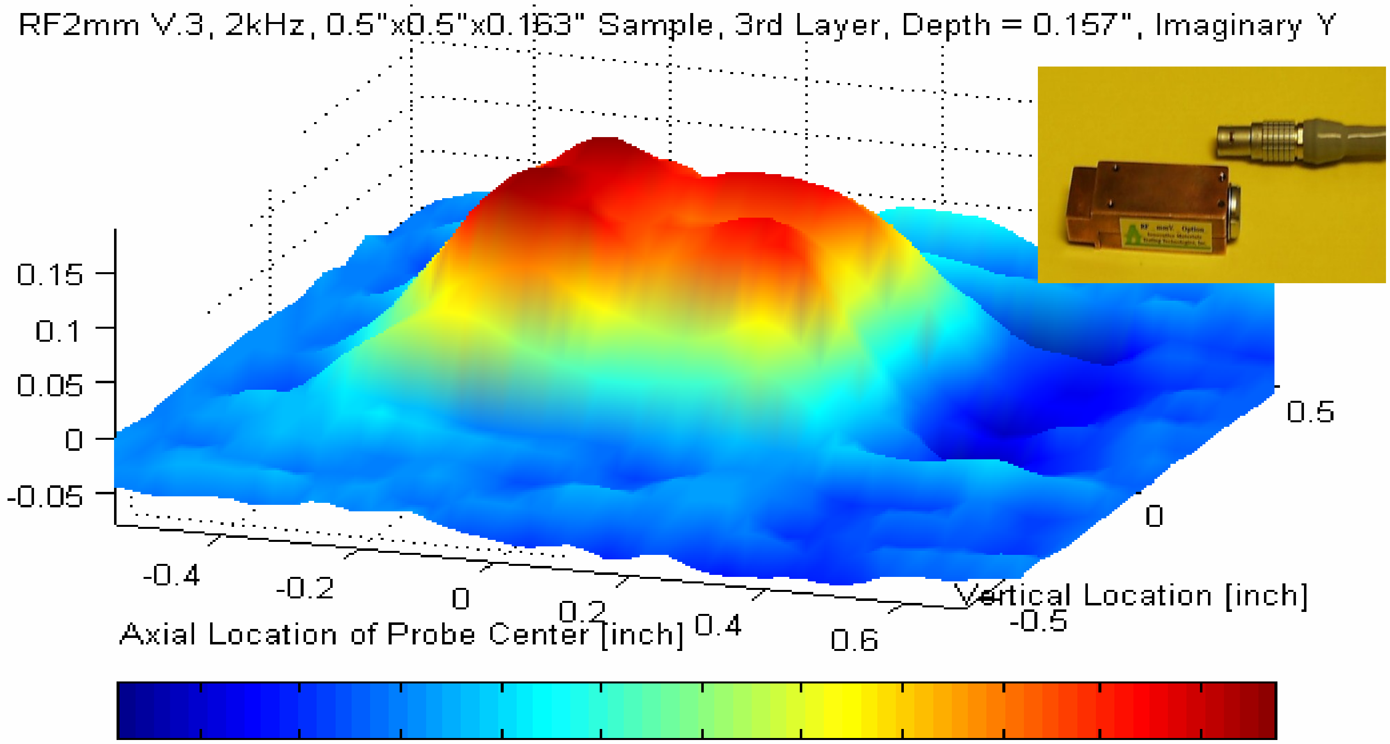
Total Thickness = 0.163”, Location = 0.157”



