



Overview of Non-destructive Testing (NDT)



Presentation source: NDT Education www.ndt-ed.org
with modifications



Outline

- Introduction to NDT
- Overview of Six Most Common NDT Methods
- Selected Applications
- NDT Personnel Certification



Definition of NDT

The use of noninvasive techniques to:
determine the integrity of a material, component or
structure

or

quantitatively measure some characteristic of an
object.

(i.e. Inspect or measure without doing harm)

The terms:

Non-destructive Examination (NDE)

Non-destructive Inspection (NDI)

Non-destructive Evaluation (NDE)

are also commonly used to describe this technology.



Methods of NDT

Visual
Tap Testing
Acoustic Emission
Ultrasonic
Flux Leakage
Microwave
Radiography
(x-ray, Gamma-ray)
Magnetic Measurements
Replication
Laser Interferometry
Thermography
Magnetic Particle
Acoustic Microscopy
Liquid Penetrant
Eddy Current



Fields where NDT is used

- Mechanical Engineering
- Aerospace Engineering
- Civil Engineering
- Electrical Engineering
- Industrial & Manufacturing Engineering
- Systems Engineering
- Medicine
- Forensics
- Security
- Art



Some Uses of NDT

- Flaw Detection and Evaluation
- 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



When are NDT Methods Used?

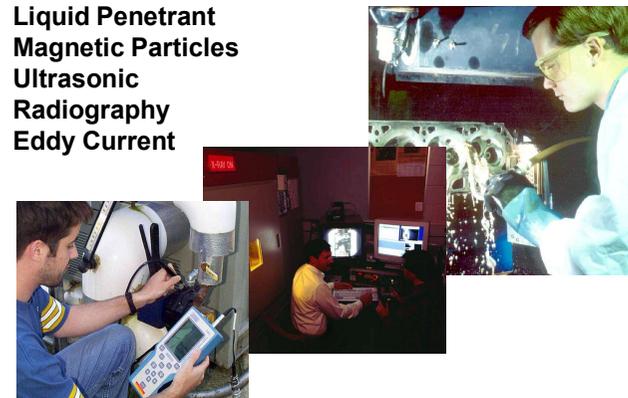
NDT is used at almost every stage in the production or life cycle of a component.

- 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



Six Most Common NDT Methods

- Visual
- Liquid Penetrant
- Magnetic Particles
- Ultrasonic
- Radiography
- Eddy Current



Visual Inspection



Most basic and common inspection method.

Tools include fiberoptic borescopes, magnifying glasses and mirrors.

Portable video inspection unit with zoom allows inspection of large tanks and vessels, railroad tank cars, sewer lines.

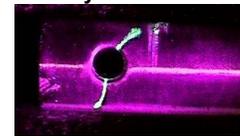


Robotic crawlers permit observation in hazardous or tight areas, such as air ducts, reactors, pipelines.

Liquid Penetrant Inspection



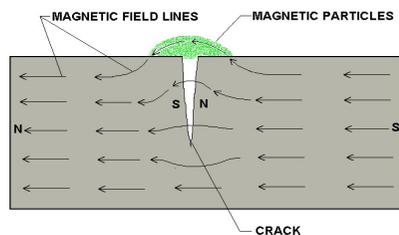
- A liquid with high surface wetting characteristics is applied to the surface of the part and allowed time to seep into surface breaking defects.
- The excess liquid is removed from the surface of the part.
- A developer (powder) is applied to pull the trapped penetrant out the defect and spread it on the surface where it can be seen.
- Visual inspection is the final step in the process. The penetrant used is often loaded with a fluorescent dye and the inspection is done under UV light to increase test sensitivity.



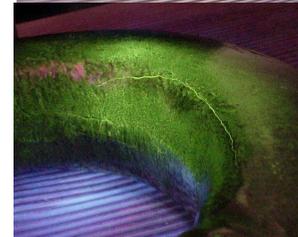
Magnetic Particle Inspection



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.

