Heat Exchanger & Boiler Tube Inspection

General Information

Techniques:

- Multiple Frequency Eddy Current
- Magnetic Biased Eddy Current
- Remote Field Eddy Current
- Rotational Eddy Current (Rotoscan)
- IRIS (Rotational Ultrasonic System)

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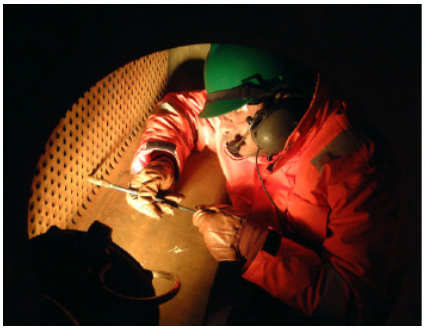
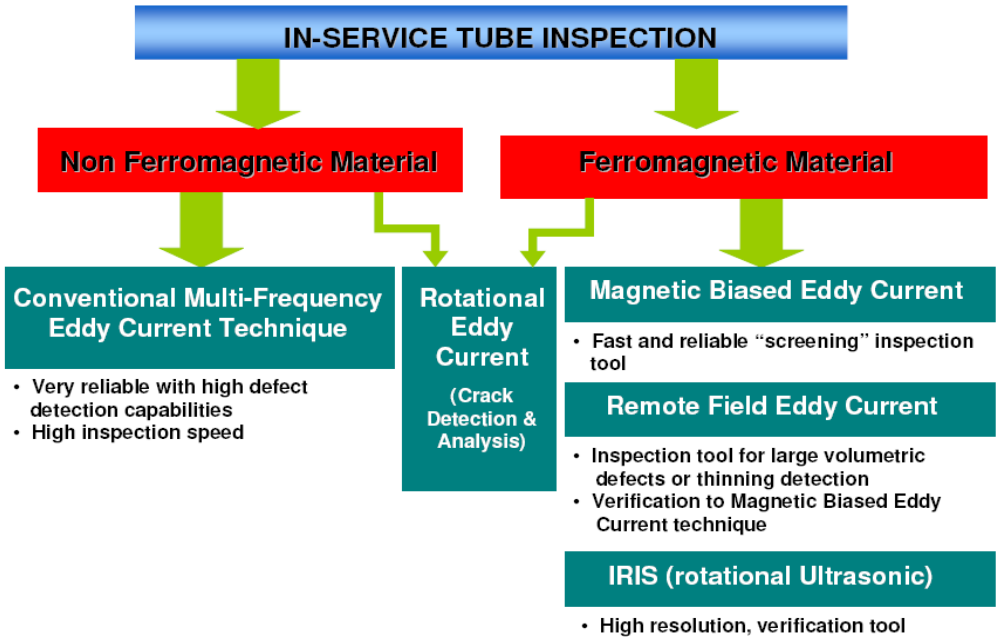


The Techniques

The following advanced tube inspection techniques offer high capabilities in defect detection and accurate defect analysis:

- Multi-Frequency Eddy Current
- Magnetic Biased Eddy Current
- Remote Field Eddy Current
- Rotating Eddy Current
- IRIS (Rotational Ultrasonic System)

With high inspection speed and low cleaning requirements, these cost effective inspection technologies are able to inspect ferromagnetic, non-ferromagnetic and Fin Fan tubes.



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Features of Techniques

	Multiple Frequency Eddy Current Testing	**Magnetic Biased Eddy Current Testing**	**Remote Field Eddy Current Testing**	**IRIS**
Materials	Non-ferromagnetic materials – Stainless Steel, Copper Nickel, Brass, Titanium	Ferromagnetic materials – Carbon Steel Monel, Duplex (Fin Fan tubes)	Ferromagnetic materials – Carbon Steel Monel, Duplex (Fin Fan tubes)	Ferromagnetic and non-ferromagnetic magerials
Average Productivity approx. per team per shift	~ 500 tubes	~ 350 tubes	~ 250 tubes	~ 80 tubes
Detection Capabilities	- Small localised defects - Vibration damage - Thinning - Cracks (depending on orientation)	- Local defects - Vibration damage - Cracks (depending on orientation)	- Volume defects - Thinning	- Local defects - Thinning
Cleaning	General cleaning. Allowing probes of Ø 1.0 to Ø 1.5mm below tube nominal internal diameter to pass through			High cleaning requirements