Test Result – Example 3.2

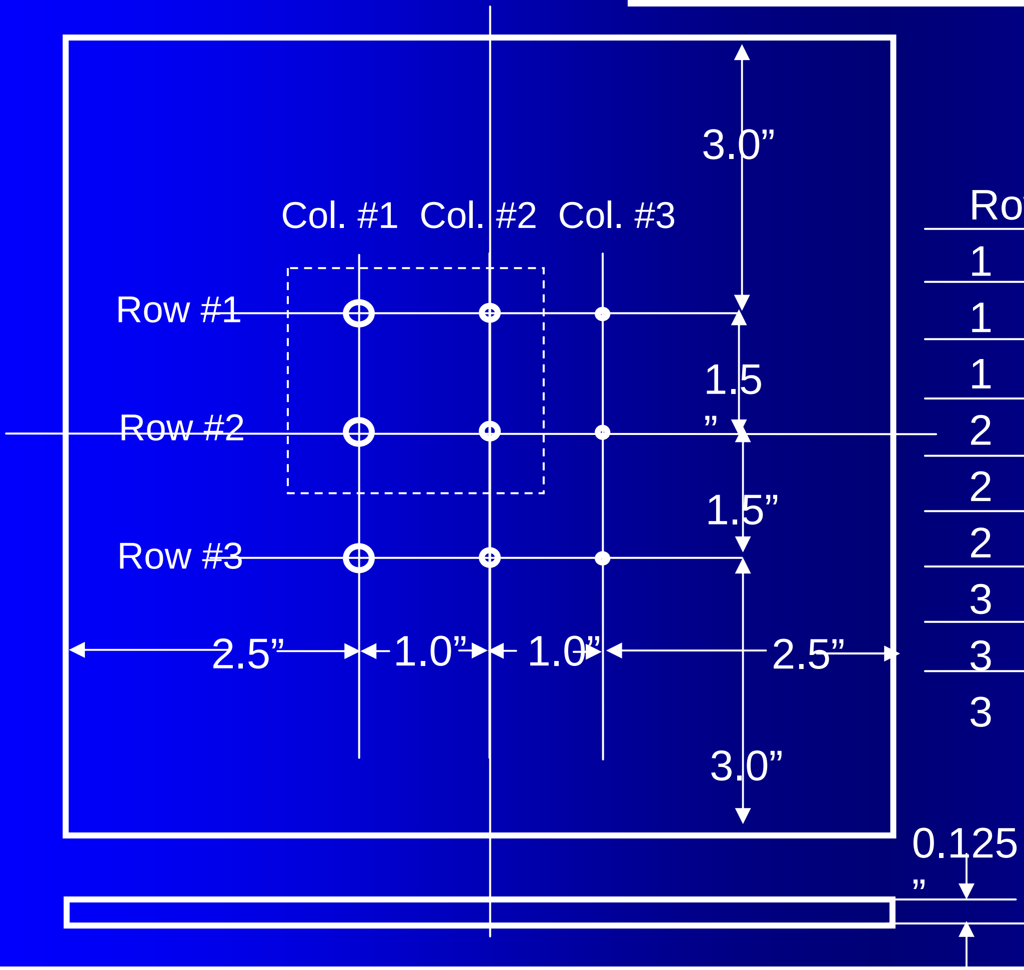
0.5” × 0.5” × 0.006” 4th Layer Bottom Side Corrosion, f=2.0 kHz

Total Thickness = 0.163”, Location = 0.157”



