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New Advances in Detecting Cracks in Raised-Head Fastener Holes Using Rotational Remote Field Eddy Current Technique

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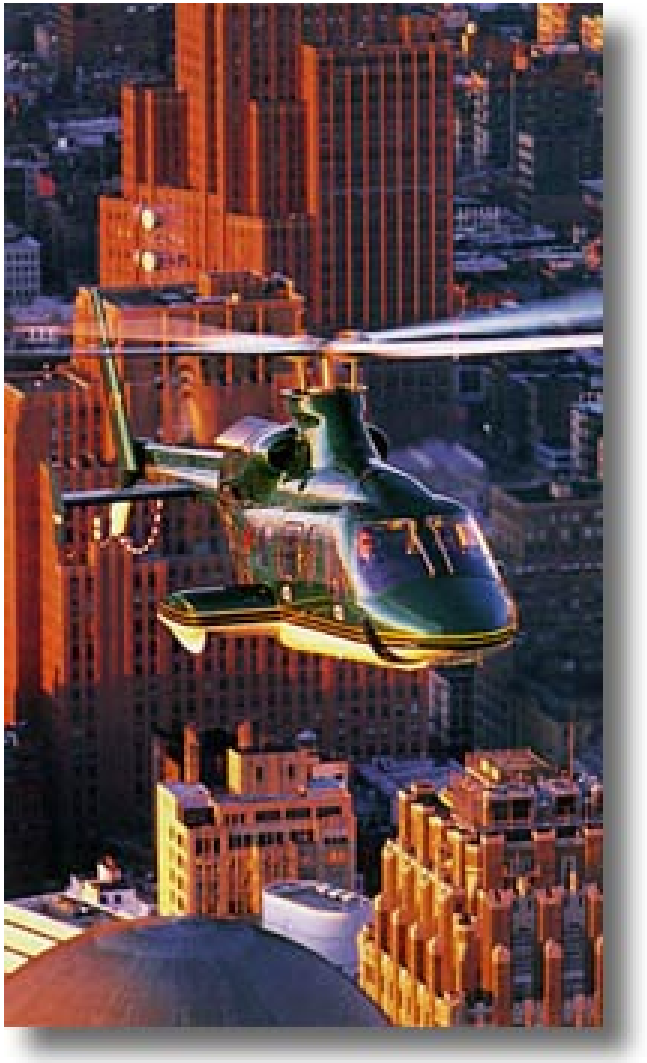

Expected great increase of the helicopter population over the next decade

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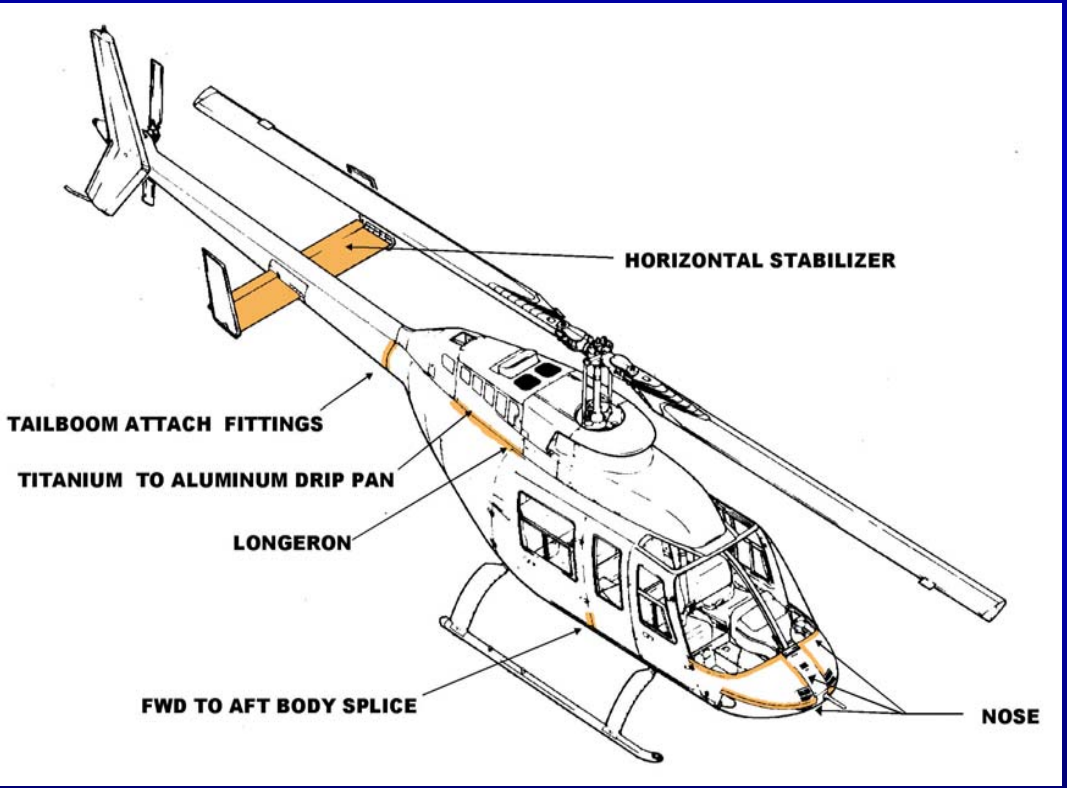
Why Research Rotorcraft Structures?

