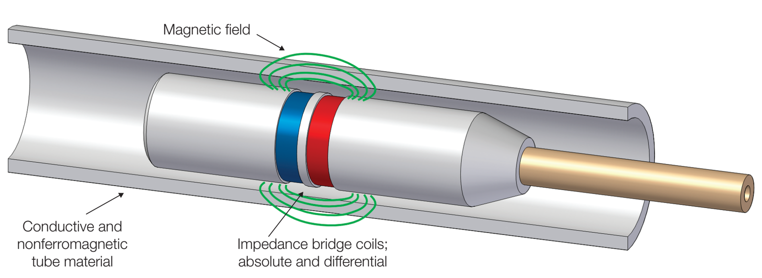
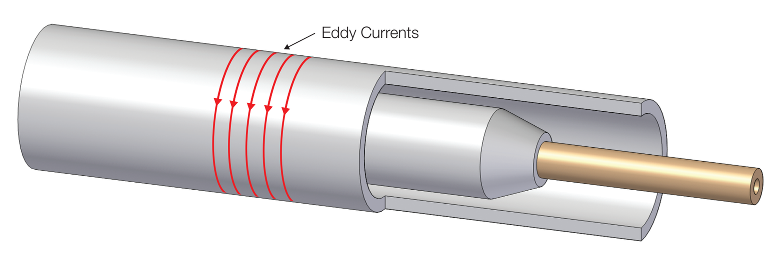
OLYMPUS®

Understanding Tube Inspection Technology

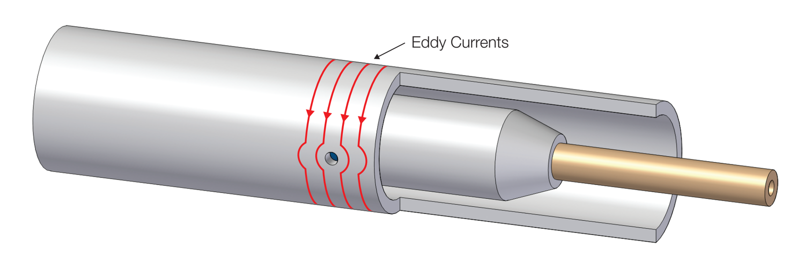
Basic Concepts of Eddy Current Testing



Two coils are excited with an alternating current, producing a magnetic field around them.

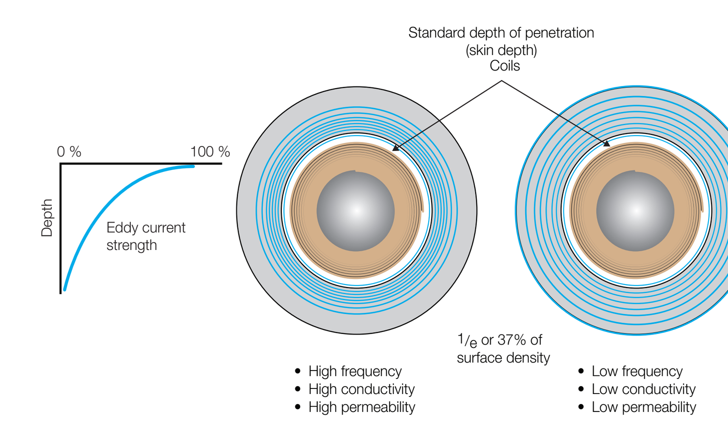


The magnetic field penetrates the tube wall and generates opposing alternating currents in the material. These currents are called "eddy currents."



The defects that change the eddy current flow change the impedance of the coils in the probe. These changes in the impedance of the coils are measured and used to detect defects in the tube.

Skin depth effect



The density of eddy currents in a material is not constant.

The density is greatest near the coil and declines as it penetrates the material.

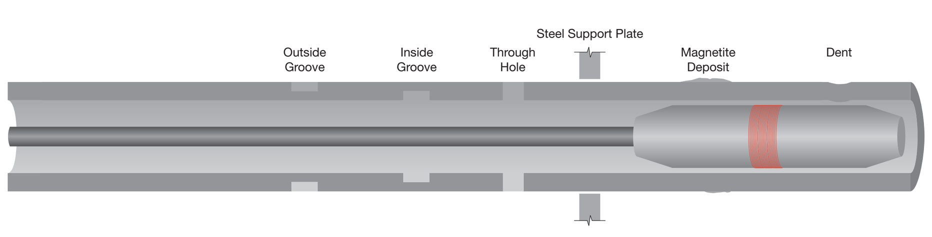
This is called the skin depth effect.

