QUANTUM NDT

Excellence Certified

Registered Office:
402, Berry's Flat, 9, Patel Colony,
B/H Dinesh Mill, Akota, Vadodara,
Gujarat - 390005

Corporate Office:
FF-19, Fourth Floor, Yogiraj Hub,
Nr. Sayajipura Water Tank, New Karelibaug,
Vadodara, Gujarat - 390019 IN

www.qndt.in
qndtindia@gmail.com
+91-9909922252/+91-9722335111

❖ Introduction

Quantum NDT Private Limited is an inspection service provider based in Gujarat, India. It is designed to cater the requirements of Oil & Gas, Petrochemical, Power Utility, Marine, Fertilizer, Chemical, Cement, Heavy Engineering and Foundry Industries in India and abroad. Quantum NDT provides conventional as well as advanced Non-Destructive Testing (NDT) & Allied Engineering Services with specialists in all aspects of NDT. Its engineering codes & practices to enchant to the stringent needs of various clients around the globe.

The company currently provides services to various Government, Semi government & Private sector organization in India & abroad. It has been diversified into state of art inspection solutions for heat exchanger tube inspection, storage tanks and pressure vessel inspection, rapid pipeline and plant piping corrosion screening and inspection and has interests in providing other maintenance related advanced as well as conventional NDT inspection services.

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❖ What we do

We offer experienced and cost-effective professional guidance and provide quality independent and confidential services. Our main focus areas are:

- Advanced NDT Techniques
  - Eddy Current Testing (ECT)
  - Remote Field Testing (RFT)
  - Magnetic Flux Leakage (MFL)
  - Near Field Testing (NFT)
  - Internal Rotary Inspection System (IRIS)
  - Remote Visual Inspection (RVI) (Boroscopy)
  - Thermography
  - Helium Leak Testing
  - Phased Array Ultrasonic Testing (PAUT)
  - Long Range Ultrasonic Testing (LRUT)
  - High Temperature Hydrogen Attack (HTHA)

- Conventional NDT Techniques
  - Visual Testing (VT)
  - Surface Eddy Current Testing
  - Ultrasonic Testing (UT)
  - Magnetic Particle Inspection (MPI)
  - Dye Penetrant Testing (DPT)
  - Radiography Testing (RT)
  - Positive Material Identification (PMI)
  - Hardness Testing (HT)
  - Oxide Scale Measurement
  - Holiday Testing (Spark Test)
  - In-Situ Metallography

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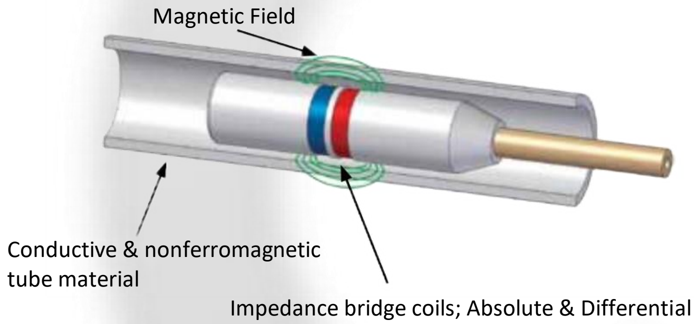
❖ Advanced NDT Techniques

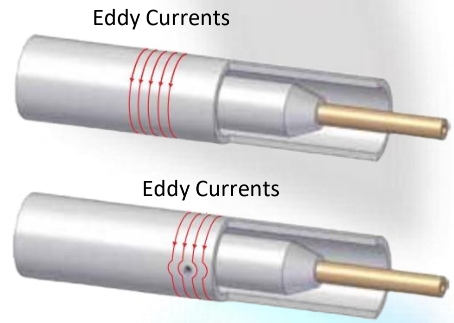
➢ Eddy Current Testing (ECT)

Eddy current testing is a noncontact method used to inspect non-ferromagnetic tubing. This technique is suitable for detecting and sizing metal discontinuities such as corrosion, erosion, wear, pitting, baffle cuts, wall loss, and cracks in nonferrous materials.

Two coils are excited with an electrical current, producing a magnetic field around them. The magnetic fields penetrate the tube material and generate opposing alternating currents in the material. These currents are called eddy currents.

Any defects that change the eddy current flow also 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.





Application:

- Condensers
- Feed water heaters
- Coolers
- Evaporators
- Chillers

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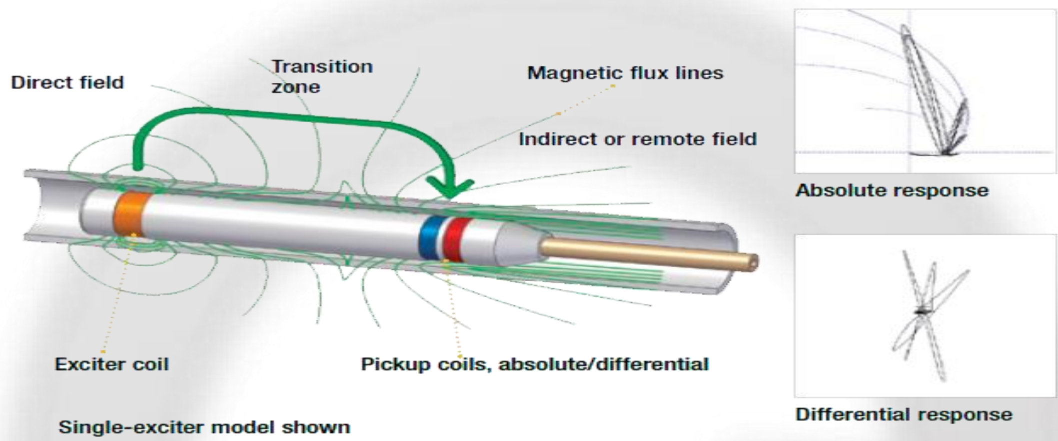
➢ Remote Field Testing (RFT)