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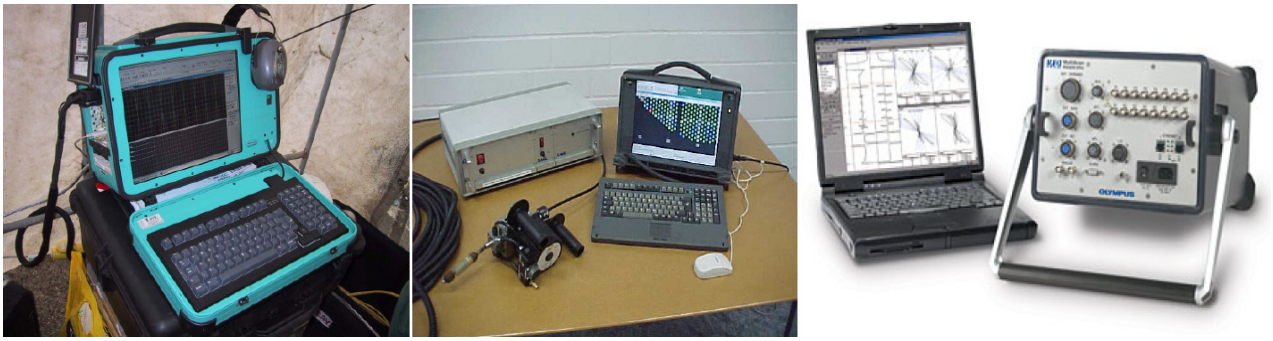
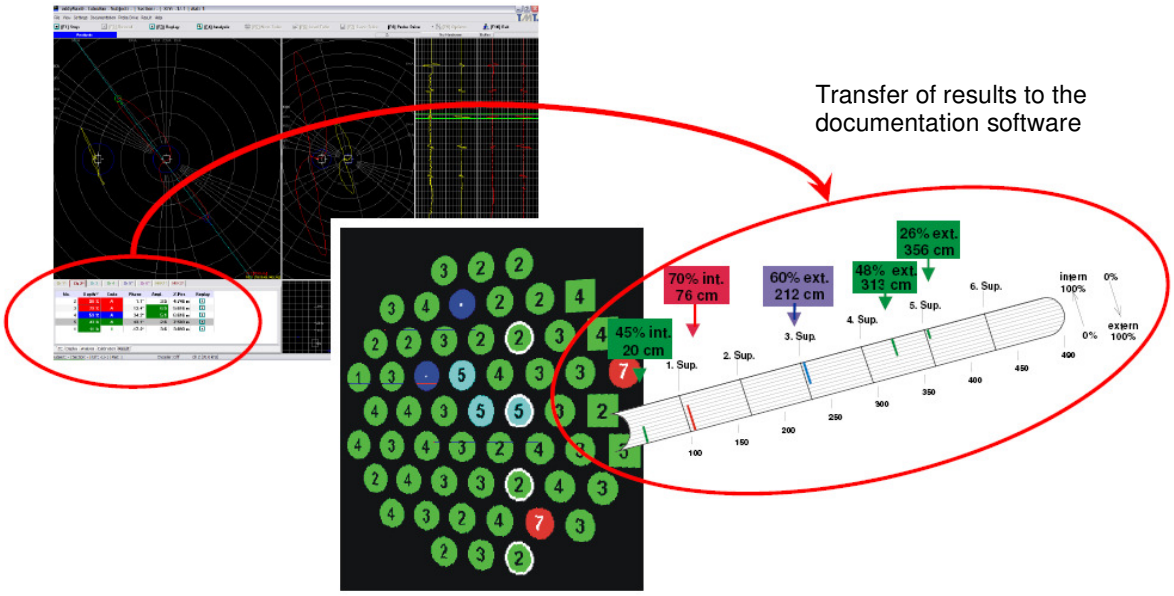


Documentation & Reporting

With the advanced and comprehensive Eddy Current Computer System and Reporting Software, the signals are analysed automatically online in “real time”.

The automatic online analysis has four frequency channels – 4 Differential, 4 Absolute and 16 Mix channels.

The results are transferred to the documentation software which generates not only a precise and accurate condition overview but also the specific inspection results for the individual tubes.