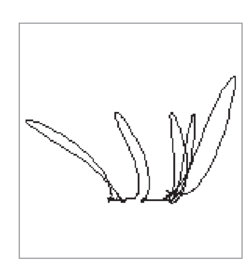
The standard depth of penetration is the depth where the eddy current density is 37% of its surface value.

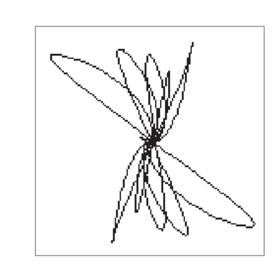
This standard depth of penetration is affected by:

- Frequency
- Conductivity
- Permeability

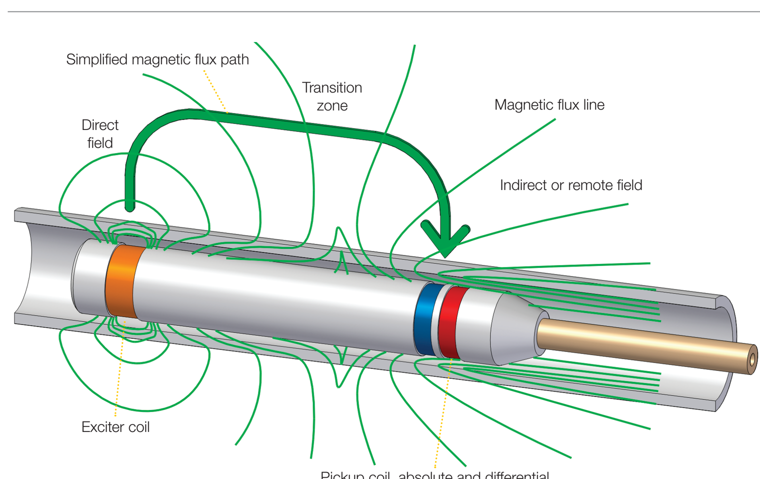
Typical defect response







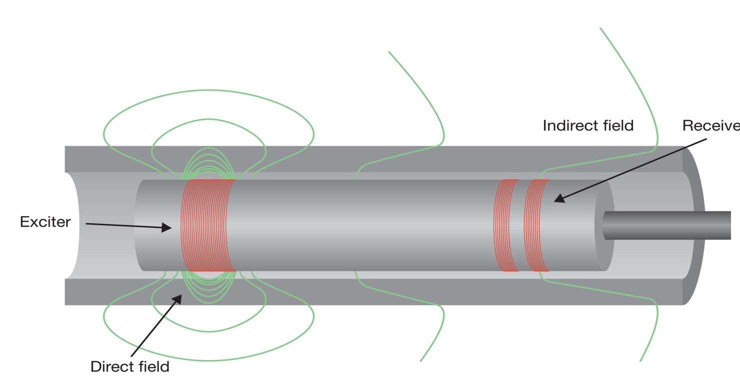
Remote Field Testing



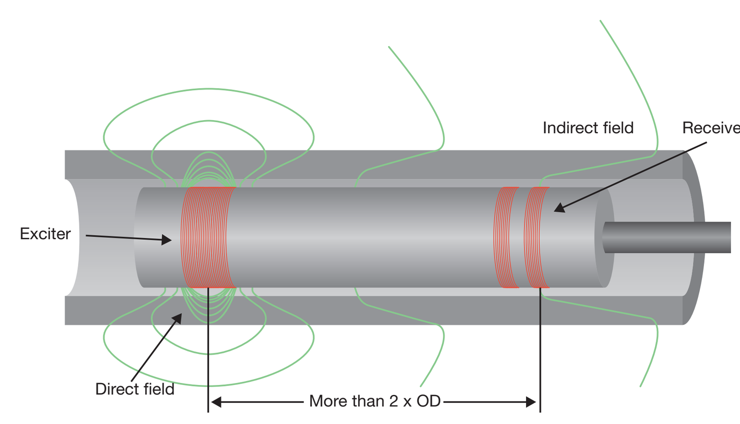
Remote field testing is a through-wall transmission technique, and the probes are used to inspect ferromagnetic tubing, such as carbon steel.

The basic probe is made of one exciter coil and two pickup (receiver) coils. Two magnetic fields are present — the direct field, near the exciter coil, and the indirect field, which propagates along the tube axis and then is rediffused back through the tube wall.

