

# EDDY CURRENT GUIDE



# FEATURED NDT METHOD

## INSPECTION KNOWLEDGE

### Eddy Current Testing (ECT)

#### What is Eddy Current Testing?

Eddy current testing is a non-destructive testing (NDT) inspection method used for a variety of purposes, including for flaw detection, material and coating thickness measurements, material identification and establishing the heat treatment condition of certain materials.

Eddy current testing is one of several non-destructive testing methods that uses the electromagnetism principle for flaw detection in conductive materials. A specially designed coil energized with an alternating-current is placed in proximity to the test surface, generating a changing magnetic field that interacts with the test-part and produces eddy currents in the vicinity.

Variations in the changing phases and magnitude of these eddy currents are then monitored using a receiver-coil or by measuring changes to the alternate current flowing in the primary excitation-coil.

The electrical conductivity variations, the magnetic permeability of the test-part, or the presence of any discontinuities, will cause a change in the eddy current and a corresponding change in phases and amplitude of the measured current. The changes are shown on a screen and are interpreted to identify defects.

#### Standards and Calibration

All the systems must be calibrated using appropriate reference standards – as for any NDT method and is an essential part of any eddy current testing procedure. The calibration blocks must be of the same material, heat treatment condition, shape and size of the item to be tested.

For defect detection, the calibration block contains artificial defects that simulate defects, whereas, for corrosion detection, the calibration block has different thicknesses. The eddy current method requires a highly skilled operator – training is essential.

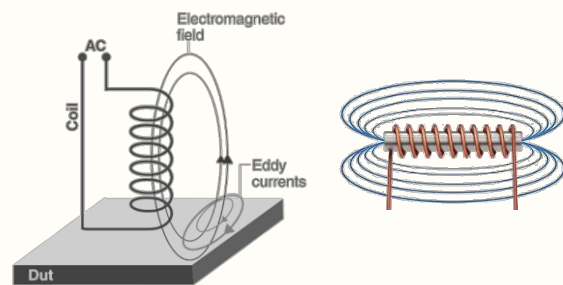


Common eddy current reference standards include:

- ▶ Conductivity standards.
- ▶ Flat plate discontinuity standards.
- ▶ Flat plate metal thinning standards. (Step or tapered wedges)
- ▶ Tube discontinuity standards.
- ▶ Tube metal thinning standards.
- ▶ Hole (with and without fastener) discontinuity standards.

#### How Does Eddy Current Testing Work?

The process relies upon a material characteristic known as electromagnetic induction. When an alternating current is passed through a conductor – a copper coil for example – an alternating magnetic field is developed around the coil and the field expands and contracts as the alternating current rises and falls. If the coil is then brought close to another electrical conductor, the fluctuating magnetic field surrounding the coil permeates the material and, by Lenz's Law, induces an eddy current to flow in the conductor. This eddy current, in turn, develops its own magnetic field. This 'secondary' magnetic field opposes the 'primary' magnetic field and thus affects the current and voltage flowing in the coil.



Any changes in the conductivity of the material being examined, such as near-surface defects or differences in thickness, will affect the magnitude of the eddy current. This change is detected using either the primary coil or the secondary detector coil, forming the basis of the eddy current testing inspection technique.

Permeability is the ease in which a material can be magnetized. The greater the permeability the smaller the depth of penetration. Non-magnetic metals such as austenitic stainless steels, aluminum and copper have very low permeability, whereas ferritic steels have a magnetic permeability several hundred times greater.

