

# **Introduction to Nondestructive Testing**

# Introduction to Nondestructive Testing

## **What is nondestructive testing?**

**NonDestructive Testing (NDT)** is the process of doing inspections, testing, or evaluating materials, components or assemblies for defects without destroying the material or component.

Or the use of noninvasive techniques to determine the integrity of a material, component or structure”.

In other words, “Inspect or measure without doing harm.”

# Introduction to Nondestructive Testing

## Who Uses NDT?

- NDT plays a vital role in assuring the safe operation of equipment and systems
- Industries that utilize NDT:
  - Airline and Aerospace
  - Automotive and Railroad
  - Construction
  - Hydroelectric, Fossil, and Nuclear Power
  - Textile and Manufacturing
  - Chemical and Petrochemical
  - Logistics and Supply
  - Medical and Pharmaceutical

# Introduction to Nondestructive Testing

## What are Some Uses of NDT?

- Flaw Detection and Evaluation - the size, shape, or orientation of a flaw (such as a crack or porosity)
- Leak Detection
- Location Determination
- Dimensional Measurements
- Structure and Microstructure Characterization
- Estimation of Mechanical and Physical Properties
- Stress (Strain) and Dynamic Response Measurements
- Material Sorting and Chemical Composition Determination
- the thickness of a material or coating
- the hardness of a material
- a material's electrical conductivity

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## When is NDT Used?

There are NDT application at almost any stage in the production or life cycle of a component.

- To assist in product development
- To screen or sort incoming materials
- To monitor, improve or control manufacturing processes
- To verify proper processing such as heat treating
- To verify proper assembly
- To inspect for in-service damage

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- **NDT test methods may be used to determine:**
  - the size, shape, or orientation of a flaw (such as a crack or porosity)
  - the thickness of a material or coating
  - the hardness of a material
  - the material composition (example, the carbon content in steel)
  - a material's electrical conductivity

# Introduction to Nondestructive Testing

## NDT Methods

Test methods are the type of penetrating medium or the equipment used to perform that test. Some of the current NDT methods are:

- ***Acoustic Emission Testing (AE)***
- ***Electromagnetic Testing (ET)***
- ***Guided Wave Testing (GW)***
- ***Ground Penetrating Radar (GPR)***
- ***Laser Testing Methods (LM)***
- ***Leak Testing (LT)***
- ***Magnetic Flux Leakage (MFL)***
- ***Microwave Testing***
- ***Liquid Penetrant Testing (PT)***
- ***Magnetic Particle Testing (MT)***
- ***Neutron Radiographic Testing (NR)***
- ***Radiographic Testing (RT)***
- ***Thermal/Infrared Testing (IR)***
- ***Ultrasonic Testing (UT)***
- ***Vibration Analysis (VA)***
- ***Visual Testing (VT)***

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**The most frequently used test methods are:**

Visual Testing (VT)

Liquid Penetrant Testing (PT)

Magnetic Particle Testing (MT)

Ultrasonic Testing (UT)

Electromagnetic Testing (ET) (Eddy Current)

Radiographic Testing (RT) (X-ray)

Acoustic Emission Testing (AE)

Each of these test methods and some of the other methods will be discussed later in this presentation and more detail provided in subsequent presentations.



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## Visual Testing (VT)

VT is the visual observation of the surface to evaluate the presence of surface discontinuities. Corrosion, misalignment of parts, physical damage and cracks are some of the discontinuities that may be detected by VT.

VT is the most commonly used test method in industry as most test methods require that the operator look at the surface of the part being inspected. VT inspections may be by direct looking, or may be by use of optical instruments such as magnifying glasses, mirrors, borescopes, and remote Viewing.



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## Testing

### Liquid Penetrant Testing (PT)

PT uses a liquid with high surface wetting characteristics is applied to the surface and allowed to seep into defects and then excess liquid is removed.