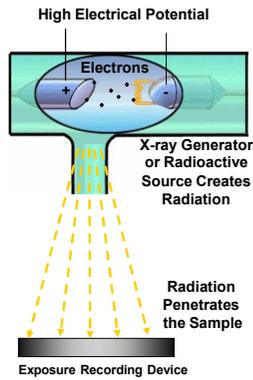
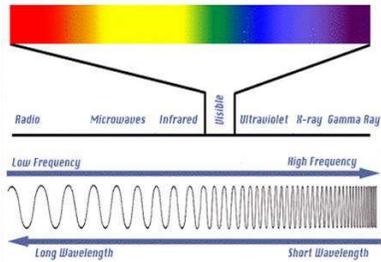


Magnetic Particle Crack Indications



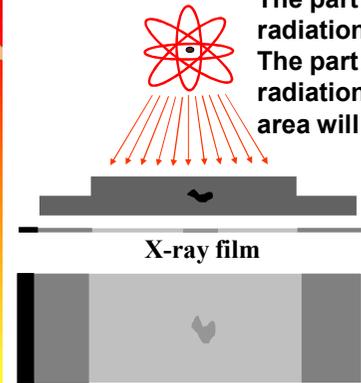
Radiography

The radiation used in radiography testing is a higher energy (shorter wavelength) version of the electromagnetic waves that we see as visible light. The radiation can come from an X-ray generator or a radioactive source.



Film Radiography

The part is placed between the radiation source and a piece of film. The part will stop some of the radiation. Thicker and more dense area will stop more of the radiation.

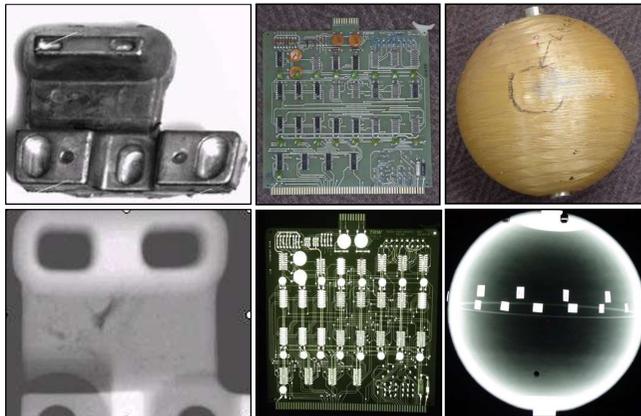


The film darkness (density) will vary with the amount of radiation reaching the film through the test object.

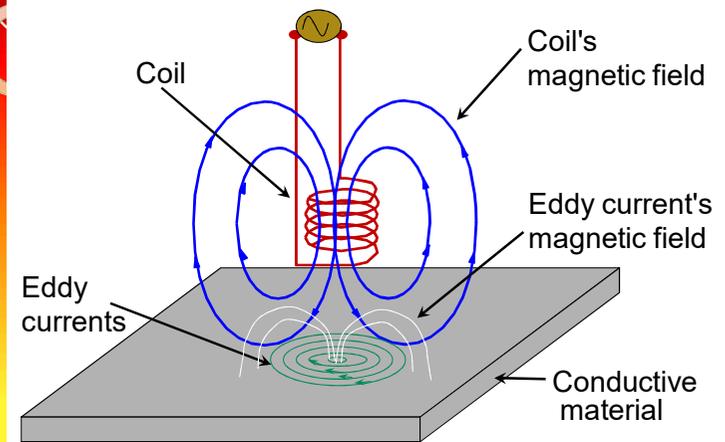
- = less exposure
- = more exposure

Top view of developed film

Radiographic Images



Eddy Current Inspection





Eddy Current Inspection

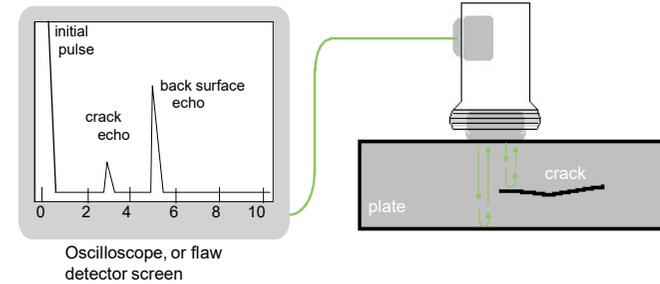
Eddy current testing is particularly well suited for detecting surface cracks but can also be used to make electrical conductivity and coating thickness measurements. Here a small surface probe is scanned over the part surface in an attempt to detect a crack.



