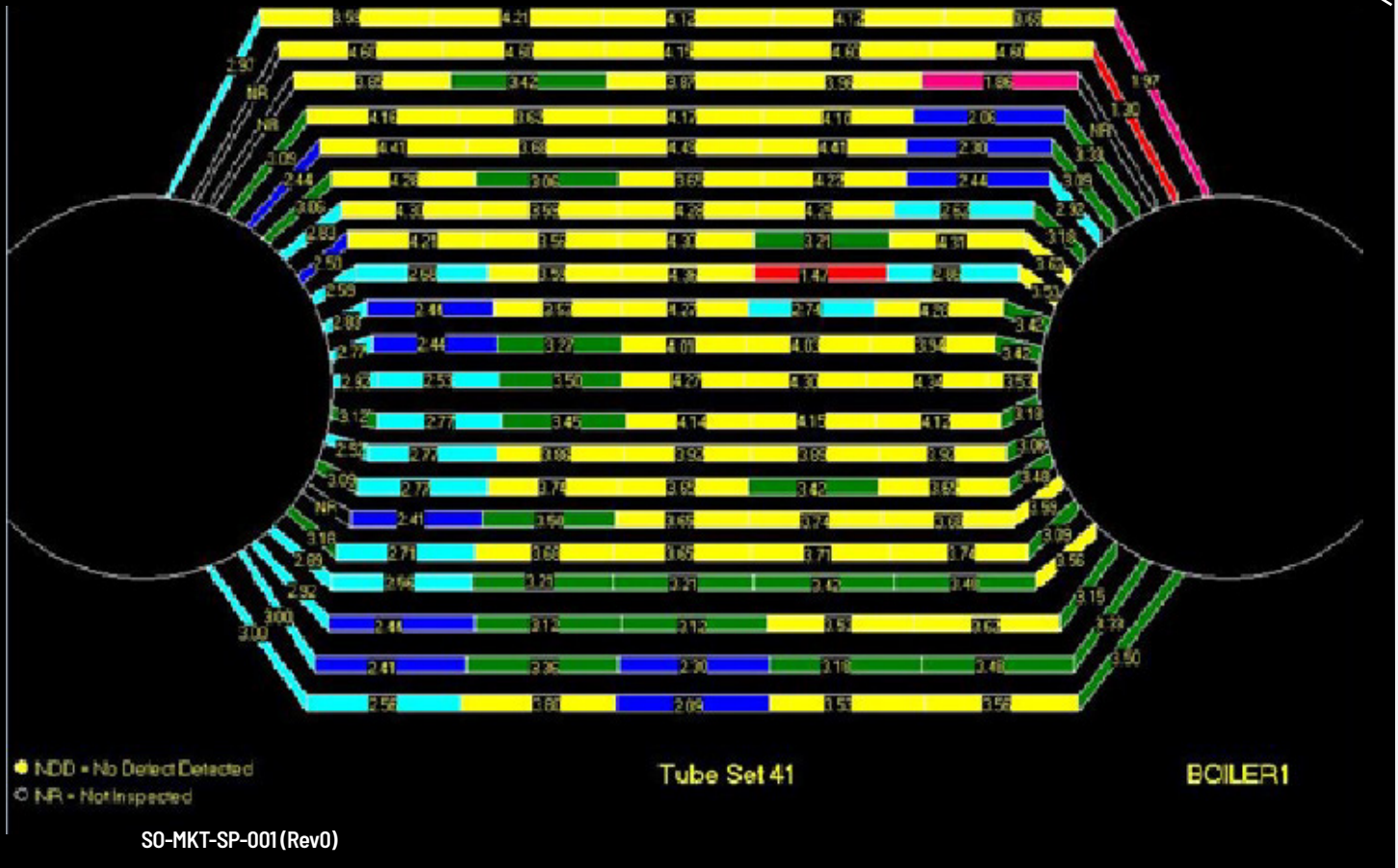
SPECIALIST PACKAGE

ADVANCED TUBE INSPECTION

SONOMATIC

THE PURPOSE

This document is composed to assist our clients and the supply chain with a high-level understanding of the technical capabilities, benefits and services associated with our Advanced Tube Inspections.