Rotorcraft vs. Fixed Wing Structures



- Smaller Joints Dimensionally
- Thinner Gage Materials
- No NDI Data / Techniques / Experience
- Unique Joint Configurations
- Rapid Accumulation of Fatigue Cycles

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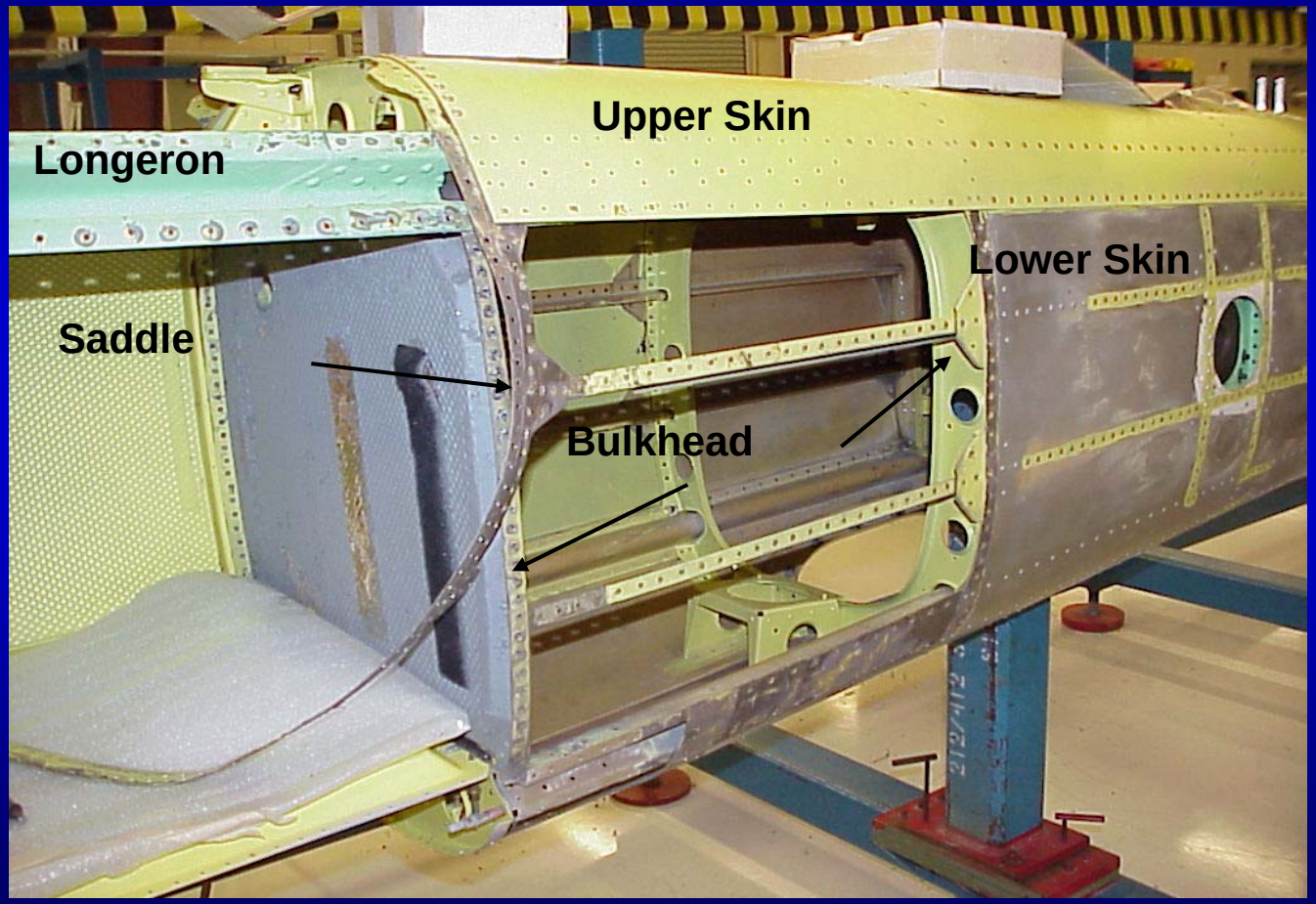
Crack Detection in Rotorcraft Structures

- high cycle fatigue joints
- under raised head fasteners



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New NDI methods are developed to detect cracks before they extend out from under the head of the fastener.

Among them rotational flat geometry remote field eddy current (FG_RFEC) method has shown its outstanding capability in detecting cracks under raised-head fasteners [1]

[1]. Yushi Sun, Dennis Roach and others, "Rotational Remote-Field Eddy-Current Method for Detecting Cracks under Raised Head Fasteners", Proceedings of Joint Conference on Aging Aircraft 2003, 8-11 September 2003, New Orleans, Louisiana

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New study

Verify the ability of the RFEC technique in detecting cracks in some harsh conditions which affect the fastener-hole material conductivity

These include:

Detect-ability with alodined and anodized fasteners;

Detect-ability with tightly installed fasteners;

Detect-ability with fasteners with scratched surface at different locations relative to fastener shaft circumference.