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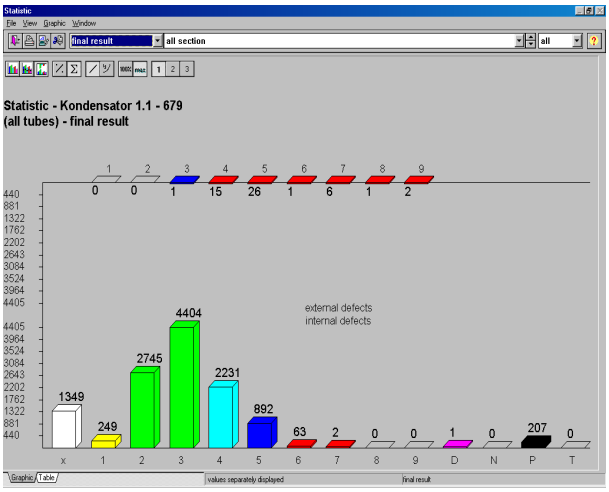
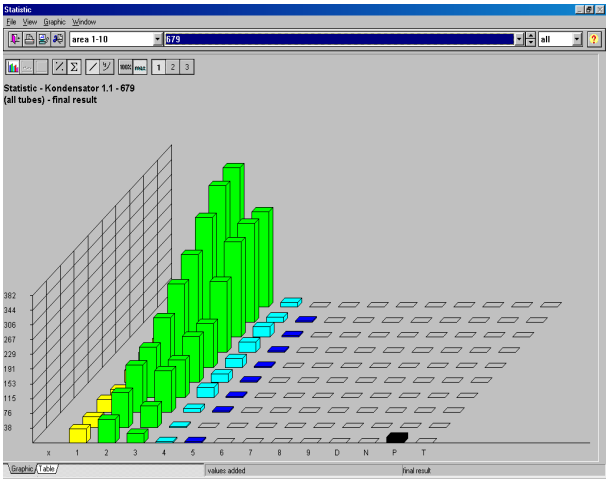
General Condition Overview and Specific Reporting for Individual Tubes





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Multiple Frequency Eddy Current Technique

Typical Materials : Non-ferromagnetic, electric conductive material
E.g. Stainless Steel, Brass, Copper, Copper Nickel Alloys, Titanium, Monel, Hastelloy. (Plain wall or with fins)

Frequency Settings : Reaching sufficient sensitivity on both tube side walls. Standard penetration depth depends on conductivity and tube wall
E.g. Titanium ~ 200 kHz, Stainless Steel ~ 100 kHz, Brass ~ 50 kHz, Copper ~ 10 kHz

Standard Sensitivity : Ø 1.5 Through Wall Hole (TWH)

Typical Analysis : From 10% wall loss onwards

Accuracy : ± 5% to ± 10% of defect depth analysis
Reasons for accuracy tolerance:-
Centering of probe, accuracy of calibration defect depth, tolerance band of calibration curve (material, defect volume), analysis capability of operator / inspection equipment

Sensitive to : Any type of material dishomogenies such as corrosion, erosion, localised pitting, vibration damages, material changes

Pitting	: > Ø 1 - 2.0mm (Ø 0.5mm), depth >20%
Holes	: > Ø 0.7 - 1.0mm (Ø 0.3mm), surface dependant
Vibration Damage	: > 20% loss (mixing required)
Cracking	: High detectability with field-crack orientation 90° (> 10%)
Thinning	: Internal > 10%, External > 20%
Local Defects	: Internal and External : > 20% / Ø 2-3mm

Inspection Details

- Speed : 35 – 60 tubes/hour (approx. 500 – 600 tubes / team / shift)
- Wall Thickness : Typical 0mm to 8mm (higher with special sensors)
- ID : From Ø 5mm (max. experience 170mm)
- Length : Standard cable up to 30m
- Bends : With U-Bend probes - beds with radius > 10 x ID
- Preparations : Generally cleaned tubes and free of electric conductive deposits. Probes of Ø 1.0 to Ø 1.5mm below tube nominal internal diameter to pass through
- Probes : Fill factor 85-95%
- Detection : Differential Mode – for localised defects
  Absolute Mode – for gradual defects and thinning

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Magnetic Biased Eddy Current Technique

Typical Materials : Ferromagnetic material
E.g. Carbon Steel, Monel, Duplex. (Plain wall or with fins)