Example 4

Corrosion Sample Used – NAVAIR Sample Simulating Corrosion Pitting



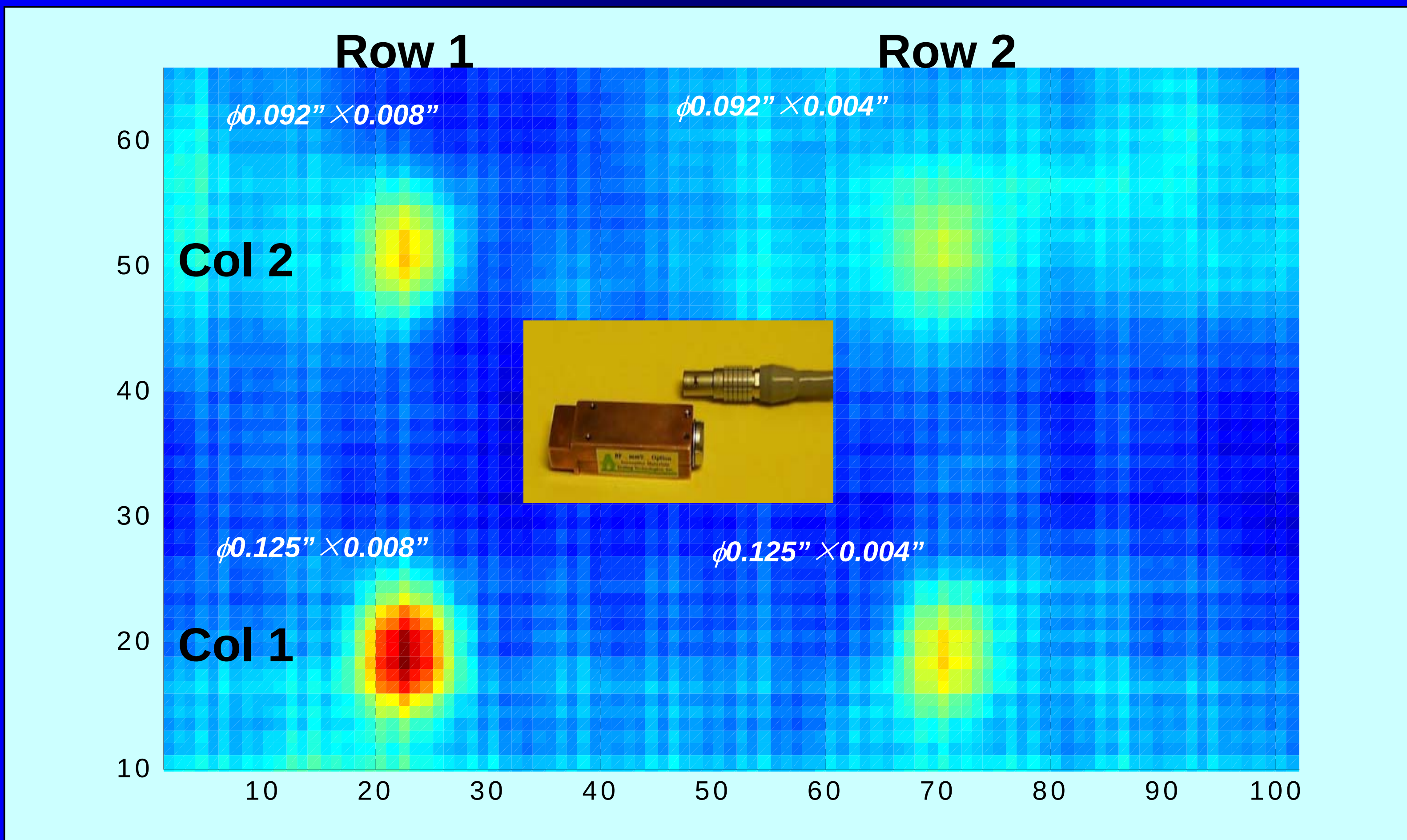
Hole Dimensions [mils]

Row #	Col. #	Diameter	Depth
1	1	125	8
1	2	92	8
1	3	62	8
2	1	125	4
2	2	92	4
2	3	62	4
3	1	125	1
3	2	92	1
3	3	62	1

Material - 7075-T6

Test Result – Example 4

A C-Scan Image from Backside Simulated Corrosion Spots of a 0.125" Thick Standard made by NAVAIR



Summary for Topic 1

1. RF4 V.3 Probe detects
   - 0.040" deep corrosion under 0.603" aluminum layers
   - 0.006" deep corrosion under 0.367" aluminum layers