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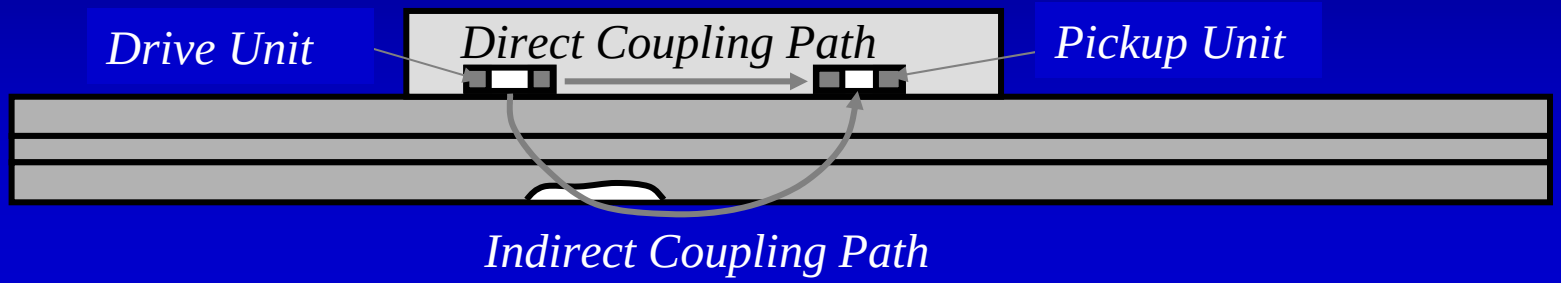
FG_RFEC TECHNIQUE



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.

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SUPER-SENSITIVE-EDDY-CURRENT SYSTEM SSEC

A modified version of a conventional eddy-scope with

1. **high gain and**
2. **low noise level.**

It bring the weak pickup signal to a readable level on a computer screen.

12” X8.75” X1.75” SSEC RF02 with Software

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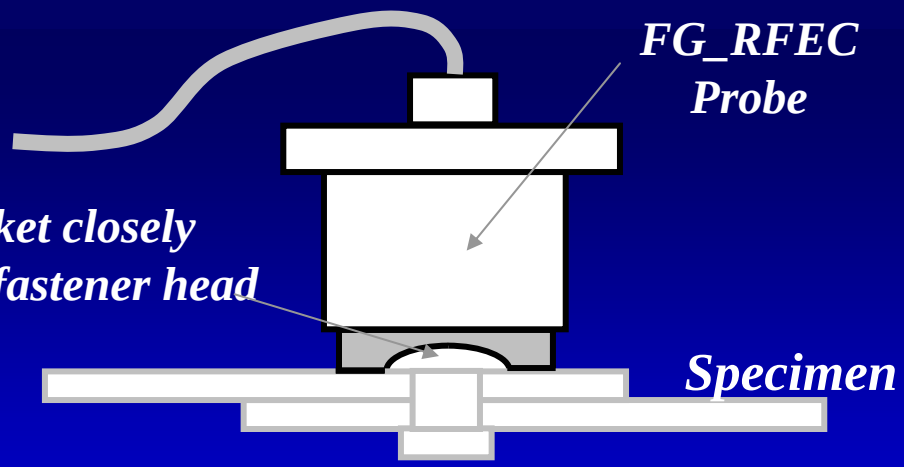
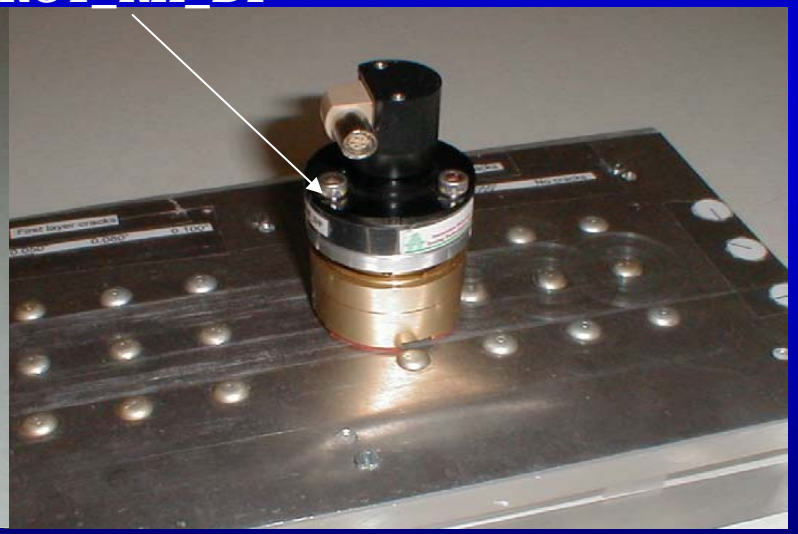


