Non-Destructive Evaluation (NDE)

Chapter 1

Introduction to NDE

Mohamad Fathi GHANAMEH

Chapter Topics

- ✓ Course Organization
- ✓ Mechanical Testing
- ✓ Nondestructive Versus Destructive Tests
- ✓ Conditions for Effective NDT
- ✓ Overview of Major NDT Methods

Chapter Topics

- ✓ NDE Areas
- ✓ NDE system
- ✓ NDE Applications
- ✓ Basic Definitions Related to NDE
- ✓ Standardization bodies
- ✓ Qualification and Certification

Course Organization

Instructor

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Lectures

Thursday 14:00 - 16:00 AM

Tutorials

Thursday 14:00 - 16:00 AM

Course Organization

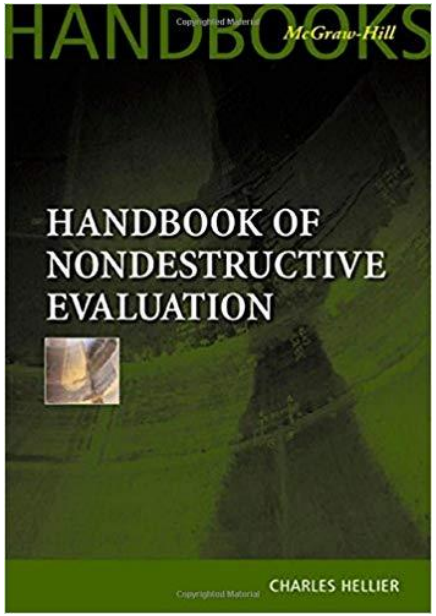
Course Documentation and Support
http://ghanameh.tarkiah.com/index.php/courses/nde

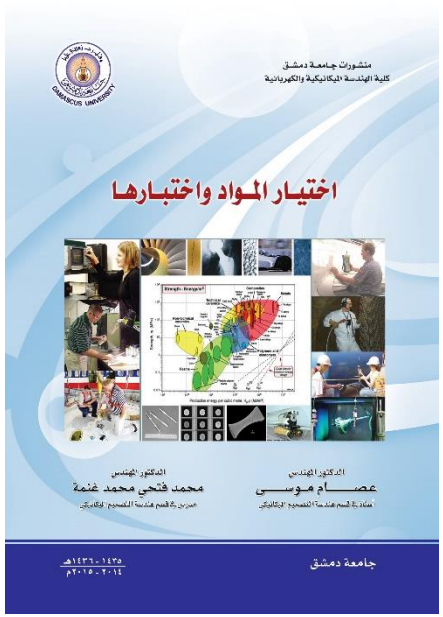
Office Hours
Monday 09:30 - 11:30 AM

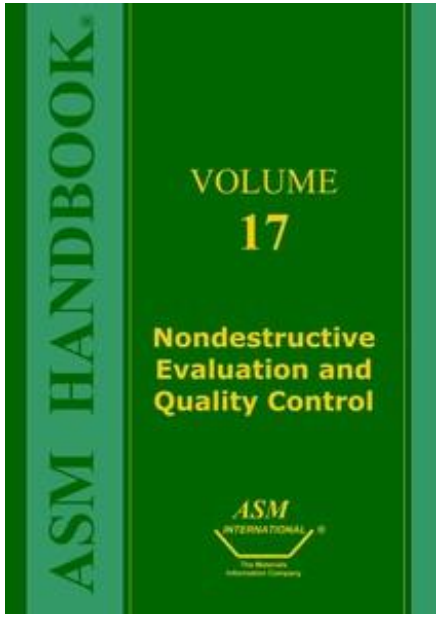
Evaluation
Quizzes, Mid-term, Final exam, Assignements and Mini Project

Textbook & References

- ✓ Chuck Hellier, "*Handbook of Nondestructive Evaluation*", McGraw-Hill Professional, 1st edition, 2001.
- ✓ M. F. GHANAMEH, I. MOSSA, "*Material Selection and Testing*", Academic Book, Damascus University , 1st edition, 2015.
- ✓ ASM Metals Handbook Volume 17, " *Nondestructive Evaluation & Quality Control*", ASM International, 1989.



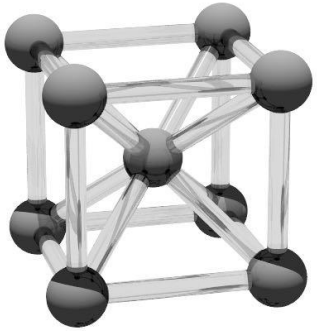


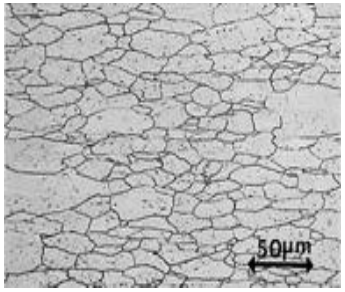


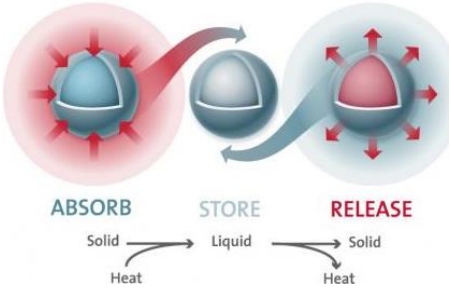
Mechanical Testing

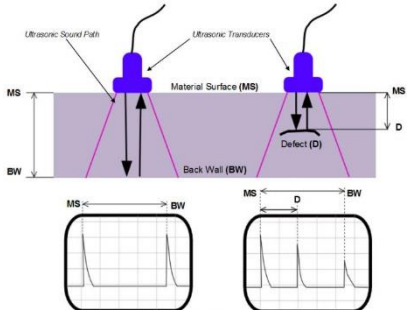
According to studied object scale

1. Internal Structure of Crystal Analyses.
2. External Structure of Crystal Analyses.
3. Phase and State Transformation Analyses.
4. Flaws Detection and Analyses.









Mechanical Testing

According to object serviceability after testing

1. Destructive testing
2. Non-Destructive testing

Nondestructive Versus Destructive Tests

Destructive testing has been defined as **Mechanical test of materials** whereby certain specific characteristics of the material can be evaluated **quantitatively**. This test is primarily **destructive**, and provide very **useful** information **and quite precise information**, It's especially related to the **material's design considerations and useful life**, It's only applies to the **specimen being examined**. Since the specimen is destroyed or mechanically changed, it is unlikely that it can be used for other purposes beyond the mechanical test.

Nondestructive Versus Destructive Tests

Destructive testing may be **dynamic** or **static** and can provide data relative to the following material attributes:

- ✓ Ultimate tensile strength
- ✓ Yield point
- ✓ Ductility
- ✓ Elongation characteristics
- ✓ Fatigue life
- ✓ Corrosion resistance
- ✓ Toughness
- ✓ Hardness
- ✓ Impact resistance

Nondestructive Versus Destructive Tests

Non-Destructive testing is primarily involve looking at (or through) or measuring something about an object (materials, components or assemblies) to determine some characteristic of this object or to find, locate, size, or determine the internal anomalies, irregularities, discontinuities, or flaws, without degrading the properties or impairing the serviceability of this object. The results are usually compared to specified requirements and standards for determining whether the object is in line with these targets.

Nondestructive Versus Destructive Tests

Key benefits of *Destructive testing* include:

- ✓ Reliable and accurate data from the test specimen
- ✓ Extremely useful data for design purposes
- ✓ Information can be used to establish standards and specifications
- ✓ Data achieved through destructive testing is usually quantitative
- ✓ Typically, various service conditions are capable of being measured
- ✓ Useful life can generally be predicted

Nondestructive Versus Destructive Tests

Limitations of *Destructive testing* include:

- ✓ Data applies only to the specimen being examined
- ✓ Most destructive test specimens cannot be used once the test is complete
- ✓ Many destructive tests require large, expensive equipment in a laboratory environment

Nondestructive Versus Destructive Tests

Key benefits of *Non-Destructive testing* include:

- ✓ The part is not changed or altered and can be used after examination
- ✓ Every item or a large portion of the material can be examined with no adverse consequences
- ✓ Materials can be examined for conditions internal and at the surface
- ✓ Parts can be examined while in service
- ✓ Many NDT methods are portable and can be taken to the object to be examined
- ✓ Nondestructive testing is cost effective, overall

Nondestructive Versus Destructive Tests

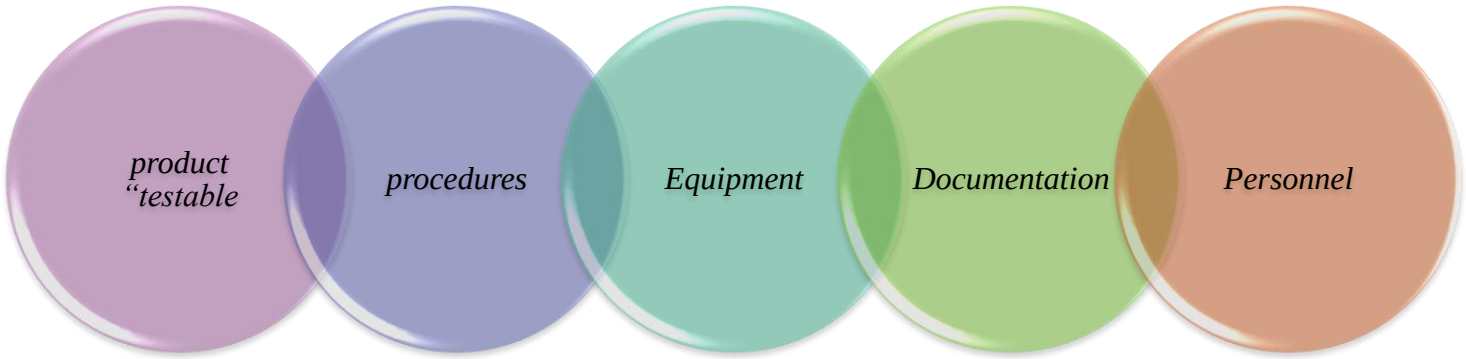
Limitations of *Non-Destructive testing* include:

- ✓ It is usually quite operator dependent
- ✓ Some methods do not provide permanent records of the examination
- ✓ NDT methods do not generally provide quantitative data
- ✓ Orientation of discontinuities must be considered
- ✓ Evaluation of some test results are subjective and subject to dispute
- ✓ While most methods are cost effective, some, such as radiography, can be expensive
- ✓ Defined procedures that have been qualified are essential

Conditions for Effective NDT

The following are major factors that must be considered in order for a nondestructive test to be effective.