Ultrasonic Inspection (Pulse-Echo)

High frequency sound waves are introduced into a material and they are reflected back from surfaces or flaws.

Reflected sound energy is displayed versus time, and inspector can visualize a cross section of the specimen showing the depth of features that reflect sound.



Ultrasonic Imaging

High resolution images can be produced by plotting signal strength or time-of-flight using a computer-controlled scanning system.



Gray scale image produced using the sound reflected from the front surface of the coin

Gray scale image produced using the sound reflected from the back surface of the coin (inspected from "heads" side)



What is NDT used for in Engineering?

- Inspection of Raw Products
 - Inspection Following Secondary Processing
 - In-Service Damage Inspection
- Quality Control** (applies to the first two items)
- Maintenance** (applies to the third item)



Inspection of Raw Products

- Forgings,
- Castings,
- Extrusions,
- etc.



Inspection Following Secondary Processing

- Machining
- Welding
- Grinding
- Heat treating
- Plating
- etc.



Inspection For In-Service Damage

- Cracking
- Corrosion
- Erosion/Wear
- Heat Damage
- etc.



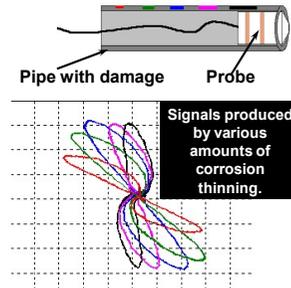
Examples of NDT Applications

- Power Plant Inspection
- Wire Rope Inspection
- Storage Tank Inspection
- Aircraft Inspection
- Jet Engine Inspection
- Pressure Vessel Inspection
- Rail Inspection
- Bridge Inspection
- Pipeline Inspection
- Special Measurements

Power Plant Inspection



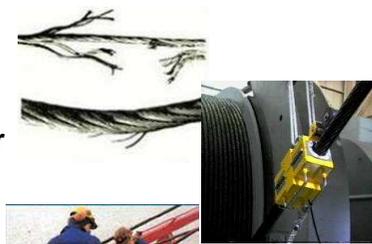
Periodically, power plants are shutdown for inspection. Inspectors feed eddy current probes into heat exchanger tubes to check for corrosion damage.



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.



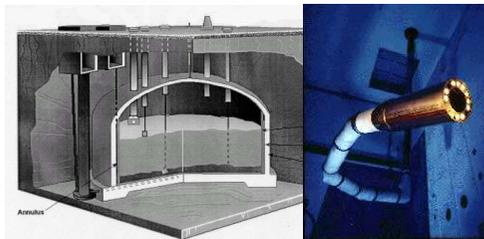
Storage Tank Inspection



Robotic crawlers use ultrasound to inspect the walls of large above ground tanks for signs of thinning due to corrosion.



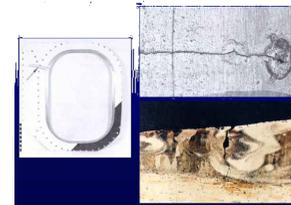
Cameras on long articulating arms are used to inspect underground storage tanks for damage.



Aircraft Inspection



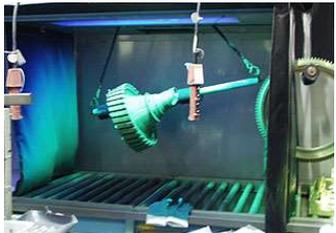
- Nondestructive testing is used extensively during the manufacturing of aircraft.
- NDT is also used to find cracks and corrosion damage during operation of the aircraft.
- A fatigue crack that started at the site of a lightning strike is shown below.



Jet Engine Inspection



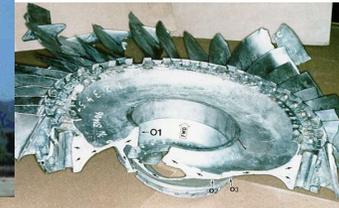
- Aircraft engines are overhauled after being in service for a period of time.
- They are completely disassembled, cleaned, inspected and then reassembled.
- Fluorescent penetrant inspection is used to check many of the parts for cracking.