Frequency Settings : Relative independent

Standard Sensitivity : Ø 1.5mm to Ø 2.5mm Through Wall Hole (TWH)

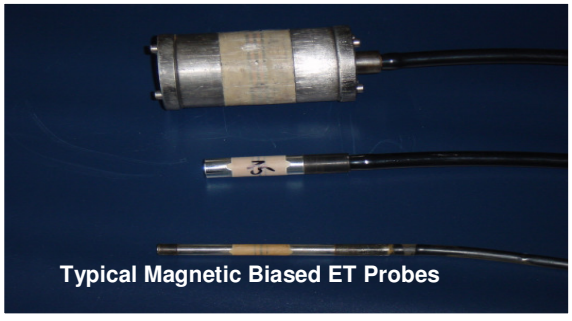
Typical Analysis : From 20% wall loss onwards (depth analysis by signal amplitude in comparison to calibration defects)

Accuracy : ± 10% to 15% of defect depth analysis
Reasons for accuracy tolerance:-
Centering of Probe, accuracy of calibration (defect volume difference calibration / tubes), analysis capability of operator / inspection equipment

Sensitive to :
- Local defects - Highly sensitive to corrosion, pits and vibration defects as only Differential Mode is being usable
- Cracks - Best detection when Eddy Current or magnetic field is broken and in perpendicular direction to crack-field
- Thinning - Not sensitive to thinning due to no Absolute Mode

Inspection Details

- Speed : 25 – 40 tubes/hour (approx. 350 to 400 tubes / team / shift)
- Wall Thickness : Typical 0mm to 4mm (higher with special sensors)
- ID : From Ø 10mm (max. experience 130mm)
- Length : Standard cable up to 30m
- Bends : Only large radius bends
- Preparations : Generally cleaned tubes and free of electric conductive deposits. Probes of Ø 1.0 to Ø 1.5mm below tube nominal internal diameter to pass through
- Probes : Fill factor 85-95%
- Detection : Only Differential Mode – for localised defects pitting, vibration defects



Typical Magnetic Biased ET Probes

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Remote Field Eddy Current Technique

Typical Materials : Ferromagnetic material
E.g. Carbon Steel, Monel, Duplex. (Plain wall or with fins)

Frequency Settings : Typical signal noise ratio between 50 Hz to 1 KHz for optimum penetration / sensitivity

Standard Sensitivity : Ø 2.5mm Through Wall Hole (TWH)

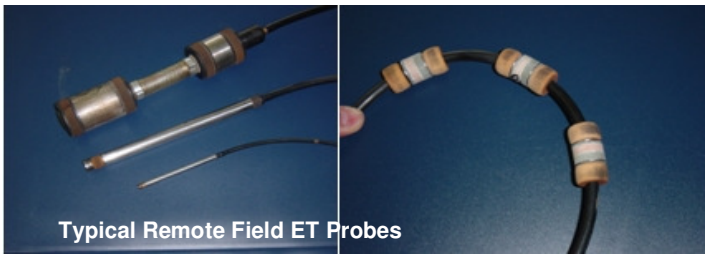
Typical Analysis : From 20% wall loss onwards

Accuracy : ± 10% to 15% of defect depth analysis
Reasons for accuracy tolerance:-
Centering of Probe, accuracy of calibration (defect volume difference calibration / tubes), analysis capability of operator / inspection equipment

Sensitive to :
Local defects - Sensitive to corrosion, pits and vibration defects from certain volume e.g. Ø 10mm / 20%
Cracks - Best detection when Eddy Current or magnetic field is broken and in perpendicular direction to crack-field
Thinning - Very sensitive to thinning (erosion)

Inspection Details

- Speed : 20 – 30 tubes/hour (approx. 250 tubes / team / shift)
- Wall Thickness : typical 0mm to 4mm (higher with special sensors)
- ID : from Ø 10mm (max. experience 80mm)
- Length : Standard cable up to 30m
- Bends : With use of flexible U-Bend probes - beds with radius > 15 x ID
- Preparations : Generally cleaned tubes and free of electric conductive deposits. Probes of Ø 1.0 to Ø 1.5mm below tube nominal internal diameter to pass through
- Probes : Fill factor 85-95%
- Detection : Differential Mode – for localised defects
  Absolute Mode – for gradual defects and thinning