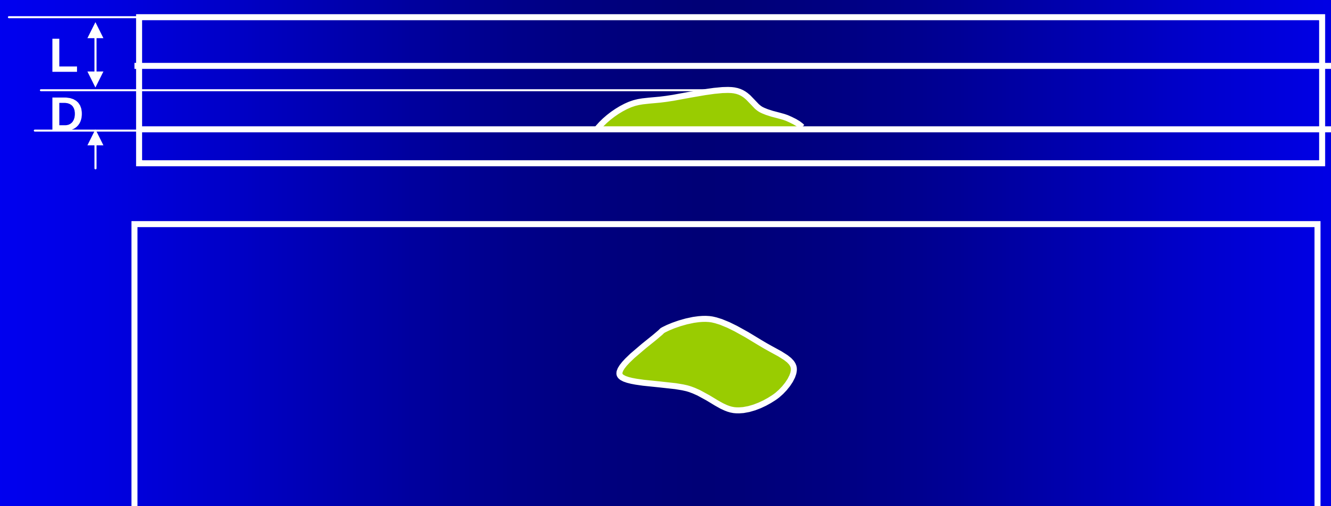
2. RF2 V.2 Probe detects
   - 0.006" corrosion under 0.157" aluminum layers
   - 0.004 corrosion under 0.125" aluminum layer

3. RF4 V.3 has deeper penetration ability, but poor signal resolution
4. RF2 V.3 has higher signal resolution, but poor in penetration depth

Topic 2
Calibration for corrosion depth and location in structure thickness

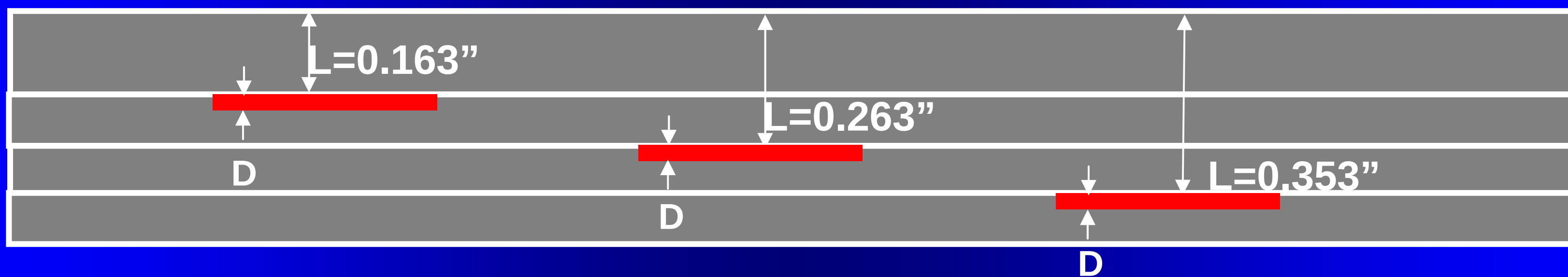
Basic Corrosion Parameters Need to Find out:

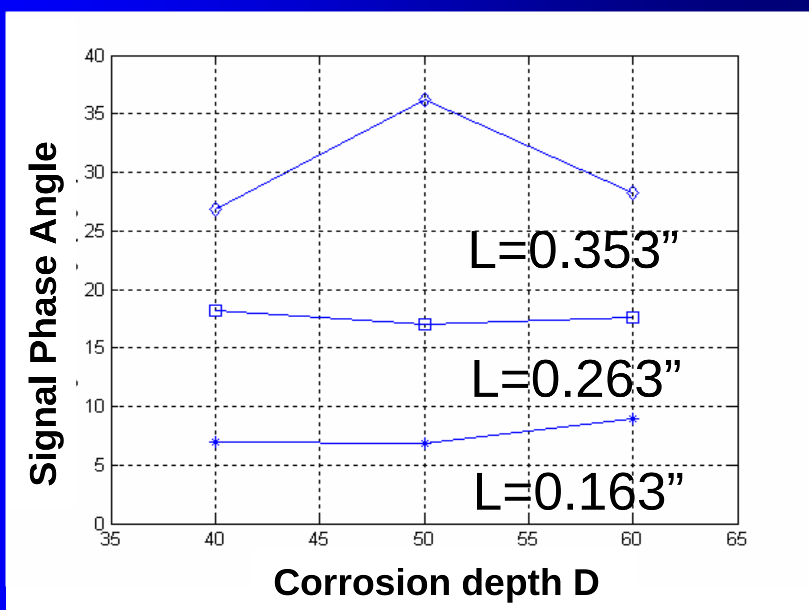
1. **Corrosion depth, D.**
2. **Location, L. Or, between which two layer?**