Remote field testing (RFT) is being used to successfully inspect ferromagnetic tubing such as carbon steel or ferritic stainless steel. This technology offers good sensitivity when detecting and measuring volumetric defects resulting from erosion, corrosion, wear, and baffle cuts.



Application:

- Boiler Generating Bank tubes
- Feed Water Heaters
- Carbon Steel Heat Exchangers

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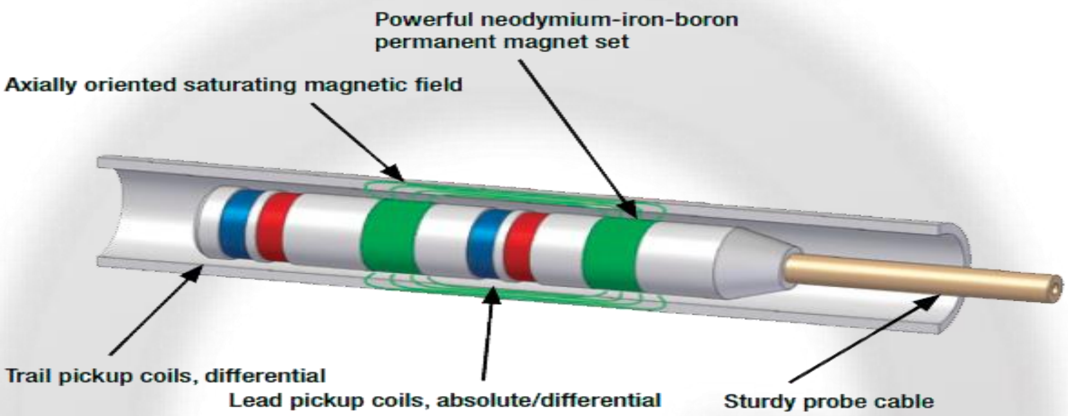
Magnetic Flux Leakage (MFL)

Magnetic flux leakage (MFL) is a fast inspection technique, suitable for measuring wall loss and detecting sharp defects such as pitting, grooving, and circumferential cracks. MFL is effective for aluminum-finned carbon steel tubes, because the magnetic field is almost completely unaffected by the presence of such fins.



Application:

- Air Coolers
- Feed Water Heaters
- Carbon Steel Heat Exchangers

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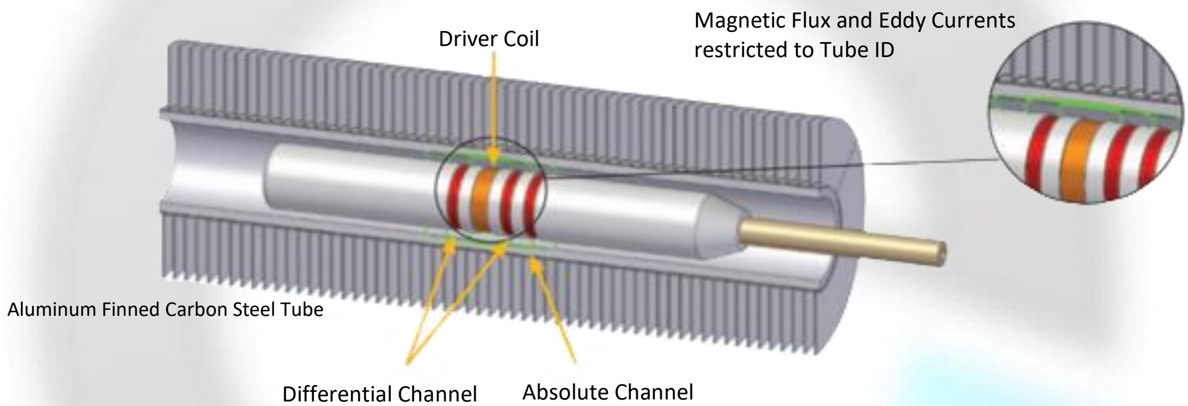
➢ Near Field Testing (NFT)

Near field testing (NFT) technology is a rapid and inexpensive solution intended specifically for fin-fan carbon-steel tubing inspection. This new technology relies on a simple driver-pickup eddy current probe design providing very simple signal analysis.

NFT is specifically suited to the detection of internal corrosion, erosion, or pitting on the inside of carbon steel tubing. The NFT probes measure lift-off or "fill factor," and convert it to amplitude-based signals (no phase analysis). Because the eddy current penetration is limited to the inner surface of the tube, NFT probes are not affected by the fin geometry on the outside of the tubes.