ADVANCED TUBE INSPECTION

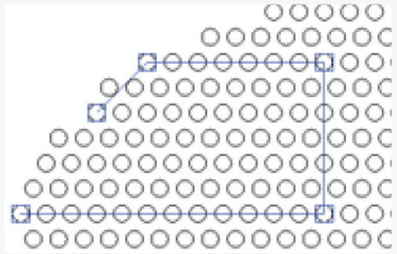
Boiler and heat exchanger tubes are subject to various biological, chemical and physical stress. This causes a number of defect mechanisms such as erosion, corrosion, cracking and other forms of material loss to occur.

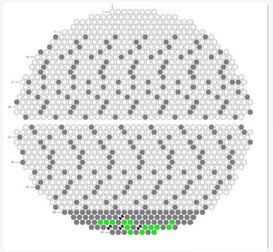
Frequent inspection of these tubes can reduce unplanned shutdowns as well as other more serious breakdowns. By utilising advanced methods of reporting, the engineers are able to make adjustments to the process and extend the life of these and other units in the plant.

STANDARD REPORTING

The client is issued with a interim report when the inspection is completed. This will contain a tube map displaying the deepest defect indication found in each of the tubes inspected and will be divided into defect depth ranges of 20%. The interim report will also include a description of the defect indications found during the inspection as well as information regarding the unit inspected.

A final report will be issued from the Sonomatic office containing more detailed information of the inspection, the technique used and the results from the inspection. Photos of the unit and tube sheet will also be included when available.

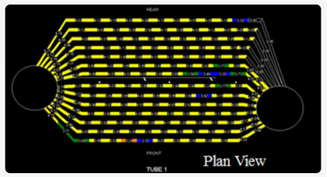


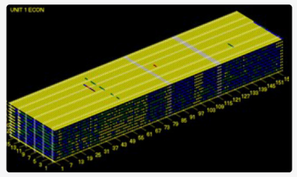


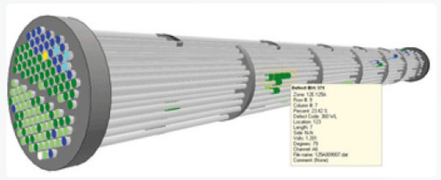
ADVANCED REPORTING

More advanced reporting options are also available, from spreadsheets with minimum remaining wall thickness measurements, IRIS inspections, or detailed 3D representation of the results showing defect indication positions in each tube.

Due to the time required for 3D inspections and 3D reporting various options are available at different resolution and levels of information.







TECHNIQUES AND APPLICATIONS

Application	Boiler Tubes		Heat Exchangers and Chillers				Fin Fan Coolers		
Technique	Remote Field Eddy Current	IRIS	Eddy Current	Magnetic Bias Eddy Current	Remote Field Eddy Current	IRIS	Eddy Current	Magnetic Bias Eddy Current	IRIS
Ferromagnetic Material	✓	✓		✓	✓	✓		✓	✓
Non Ferromagnetic Material			✓			✓	✓		✓
Capability of Detection	General wall loss and large volume corrosion	General wall loss and localised pitting	General wall loss, localised pritting, baffle wear and cracking (orientation dependand)	Localised pitting and cracking (orientation dependant)	General wall loss and large volume corrosion	General wall loss and localised piting Results may be limited in thin tubes	General wall loss, localised pitting, baffle wear and cracking (orientation dependant)	Localised pitting and cracking (orientation dependant)	General wall loss and localised pitting. Results may be limited in thin tubes
Normal Production Average for 12 hours	300 - 500 tubes	75 - 100 tubes 150 - 300 tubes when the boiler is flooded with water	400 - 600 tubes	300 - 500 tubes	300 - 500 tubes	100 - 500 tubes	400 - 600 tubes	300 - 500 tubes	75 - 100 tubes
Cleaning Requirement	70% Fill Factor is required for the probe and scale needs to be non magnetic	100% as this is an Ultrasonic Technique	90% Fill Factor is required for the probe and scale needs to be non magnetic	90% Fill Factor is required for the probe	70% Fill Factor is required for the probe and scale needs to be non magnetic	Bare material as this is an Ultrasonic Technique	90% Fill Factor is required for the probe and scale needs to be non magnetic	90% Fill Factor is required for the probe	100% as this is an Ultrasonic Technique
	Always remember that better tube cleaning ensure higher quality inspection with lower equipment wer and less chance for delays due to prode failire.								