Probe RF2_ROT_RH_DP

Ball-bearing
rotation guide



Two-layer, 0.040”+0.040”, panel
with raised head fasteners

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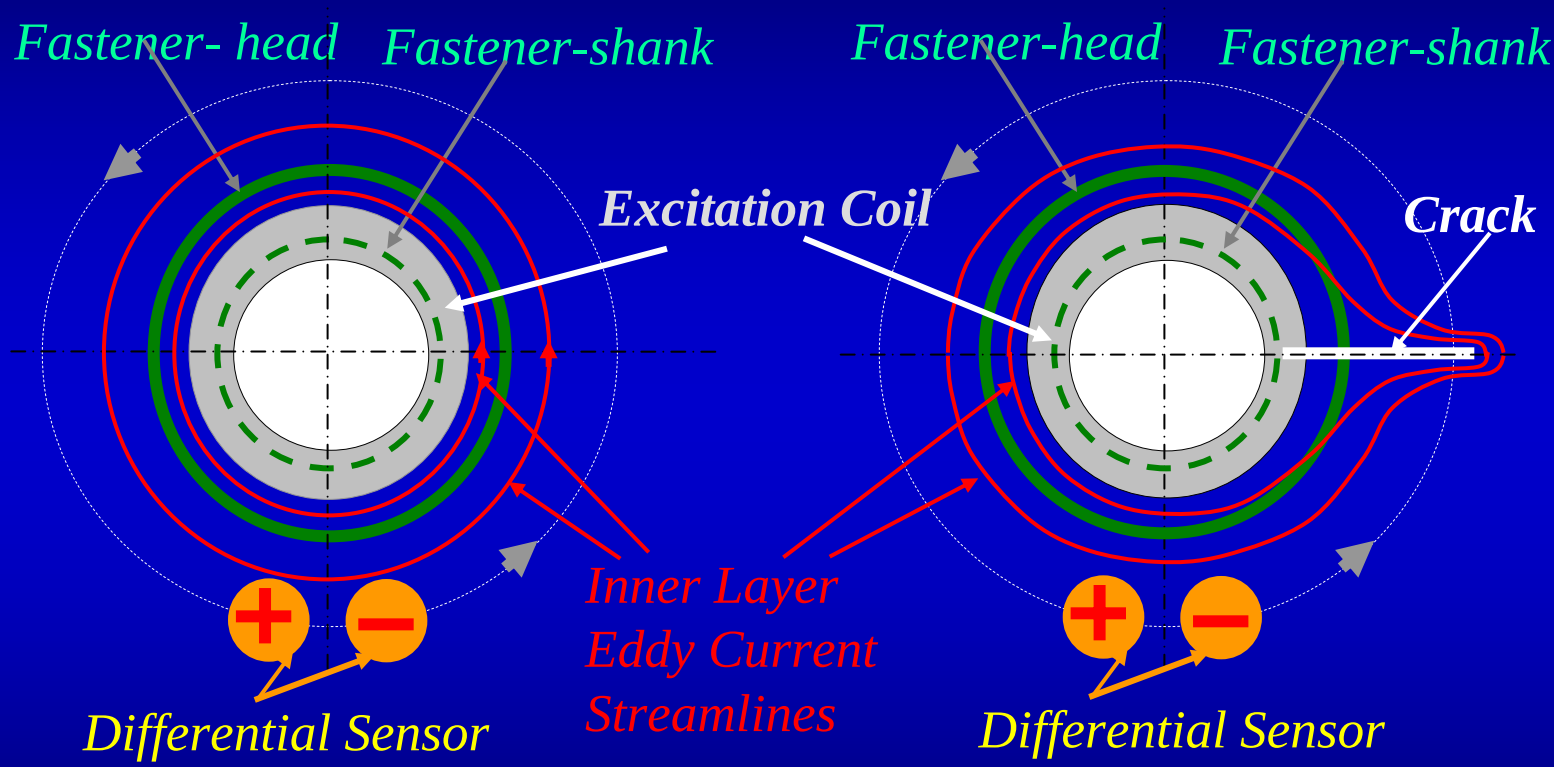
ROTATIONAL SCAN MODE



Zero Signal when No Crack

Sharp Signal when Passing A Crack

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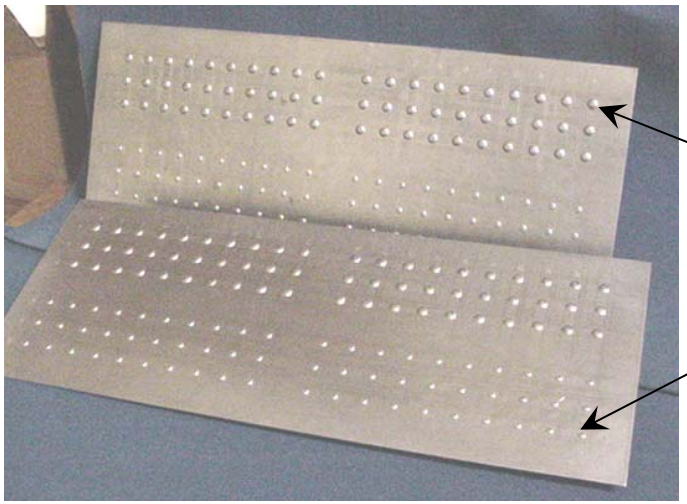
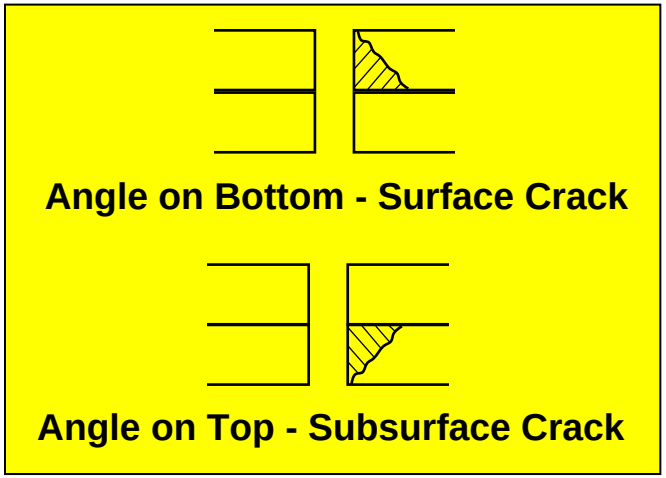
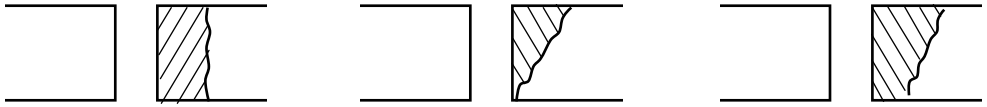
Probability of Detection Test Specimens for In-Service Fatigue Crack Inspections



Statistically valid array of crack panels to determine POD and false call rate
(optimum S/N ratio results)