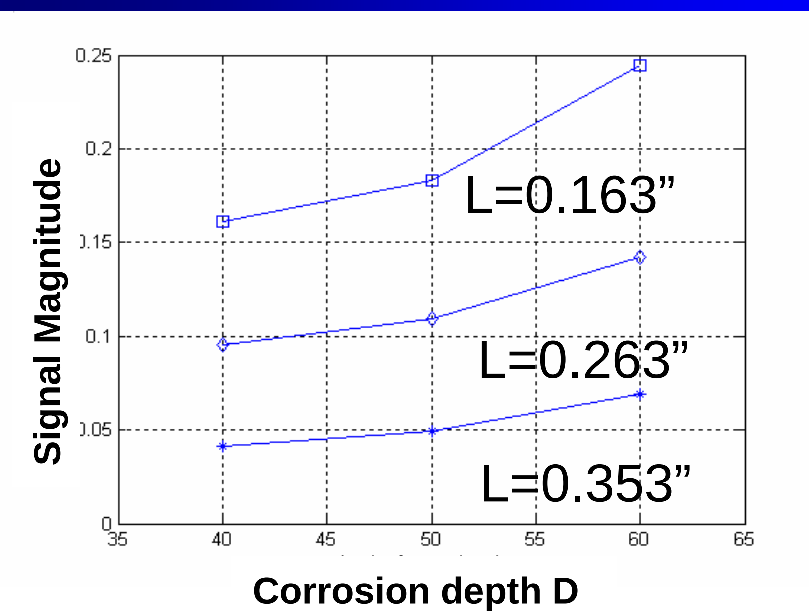


Part I – Deeply hidden corrosion detection

Corrosion Calibration Standard for Estimation of L and D (1)







Summary for Topic 2

Deeply hidden Corrosion can be detected and calibrated using its signal phase angle and magnitude

First, use signal phase angle to determine the location, or on which layer the corrosion is found

Then, use the signal magnitude to estimate the depth of the corrosion.