A developer is applied the trapped penetrant is pulled out of the defect where it can be seen.

Visual inspection is then performed.

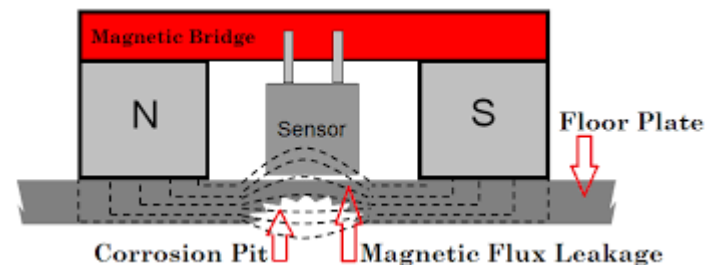
The penetrant used is often loaded with a fluorescent dye and the inspection is done under UV light to increase test sensitivity.



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## Magnetic Flux Leakage (MFL)

MFL detects anomalies in normal flux patterns created by discontinuities in ferrous material saturated by a magnetic field. This technique can be used for piping and tubing inspection, tank floor inspection and other applications. This technique can be done without removing the insulation, resulting in a fast, economic way to inspect long runs of pipe or tubing.



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## Ultrasonic Testing (UT)

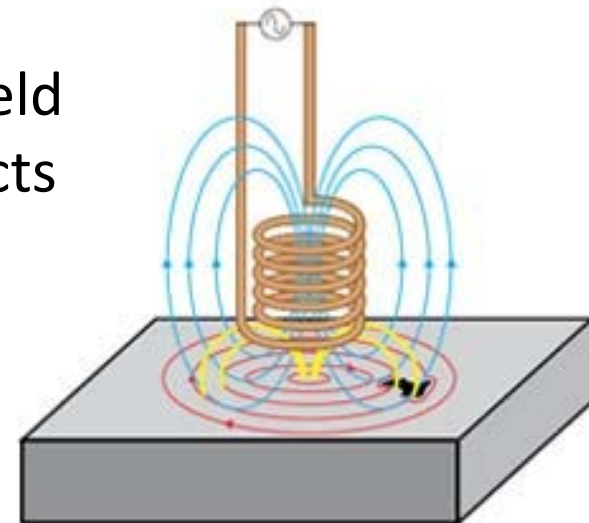
UT uses the same principle as is used in naval SONAR and fish finders. Ultra-high frequency sound is introduced into the part being inspected and if the sound hits a material with a different acoustic impedance (density and acoustic velocity), some of the sound will reflect back to the sending unit and can be presented on a visual display.



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## Electromagnetic Testing (ET)

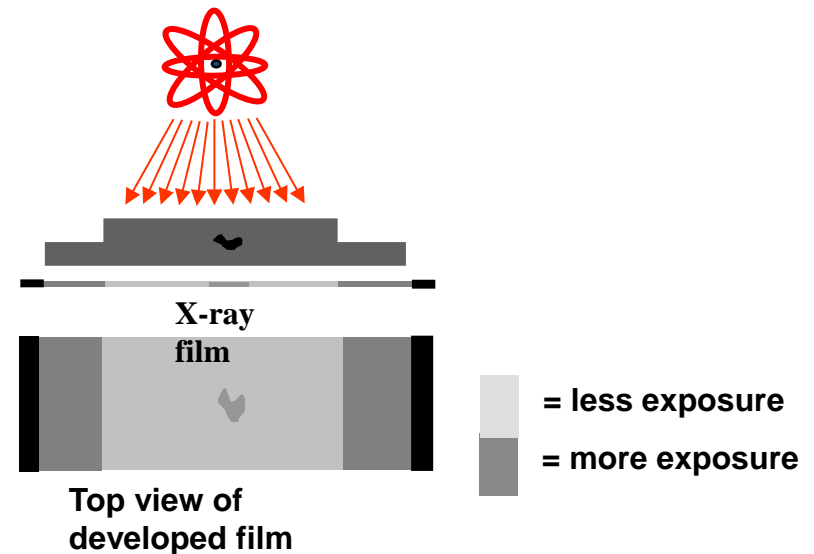
Electromagnetic testing is a general test category that includes Eddy Current testing (ECT), Alternating Current Field Measurement (ACFM) and Remote Field testing. While magnetic particle testing is also an electromagnetic test, due to its widespread use it is considered a stand-alone test method rather than an electromagnetic testing technique. All of these techniques use the induction of an electric current or magnetic field into a conductive part, then the resulting effects are recorded and evaluated.