Variation in rivet clamp-up induces signal variations in uncracked sites similar to those measured on rotorcraft test beds

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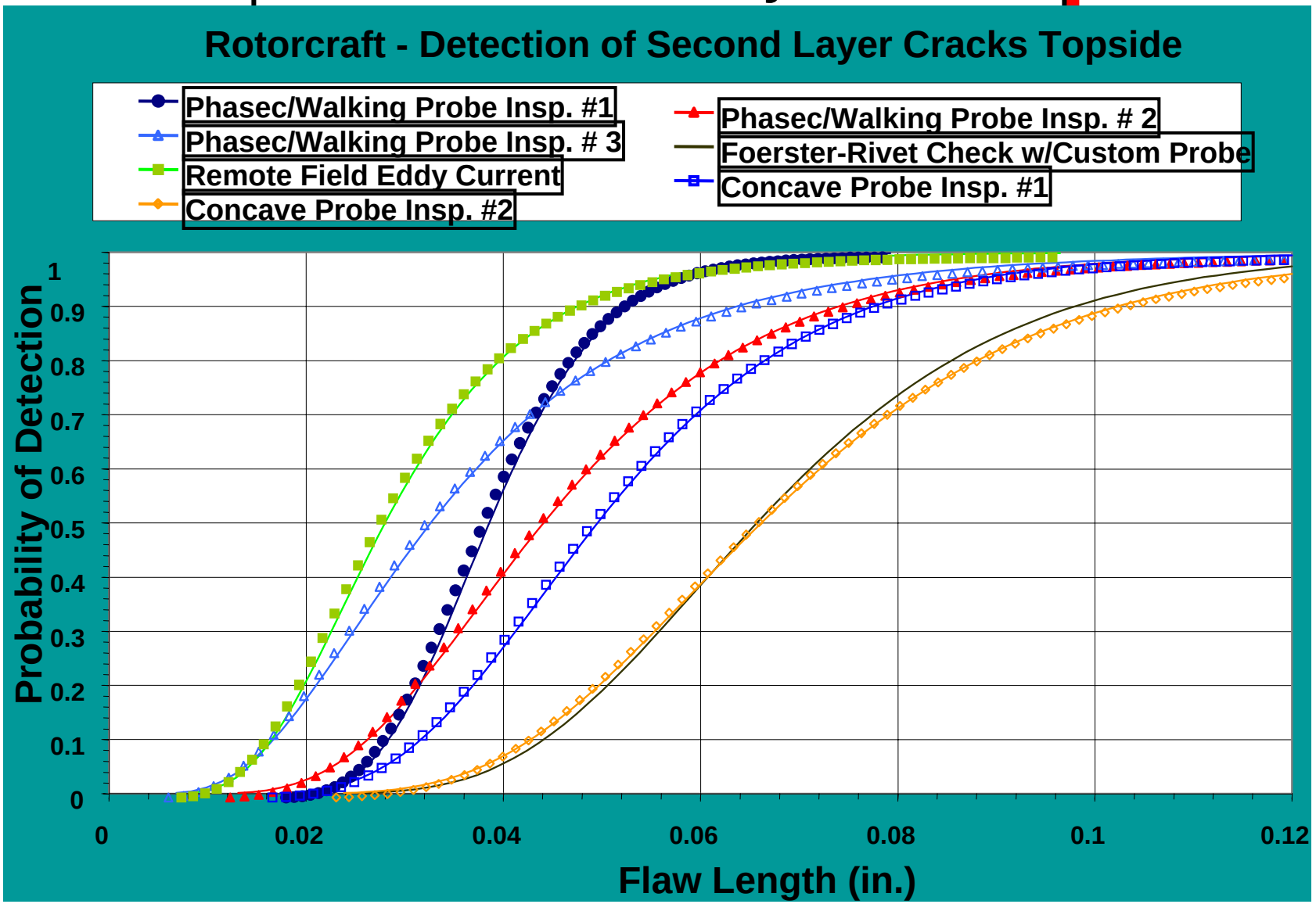
Detection of 2nd Layer Cracks



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JOINT CONDUCTIVITY VARIATIONS

Two main contributors to the conductive path between the fastened layers and a fastener:

1) The EC signals change in accordance with the level of conductivity between the surface and subsurface skins, and

2) Specific features of the rivets, such as anodized and alodined rivet coating, tightly installed fasteners, and surface scratch.