1. *The product must be "testable" .*
2. *Approved procedures must be followed.*
3. *Equipment is operating properly.*
4. *Documentation is complete.*
5. *Personnel are qualified.*



Conditions for Effective NDT

The following are major factors that must be considered in order for a nondestructive test to be effective.

1. ***The product must be "testable."*** There are limitations inherent with each of the nondestructive test methods and it is essential that these limitations be known so that the appropriate method is applied based on the variables associated with the test object. For example, it would be very difficult to provide a meaningful ultrasonic test on a small casting with very complex shapes and rough surfaces. In this case, it would be much more appropriate to consider radiography. In another case, the object may be extremely thick and high in density, making radiography impractical. Ultrasonic testing, on the other hand, may be very effective. In addition to the test object being "testable," it must also be **accessible**.

Conditions for Effective NDT

The following are major factors that must be considered in order for a nondestructive test to be effective.

2. ***Approved procedures must be followed.*** It is essential that all nondestructive examinations be performed following procedures that have been **developed in accordance with the requirements** or specifications that apply. In addition, it is necessary to **qualify or "prove" the procedure** to assure that it will detect the applicable discontinuities or conditions and that the part can be examined in a manner that will satisfy the requirements. Once the procedure has been qualified, a certified NDT Level III individual or other quality assurance person who is suitably qualified to properly assess the adequacy of the procedure should **approve it**.

Conditions for Effective NDT

The following are major factors that must be considered in order for a nondestructive test to be effective.

3. ***Equipment is operating properly.*** All equipment to be used must be in **good operating condition** and **properly calibrated**. In addition, control checks should be performed periodically to assure that the equipment and accessory items are functioning properly. Annual calibrations are usually required but a "functional" check is necessary as a prerequisite to actual test performance.

Conditions for Effective NDT

The following are major factors that must be considered in order for a nondestructive test to be effective.

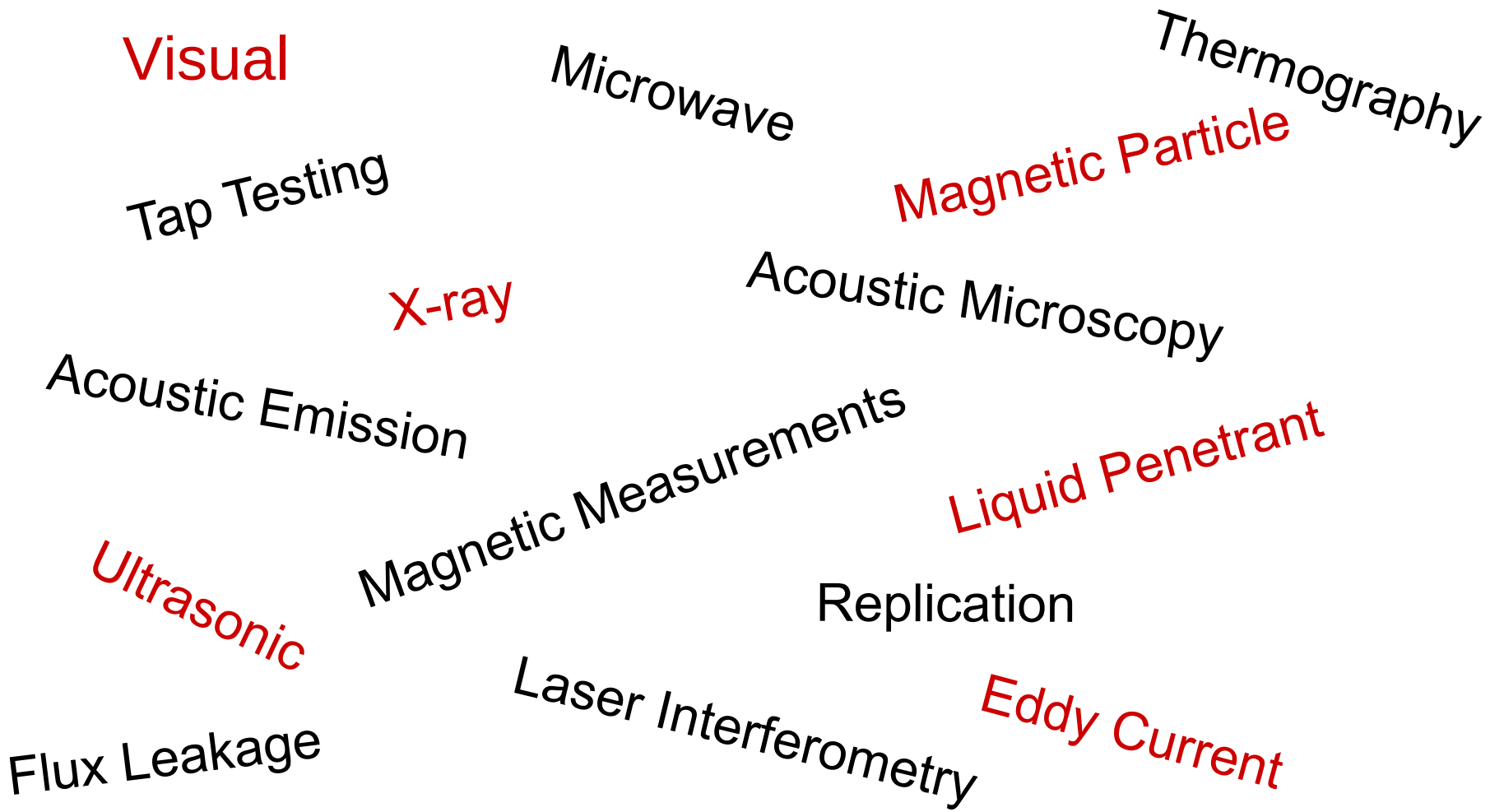
4. ***Documentation is complete***. It is essential that proper test documentation be **completed at the conclusion of the examination.** This should address all of the key elements of the examination, including calibration data, equipment and part description, procedure used, identification of discontinuities if detected, etc. These are all key elements. In addition, the test documentation should be legible. There have been cases where the examination was performed properly and yet the documentation was so difficult to interpret that it cast doubt on the results and led to concerns regarding the validity of the entire process.

Conditions for Effective NDT

The following are major factors that must be considered in order for a nondestructive test to be effective.

5. ***Personnel are qualified.*** Since nondestructive testing is a "hands-on" technology and depends greatly on the capabilities of the individuals performing the examinations, **personnel must not only be qualified, but also properly certified**. Qualification involves both formalized planned training, testing, and defined experience.

Overview of Major NDT Methods



Overview of Major NDT Methods

Visual and Optical Testing	(VT)
Liquid Penetrant Testing	(PT)
Magnetic Particle Testing	(MT)
Eddy Current Testing - Electromagnetic induction	(ET)
Ultrasonic Testing	(UT)
Radiography Testing	(RT)

Thermography	(TIRT)
Microwave	(MWT)
Acoustic Emission	(AT)
pressure and leak test	(LT)
Strain test	(ST)

Overview of Major NDT Methods

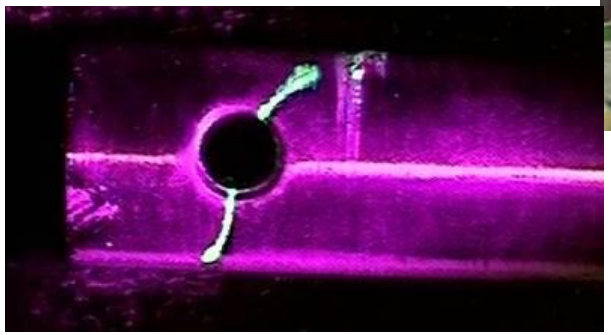
Visual testing (VT)

Overview of Major NDT Methods

Method	Visual testing (VT)
Principles	Uses reflected or transmitted light from test object that is imaged with the human eye or other light-sensing device
Application	Many applications in many industries ranging from raw material to finished products and in-service inspection
Advantages	Can be inexpensive and simple with minimal training required. Broad scope of uses and benefits
Limitations	Only surface conditions can be evaluated. Effective source of illumination required. Access necessary

Overview of Major NDT Methods

Penetrant testing (PT)

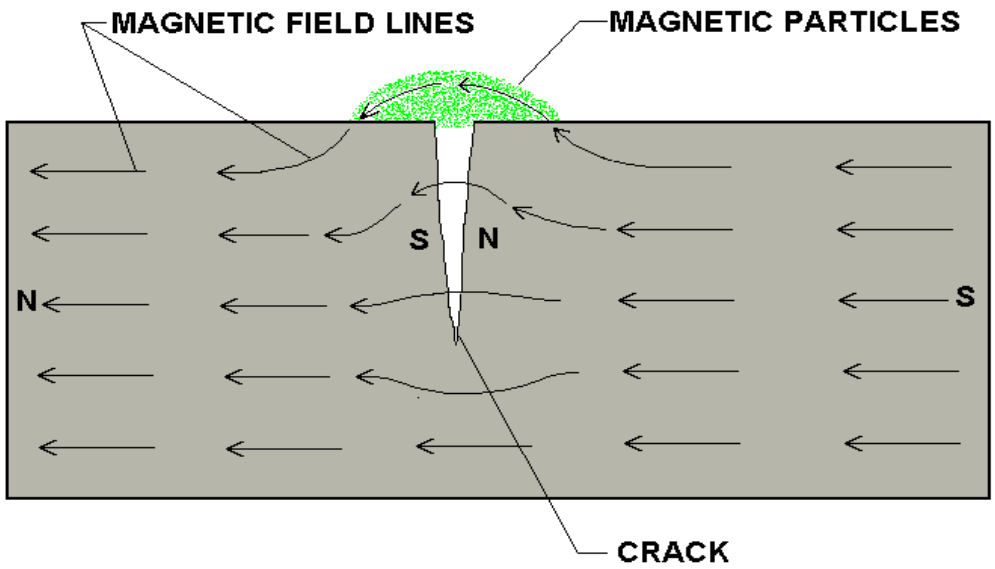


Overview of Major NDT Methods

Method	Penetrant testing (PT)
Principles	A liquid containing visible or fluorescent dye is applied to surface and enters discontinuities by capillary action
Application	Virtually any solid nonabsorbent material having uncoated surfaces that are not contaminated
Advantages	Relatively easy and materials are inexpensive. Extremely sensitive, very versatile. Minimal training
Limitations	Discontinuities open to the surface only. Surface condition must be relatively smooth and free of contaminants