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## Radiographic Testing (RT)

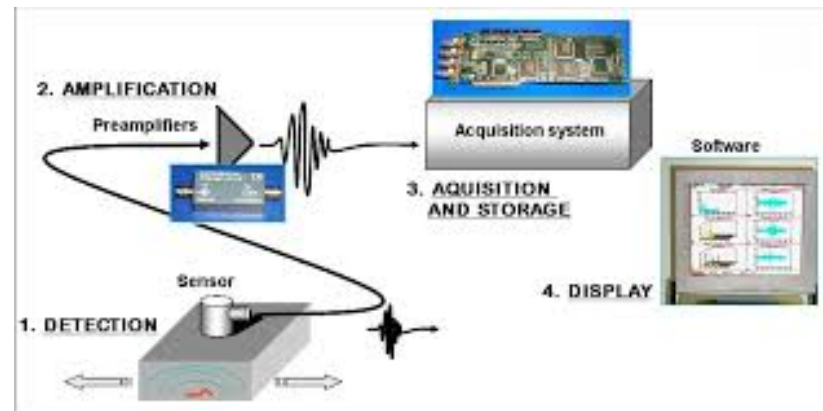
RT involves exposing a test object to radiation so that the radiation passing through the object is recorded on a medium placed against the opposite side. The recording media can be industrial x-ray film or one of several types of digital radiation detectors. If there is a void or defect in the part, more radiation passes through, causing a darker image on the film or detector.



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## Acoustic Emission Testing (AE)

AE is performed by applying a localized external force such as an abrupt mechanical load or rapid temperature or pressure change to the part being tested. The resulting stress waves in turn generate short-lived, high frequency elastic waves in the form of small material displacements, or plastic deformation, on the part surface that are detected by sensors that have been attached to the part surface. When multiple sensors are used, the resulting data can be evaluated to locate discontinuities in the part.



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## Guided Wave Testing (GW)

GW uses controlled excitation of ultrasonic waves that travel along the length of a pipe, reflecting from changes in the pipe stiffness or cross section. A transducer ring or exciter coil is used to introduce the guided wave into the pipe and each transducer/exciter. Control and analysis software is used to drive the transducer/exciter and to analyze results. The transducer/exciter is designed specifically for the diameter of the pipe, and can inspect the pipe wall over long distances without having to remove coatings or insulation. GW can locate both ID and OD discontinuities but cannot differentiate between them.





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## Ground-penetrating Radar (GPR)

GPR is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. GPR can have applications in a variety of media, including rock, soil, ice, fresh water, pavements and structures. In the right conditions, practitioners can use GPR to detect subsurface objects, changes in material properties, and voids and cracks.



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## Laser Testing Methods (LM)

LM includes three techniques, Holography, Shearography and Profilometry. As the method name implies, all three techniques use lasers to perform the inspections.