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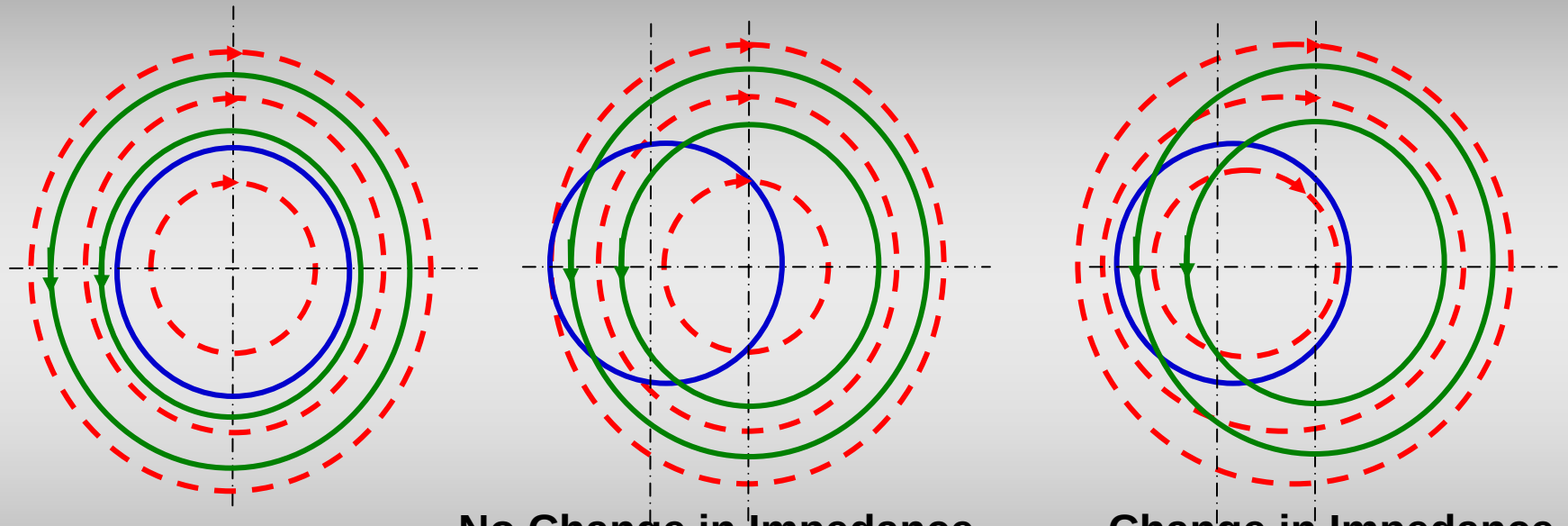
A. Drive At Fastener Center - Reference

B. Drive Away from Fastener Center 1 – Conductive Joint

C. Drive Away from Fastener Center 2 – Nonconductive Joint



No Change in Impedance

Change in Impedance

Drive current lines

Eddy current stream lines

Fastener shank - joint

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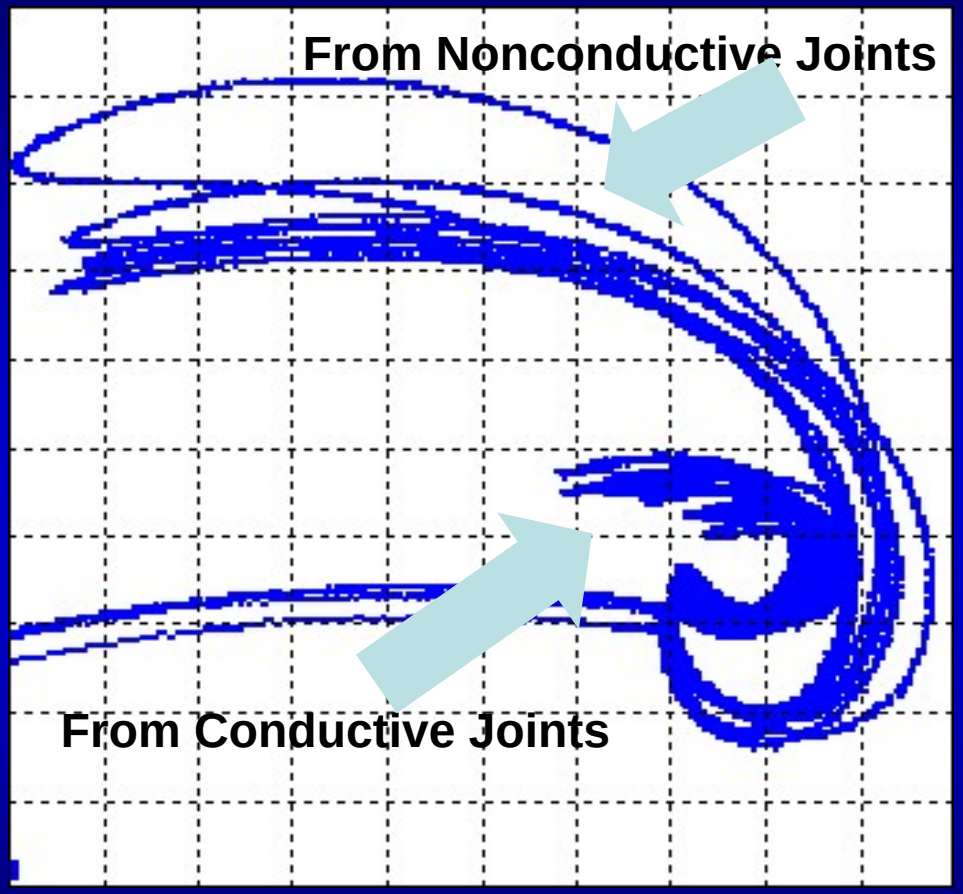
Decrease of Impedance Plane in Conventional Eddy Current Inspection