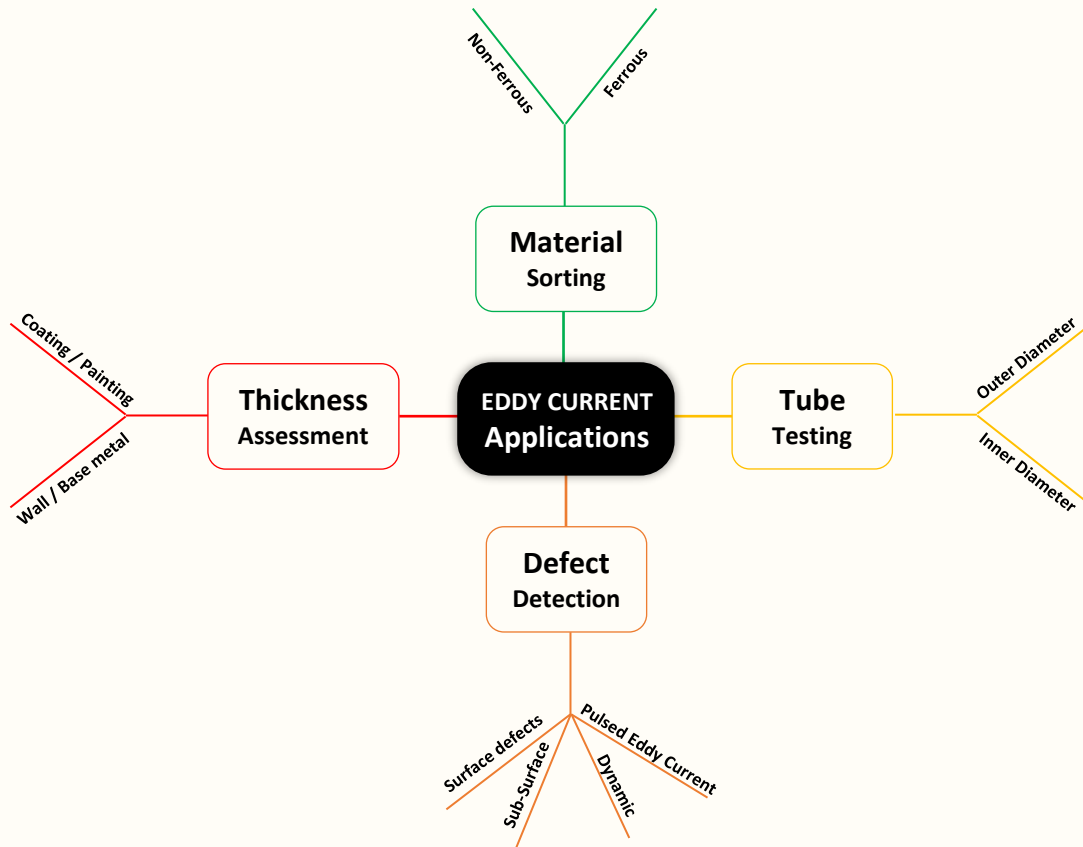
Eddy current density is higher, and defect sensitivity is greatest, at the surface and this decreases with depth. The rate of the decrease depends on the "conductivity" and "permeability" of the metal. The conductivity of the material affects the depth of penetration. There is a greater flow of eddy current at the surface in high conductivity metals and a decrease in penetration in metals such as copper and aluminum.

The depth of penetration may be varied by changing the frequency of the alternation current – the lower the frequency, the greater depth of penetration. Therefore, high frequencies can be used to detect near-surface defects and low-frequencies to detect deeper defects. Unfortunately, as the frequency is decreased to give greater penetration, the defect detection sensitivity is also reduced. There is therefore, for each test, an optimum frequency to give the required depth of penetration and sensitivity.

Continue Eddy Current Testing

ECT Applications

Inspection of parts or components including: Welded joints - Bores of in-service tubes - Bores of bolt holes - Metal tubes - Friction stir welds - Gas turbine blades - Nozzle welds in nuclear reactors - Cast Iron Bridge - Lack of fusion - Identification of both ferrous and non-ferrous metals and with certain alloys in particular the aluminum alloys - Establishing the heat treatment condition - Determining whether a coating is non-conductive - Heat treat verification of metals - Generalized corrosion (particularly in the aircraft industry for the examination of aircraft skin and more.



Eddy Current Advantages

- ▶ Able to detect surface and near-surface cracks as small as 0.5mm
- ▶ Able to detect defects through several layers, including non-conductive surface coatings, without interference from planar defects
- ▶ Non-contact method making it possible to inspect high-temperature surfaces and underwater surfaces
- ▶ Effective on test objects with physically complex geometries
- ▶ Provides immediate feedback
- ▶ Portable and light equipment
- ▶ Quick preparation time – surfaces require little pre-cleaning and couplant is not required
- ▶ Able to the measure electrical conductivity of test objects
- ▶ Can be automated for inspecting uniform parts such as

Eddy Current Limitations

- ▶ Can only be used on conductive materials.
- ▶ The depth of penetration is variable.
- ▶ Very susceptible to magnetic permeability changes – making testing of welds in ferromagnetic materials difficult – but with modern digital flaw detectors and probe design, not impossible.
- ▶ Unable to detect defects that are parallel to the test object's surface.
- ▶ Careful signal interpretation is required to differentiate between relevant and non-relevant indication.