Overview of Major NDT Methods

Magnetic particle testing (MT)

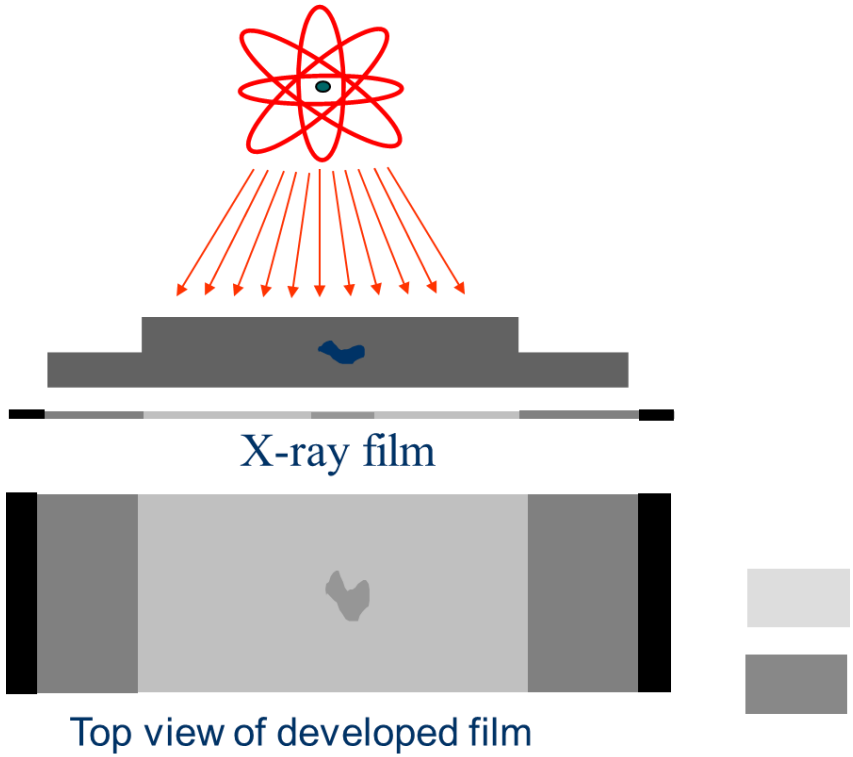


Overview of Major NDT Methods

Method	Magnetic particle testing (MT)
Principles	Test part is magnetized and fine ferromagnetic particles applied to surface, aligning at discontinuity
Application	All ferromagnetic materials; For surface and slightly subsurface discontinuities; large and small parts
Advantages	Relatively easy to use; Equipment/material usually inexpensive; Highly sensitive and fast compared to PT
Limitations	Only surface and a few subsurface discontinuities can be detected; Ferromagnetic materials only

Overview of Major NDT Methods

Radiographic testing (RT)

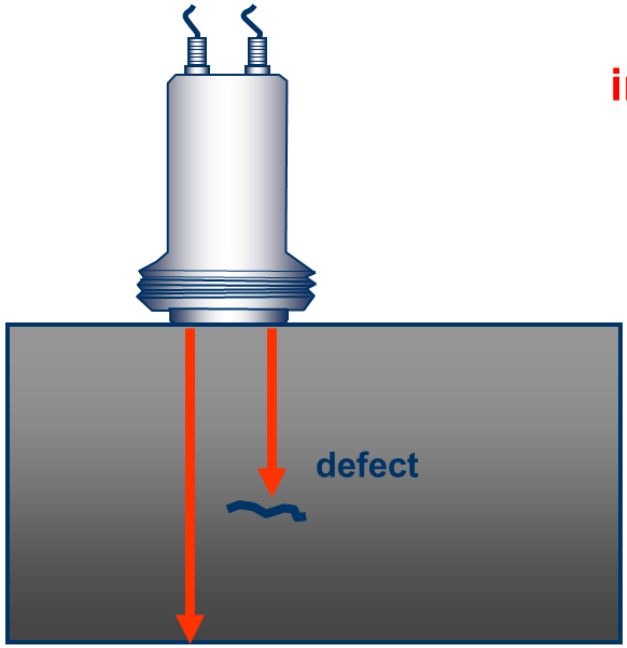


Overview of Major NDT Methods

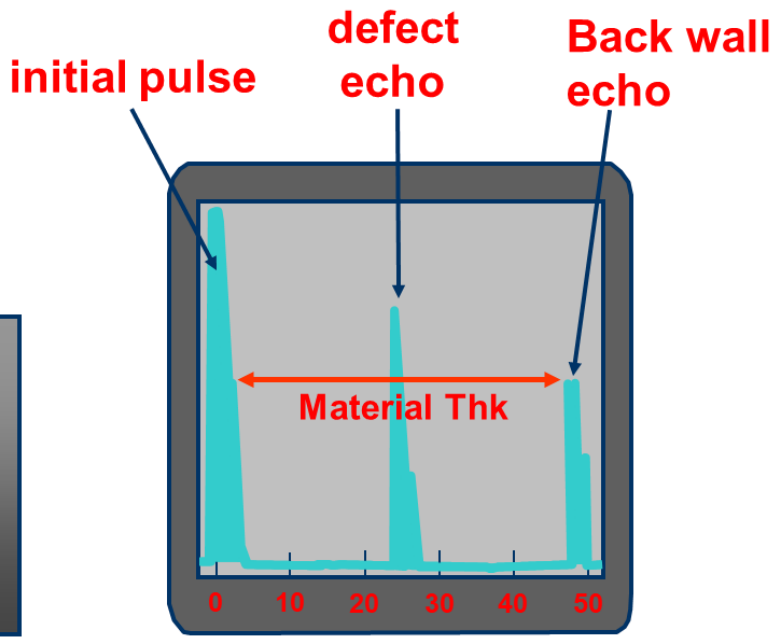
Method	Radiographic testing (RT)
Principles	Radiographic film is exposed when radiation passes through the test object. Discontinuities affect exposure
Application	Most materials, shapes, and structures. Examples include welds, castings, composites, etc., as manufactured or in-service
Advantages	Provides a permanent record and high sensitivity. Most widely used and accepted volumetric examination
Limitations	Limited thickness based on material density. Orientation of planar discontinuities is critical. Radiation hazard

Overview of Major NDT Methods

Ultrasonic testing (UT)



Compression Probe



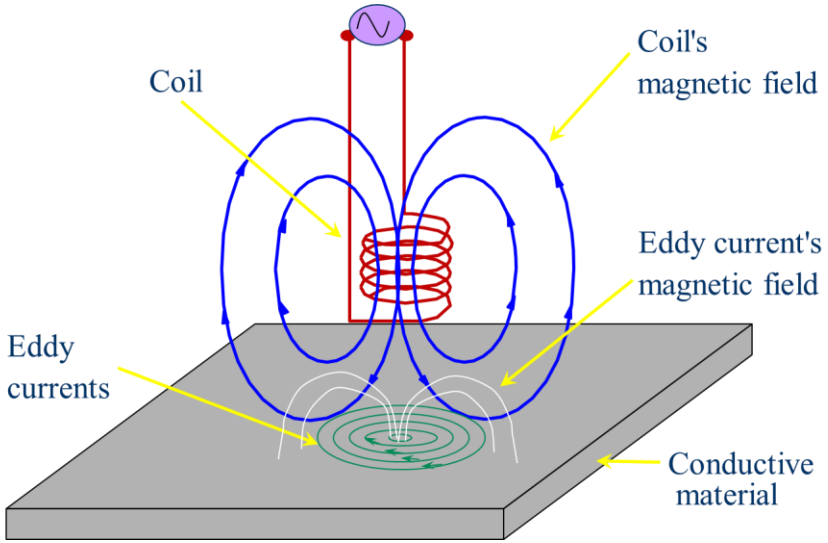
CRT Display

Overview of Major NDT Methods

Method	Ultrasonic testing (UT)
Principles	High-frequency sound pulses from a transducer propagate through the test material, reflecting at interfaces
Application	Most materials can be examined if sound transmission and surface finish are good and shape is not complex
Advantages	Provides precise, high-sensitivity results quickly. Thickness information, depth, and type of flaw can be obtained from one side of the component
Limitations	No permanent record (usually). Material attenuation, surface finish, and contour. Requires couplant

Overview of Major NDT Methods

Eddy current testing (ET)

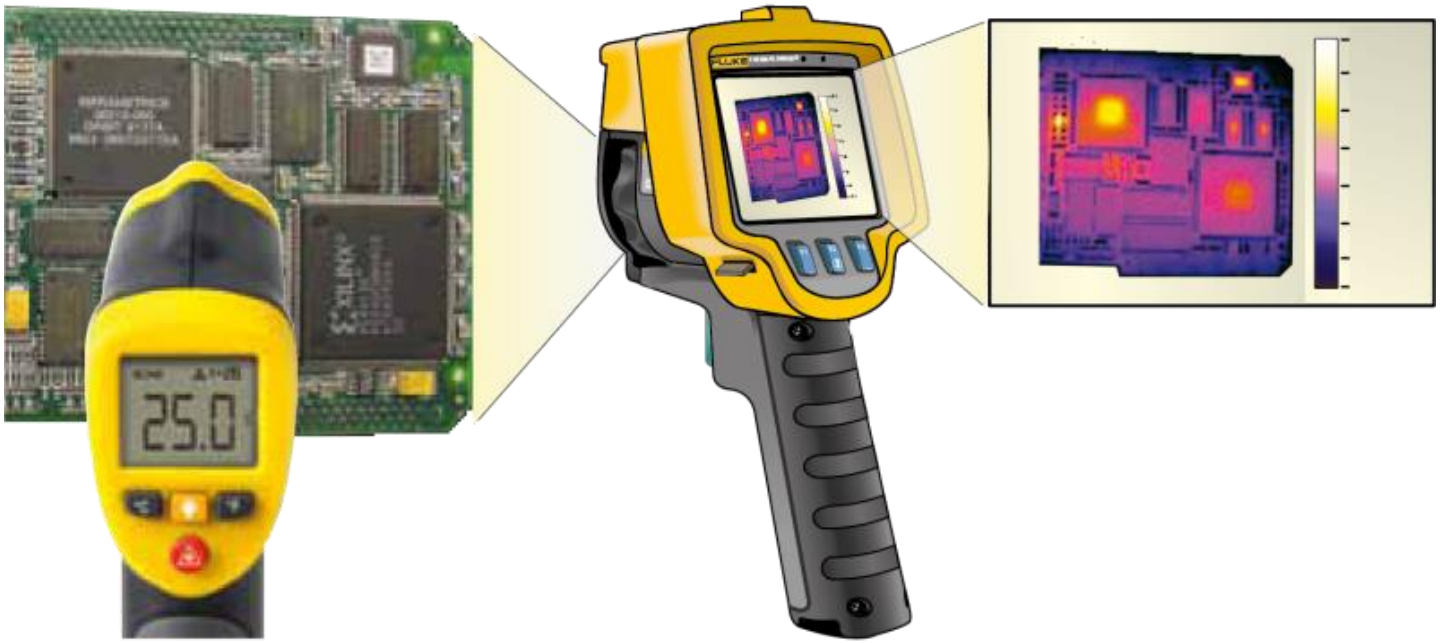


Overview of Major NDT Methods

Method	Eddy current testing (ET)
Principles	Localized electrical fields are induced into a conductive test specimen by electromagnetic induction
Application	Virtually all conductive materials can be examined for flaws, metallurgical conditions, thinning, and conductivity
Advantages	Quick, versatile, sensitive; can be non-contacting; easily adaptable to automation and in-situ examinations
Limitations	Variables must be understood and controlled. Shallow-depth of penetration, lift-off effects and surface condition