A Crack Signal may be between Them

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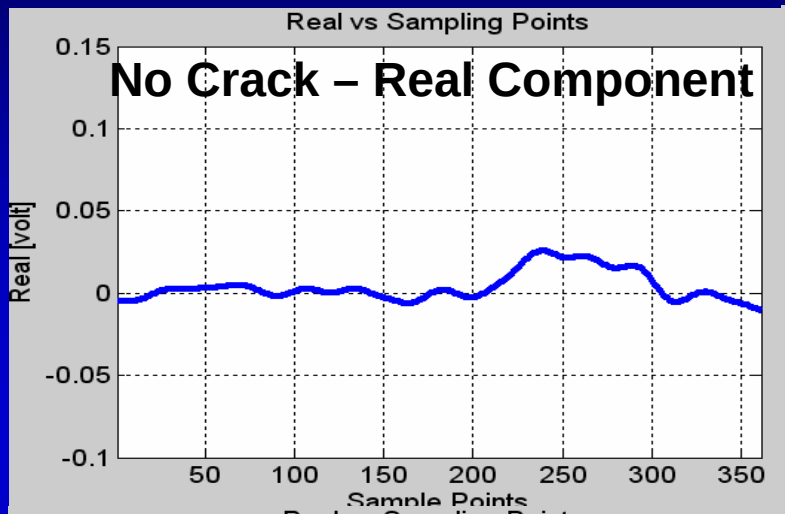
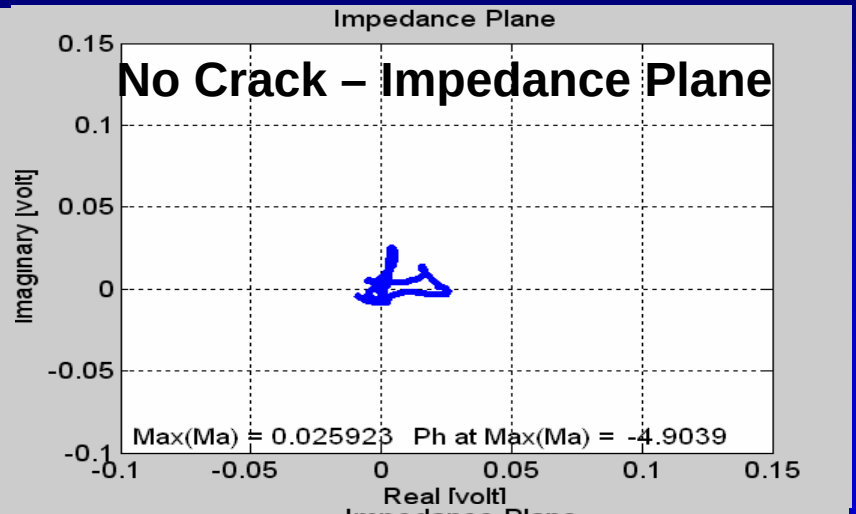
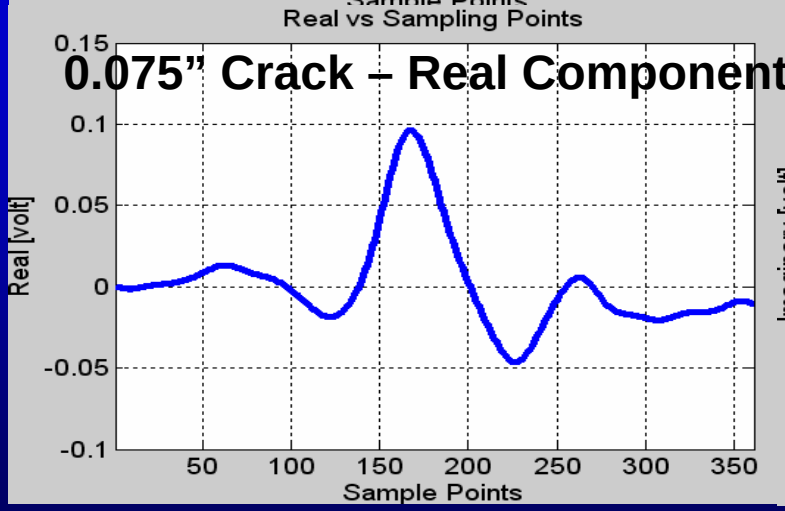
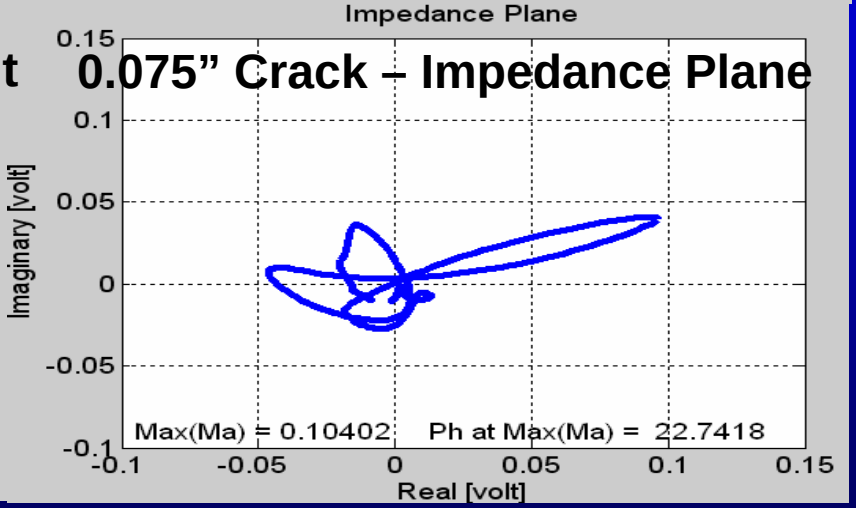
Signals Detected from Very Conductive Fastener Joins Using FG_RFEC Probe – 1st Layer Crack