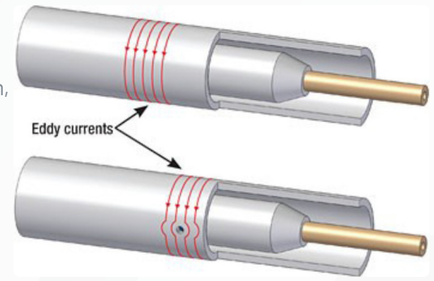
STANDARD EDDY CURRENT

Principles of the Standard Eddy Current inspection technique for tube inspection:

When a coil excited by an alternating current is brought in close proximity to a conducting material, eddy currents are generated in the material by the process of electromagnetic induction. The magnetic field associated with the eddy currents gives rise to an impedance change in the coil. The introduction of a defect into the conducting material results in a reduction and redistribution of the eddy current field and hence a further change in coil impedence. It is these changes in coil impedance, which are measured and form the basis for defect location and analysis in eddy current inspection.

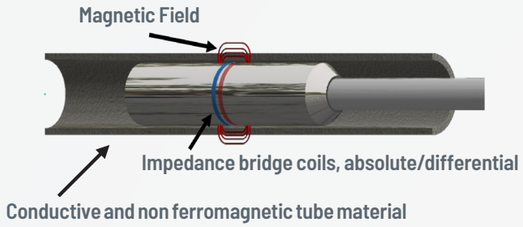
Advantages of Standard Eddy Current inspection:

- It is a very accurate technique. The eddy current technique can measure variations in generalised wall thickness down to 0.05mm, while located defects (pits) as small as 1mm can be detected and sized to an accuracy of ± 10% of the wall thickness.
- 400 to 600 tubes inspected per shift.
- Flexible probes for inspecting U bends.
- Range of 8mm to 150mm ID can be inspected.



Limitations of Standard Eddy Current inspection:

- The only real limitations are the defects within the tube sheet and circumferential cracking, can be missed. Although these limitations can be overcome by the use of specially designed probes.
- Probe Fill Factor is required to be above 80%.



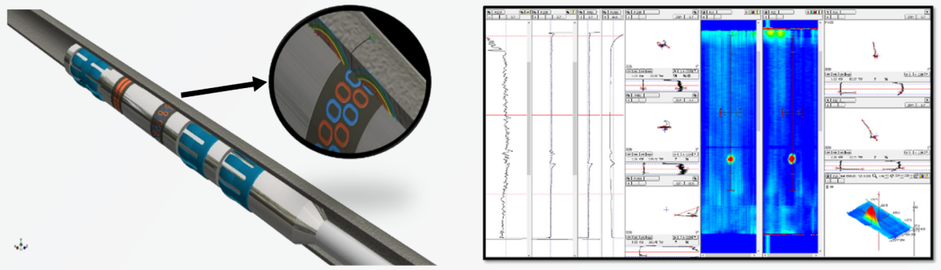
EDDY CURRENT ARRAY

Principles of the Eddy Current Array (ECA) inspection technique for tube inspection:

Eddy Current Array groups several individual coils inside a probe, where they are excited in such a way as to eliminate the interference from mutual inductance between them. This is a process referred to as multiplexing, which enables the coils to work together to thoroughly sweep the interior surface of each tube.

The ingenious coil configuration in an ECA tubing probe allows eddy currents to flow perpendicular to circumferential defects, making them much easier to isolate and characterise. This further optimises the distance between transmitter and receiver coils to make the expansion signal flat compared to other signals, making the signal easy to filter out.

Using analysis software makes using the additional data from the ECA probe to display C-scans possible. Circumferential defects, their circumferential length and depth are clearly visible in C-scans.



Advantages of Standard Eddy Current inspection:

- Quantifying the circumferential extent of crack defects.
- Accurately locating and characterising crack defects in the vicinity of the roll transition.
- Unlike rotating probes, the solution can be used for full-length tube examinations.
- C-scans give personnel without extensive eddy current testing data analysis experience the necessary confidence about their inspection results.

REMOTE FIELD EDDY CURRENT

The RFT system uses the principle of the 'Remote Field Effect'. The phase response of an input signal is changed in proportion to the wall thickness. Exciter and detection coils are typically separated by 3 to 5 times the tube diameter.

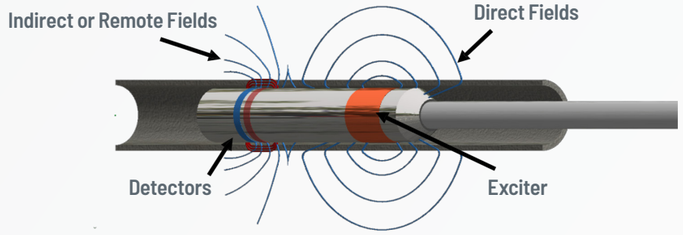
The distance between coils is such that we are operating outside the 'Direct Field' in the 'Indirect Field'.