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## Leak Testing (LT)

LT as the name implies, is used to detect through leaks using one of the four major LT techniques:

Bubble,

Pressure Change,

Halogen Diode and

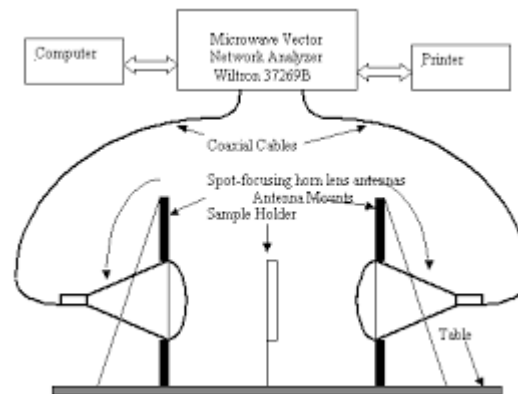
Mass Spectrometer Testing.



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## Microwave Nondestructive Testing (MNMT)

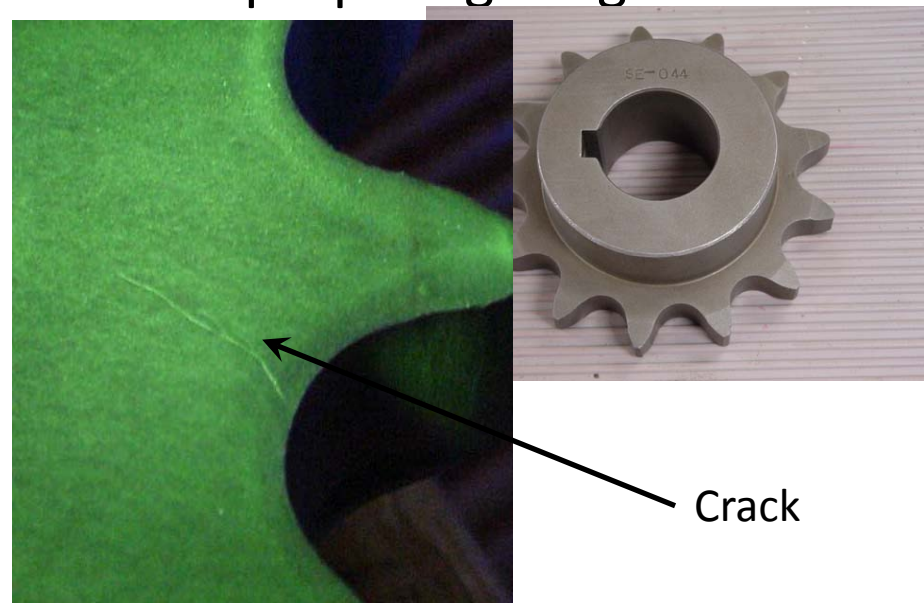
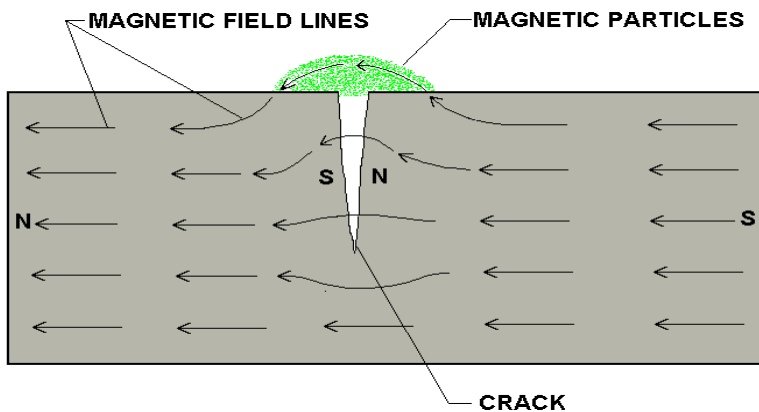
MNMT techniques have advantages over other NDT methods (such as radiography, ultrasonics, and eddy current) regarding low cost, good penetration in nonmetallic materials, good resolution and contactless feature of the microwave sensor (antenna).