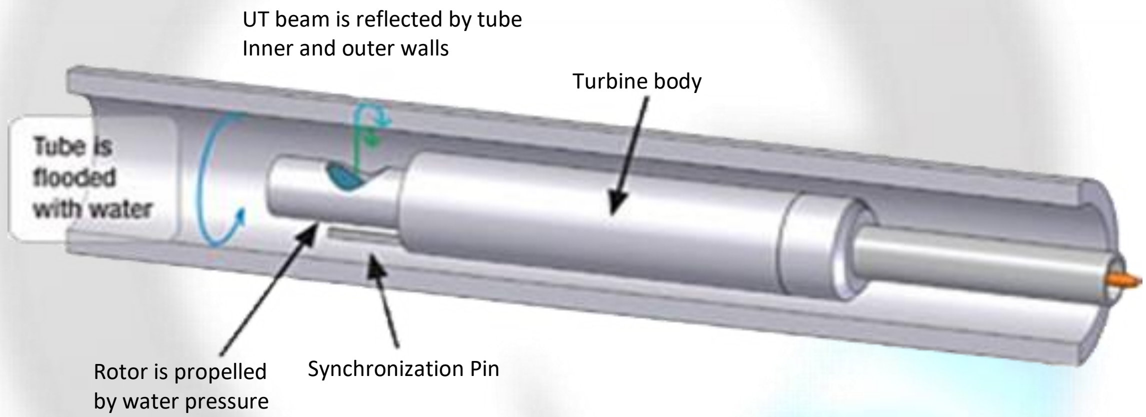
Application:

- Air Coolers
- Carbon Steel Heat Exchangers

➢ Internal Rotary Inspection System (IRIS)

The ultrasonic IRIS option is used to inspect a wide range of materials, including ferrous, nonferrous, and nonmetallic tubing. This technique detects and sizes wall loss resulting from corrosion, erosion, wear, pitting, cracking, and baffle cuts. Olympus digital IRIS inspection technology is used extensively as a prove-up technique for remote field testing, magnetic flux leakage, and eddy current inspections. The system uses an immersion pulse echo technique in which a stream of water is used to spin a turbine containing the transducer. The turbine rotates a mirror, set at 45 degrees, to reflect the ultrasonic pulses radially into the tube wall. Reflections from the inner and outer walls of the tube follow the same path back to the transducer. The time interval between the first echo (the inner wall) and the second echo (the outer tube wall) measures the tube's wall thickness.

One hundred percent of the tube is inspected through a helical path, which is created when the transducer head traverses through the tube.



Application:

- Boiler Gen Bank tubes
- Feed Water Heaters
- Air Coolers
- Heat Exchangers

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➢ Remote Visual Inspection (RVI)

Remote Visual Inspection (Videoscopy) allows us to inspect the areas or objects which are hard to reach for human eyes without dismantling the machine or its surrounding structure. Videoscopy allows us to identify the discontinuities like surface defects, poor welding, pitting, corrosion, degradation, blockages, foreign material etc. before they cause any major problems.

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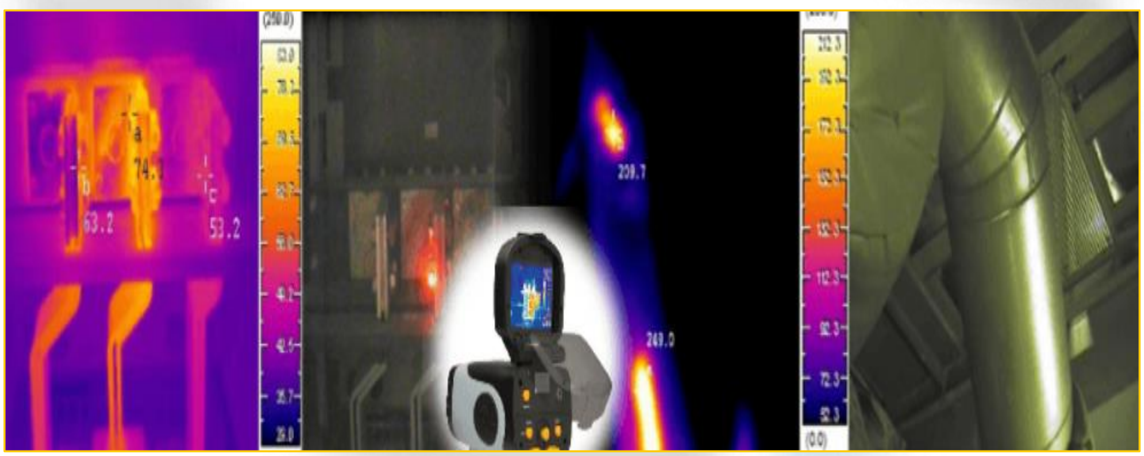
➢ Thermography

Thermography is a method of inspecting electrical and mechanical equipment by obtaining heat dissipating pictures. This inspection method is based on the fact that most components in a system show an increase in temperature when malfunctioning. The increase in temperature in an electrical circuit could be due to lose connections or a worn bearing in the case of mechanical equipment. By observing the heat patterns in operational system components, faults can be located and their seriousness evaluated.