Overview of Major NDT Methods

Thermal infrared testing (TIR)

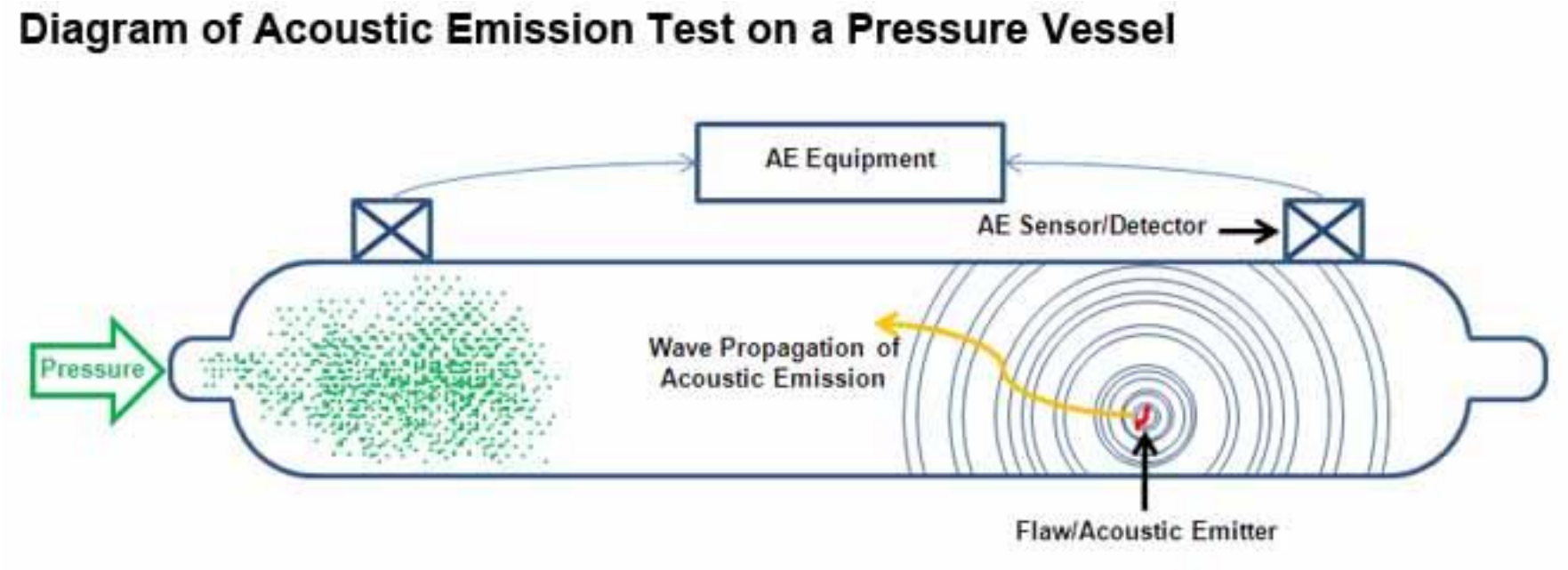


Overview of Major NDT Methods

Method	Thermal infrared testing (TIR)
Principles	Temperature variations at the test surface are measured/detected using thermal sensors/detectors instruments/cameras
Application	Most materials and components where temperature changes are related to part conditions/ thermal conductivity
Advantages	Extremely sensitive to slight temperature changes in small parts or large areas. Provides permanent record
Limitations	Not effective for detection of flaws in thick parts. Surface only is evaluated. Evaluation requires high skill level

Overview of Major NDT Methods

Acoustic emission testing (AE)



Overview of Major NDT Methods

Method	Acoustic emission testing (AE)
Principles	As discontinuities propagate, energy is released and travels as stress waves through material. These are detected by means of sensors
Application	Welds, pressure vessels, rotating equipment, some composites and other structures subject to stress or loading
Advantages	Large areas can be monitored to detect deteriorating conditions. Can possibly predict failure
Limitations	Sensors must contact test surface. Multiple sensors required for flaw location. Signal interpretation required.

NDE Areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

1. Flaw detection and evaluation
2. Leak detection and evaluation
3. Metrology (measurement of dimension) and evaluation
4. Location determination and evaluation
5. Structure or microstructure characterization
6. Estimation of mechanical and physical properties
7. Stress (strain) and dynamic response determination

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

1. Flaw detection and evaluation: Flaw detection is usually considered the most important aspect of NDE.

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

2. **Leak detection and evaluation:** Leak testing concerns the escape or entry of liquids or gases from pressurized or into evacuated components or systems intended to hold these liquids.

   Bubble Testing, Pressure testing

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

3. **Metrology** (measurement of dimension) and evaluation
   The measurement of dimensions is one of the most widely used NDE activities, although it is often not considered with other conventional NDE activities,
   Laser Inspection, Coordinate Measuring Machines, and Machine Vision and Robotic Evaluation.

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

4. **Location determination and evaluation:** An occasional problem is whether an assembled unit actually contains the necessary components.

   x-ray radiography, x-ray computed tomography, neutron radiography.

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

5. **Structure or microstructure characterization:** Microstructure can often be characterized by determining physical or mechanical properties with NDE techniques because there is usually a correlation among microstructure, properties, and NDE response.

   Replication Microscopy Techniques, Conventional optical microscopy techniques

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

6. **Estimation of mechanical and physical properties:** Eddy current, ultrasonic, x-ray and neutron radiography, computed tomography, thermography, microwave and acoustic microscopy phenomena are affected by microstructure, which can be related to some mechanical or physical properties.

NDE areas

Nondestructive evaluation can be conveniently divided into following distinct areas:

7. **Stress (strain) and dynamic response determination:** The local strain can be determined by using strain sensing methods such as:

photo-elastic, brittle coatings, or strain gages;

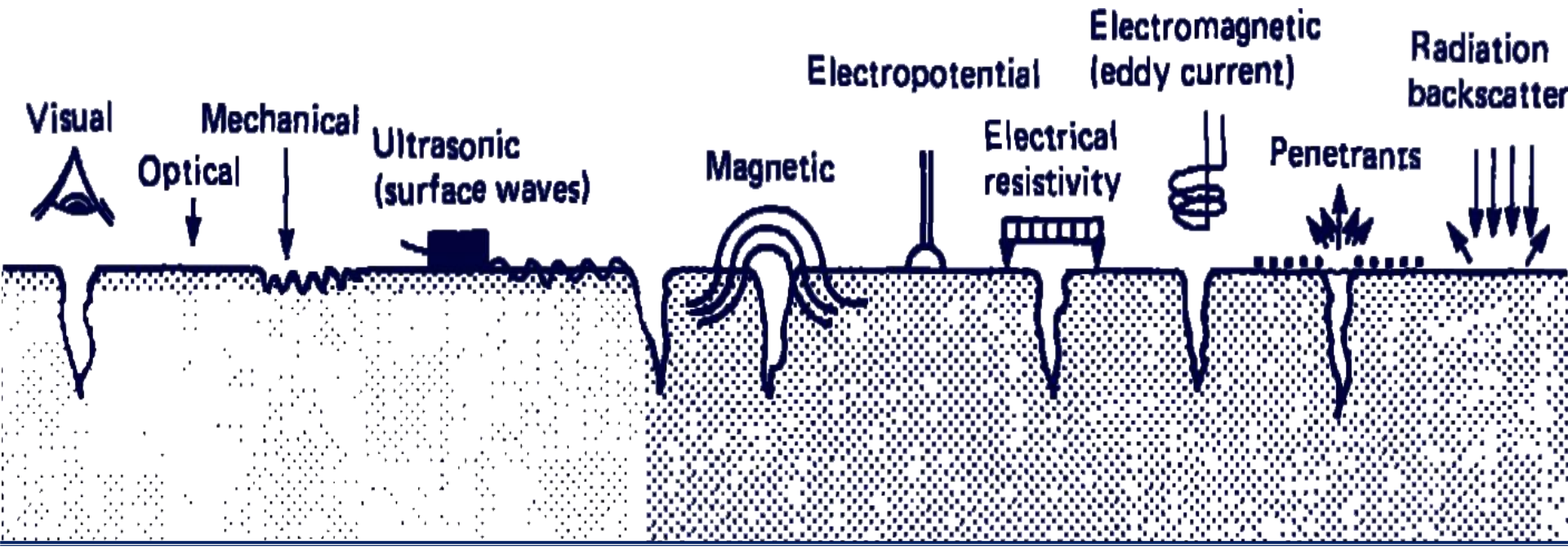
Dynamic behavior of an object can be evaluated during real or simulated service by employing strain sensing technology while the object is being dynamically loaded.

signature analysis. many causes: machine noise, vibrations, and structural instability (buckling or cracking)