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## Magnetic Particle Testing (MT)

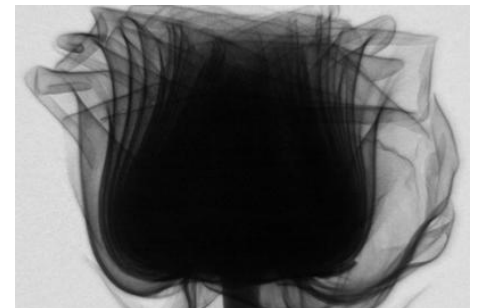
In MT the part is magnetized. Finely milled iron particles coated with a dye pigment are then applied to the specimen. These particles are attracted to magnetic flux leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.



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## Neutron Radiographic Testing (NR)

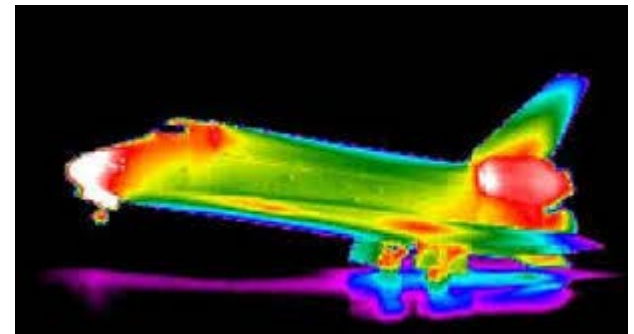
NR uses an intense beam of low energy neutrons as a penetrating medium rather than the gamma- or x-radiation used in conventional radiography. Generated by linear accelerators, betatrons and other sources, neutrons penetrate most metallic materials, rendering them transparent, but are attenuated by most organic materials (including water, due to its high hydrogen content) which allows those materials to be seen within the component being inspected. When used with conventional radiography, both the structural and internal components of a test piece can be viewed.



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## Thermal/Infrared Testing (IR)

IR, or infrared thermography, is used to measure or map surface temperatures based on the infrared radiation given off by an object as heat flows through, to or from that object. The majority of infrared radiation is longer in wavelength than visible light but can be detected using thermal imaging devices, commonly called "infrared cameras." For accurate IR testing, the part(s) being investigated should be in direct line of sight with the camera. Used properly, thermal imaging can be used to detect corrosion damage, delamination's, disbonds, voids, inclusions as well as many other detrimental conditions.



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## Vibration Analysis (VA)

Vibration analysis refers to the process of monitoring the vibration signatures specific to a piece of rotating machinery and analyzing that information to determine the condition of that equipment. Three types of sensors are commonly used: displacement sensors, velocity sensors and accelerometers.





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## Common Application of NDT

### Inspection of Raw Products

Forgings



Castings



Extrusions



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## Common Application of NDT

Inspection Following Secondary Processing

Machining

Welding

Grinding

Heat  
treating

Plating



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## Common Application of NDT In-Services Damage Inspection