The inspection tool used by Thermographer is the Thermal Imager. These are sophisticated devices which measure the natural emissions of infrared radiation from a heated object and produce a thermal picture. Modern Thermal Imagers are portable with easily operated controls. As physical contact with the system is not required, inspection can be made under fully operational conditions resulting in no loss of production or downtime.

Potential applications include:

- Inspection of panels / electrical equipment
- Inspection of mechanical / rotating equipment



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Helium Leak Testing

Helium is the best choice of tracer gas to find leaks for a number of reasons. It is non-toxic, inert, non-condensable, non-flammable and not normally present in the atmosphere at more than trace amounts (5 ppm). Due to its small atomic size, helium passes easily through leaks. The only molecule smaller than Helium is Hydrogen which is not inert. It is also relatively inexpensive and is available in various size cylinders.

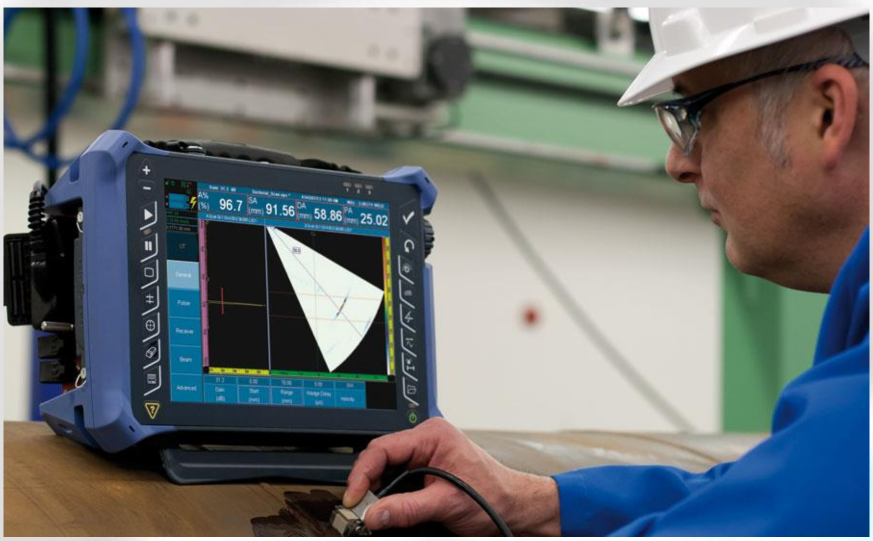
A helium leak detector, also known as a Mass Spectrometer Leak Detector (MSLD), is used to locate and measure the size of leaks into or out of a system or containing device. The tracer gas, helium, is introduced to a test part that is connected to the leak detector. The helium leaking through the test part enters through the system and this partial pressure is measured and the results are displayed on a meter.

Helium Leak Detection Applications

Quality control of production parts and assemblies using helium leak detectors can help assure the integrity of your production process. Typical examples include: hermetically sealed packages, valves, manifolding, seals, vacuum vessels and systems, medical devices, high purity piping, brake lines, fuel lines, hydraulic lines, refrigeration assemblies, radiators, heat exchangers, condensers, storage tanks.

➢ Phased Array Ultrasonic Testing (PAUT)

An array transducer is simply one that contains a number of separate elements in a single housing, and phasing refers to how those elements are sequentially pulsed. A phased array system is normally based around a specialized ultrasonic transducer that contains many individual elements (typically from 16 to 256) that can be pulsed separately in a programmed pattern. These transducers may be used with various types of wedges, in a contact mode, or in immersion testing. Their shape may be square, rectangular, or round, and test frequencies are most commonly in the range from 1 to 10 MHz.



Phased array systems pulse and receive from multiple elements of an array. These elements are pulsed in such a way as to cause multiple beam components to combine with each other and form a single wave front traveling in the desired direction. Similarly, the receiver function combines the input from multiple elements into a single presentation.

Because phasing technology permits electronic beam shaping and steering, it is possible to generate a vast number of different ultrasonic beam profiles from a single probe assembly, and this beam steering can be dynamically programmed to create electronic scans:

This enables the following capabilities:

- Software control of beam angle, focal distance, and beam spot size. These parameters can be dynamically scanned at each inspection point to optimize incident angle and signal-to-noise for each part geometry.
- Multiple-angle inspection can be performed with a single, small, multi-element probe and wedge, offering either single fixed angles or a scan through a range of angles.
- These capabilities provide greater flexibility for inspection of complex geometries and tests in which part geometry limits access.
- Multiplexing across many elements allows motionless high-speed scans from a single transducer position. More than one scan may be performed from a single location with various inspection angles.

Advantages:

Ultrasonic phased array systems can potentially be employed in almost any test where conventional ultrasonic flaw detectors have traditionally been used. Weld inspection and crack detection are the most important applications, and these tests are done across a wide range of industries including aerospace, power generation, petrochemical, metal billet and tubular goods suppliers, pipeline construction and maintenance, structural metals, and general manufacturing. Phased arrays can also be effectively used to profile remaining wall thickness in corrosion survey applications.