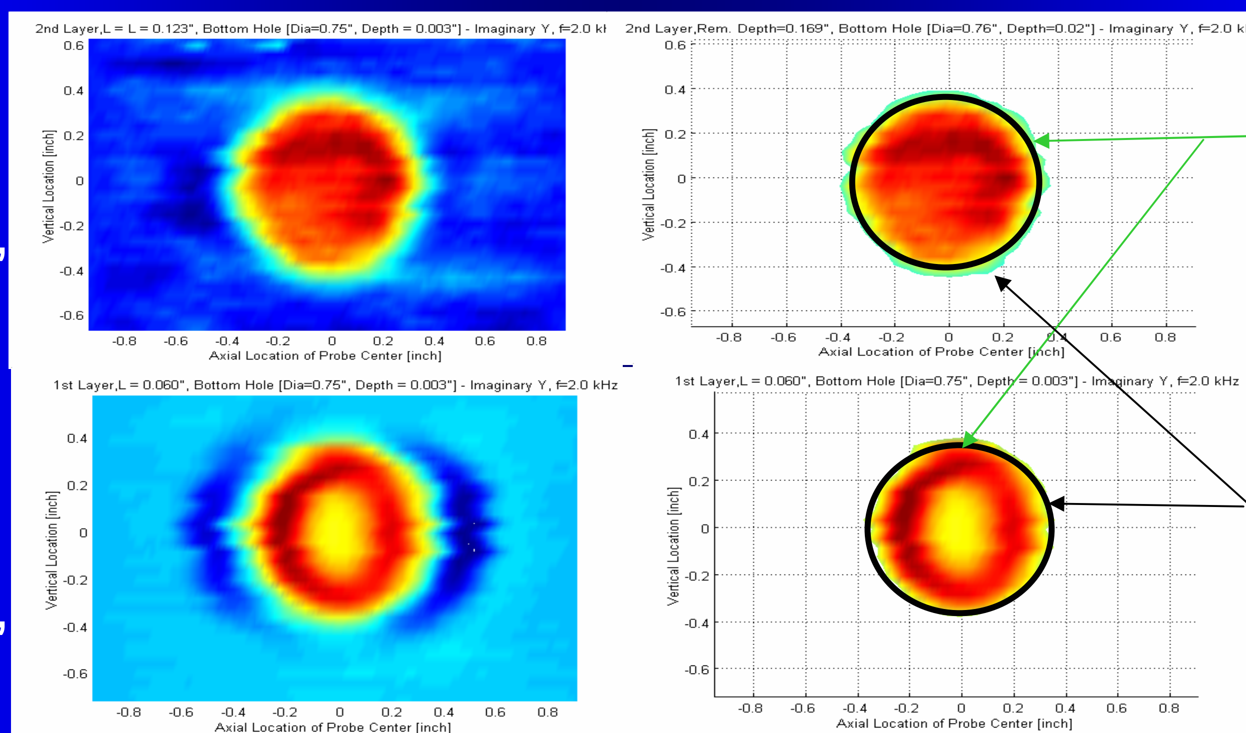
Topic 3
Corrosion shape estimation

Corrosion size and shape estimation
Example 1 for RF2 V3 – Φ 0.500” flat bottom circle

Original image | **Estimation**

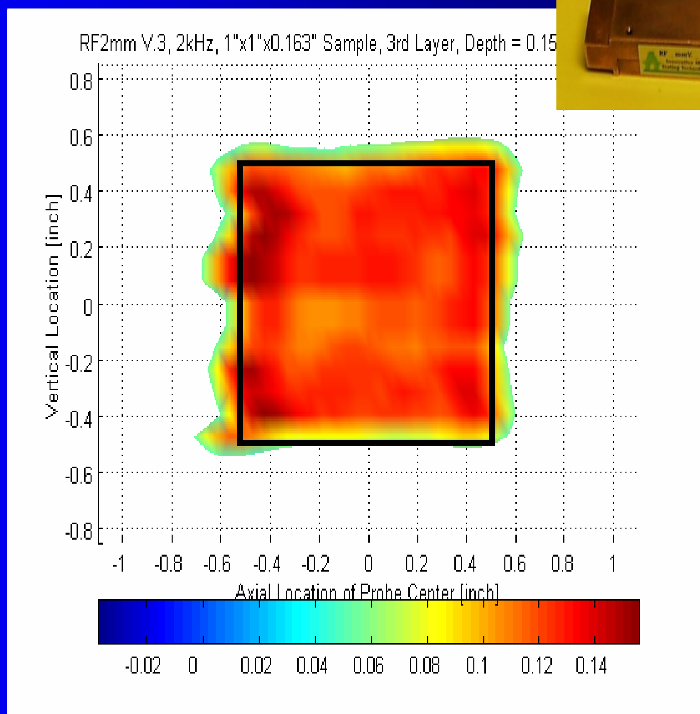
Rf2 V3
2 kHz
L=0.123”
D=0.003”

Rf2 V3
2 kHz
L=0.060”
D=0.003”