Cracking



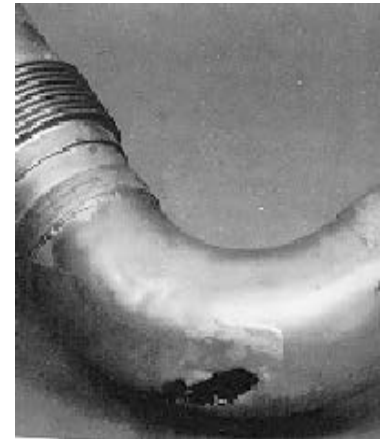
Corrosion



Heat Damage



Erosion/Wear



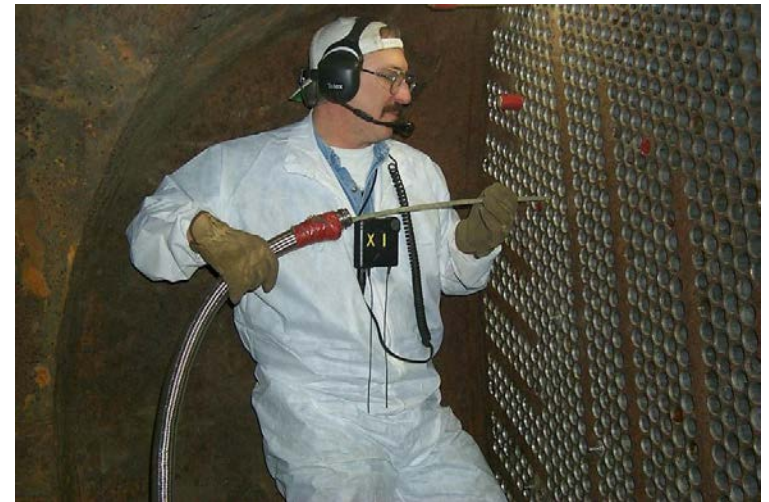
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## Examples of NDT

### Power Plant Inspection -

Periodically, power plants are shutdown for inspection.

Inspectors feed eddy current probes into heat exchanger tubes to check for corrosion damage



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## Examples of NDT

### Wire Rope Inspection -

Electromagnetic devices and visual inspections are used to find broken wires and other damage to the wire rope that is used in chairlifts, cranes and other lifting devices.



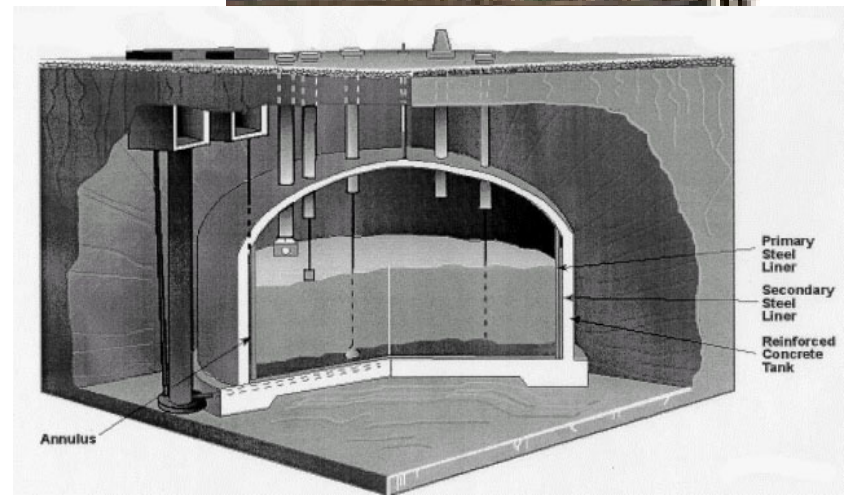


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## Examples of NDT

### Storage Tank Inspection -

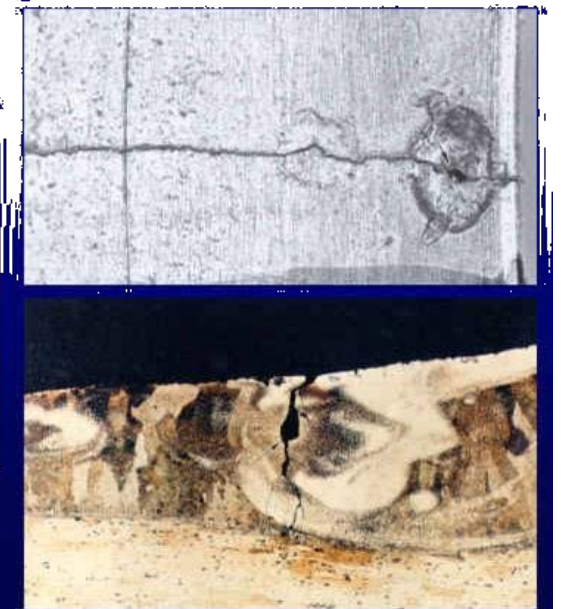
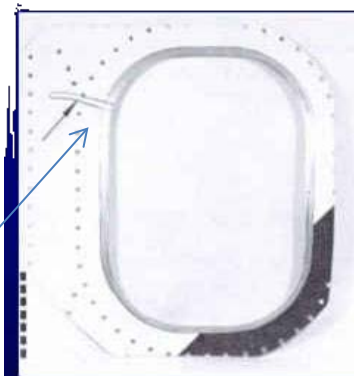
Robotic crawlers use ultrasound to inspect the walls of large above ground tanks for signs of thinning due to corrosion. Cameras on long articulating arms are used to inspect underground storage tanks for damage