The benefits of phased array technology over conventional UT come from its ability to use multiple elements to steer, focus and scan beams with a single transducer assembly. Beam steering, commonly referred to sectorial scanning, can be used for mapping components at appropriate angles. This can greatly simplify the inspection of components with complex geometry. The small footprint of the transducer and the ability to sweep the beam without moving the probe also aids inspection of such components in situations where there is limited access for mechanical scanning. Sectorial scanning is also typically used for weld inspection. The ability to test welds with multiple angles from a single probe greatly increases the probability of detection of anomalies. Electronic focusing permits optimizing the beam shape and size at the expected defect location, as well as further optimizing probability of detection. The ability to focus at multiple depths also improves the ability for sizing critical defects for volumetric inspections. Focusing can significantly improve signal-to-noise ratio in challenging applications, and electronic scanning across many groups of elements allows for C-Scan images to be produced very rapidly.

Long Range Ultrasonic Testing (LRUT)

Pipelines and piping with limited external accessibility, e.g. at road crossings, buried |pipe, insulated pipe, overhead piping with limited access or other barriers to inspection could conventionally only be examined with very high and costly effort. Long Range Ultrasonic Testing ("LRUT") service is fast and cost-effective. LRUT provides efficient screening of long pipe sections for corrosion and other damage mechanisms. From a single measurement location, LRUT emits guided waves to reach distant pipes and to those considered inaccessible via other means of inspection.

Pipeline systems in operation include insulated and buried sections with challenging and difficult-to-access areas, such as those located at high elevation. Conventionally, inspecting them is time-consuming and costly. Visual examination by qualified piping personnel is key to identifying threats. However, as corrosion and other damage mechanisms are typically a hidden threat, a visual examination is often not sufficient. Access for inspection is not always ideal due to the increased risk of product release and associated health, safety, and environmental risks.

LRUT technology provides a new approach to pipeline inspection. Using low frequency ultrasound guided waves traveling along the pipe offers 100% coverage of the pipe wall without moving the transducer tool/from a single measurement location. Besides, itt offers several advantages over conventional inspection methods. It is an efficient and effective method to quickly review long sections of pipe assets for possible integrity issues such as corrosion or damage including accurate position information of identified features. The LRUT technology works effectively while the piping system operates, including insulated and buried sections. Only a ring of transducers is fitted around the pipeline at an accessible location; the transducers generate and receive low-frequency ultrasonic guided waves along the pipe. The returning echoes generate reference signals making it possible to identify defects such as corrosion and other anomalies. Typical test ranges of ±30m (±98ft) can be achieved from a single location (60m/197ft in both directions), with up to 150m (450ft) under ideal conditions.

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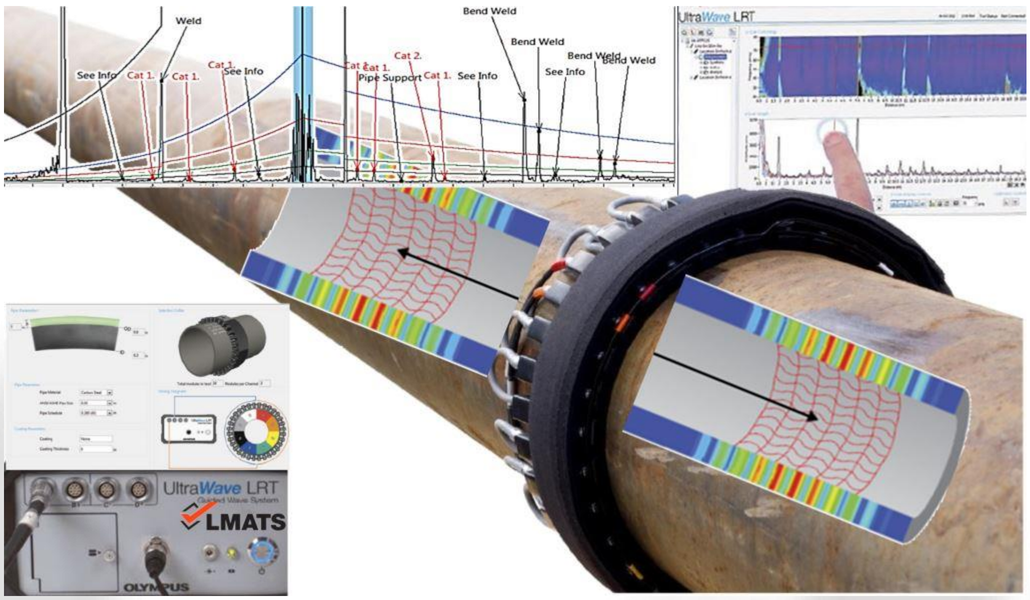

KEY ADVANTAGES:

- Rapid screening with 100% coverage.
- Screening long sections of pipe at once / in one measurement.
- No need for a liquid couplant, which is necessary for conventional ultrasonic testing.
- Maintenance cost reduction by not having to remove the insulation or coating.
- Reliable detection of internal and external metal loss (corrosion/erosion) even under insulation.
- Focusing capability to evaluate corrosion distribution around pipe circumference.
- Ideal where conventional testing is impossible or very costly, e.g. clamped, insulated, elevated or buried pipes, road crossings, offshore pipes, etc.
- Testing of elevated or complex piping from convenient locations.
- Direct onsite data review.
- Pipe diameter range from 6'' to 78'' is standard. (For pipe diameters 2", 3" and 4'' a smaller version is available).