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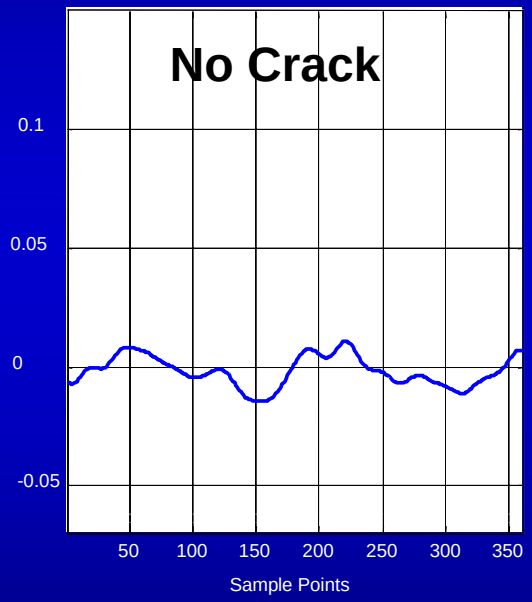
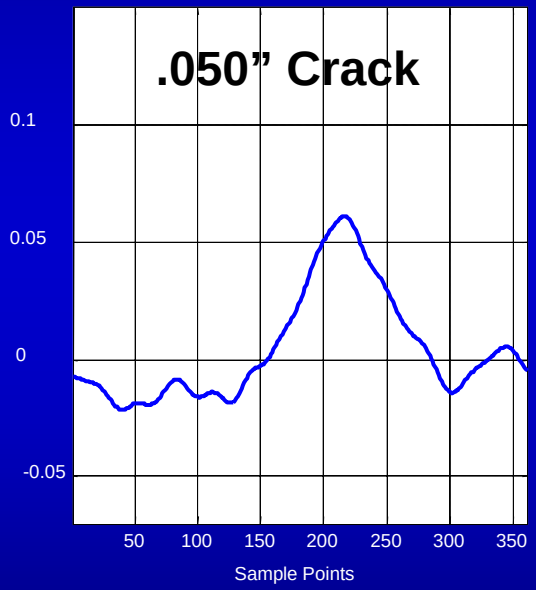
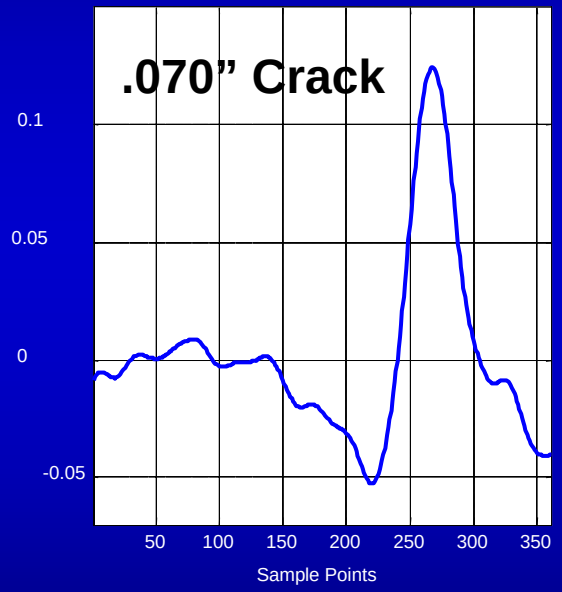
Signals Detected from Very Conductive Fastener Joins Using FG_RFEC Probe – 2nd Layer Crack Imaginary Components







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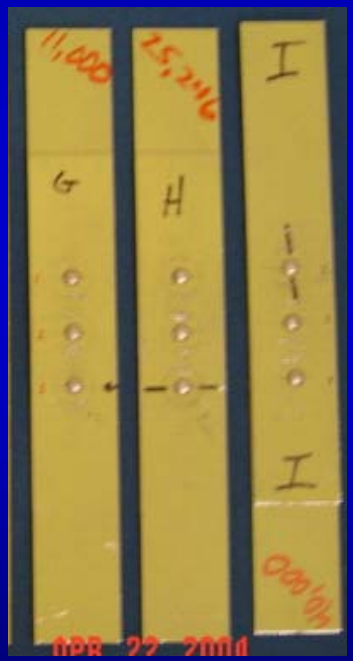
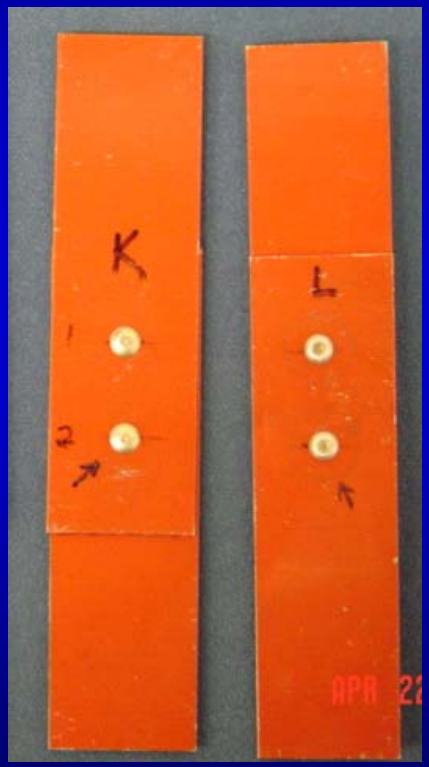
Twelve specimens with natural fatigue cracks crack lengths ranged from 0.020” to 0.210”





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Comparison of Four Eddy Current Techniques

Pencil Probe – found only cracks extending beyond rivet head

Walking Probe – found 20 out of 24 cracks; 2 false calls

Concave EC Probe – found all 24 cracks; 3 false calls

RFEC – found all cracks; 1 false call

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SUMMARY

1.

Appropriate application of nondestructive inspection (NDI) equipment will play a critical role in helicopter managing safety.

2.

In helicopter applications more accuracy is required for crack growth predictions and greater sensitivity is required of NDI.

3.

Among currently available EC techniques FG_RFEC technique shows good promise in POD study and in detecting raised head fastener hole cracks with alodined and very conductive fastener joints.