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## Examples of NDT Aircraft Inspection -

Nondestructive testing is used extensively during the manufacturing of aircraft. NDT is also used to find cracks and corrosion damage during operation of the aircraft. A fatigue crack that started at the site of a lightning strike is shown.

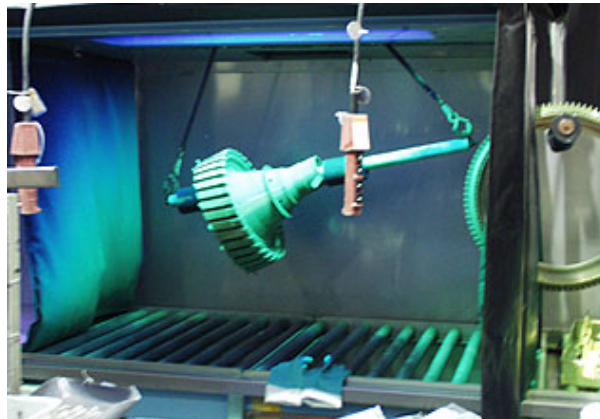


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## Examples of NDT

**Jet Engine Inspection** Aircraft engines are overhauled after being in service for a period of time. They are completely disassembled, cleaned, inspected and then Reassembled.

Fluorescent penetrant inspection is used to check many of the parts for cracking.





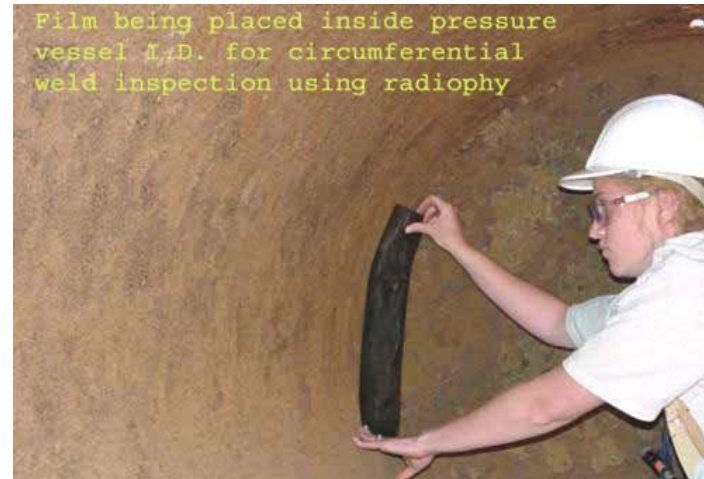
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## Examples of NDT

### Pressure Vessel Inspection -

The failure of a pressure vessel can result in the rapid release of a large amount of energy.

To protect against this dangerous event, the tanks are inspected using radiography and ultrasonic testing.



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## Examples of NDT

**Rail Inspection** - Special cars are used to inspect thousands of miles of rail to find cracks that could lead to a derailment.



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## Examples of NDT

**Bridge Inspection** - The US has 578,000 highway bridges. Corrosion, cracking and other damage can all affect a bridge's performance. Bridges get a visual inspection about every 2 years. Some bridges are fitted with acoustic emission sensors that "listen" for sounds of cracks growing.



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## Examples of NDT

**Pipeline Inspection** - NDT is used to inspect pipelines to prevent leaks that could damage the environment. Visual inspection, radiography and electromagnetic testing are some of the NDT methods used.