+91-9909922252/+91-9722335111
qndtindia@gmail.com / info@qndt.in
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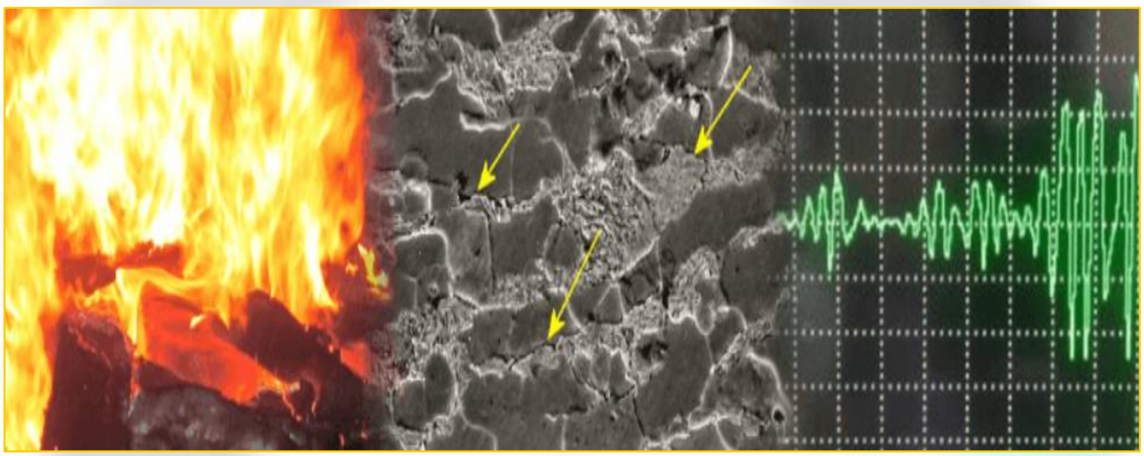
➢ High Temperature Hydrogen Attack (HTHA)

High temperature hydrogen attack (HTHA) is observed in steels exposed to temperature above 200 °C. At high temperature atomic hydrogen diffuses in steel. This hydrogen reacts with carbon of steel and forms CH4. The methane so formed bubbles at grain boundary and forms voids at grain boundary.
MC + 4H = M + CH4
These bubbles exert pressure and also coalesce resulting in to fissures. The growth of voids and fissures weakens the metal and the fissures develop in to major crack. This reaction decarburizes the steel, produces micro cracks/fissures and lowers toughness of steel but not necessarily cause loss in thickness.



The procedure for testing is based on API 941 using different approaches like:

- Attenuation measurement
- Velocity measurement
- Spectral analysis
- Analyzing back scattered signals
- Testing weld joints and HAZ using high frequency shear wave ultrasound
- Advanced ultrasonic testing like Phased array and TOFD

Extent of damage by HTHA can be assessed using above techniques and also testing from inside using other techniques like WFMPI (Wet fluorescent magnetic particle inspection), in-situ metallography and hardness testing. Testing from both the sides overcomes the limitations as encountered during testing from outside only.

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❖ Conventional NDT Techniques

➢ Visual Testing (VT)

Visual testing (VT) is the oldest and most common nondestructive testing (NDT) techniques. It is typically the first step in the examination process to inspect a variety of product forms including castings, forgings, machined components and weld elements.

Compared to other techniques, visual testing is low in cost and easy to apply, and often eliminates the need for further types of testing. Some of the industries that use VT include structural steel, automotive, petrochemical, power generation, and aerospace.

Visual inspection is the process of examination and evaluation of systems and components by use of human sensory systems aided only by mechanical enhancements to sensory input such as magnifiers, dental picks, stethoscopes, and the like. The inspection process may be done using such behaviors as looking, listening, feeling, smelling, shaking, and twisting.

It includes a cognitive component wherein observations are correlated with knowledge of structure and with descriptions and diagrams from service literature.

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➢ Surface Eddy Current Testing

Advanced portable eddy current (EC) flaw detectors inspect metallic parts and perform highly reliable flaw detection of surface and near-surface defects. Eddy current probes generate magnetic fields that induce current that flows in a test piece influencing the magnetic field and magnitude and phase of voltage in the coil. Applications include the detection of surface or near-surface defects, alloy sorting, and the inspection of bolt holes.

Applications:

- Aircraft inspection for cracks and corrosion damage
- Material sorting
- Bolt-hole defect detection
- Heat exchanger examination to ASME code
- General static as well as dynamic eddy current tests
- Conductivity measurement options
- Coating thickness measurement options

+91-9909922252/+91-9722335111

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➢ Ultrasonic Testing (UT)

Ultrasonic testing (UT) uses high frequency sound energy to conduct examinations and make measurements. Ultrasonic inspection can be used for flaw detection/evaluation, dimensional measurements, material characterization, and more.