Typical Remote Field ET Probes

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Rotating Eddy Current Technique (Rotoscan)

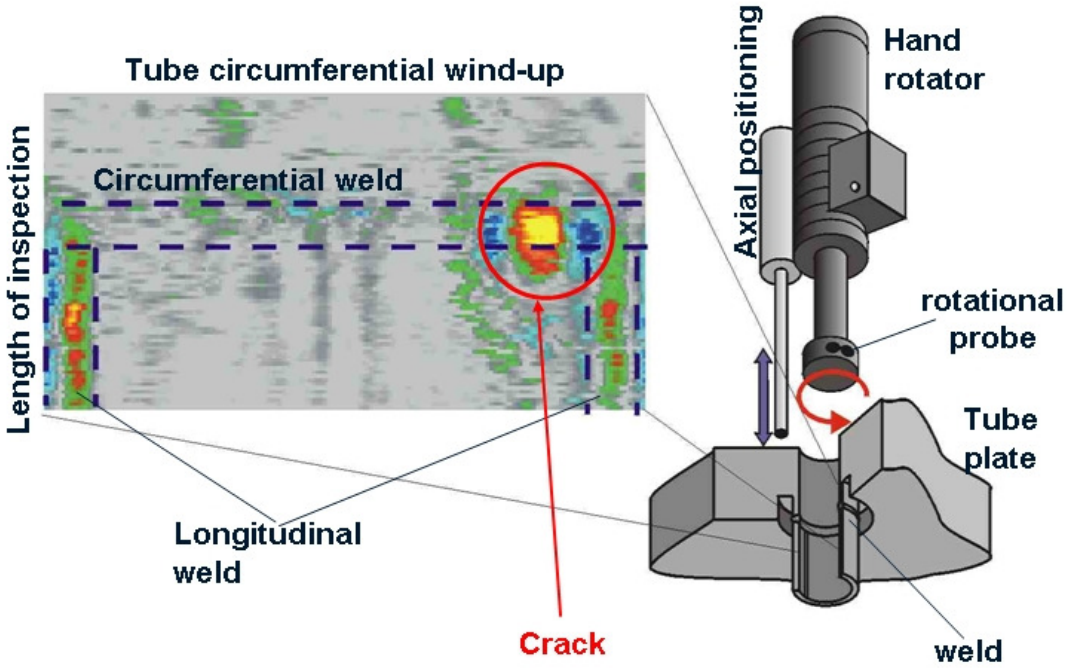
Typical Materials : Ferromagnetic material
E.g. Carbon Steel, Monel, Duplex. (Plain wall, limited to finned tubes)

Typical Usage : Detection of defects at tube expanded zones

Sensitive to : Local defects - External and internal defects like pitting and corrosion in tube material and tube entrance
Cracks - From 0.5mm depth (longitudinal and circumferential) in tube expansion zone, back side welded tubes and circumferential tube cracking due to wrong expansion

Inspection Details

- Speed : 500 – 700 tube expanded zones per shift
- Probes : Fill factor up to 100% (with flexible sensors)
- Detection : Differential Mode – for localised defects
  Absolute Mode – for gradual defects and thinning



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IRIS (Rotational Ultrasonic System)

Typical Materials : Ferromagnetic and non-ferromagnetic material

Standard Sensitivity : Very sensitive in defect detection

Accuracy : Very accurate in defect detection (a three dimensional picture showing the defect profile and depth can be obtained)

Sensitive to :
- Local defects - Highly sensitive to volumetric defects, good resolution in tube circumference
- Cracks - Not sensitive to cracking
- Thinning - Sensitive to thinning (erosion)

Inspection Details

- Speed : Slow technique (approx. 80 tubes / team / shift)
  Actual inspection speed depends on a number of factors but is generally approx. 2.4m/sec to achieve a coverage of 100%
- Bends : Not inspectable
- Preparations : Water must be introduced into the tube to act as a couplant.
  Tubes must be absolutely cleaned down to the bare metal (unlike other techniques which tolerate some degree of scaling)
- Probes : Must be centralised within the tube or the signals will be lost. A dead zone could occur due to the effect of “probe ringing”
- Detection : Only volumetric defects are detected. Not sensitive to cracking
- Operator : Very experienced operators are required for successful IRIS inspection


Typical IRIS Sensors


IRIS Probe being manipulated into tubes flooded with water

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