### Continue Eddy Current Testing

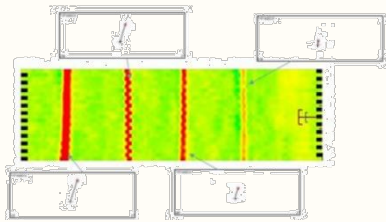
#### What is Eddy Current ARRAY?

Eddy current array and conventional eddy current technology share the same basic principle. Alternating current injected into a coil creates a magnetic field (in blue). When the coil is placed over a conductive part, opposed alternating currents (eddy currents, in red) are generated. Defects in the part disturb the path of the eddy currents (in yellow). This disturbance can be measured by the coil.

Eddy current array (ECA) is an assembly of single eddy current sensors or coils that are multiplexed in a certain order to obtain the required sensitivity. There are many different designs of eddy current probes, including flexible probes, padded probes or spring-loaded fingers.

Eddy current array (ECA) technology provides the ability to electronically drive multiple eddy current coils placed side by side in the same probe assembly. Data acquisition is performed by multiplexing the eddy current coils in a special pattern to avoid mutual inductance between the individual coils.

Most conventional eddy current flaw detection techniques can be reproduced with an ECA inspection. With the benefits of single-pass coverage, and enhanced imaging capabilities, ECA technology provides a remarkably powerful tool and significant time savings during inspections.



#### Advantages of Eddy Current Array

- ▶ Reduction in inspection time, as: The coils in the probe have been specifically arranged to cover a particular area the scanning speed can be adjusted A wider range of samples of can be inspected due to a wider range of probe types that are available
- ▶ Multi-frequency approach – possible to inspect a test object with several central frequencies simultaneously – allowing the user to assess the most optimized central frequency for the inspection
- ▶ Post analysis of results – the equipment's built-in software enables the use of filters and other process to highlight or hide certain features

#### Limitations of Eddy Current Array

- ▶ Eddy current array inspections use advanced equipment that requires additional operator training.
- ▶ Longer set-up time than a conventional eddy current inspection.

#### Industries That Benefit from Eddy Current

##### Aviation and Aerospace

Eddy current technology is commonly used for crack and corrosion detection, and conductivity testing in the aviation and aerospace industries. Eddy current equipment is highly sensitive when detecting surface and subsurface cracks and corrosion, which is important in these industries where the smallest defects could cause costly or even catastrophic failures. Conductivity testing can be used to identify and sort ferrous and nonferrous alloys, and to verify heat treatment. Eddy current devices are used to inspect wheels, struts, propellers, airframes, hubs, engine components, and other key parts.

##### Oil and Gas

Eddy current equipment is used for crack detection in welds throughout the oil and gas industry. Nondestructive testing is critical for both the integrity of equipment and the safety of petroleum refining and extraction operations. Detecting cracks in welds in metal pipelines is critical in the oil and gas industry.

##### Shipbuilding

Eddy current equipment is used for crack detection in welds in the shipbuilding industry. Weld inspection is important in shipbuilding because, if the welds fail, often the structure will fail, and this leads to costly repairs and potential health and safety risks. The most critical flaws are cracks, lack of fusion or penetration, and undercut; it is these flaws that most quality codes and standards in shipbuilding are designed to avoid. Eddy current technology is highly sensitive to surface and subsurface cracks in welds, which helps manufacturers ensure high-quality welds and respond to any damage quickly.

##### Automotive

Eddy current equipment is used for inspecting components for defects and carrying out hardness and heat-treatment testing in the automotive industry. Eddy current inspection systems can be automated and added to the manufacturing process. A machine picks up a part or component, moves it into the test position, brings the test coil down on the part or lifts the part onto the coil, and sends the signal to the instrument. Automated eddy current inspections are fast, clean, and keep the line moving. Identifying defects in the automotive industry is essential for ensuring quality control and meeting health and safety guidelines.

##### Power Generation and Chemical Refinery

Eddy current equipment is used for tube testing and weld inspection in the power generation and chemical refinery industries. These industries require precise and reliable technology to inspect critical assets and ensure safe, cost-effective operations. Eddy current equipment enables remote inspection of areas unsafe for humans to operate because of hostile and dangerous conditions. Uses for eddy current equipment in the power generation and chemical refinery industries include the inspection of turbines, primary and secondary pipes, welds and vessel components, heat exchangers, reactor vessels, nuclear fuel pools, and more. Eddy current technology provides reliable and accurate condition inspection. Unidentified defects can be catastrophic in an industry that operates with dangerous chemicals and machinery.