A typical UT inspection system consists of several functional units, such as the pulser/receiver, transducer, and display devices. A pulser/receiver is an electronic device that can produce high voltage electrical pulses. Driven by the pulser, the transducer generates high frequency ultrasonic energy. The sound energy is introduced and propagates through the materials in the form of waves. When there is a discontinuity (such as a crack) in the wave path, part of the energy will be reflected back from the flaw surface. The reflected wave signal is transformed into an electrical signal by the transducer and is displayed on a screen. In the applet, the reflected signal strength is displayed versus the time from signal generation to when a echo was received. Signal travel time can be directly related to the distance that the signal travelled. From the signal, information about the reflector location, size, orientation and other features can sometimes be gained.

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Advantages of Ultrasonic Testing

- It is sensitive to both surface and subsurface discontinuities.
- The depth of penetration for flaw detection or measurement is superior to other NDT methods.
- Only single-sided access is needed when the pulse-echo technique is used.
- It is highly accurate in determining reflector position and estimating size and shape.
- Minimal part preparation is required.
- Electronic equipment provides instantaneous results.
- Detailed images can be produced with automated systems.

Magnetic Particle Inspection (MPI)

An extremely cost-effective method for the detection of surface and near surface flaws in ferromagnetic materials, MPI is primarily used for crack detection. Following magnetization, the specimen is covered with a detection medium (ferrous oxide particles), either dry or suspended in a liquid. Surface breaking flaws distort the magnetic field causing local magnetic flux leakage that attracts the detection medium producing a buildup that can be seen visually.

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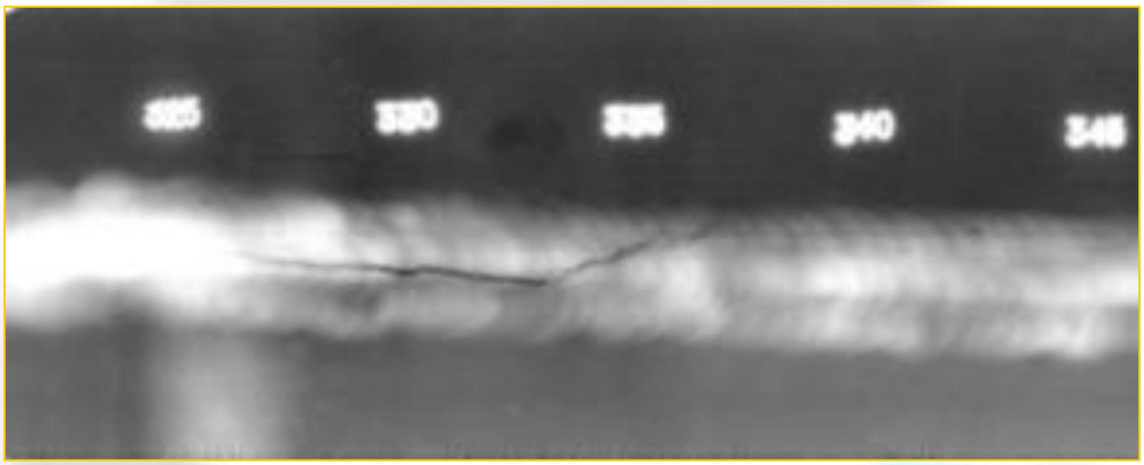
Dye Penetrant Testing (DPT)

DPT is low cost method of detecting surface breaking flaws, such as cracks, cold laps, porosity etc. Dye penetrant is drawn into a surface breaking flaw by capillary action and excess surface penetrant is then removed; a developer is then applied to the surface, drawing out the penetrant in the crack and producing a surface indication. The technique can be applied to many non-porous clean materials, metallic or non-metallic.

➢ Radiography Testing (RT)

A well-established NDT technique, radiography uses gamma-rays or x-rays to produce the image of an object onto film. The source of radiation is either an x-ray tube, which is normally described by the electrical voltage across the x-ray tube with the higher the voltage the higher the penetrating power of the radiation or a sealed source of radioactive material emitting gamma-rays: iridium 192, cobalt 60, selenium 75, ytterbium 169. Applications include wall loss detection and sizing in pipes and plate through to manufacturing defects in welds, forgings castings etc.



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➢ Positive Material Identification (PMI)

It has been a long-established fact that a minor mix-up in the material could result in a major mishap and huge financial losses for the user. In order to prevent this from happening, all quality conscious project managers are increasingly prescribing Positive Material Identification (PMI) at each stage of plant commissioning. Mix-up can be at the vendor's end, during storage at the user end or at the time of actual fabrication. Thus, if PMI exercise is done at all these levels, a 100% confidence can be built up as far as material mix-up is concerned.

In view of this requirement of Indian Industry, Quantum NDT provides PMI services with state of art Niton XL2-800 equipment. Niton XL2-800 will be able to analyse alloying elements like Mn, Cr, Ni, Nb, V, Ti, Cb, Mo, W, V. Please note, we would not be able to analyse elements like C, S, P, Si, N by this equipment.

We can also provide services for portable Spectro which would be in a position to analyse elements like C, S, P, Si using Arc Met 8000.

We can analyze carbon wherever we can get a good 25 X 25 mm flat surface. Also note that 'Arc Met' cannot be used for smaller size pipes and fittings. Its best performance is for larger than 50 NB size. For optical emissions-based PMI, we need 99.99% pure argon gas as well. It is important to note that for use of portable OES, surfaces need to be grinded and flattened to at least 25 X 25 mm size in order to generate a spark from the OES. If the samples do not permit them being flattened then analysis may not be possible with the portable OES. Due to the weight and the expensive nature of the OES machine, it is not possible to use this machine at high altitudes. The machine cannot be used on scaffolding unless proper platform arrangements are made.