Advantages of Remote Eddy Current inspection:

- About 300 - 500 tubes inspected per shift.
- Very effective in detecting generalised wall loss.
- Ideally suited for thick wall tubing as in boilers.
- Flexible probes for inspecting bends in boilers.
- Range of 10mm - 150mm ID can be inspected.
- Localised ind +>3mm when tube is cleaned (% of circumference).

Limitations of Remote Eddy Current inspection:

- Not sensitive to small defects =<3mm.
- Not sensitive to defects at tube ends or under baffle plates.
- Over sensitive to fins. Defect are masked by fin signals so fin tubes can't be tested.



MAGNETIC BIAS EDDY CURRENT

Definition of Magnetic Bias:

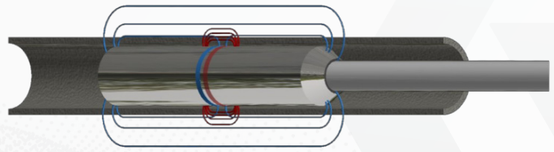
A steady magnetic field applied to the magnetic material for partial or full saturation.

Principles of the Magnetic Bias Eddy Current inspection technique for tube inspection:

When standard eddy current is applied to ferrous tubes the eddy current field is affected by the magnetic properties of the material. The Magnetic Bias probe creates a magnetic field in the material and is set to exactly the correct intensity in order to limit the effects of the magnetic properties of the material. This allows enough of the eddy currents to bypass the skin effect and penetrate the material. Defects in the material will cause a change in the permability of the material as that position as well as the amount of eddy currents at that point. The detector coil will then pick up this change in eddy currents and the system will then visually present that information on the computer screen. Full saturation can be achieved in partial magnetic materials.

Advantages of Magnetic Bias Eddy Current inspection:

- Partial magnetic materials can be inspected the same as non-magnetic materials with normal Eddy Current.
- It is a very quick screening technique for Ferro Magnetic Materials. The Magnetic Bias eddy current technique can measure localised defects (pits) as small as 2mm can be detected and sized to an accuracy of ± 10% of the wall thickness.
- 300 to 500 tubes inspected per shift.
- Although cleaning is still required only a 90% fill factor is required for the inspection.



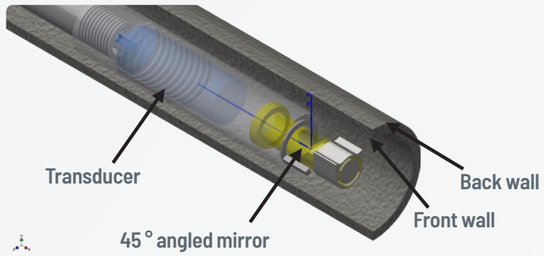
Limitations of Magnetic Bias Eddy Current inspection:

- The technique is only sensitive to localised defects such as pitting. Generalised wall loss can't be detected.
- Defect indication needs to be backed up by other techniques as spurious indications can be caused by inclusions in the material.
- Tube sizes are limited to internal diameters between 12mm and 32mm and wall thickness less than 3mm for ID's greater than 17 and 2.11 for ID's smaller than.

IRIS (INTERNAL ROTATING INSPECTION SYSTEM) TECHNIQUE

Principles of the IRIS inspection technique for tube inspection:

A beam from an ultrasonic transducer is reflected from a mirror set at 45 degrees so that the reflected ultrasonic beam impinges on the tube I.D. at right angles. Part of this beam is then reflected from the tube I.D. while the remainder is transmitted through the wall thickness and is reflected from the tube O.D. The time difference between the two reflected signals is then used to measure the tube wall thickness.



Advantages of the IRIS inspection

It is a very accurate technique. Wall thickness of measurements can be made to an accuracy within 0.1mm. It is a fairly sensitive technique. The sensitivity achieved will depend on tube dimensions and tube cleanliness. In general, it can be stated that it should be possible to detect a 1.5mm defect in up to 1inch tubing that has been properly cleaned.