NDE Method selection

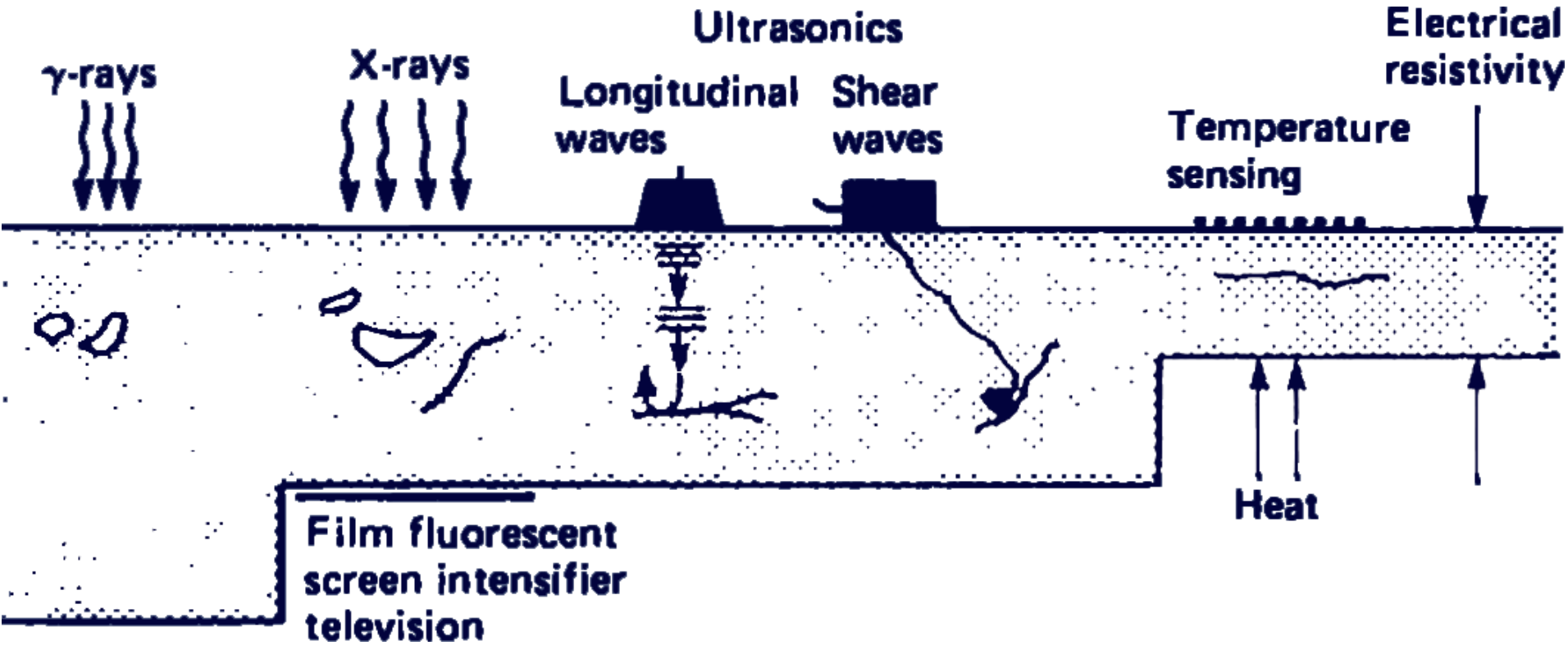
According to kind of detected Flaws

- ✓ Surface discontinuities or flaws



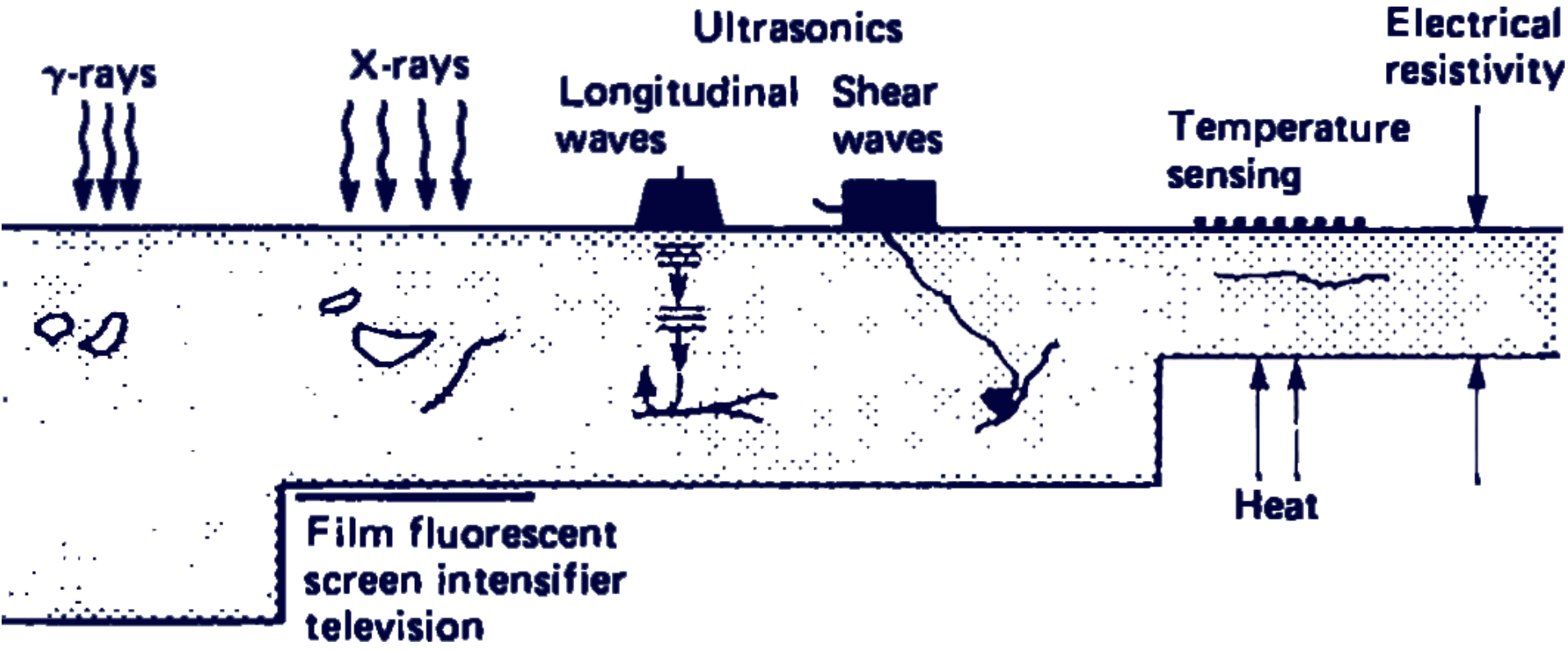
NDE Method selection

- ✓ Subsurface discontinuities or flaws

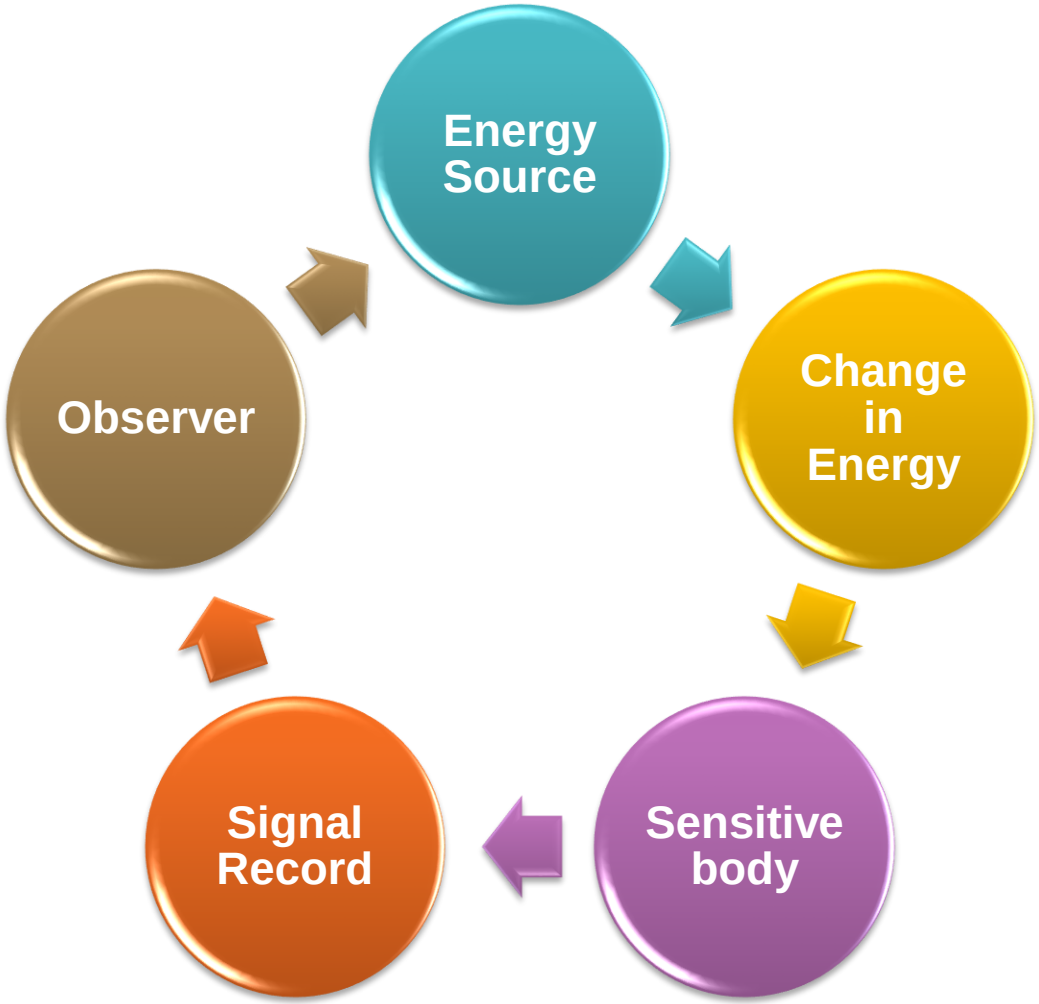


NDE Method selection

- ✓ Internal discontinuities or flaws

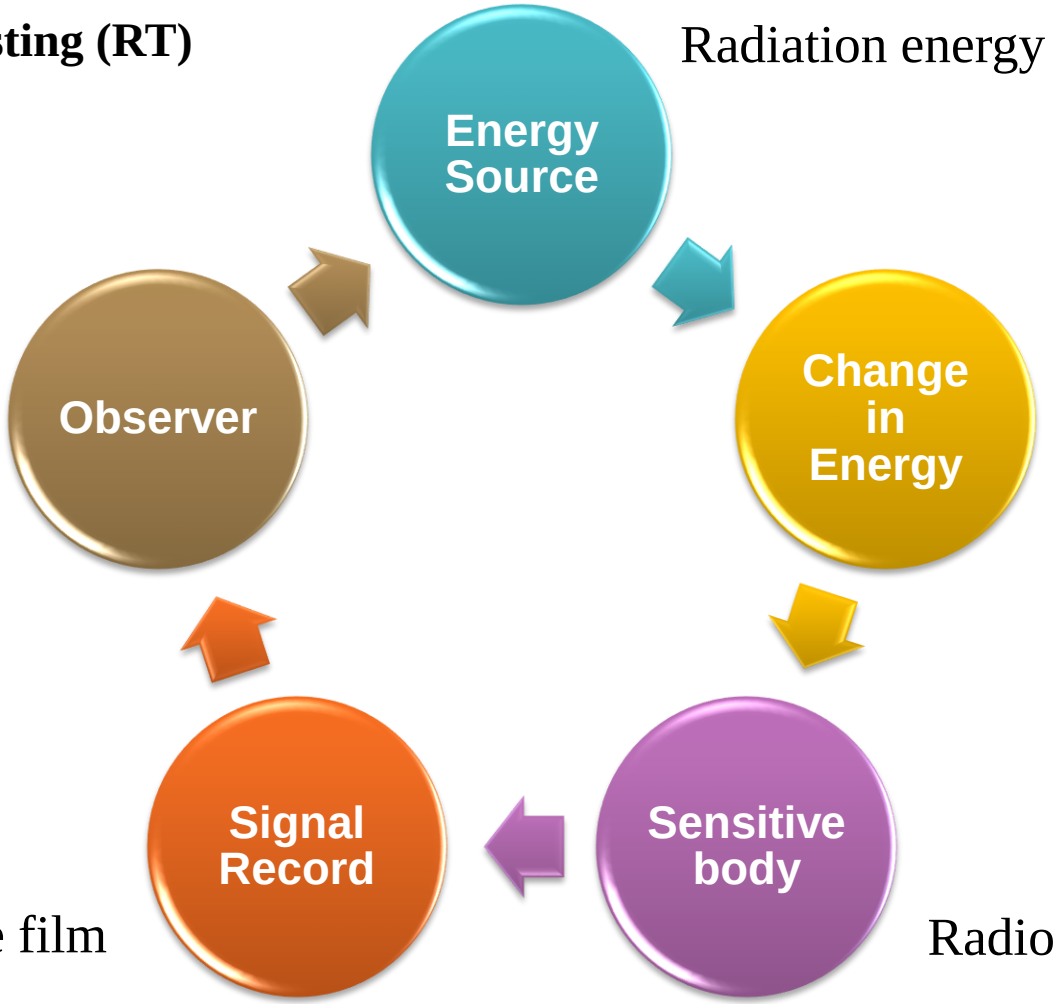


NDE system


Energy Source
Change in Energy
Sensitive body
Signal Record
Observer

NDE system

Radiographic Testing (RT)



Radiation energy

Passed Radiation changes with the intensity of the object

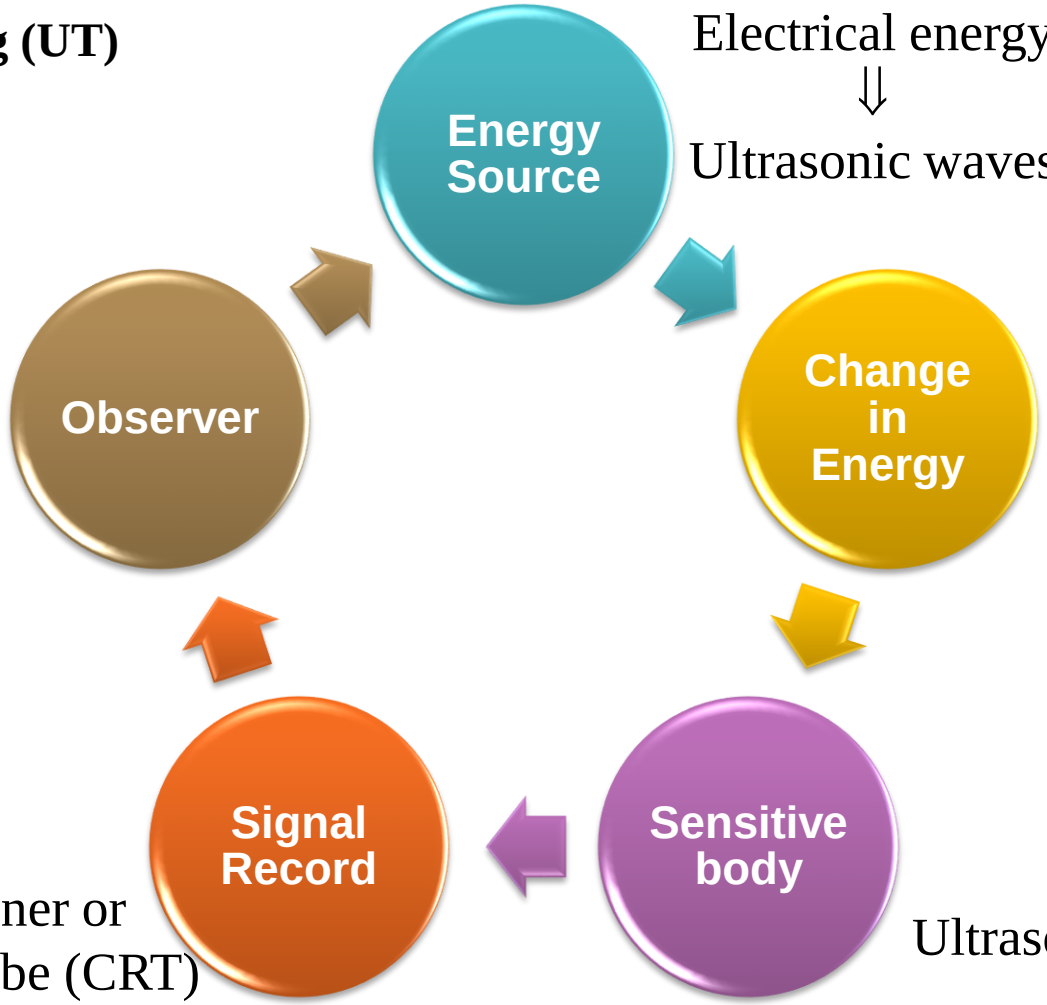
Radiography film

Developing the film

Inspector

NDE system

Ultrasonic testing (UT)



Electrical energy
⇓
Ultrasonic waves

Reflection the ultrasonic waves at discontinuities surfaces

Ultrasonic Transducer

Display scanner or Cathode Ray Tube (CRT)

Inspector

NDE Applications

There are NDE 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