Potential applications include:

- Inspection of panels / electrical equipment
- Inspection of mechanical / rotating equipment

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➢ Hardness Testing

The Leeb Rebound Hardness Test (LRHT) is one of the four most used methods for testing metal hardness. This portable method is mainly used for testing sufficiently large workpieces (mainly above 1 kg). It measures the coefficient of restitution. It is a form of nondestructive testing.

Advantages and Application:

- The assembled machinery and permanently installed parts
- Die cavity of molds
- Heavy work pieces
- Failure analysis of pressure vessel, steam turbo-generator set and other equipment
- Narrow testing space where work piece Installed
- Bearings and other parts
- Case which require the test result with normalized original recording
- Material identification of the metal material warehouse
- Quick tests of large range and multipoint measuring positions of heavy workpiece

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Oxide Scale Measurement

The very high temperatures found inside steam boilers (in excess of 1500 °F (800 °C) can cause the formation of a specific type of hard, brittle iron oxide called magnetite on the inside and outside surfaces of steel boiler tubing. At very high temperatures, water vapor will react with the iron in the steel to form magnetite and hydrogen.

The speed of this reaction increases with temperature. Oxygen atoms will diffuse inward through the magnetite layer, and iron atoms will diffuse outward, so the scale continues to grow even after the tube surface is completely covered.

Magnetite scale acts as thermal insulation on the pipe, since the thermal conductivity of scale is only about 5% that of steel. When heat can no longer transfer efficiently from the flame through the tube into the steam inside, the tube wall will heat up to temperatures beyond the intended operating range. Long-term exposure to overly high temperatures, combined with the very high pressure inside the tube, leads to intergranular micro-cracking in the metal and to creep deformation (a slow swelling or bulging of the metal), which, in turn, eventually leads to tube failure by bursting. A secondary issue is oxide exfoliation, in which pieces of oxide scale break off (usually due to thermal stresses during boiler startup or shutdown). These hard pieces will be carried by the steam flow into the turbine, where, over time, they will cause erosion damage.

Ultrasonic testing provides a quick and nondestructive method for measuring scale. Handheld, portable instruments can measure internal oxide layers down to a minimum thickness of approximately 0.2 mm or 0.008 in. The specialized transducer, which is a 20 MHz shear wave probe, can be used along with shear wave couplant to measure down to approximately 0.152 mm or 0.006 in. In all cases, the coupling surface must be smooth and, in some cases, surface preparation will be required.

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qndtindia@gmail.com / info@qndt.in
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➢ Holiday Testing (Spark Test)

A holiday test is an inspection method used to detect discontinuities in painted/coated surfaces using specialized tools and equipment. These tools, called holiday detectors, are portable devices that are swept across the coated surface.

Holidays tests work on the concept of electrical conductivity. Metal substrates are excellent conductors of electricity, and therefore allow current to flow through them. On the other hand, many coatings are poor conductors of electricity and resist the flow of electricity. Using this principle, holiday tests use instruments to locate flaws in anticorrosive paints and coatings.
During holiday testing, a ground wire and probing electrode are attached to the same power source. The ground wire is clamped to the specimen being tested while the probe is swept across the surface of the metal substrate. If the probe comes into contact with a coating discontinuity, the exposed metal completes the electrical circuit between the electrode and the grounding wire, resulting in a flow of electricity. This electricity shows up on an indicator, alerting the equipment operator of the defect.

While holiday tests are effective, they do possess limitations. Because these tests depend on the coating being non-conductive, they are not effective on conductive metallic coatings, such as zinc-rich primers.

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➢ In-Situ Metallography (Replica)

Performed as an NDT service, In-situ Metallography determines in-service degradation of critical components of process plants operating under high temperature, high-pressure or corrosive atmosphere. Our Metallurgists have vast experience in the interpretation of microstructures. More than 10,000 replica microstructure interpretations have been carried out and captured in our database. The databank so generated contains extensive information on the microstructures of parts & components from various plants that have been captured over the course of several years of services. The database also includes rare collection of records of various microstructural damage for industries such as power, oil and gas, refinery, petrochemical, fertilizers, and other process industries. The In-situ Metallography team is highly skilled in the art of replica preparation. We have custom-developed special purpose on-site / field surface preparation & polishing devices & techniques which assist to enable metallographic polishing in difficult locations and allow the field technicians' team to carry out high quality replication even on warm components.

The In-situ metallography is performed for following areas:

- To find out in-service degradation of critical components of the process plants operating under high temperature /high pressure/ corrosive atmosphere.
- Damage assessment of fire affected equipment of the plants.
- Microstructural survey for critical components viz., Boilers, Pipelines, Reactors and Vessels for condition monitoring / health assessment.
- To develop a data bank of critical components for equipment of process plant by periodical monitoring for preventive maintenance and planning for inventory control.
- To provide suggestions on the welding of components of process plants.
- To check the quality of the microstructure of components for intended service before put in to use.