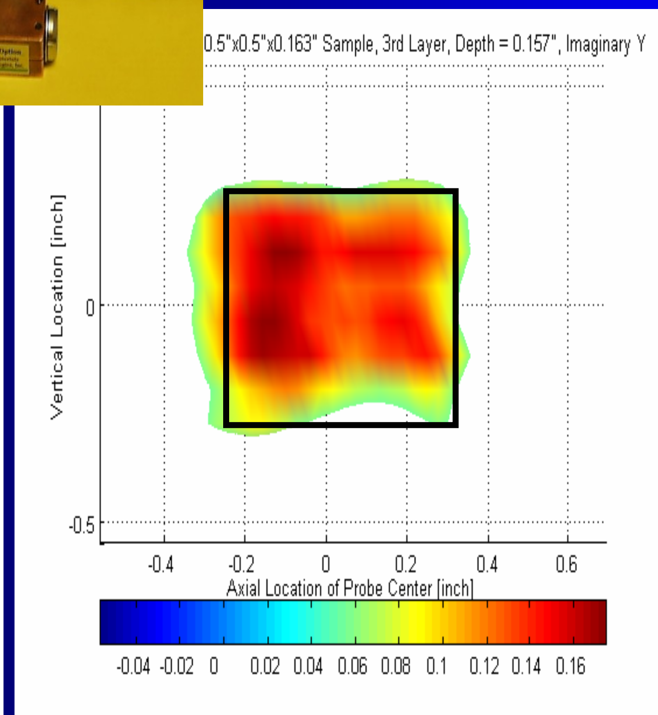


Corrosion size and shape estimation
Example 2 for RF2 V3 – Flat bottom squares

Case 1

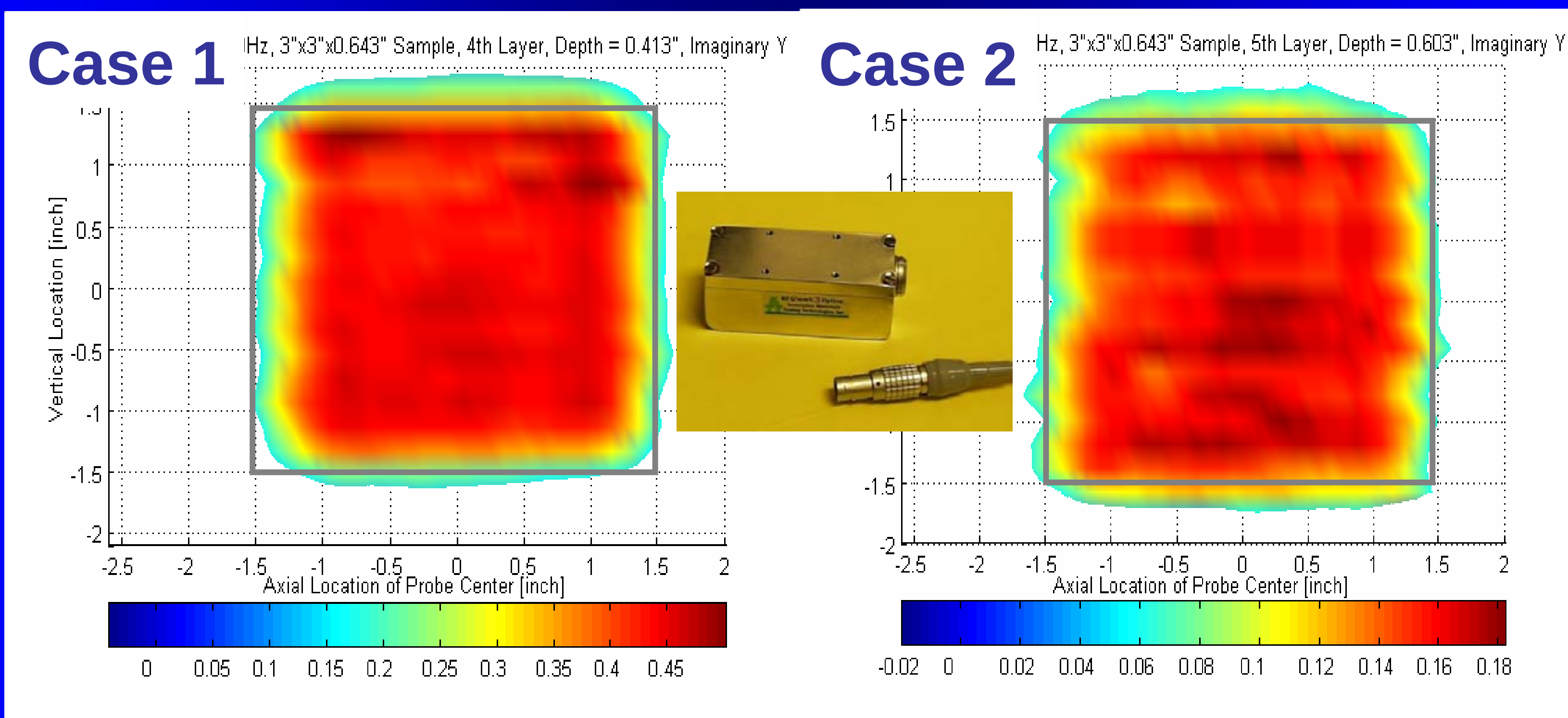


Case 2



1”×1”×0.006”, L=0.157”　　**0.5”×0.5”×0.006”, L=0.157”**

Corrosion size and shape estimation
Examples 3 for RF4 V3 – Flat bottom squares



3”×3”×0.040”, L=0.413”