The zone where the indirect field is dominant is called the remote field. This zone is present at a distance greater than two tube diameters.

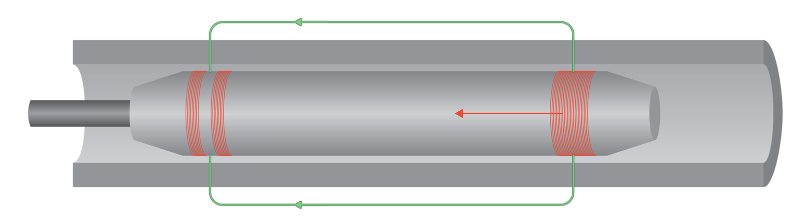


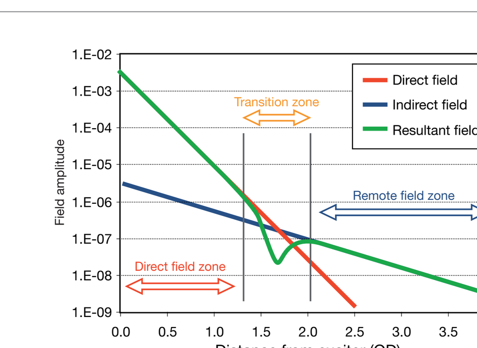
The indirect field is diffused outward through the tube wall; it then propagates along the tube axis and is then rediffused back through the tube wall.



The zone in which the indirect field is dominant is called the remote field zone. This zone is present at a distance greater than two tube diameters.

Location of remote field zone





Typical defect response

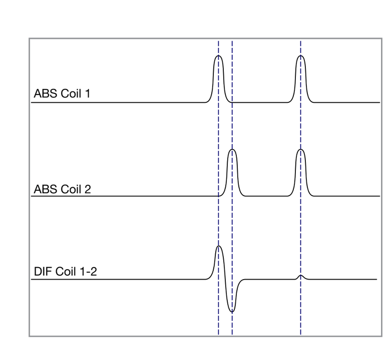
When the probe moves past a defect in the tube, the response is composed in terms of two effects:

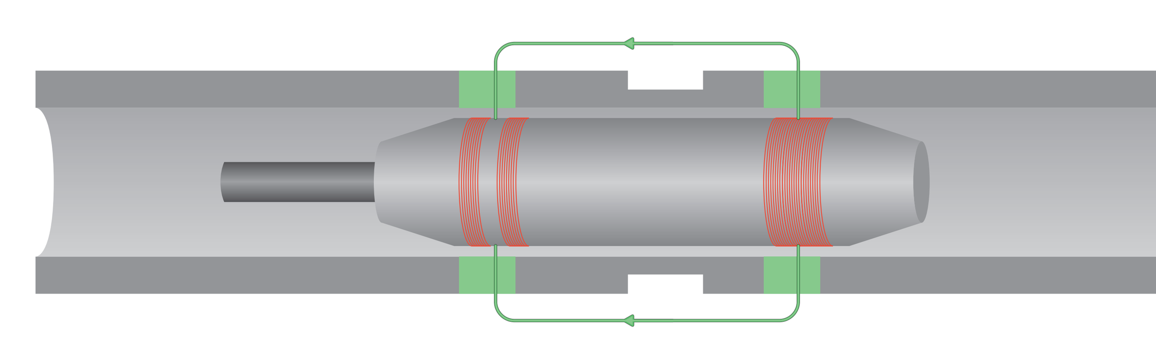
Receiver effect

- The first receiver produces a signal when it moves past the defect, and it is followed shortly after by a similar signal from the second receiver coil.
- The subtraction of both receiver signals generates the S-shaped differential signal.

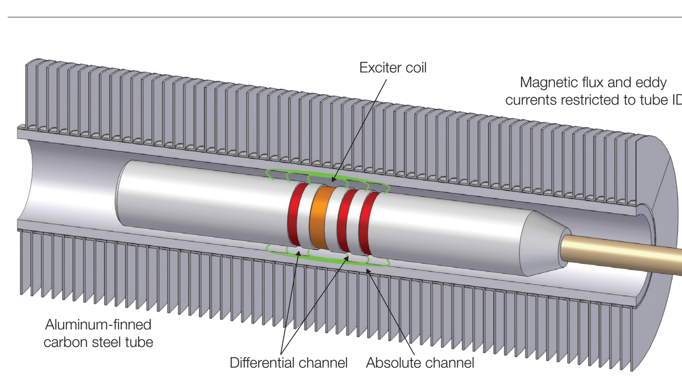
Exciter effect

- The exciter coil moves past the defect, affecting the field sensed by the receivers.
- Both receiver coils sense the exciter effect at the same time and produce almost identical signals on the absolute channel.