Crash of United Flight 232 Sioux City, Iowa, July 19, 1989



A defect that went undetected in an engine disk was responsible for the crash of United Flight 232.



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.

Pipe being placed inside pressure vessel for circumferential weld inspection using radiography

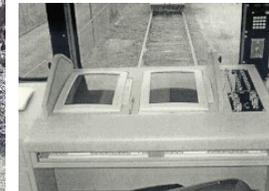


Isotope radiography of weld on pressure vessel

Rail Inspection



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





Bridge Inspection

- The United States alone has more than 500,000 highway bridges.
- Corrosion, cracking and other damage can all affect a bridge's performance.
- The collapse of the Silver Bridge in 1967 resulted in loss of 47 lives.
- Bridges get a visual inspection about every 2 years.
- Some bridges are fitted with acoustic emission sensors that "listen" for sounds of cracks growing.

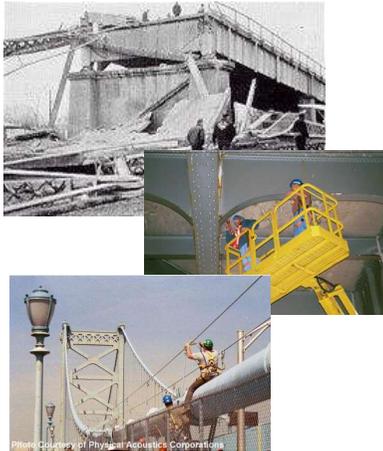


Photo Courtesy of Physical Acoustics Corporation



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.



Photo Courtesy of Inuktun
Remote visual inspection using a robotic crawler.



Magnetic flux leakage inspection. This device, known as a pig, is placed in the pipeline and collects data on the condition of the pipe as it is pushed along by whatever is being transported.



Photo Courtesy of Tylon International
Radiography of weld joints.



Special Measurements

Boeing employees in Philadelphia were given the privilege of evaluating the Liberty Bell for damage using NDT techniques. Eddy current methods were used to measure the electrical conductivity of the Bell's bronze casing at various points to evaluate its uniformity.



NDT Personnel Certification

- NDT personnel are often certified to meet certain qualifications.
- Standard practices that specify the certification requirements and procedures are established by professional organizations such as:
 - American Society for Nondestructive Testing (ASNT)
 - ASNT-CP-189, Qualification and Certification of Nondestructive Testing Personnel & Recommended Practice; SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing
 - Aviation Transport Association (ATA)
 - ATA-105, Guidelines for Training and Qualifying Personnel in Nondestructive Testing Methods.
 - Aerospace Industries Association, National Aerospace Standard (AIA-NAS)
 - AIA-NAS-410, NAS Certification and Qualification of Nondestructive Test Personnel.
 - International Organization for Standards (ISO)
 - ISO 9712, Nondestructive testing - Qualification and certification of personnel.



NDT Personnel Certification

- NDT certification is per method (e.g.VT, PT, MT, UT, RT, etc.).
- NDT certification requires; Training + Experience + Examinations.
- There are two approaches for personnel certification:
 - **Employer Based Certification:** Performed by employer in accordance with their own Written Practice which is usually based on a standard recommended practice.
 - **Personal Central Certification:** Obtained from a central certification authority that is recognized by most employers (such as ASNT).



NDT Personnel Certification

- NDT personnel are generally certified to several different levels of competence within each of the NDT methods:
 - **Level I** : are technicians qualified to perform only specific calibrations and tests under close supervision and direction by higher level personnel.
 - **Level II** : are engineers or experienced technicians who are able to set up and calibrate testing equipment, conduct the inspection according to codes and standards (instead of following work instructions) and compile work instructions for Level I technicians.
 - **Level III** : are usually specialized engineers or very experienced technicians who can establish NDT techniques and procedures and interpret codes and standards. Level III holders also can train NDT personnel and issue Level I & II certificates (*in the methods in which they are certified in*).



For More Information on NDT



The NDT Resource Center

www.ndt-ed.org

The American Society for Nondestructive Testing

www.asnt.org