### Continue Eddy Current Testing

## ECT Testing of Chiller Tubes

Eddy current testing is a nondestructive testing method commonly used to inspect tubing in heat exchangers, condensers, air coolers, and other appliances. Eddy current testing is a high-speed method that can be performed to inspect through painting and coatings and is used to assess the condition and lifespan of tubes. Tubes can become damaged over time through corrosion, pitting, cracks, erosion, and other changes. Detecting these flaws is a vital process to help keep appliances working reliably and to meet certain quality and health and safety standards. Different tubes are subject to different stresses, meaning their inspection often requires different equipment and processes. In this article, we will discuss what eddy current equipment you need for inspecting chiller and heat exchanger tubes to save repair costs and ensure quality standards are met.

### Eddy Current Testing of Chiller Tubes

Chiller tubes undergo daily stress, which can lead to rust and corrosion. This rust can also infiltrate the evaporator tubes of the chillers, potentially leading to further damage to the compressor and preventing the water from chilling effectively. Common defects to look out for include:

- Pitting.
- Freeze ruptures.
- External corrosion.
- Internal pitting.

Left untreated, these flaws can lead to costly repairs. This is why regular nondestructive testing is used to help detect these malformations early.

### Chiller Tube Inspection Equipment

Using eddy current testing equipment on chiller tubes is a proven and effective flaw detection method. Any irregularities will disrupt the eddy current flow generated by the probe, signaling to the user that there may be a flaw in the test material. The ideal equipment for chiller tube inspection includes a testing instrument that enables simultaneous injections and multiplexed frequencies. These two features result in:

- Improved efficiency
- Increased inspection speed
- Remote field testing (RFT)

The multitiered frequency is used to detect a range of flaws, from surface cracks to irregularities deep below the surface. You should look for chiller tube inspection equipment that can be used to inspect most tubing materials, including carbon steel or magnetic alloys. Using cutting-edge technology can help inspectors detect these flaws when they're beginning to develop, eliminating costly overhead costs further down the line. This makes investing in effective instrumentation important when inspecting chiller tubes.

Eddy current testing is an efficient choice for the inspection of chiller tubes.

## ECT Testing of Heat Exchanger Tubes

Eddy current testing equipment is also a reliable and highly effective method for measuring wall thickness and cracks in heat exchanger tubes. Like chiller tubes, inspection of heat exchanger tubes requires quality instrumentation to accurately identify defects at an early stage. High-fluid pressure causes expansions and contractions in heat exchanger tubes, making them more susceptible to surface and subsurface defects.

### Heat Exchanger Tube Inspection Equipment

Users have two primary choices when it comes to eddy current equipment for heat exchanger tube inspection. A testing instrument combining multiplex and simultaneous injection will lead to faster inspection times and more accurate data, these are used solely for heat exchanger testing. Another option would be a tubing/surface instrument, which can be used for heat exchange inspection along with other applications.

Multiplex eddy current equipment enables you to test all the different tube types, which is ideal for users who want to use their instrument for a diverse range of applications. These devices can be used for detecting abnormalities, such as cracking, pitting, and cuts. They can also be used for remote field testing (RFT), enabling users to obtain accurate data in any testing radius. Using a device with multiplex technology, users can take advantage of:

- Enhanced detection probability for surface and subsurface flaws
- SI technology that increases inspection time, enables RFT, and supports multiple coil frequencies.

A final option for users looking to use eddy current technology to inspect heat exchanger tubes is remote acquisition units with tubing and surface array configurations. This enables the detection of surface and subsurface indications using surface array.

The best eddy current testing equipment for heat exchanger tubes should possess the following features:

- Superior detection quality
- Lightweight portability
- Automated analysis software
- Fast inspection speed

The software is one of the most important aspects when it comes to choosing to eddy current testing equipment for tubes. Your software should be able to provide fast analysis results and reporting as data is acquired, as well as being capable of distinguishing between circumferential and axial indicators. Quality should be a serious consideration when investing in eddy current technology for heat exchanger tube testing. Inferior equipment can lead to missed flaws, operational failures, and inflated repair costs.

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