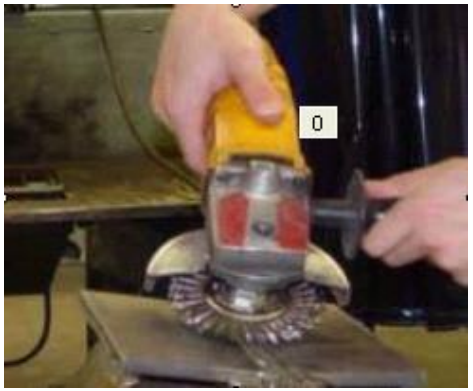
NDE Applications

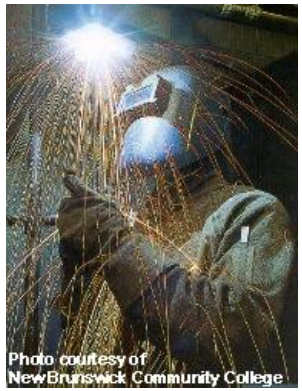
There are NDE application at almost any stage in the production or life cycle of a component.

NDE Applications

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

- In-process inspection: during the fabrication of part or the system.





Following Secondary Processing

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

Raw Products

Forgings, Castings, Extrusions, etc.

NDE Applications

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

- Final inspection: when the of part or the system is completed and ready for delivery

NDE Applications

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

- In-service inspection: during service life of part or the system

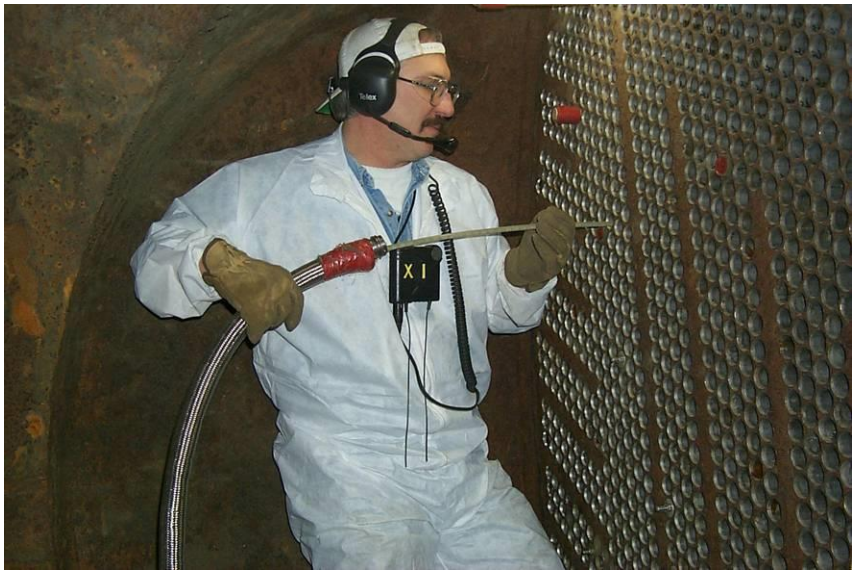
Inspection For In-Service Damage

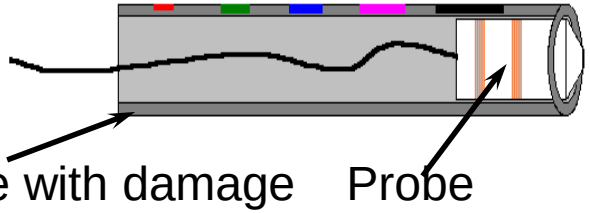
Cracking, Corrosion, Erosion, Wear, Heat Damage, etc.