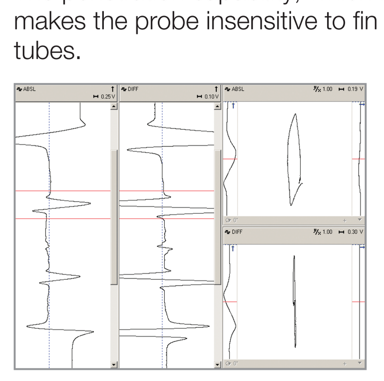


Near Field Testing

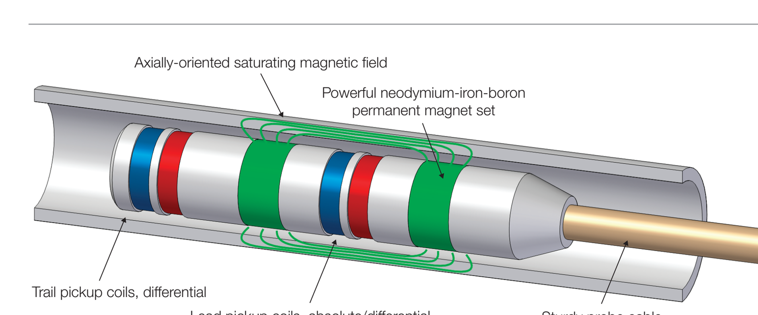


Near field testing for fin-fan tubing relies on a simple driver-pickup eddy current probe without requiring an external reference coil. It is designed to provide very simple signals for analysis. The probe measures the lift-off or fill factor and then converts it into amplitude-based signals.

The penetration capability, which is limited to the inside surface, makes the probe insensitive to fin geometry on the outside of the tubes.



Magnetic Flux Leakage



Two strong, permanent magnets, coupled to a steel core, generate a magnetic field that saturates the tube wall.

An absolute coil (ABS) is wound around the core to measure magnetic field variations caused by general wall loss.

Flux leakage is detected by a differential coil (Lead), located between the magnets.

A trailing coil (Trail), at the end of the probe, detects the residual magnetism from internal pits.

OD defect detection

If there is an outside-diameter defect located in the tube:

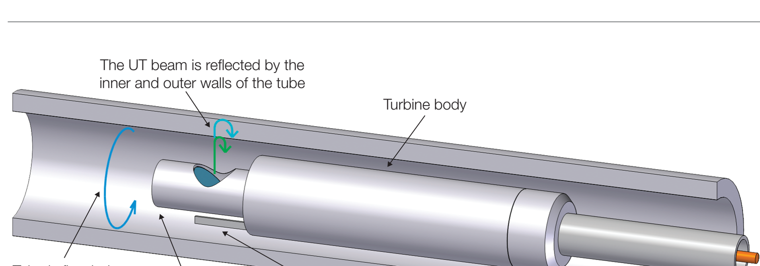
- The magnetic flux lines are not only distorted into the air outside the tube but also within the tube.
- Because the tube wall is already saturated, the flux-line distortions cannot be contained in the remaining wall, and a flux leakage is created on the inside diameter (ID).
- The lead coil can detect this flux leakage because it is located between the magnets, in the middle of the magnetic circuit.
- The trailing coil, which is outside the magnetic circuit, cannot detect the defect because there is no flux leakage inside the tube.

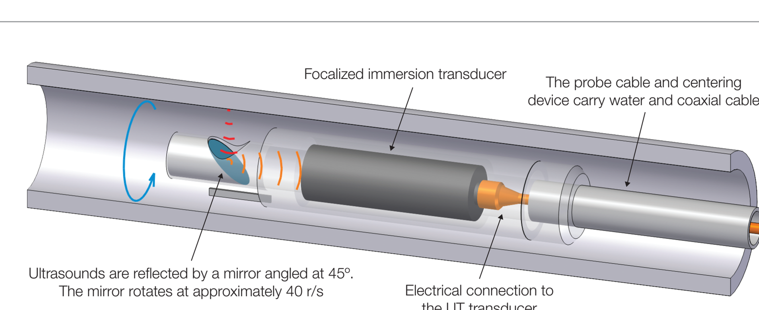
ID defect detection

If there is an inside-diameter defect located in the tube:

- The magnetic flux lines are distorted in the tube when the magnetic circuit passes the defect.
- At this point, the lead coil can detect the flux leakage.
- After the magnetic circuit passes the defect, some residual magnetism remains on the defect.
- The trailing coil detects this residual magnetism and produces a signal output.