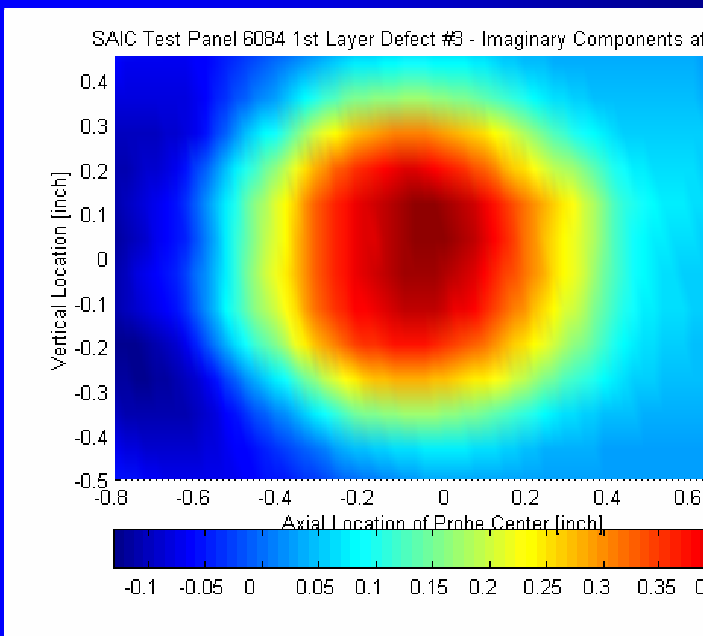
3”×3”×0.040”, L=0.603”

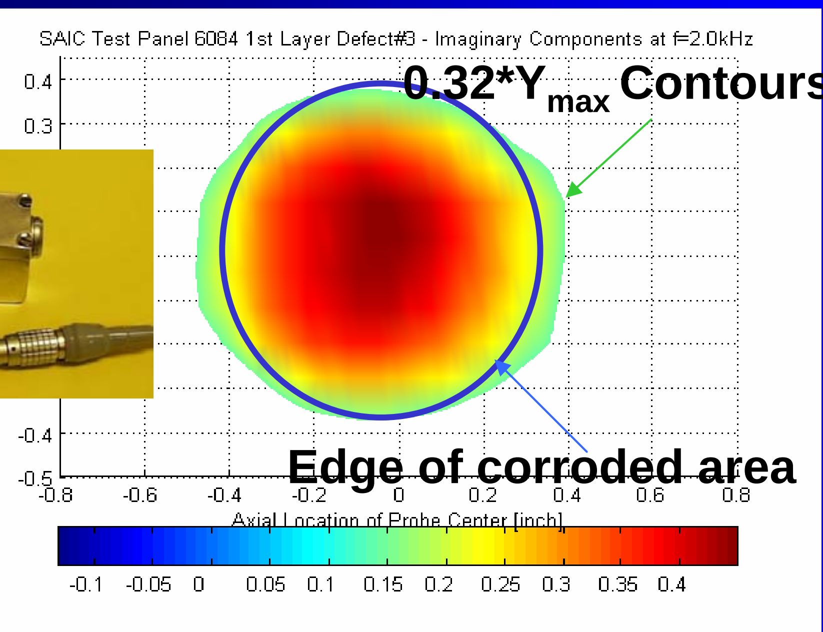
Corrosion size and shape estimation
Example 4 for RF4 V3 – Φ0.500" flat bottom circle

F = 2.0 kHz L=0.125" D=0.020"

Original Image

Estimation





Summary for Topic 3

Corrosion size can be estimated if the corrosion area has approximately the same depth.

In current lab test results, a 0.32*signal magnitude equal-contour is used for the estimation.