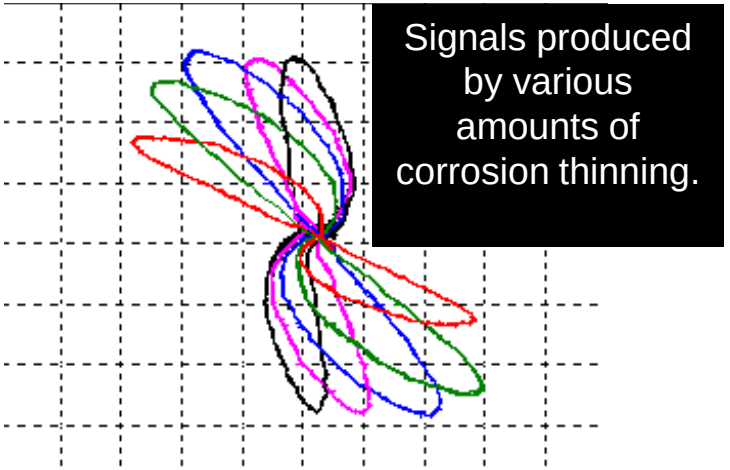



Power Plant Inspection

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

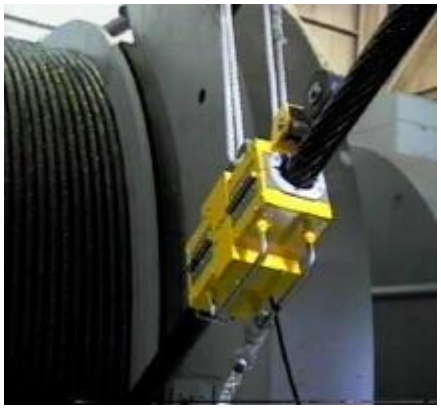






Wire Rope Inspection

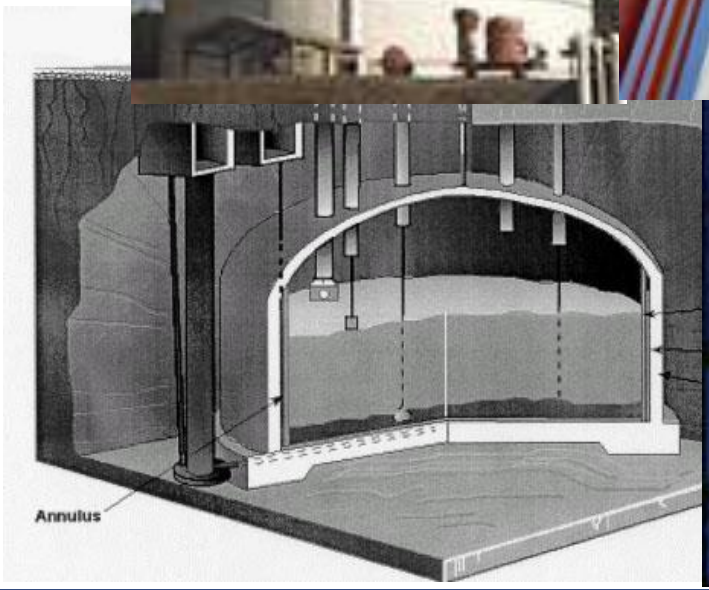
Electromagnetic devices and visual inspections are used to find broken wires and other damage to the wire rope that is used in chairlifts, cranes and other lifting devices.



Storage Tank Inspection

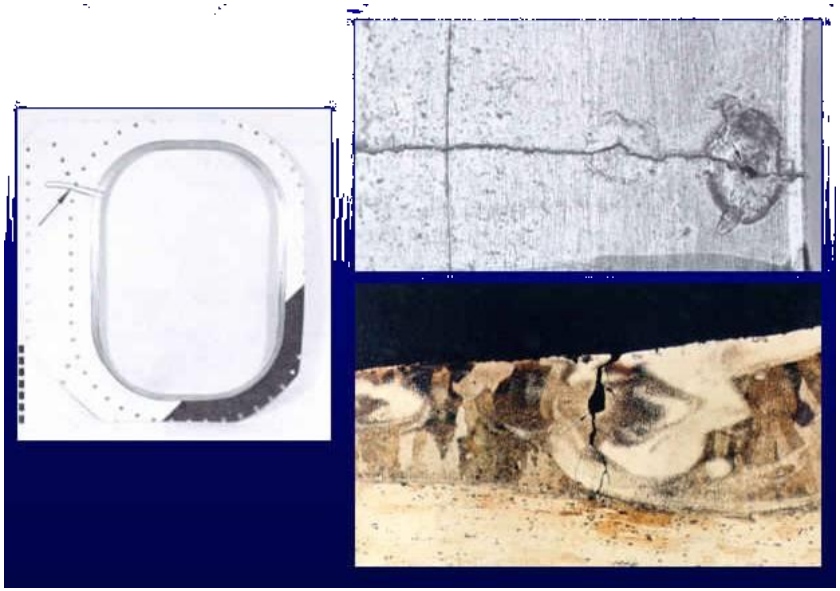
Robotic crawlers use ultrasound to inspect the walls of large above ground tanks for signs of thinning due to corrosion.

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



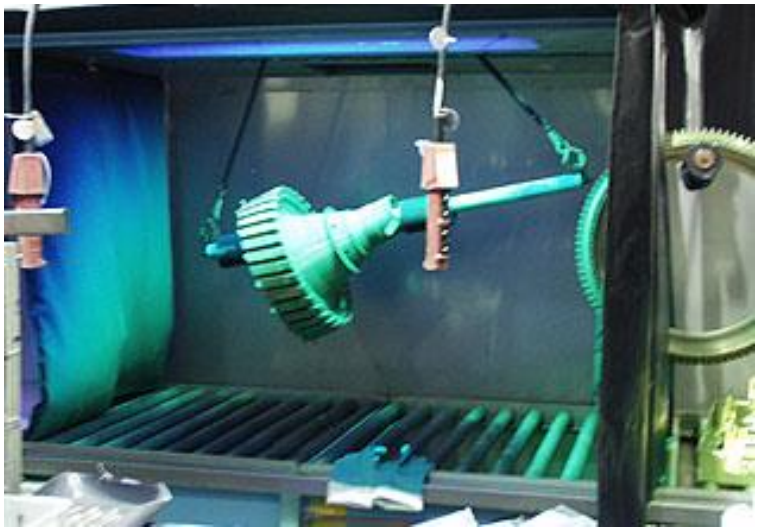
Aircraft Inspection

- 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

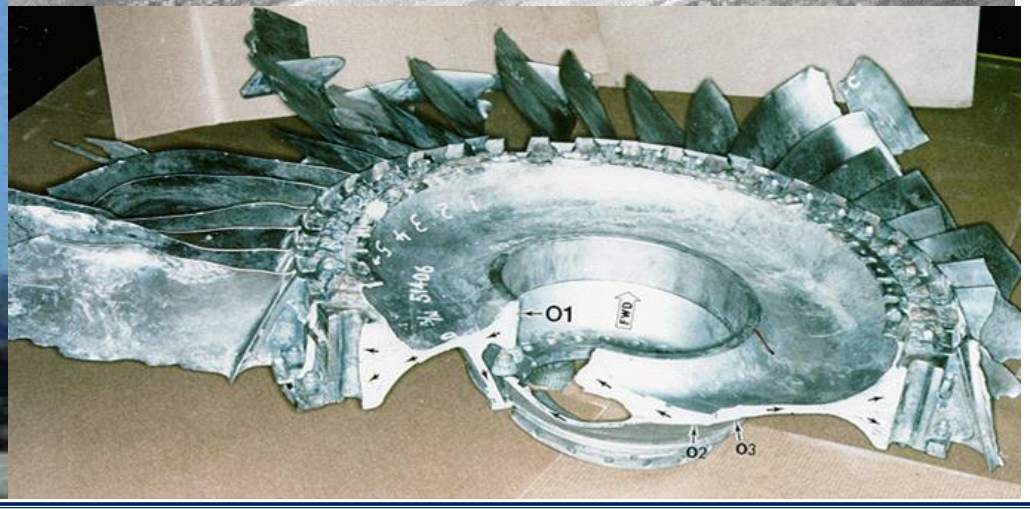
- Aircraft engines are overhauled after being in service for a period of time.
- They are completely disassembled, cleaned, inspected and then reassembled.
- Fluorescent penetrant inspection is used to check many of the parts for cracking.



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

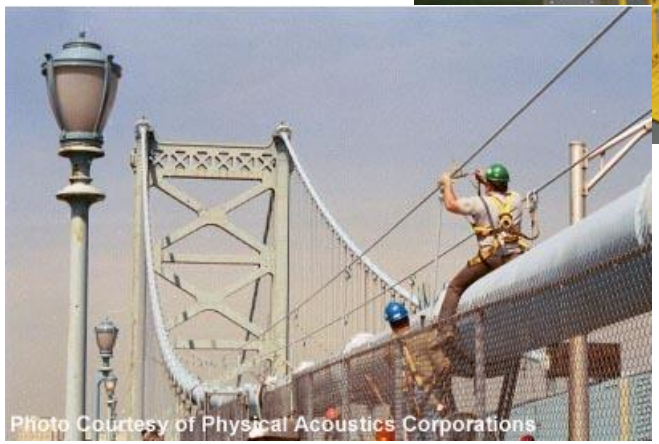
The failure of a pressure vessel can result in the rapid release of a large amount of energy. To protect against this dangerous event, the tanks are inspected using radiography and ultrasonic testing.

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 US has 578,000 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.



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


Photo Courtesy of Yxlon International

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 a various points to evaluate its uniformity.

History of NDE

When did NDE begin?

It is impossible to identify a specific date that would indicate exactly when nondestructive testing as we know it today, began.

History of Nondestructive Testing

When did NDE begin?

In ancient times, the audible ring of a Damascus sword blade would be an indication of how strong the metal would be in combat. This same “sonic” technique was used for decades by blacksmiths as they listened to the ring of different metals that were being shaped. This approach was also used by early bell-makers.

History of Nondestructive Testing

When did NDT begin?

Visual testing, while not “officially” considered a part of early NDT technology, had been in use for many years for a wide range of applications.

History of Nondestructive Testing

When did NDT begin?

Heat sensing was used to monitor thermal changes in materials.

History of Nondestructive Testing

When did NDT begin?

BC (approx.)	Visual testing becomes the first NDT method when God creates the heavens and earth and “sees” that it is good!
1800	First thermography observations by Sir William Herschel
1831	First observation of electromagnetic induction by Michael Farraday
1840	First infrared image produced by Herschel’s son, John
1868	First reference to magnetic particle testing reported by S. H. Saxby, by observing how magnetized gun barrels affect a compass
1879	Early use of eddy currents to detect differences in conductivity, magnetic permeability, and temperature initiated by E. Hughes

History of Nondestructive Testing

When did NDT begin?