Internal Rotary Inspection System (IRIS)

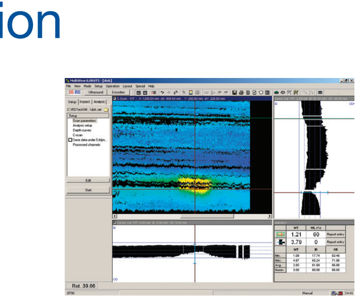


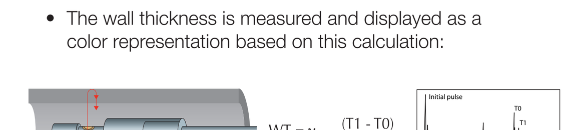


- A transducer located inside a turbine generates an ultrasonic pulse along the axis of the tube.
- The ultrasound is reflected by a mirror angled at 45° and oriented toward the tube wall.
- The ultrasound is partially reflected by the tube inside diameter (ID), then transmitted through the wall, and finally reflected by the tube outside diameter (OD).
- The ultrasonic velocity of the tube material enables the wall thickness to be calculated by using the time-of-flight difference between the OD and ID echoes.

Ultrasonic echo detection

- A detection level is set to a value that enables the detection of the synchronization pin, ID, and OD echoes.
- The first echo is named T0 and the second echo is named T1.
- If T0 is detected within the synchronization gate, a new rotation is displayed on the C-scan.
- The wall thickness is measured and displayed as a color representation based on this calculation:

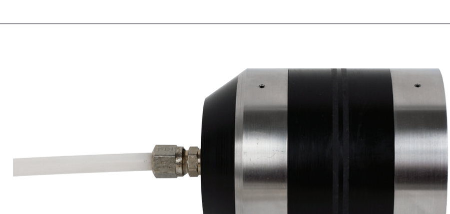




Ultrasonic path in tube

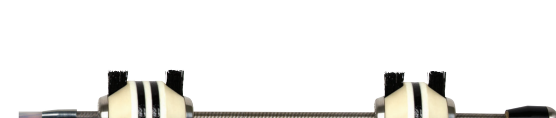
- The transducer generates an initial pulse.
- A synchronization pin generates an echo once every rotation.
- The ID echo is generated with a strong amplitude after the pin indication.
- Shortly after, the OD echo is generated with a much smaller amplitude (because the ultrasonic velocity is higher in metal than in water).

Probe Types



ECT

- Eddy current testing is used to inspect nonferrous materials including austenitic stainless steel, brass, copper-nickel, titanium, finned copper, and more.
- The eddy current technique is suitable for detecting and sizing metal discontinuities typically found in tubing applications.
- It can detect and size defects like corrosion, erosion, wear, pitting, baffle cuts, wall loss, and cracks.
- Eddy current equipment is well-suited for inspecting condenser tubing, feedwater heaters, and air conditioners.



RFT

- The remote field testing technique is used for inspecting ferromagnetic tubing such as carbon steel and ferritic stainless steel.
- RFT is very sensitive to wall loss resulting from corrosion, erosion, wear, pitting, and baffle cuts.
- Remote field equipment is perfectly suited for inspecting heat exchangers, feedwater heaters, and boiler tubes.

NFT

- The near field testing technique has been developed specifically for inspecting ferromagnetic fin-fan tubes.
- The near field is not affected by the presence of fins or by fin geometry.
- NFT does not require an external balance coil or probe.

MFL

- Magnetic flux leakage is recommended for the inspection of aluminium-finned carbon steel tubes because the magnetic flux is not affected by the presence of the fins.
- The MFL technique detects irregularities such as corrosion and steam erosion.
- It is also suitable for detecting circumferential cracks (a type of flaw that is not detected by RFT and IRIS inspections).

IRIS

- The internal rotary inspection system is an ultrasonic technique well-suited for petrochemical and balance-of-plant tube inspections.
- It measures wall thickness, material loss, and defect orientation in tubing ranging from 0.5 in. to 3 in. ID.
- The equipment is designed to inspect tube/shell heat exchangers, air coolers, and boiler tubes.

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