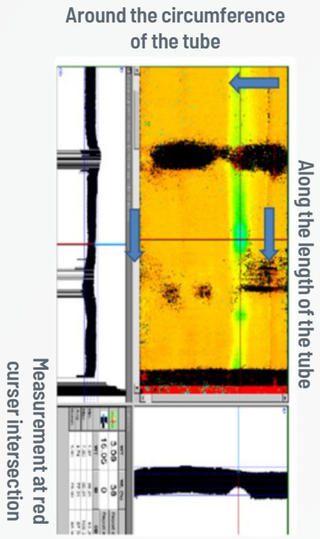
A three dimensional picture of the defect is obtained, thus the defect profile in addition to its depth is obtained.

Disadvantages of the IRIS inspection

It is a relatively slow technique as it is only possible to test an average of 100 to 150 tubes in a day.

As IRIS is an ultrasonic technique, very high levels of tube cleaning is required prior to the inspection.

Due to probe blanking, the minimum measurement possible with IRIS is between 0.4mm and 0.8mm depending on the software setup. This would mean that any defect deeper than 67% in a 1.2mm wall thickness will show as 67% and any defect deeper than 80% in a 2mm wall thickness will show as 80%.



TECHNIQUES AND APPLICATIONS

DEFHI® ECA PROBE

These probes are designed to inspect the non-ferromagnetic tubing found in condensers, feedwater heaters, and heat exchangers. They are especially good at detecting circumferential cracks at tube support plates and tube sheets (a major limitation of bobbin probes). They can also detect and size usual defects such as wear, corrosion, pitting, micro-pitting, and stress corrosion racking.

Highlights:

- Designed for non-ferromagnetic tubing.
- One-pass combination bobbin and array probe.
- Sizing of circuferential and axial cracks.
- Highly kink-resistant cable, replaceable centering devices.
- Wider frequency range (HW to HF).
- Analysis with strip charts for bobbin and C-scans for array imaging 1.
- Optimum resolution and uniform sensitivity with oval coil technology.

NET PROBE

These probes are designed to inspect aluminium-finned carbon steel tubes in fin-fan coolers. The coil configuration allows reliably detecting internal defects such as corrosion, erosion, pitting, and axial cracking. The probes are sleeved with stainless steel.

Highlights:

- Optimised for internal defect detection.
- Designed to inspect aluminum-finned carbon steel tubes in fin-fan coolers.
- Uncompromising durability.
- Stainless steel body.
- Highly kink-resistant, very flexible cable.
- Superior absolute baseline signal.
- 19-pin amphenol connector.

NFA PROBE

These probes are designed to inspect aluminum-finned carbon steel tubes of fin-fan coolers and ferromagnetic heat exchangers. The coil configuration allows reliably detecting and sizing internal defects such as ID pitting, internal cracking at the tubesheets, internal erosion and wall loss.

Highlights:

- High-resolution array scans (C-scans) of fin-fan air cooler tubes at NFT speeds.
- Axial and circumferential crack detection.
- Rugged and easy to use — no magnets.
- Hardened-steel, replaceable wear guides.
- Wide variety of probe diameters.
- Designed to inspect aluminum-finned carbon steel tubes of fin-fan coolers and ferromagnetic heat exchangers.
- Defect detection and sizing in a single pass.

DUAL-DRIVER RFT PROBE

These probes are designed to inspect the non-ferromagnetic tubing found in condensers, feedwater heaters, and heat exchangers. They are especially good at detecting circumferential cracks at tube support plates and tube sheets (a major limitation of bobbin probes). They can also detect and size usual defects such as wear, corrosion, pitting, micro-pitting, and stress corrosion racking.

These probes set a new standard in durability. They are optimised for differential signal analysis and to detect defects close to tube support plates. At 20.0 mm (0.787 in) and above, the probe's body is made of advanced, lightweight polymer. Below this diameter, the probes are sleeved with stainless steel.

These probes are particularly well suited to detecting most common defects (corrosion, erosion, wear, pitting) and in the ferromagnetic tubing of feedwater heaters, heat exchangers, and piping.

Highlights:

- Preamplifier in the probe head (30 dB).
- Optimised for differential signal analysis.
- Uncompromising durability.
- Highly kink-resistant, very flexible cable.
- Optimised for differential signal analysis.
- Low friction noise.
- 19-pin Amphenol connector.

QA AND HS&E

Sonomatic operate under an integrated QHSE management system and are committed to the highest quality and safety of service provision | ISO 9001: 2015: 00007140 | ISO 14001:2015:00037371 | ISO 45001:2018:00037372 | ISO 17020: 2012: 4276 | Achilles FPAL Verified: 076712 | SEQual 1988 | British Safety Council Member: S0388440 |

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