1880–1920	“Oil and whiting” technique, forerunner of present-day penetrant test used for railroad axles and boilerplates
1895	X-rays discovered by Wilhelm Conrad Roentgen
1898	Radium discovered by Marie and Pierre Curie
1922	Industrial Radiography for metals developed by Dr. H. H. Lester
1927–28	Electric current innduction/magnetic field detection system developed by Dr. Elmer Sperry and H. C. Drake for the inspection of railroad track
1929	Magnetic particle tests/equipment pioneered by A. V. deForest and F. B. Doane

History of Nondestructive Testing

When did NDT begin?

1929	First experiments using quartz transducers to create ultrasonic vibrations in materials were conducted by S. Y. Sokolov in Russia
1930	Practical uses for gamma radiography using radium were demonstrated by Dr. Robert F. Mehl
1935–1940	Penetrant techniques developed by Betz, Doane, and DeForest
1935–1940's	Eddy current instrument developments by H. C. Knerr, C. Farrow, Theo Zuschlag, and Dr. F. Foerster
1940–1944	Ultrasonic test method developed in United States by Dr. Floyd Firestone

History of Nondestructive Testing

When did NDT begin?

1942	First ultrasonic flaw detector using pulse-echo introduced by D. O. Sproule (United Kingdom)
1946	First portable ultrasonic thickness measuring instrument, the Audigage, was introduced by Branson
1950	Acoustic emission introduced as an NDT method by J. Kaiser
Mid 1950's	First ultrasonic testing immersion B and C scan instruments developed by Donald C. Erdman

History of Nondestructive Testing

When did NDT begin?

From the late 1950's to present, NDT has seen unprecedented development, innovation, and growth through new instrumentation and materials. The ability to interface much of the latest equipment with computers has had a dramatic impact on this technology. The ability to store vast amounts of data with almost instant archival capability has taken NDT to a level once only imagined, The quest to detect and identify smaller discontinuities will not end until catastrophic failures can no longer be related to the existence of material flaws.

Basic Definitions Related to NDE

Procedure

In non-destructive testing, a procedure is an orderly sequence of rules or instructions which describe in detailed terms where, how and in which sequence an NDT method should be applied to a production.

Technique

A technique is a specific way of utilizing a particular non-destructive testing method. Each technique is identified by at least one particular important variable from another technique within the method (Example: RT method-X ray/gamma ray Techniques)

Examination and testing

Examination and testing are those quality control functions which are carried out, during the fabrication of an industrial product, by quality persons who are employees of the manufacturer. Testing may also be defined as the physical performance of operations (tests) to determine quantitative measures of certain properties. Most of the non-destructive testing is performed under this heading.

Inspection

Inspections are the quality control functions which are carried out, during the fabrication of an industrial product by an authorized inspector. They include measuring, examining, testing, gauging or otherwise comparing the findings with applicable requirements.

Authorized Inspector

An authorized inspector is a person who is not the employee of the manufacturer of an industrial product but who is properly qualified and has the authority to verify to his satisfaction that all examinations specified in the construction code of the product have been made to the requirements of the referencing section of the construction code.

Report

A report of a non-destructive examination or of testing is a document which includes all the necessary information required to be able to:

- Take decisions on the acceptance of the defects by the examination.
- Facilitate repairs of unacceptable defects.
- Permit the examination or testing to be repeated.

Report

All NDT shall be properly documented in such a way that the performed testing can be easily retraced at a later stage. The reports shall identify the unacceptable defects present in the tested area, and a conclusive statement as to whether the part or structure satisfies the acceptance criteria or not.

Report

The report shall include a reference to the applicable standard, NDT procedure and acceptance criteria.

In addition, as a minimum, the following information must be given:

1. object and drawing references
2. place and date of examination
3. material type and dimensions
4. post heat treatment, if required
5. location of examined areas,
6. type of joint and joining process used if applicable
7. name of the company and operator carrying out the testing including certification level of the operator

Report

The report shall include a reference to the applicable standard, NDT procedure and acceptance criteria.

In addition, as a minimum, the following information must be given:

8. surface conditions
9. temperature of the object
10. number of repairs if specific area repaired twice or more
11. contract requirements e.g. order no., specifications, special agreements etc.
12. sketch showing location and information regarding detected defects,
13. extent of testing

Report

The report shall include a reference to the applicable standard, NDT procedure and acceptance criteria.

In addition, as a minimum, the following information must be given:

13. test equipment used
14. description of the parameters used for each method
15. description and location of all recordable indications
16. examination results with reference to acceptance level.
17. number of repairs to be specified in the report, such as once or twice repairs in the same area.

Records

Records are documents which will give, at any time in the future, the following information about a non-destructive testing examination,

- the procedure used to carry out the examination,
- the data recording and data analysing techniques used,
- the results of the examination.

Guide and Recommended practices

Guides and recommended practices are standards that are offered primarily as aids to the user. They use verbs such as "should" and "may" because their use in usually optional. However, if these documents are referenced by codes or contractual agreements, their use may become mandatory. If the codes or agreements contain non-mandatory sections or appendices, the use of referenced guides and recommended practices by them, are at the user's discretion.

Standards

Standards are documents that govern and guide the various activities occurring during the production of an industrial product. Standards describe the technical requirements for a material, process, product, system or service. They also indicate as appropriate, the procedures, methods, equipment or tests to determine that the requirements have been met.

Standardization

Standardization of a process can be defined as the setting up of process parameters so that it constantly produces a product of uniform characteristics.

Codes and Specifications

Codes and specifications are similar types of standards that use the verbs "shall" or "will" to indicate the mandatory use of certain materials or actions or both. Codes differ from specifications in that their use is mandated with the force of law by governmental jurisdiction. The use of specifications becomes mandatory only when they are referenced by codes or contractual documents.

A prime example of codes is the ASME boiler and pressure vessel code which is a set of standards that assure the safe design, construction and testing of boilers and pressure vessels.

Standardization bodies

American Society for Testing and Materials

American Society for Testing and Material
ASTM

ISO International Organization for Standardization

International Standard Organization
ISO

ASNT®

The American Society for Nondestructive Testing

American Society for Non-Destructive Testing
ASNT

Standardization bodies

German Industrial standard
DIN

American Society Mechanical Engineers
ASME

Institut Marocain de Normalisation
IMANOR

Syrian Arab standards and metrology organization
SASMO

Standardization bodies

International Institute of Welding
IIW

European Norm
EN

Association Française de Normalisation
AFNOR

British Standards
BSI

Qualification and Certification

Certification

Procedure used by the certification body to confirm that the qualification requirements for a method, level and sector have been fulfilled, leading to the issuing of a certificate

Qualification

Demonstration of physical attributes, knowledge, skill, training and experience required to properly perform NDT tasks

Qualification and Certification

Personnel performing testing shall be qualified and certified to an appropriate level in accordance with EN 473, ISO 9712, SNT–TC–1A or other equivalent recognized standard or certification schemes.

Personnel performing non-destructive testing is classified into three levels:

- ✓ *Level 1*
- ✓ *Level 2*
- ✓ *Level 3*

Qualification and Certification

Level 1

An individual certificated to Level 1 has demonstrated competence to carry out NDT according to written instructions and under the supervision of level 2 or 3 personnel. Within the scope of the competence defined on the certificate, level 1 personnel may be authorized to:

- ✓ set up NDT equipment
- ✓ perform the test
- ✓ record and classify the results of the tests in terms of written criteria

Qualification and Certification

Level 1

An individual certificated to Level 1 has demonstrated competence to carry out NDT according to written instructions and under the supervision of level 2 or 3 personnel. Within the scope of the competence defined on the certificate, level 1 personnel may be authorized to:

- ✓ report the results
- ✓ Level 1 certificated personnel shall not be responsible for the choice of test method or technique to be used, nor for the assessment of the test results.

Qualification and Certification

Level 2

An individual certificated to Level 2 has demonstrated competence to perform non-destructive testing according to established or recognized procedures. Within the scope of the competence defined on the certificate, level 2 personnel may be authorized to:

- ✓ select the NDT technique for the test method to be used.
- ✓ define the limitations of application of the testing method
- ✓ translate NDT standards and specifications into NDT instructions
- ✓ set up and verify equipment settings
- ✓ perform and supervise tests

Qualification and Certification

Level 2

An individual certificated to Level 2 has demonstrated competence to perform non-destructive testing according to established or recognized procedures. Within the scope of the competence defined on the certificate, level 2 personnel may be authorized to:

- ✓ interpret and evaluate results according to applicable standards, codes or specifications
- ✓ prepare written NDT instructions
- ✓ carry out and to supervise all level 1 duties.

Qualification and Certification

Level 3

An individual certificated to Level 3 has demonstrated competence to perform and direct non-destructive testing operations for which he is certificated. An individual certificated to level 3 may:

- ✓ assume full responsibility for a test facility or examination center and staff
- ✓ establish and validate NDT instructions and procedures
- ✓ interpret standards, codes, specifications and procedures
- ✓ designate the particular test methods, procedures and NDT instructions to be used
- ✓ carry out and to supervise all level 1 and 2 duties.

Qualification and Certification

There are two methods of certification;

1. In-house (second party)
2. Central agency (third party)

Qualification and Certification

1. In-house (second party)

SNT-TC-1A and the ANSI CP-189 documents are examples of the Second Party method This is perhaps best suited to companies where their NDT staff is employed in a limited environment and the operators can be trained at the specific tasks in their shop. It is also ideal for companies where they use specialized equipment and techniques not found outside of that shop environment. The training and examination can then be customized to the exact tasks at hand. This method of certification is the sort of scheme now associated with “performance demonstration” schemes where unique applications require a specialized program.

Qualification and Certification

1. In-house (second party)

In Second Party schemes certification is issued by the employer. This places the responsibility for the operators' performance directly on the employer. There are pros and cons to this option. The certificate issued by the company is company-specific. Once the NDT technician is no longer an employee of that company their certification is invalid.

Qualification and Certification

2. Central agency (third party)

The Third Party schemes were derived, at least in part, to prevent such “short-cuts”. Third Party schemes are based on the premise that an agency completely separate from the individual NDT technician and their employer will be able to impartially assess the qualifications of the individual looking for certification. Third Party schemes have become popular in most countries outside the USA and they have been around for several decades.

Qualification and Certification

Eligibility for certification

Qualification and Certification of NDE Personnel is based on these five basic factors:

1. Training Requirements
2. Experience in the given NDE method
3. Vision Requirements
4. Basic Educational Qualification
5. Examination Requirements