UNIT-4

TESTING AND INSPECTION

Major types of NDT

- Detection of surface flaws
  - Visual
  - Magnetic Particle Inspection
  - Fluorescent Dye Penetrant Inspection
- Detection of internal flaws
  - Radiography
  - Ultrasonic Testing
  - Eddy current Testing

1. VISUAL INSPECTION

- All parts should be given a preliminary visual inspection either as they are removed from the engine at the completion of disassembly.
- It is method of direct examination by magnifying glass.
- Defects and damages can be identified using visual inspection.

1. Visual Inspection

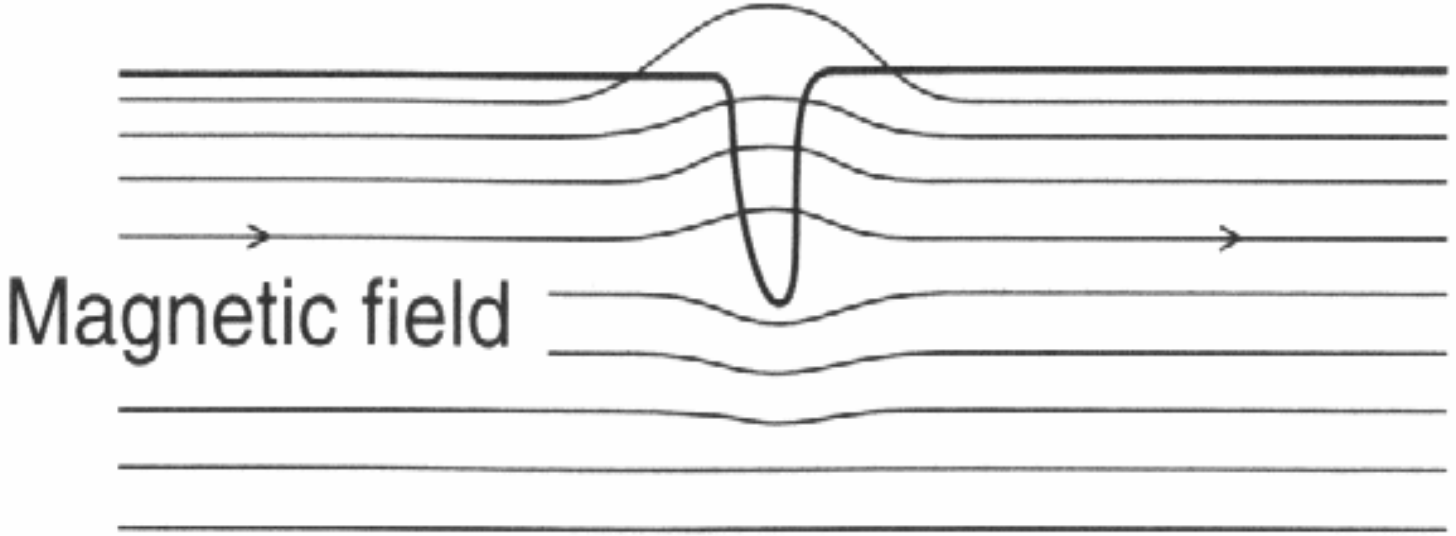
Most basic and common inspection method.

Tools include fiberscopes, borescopes, magnifying glasses and mirrors.

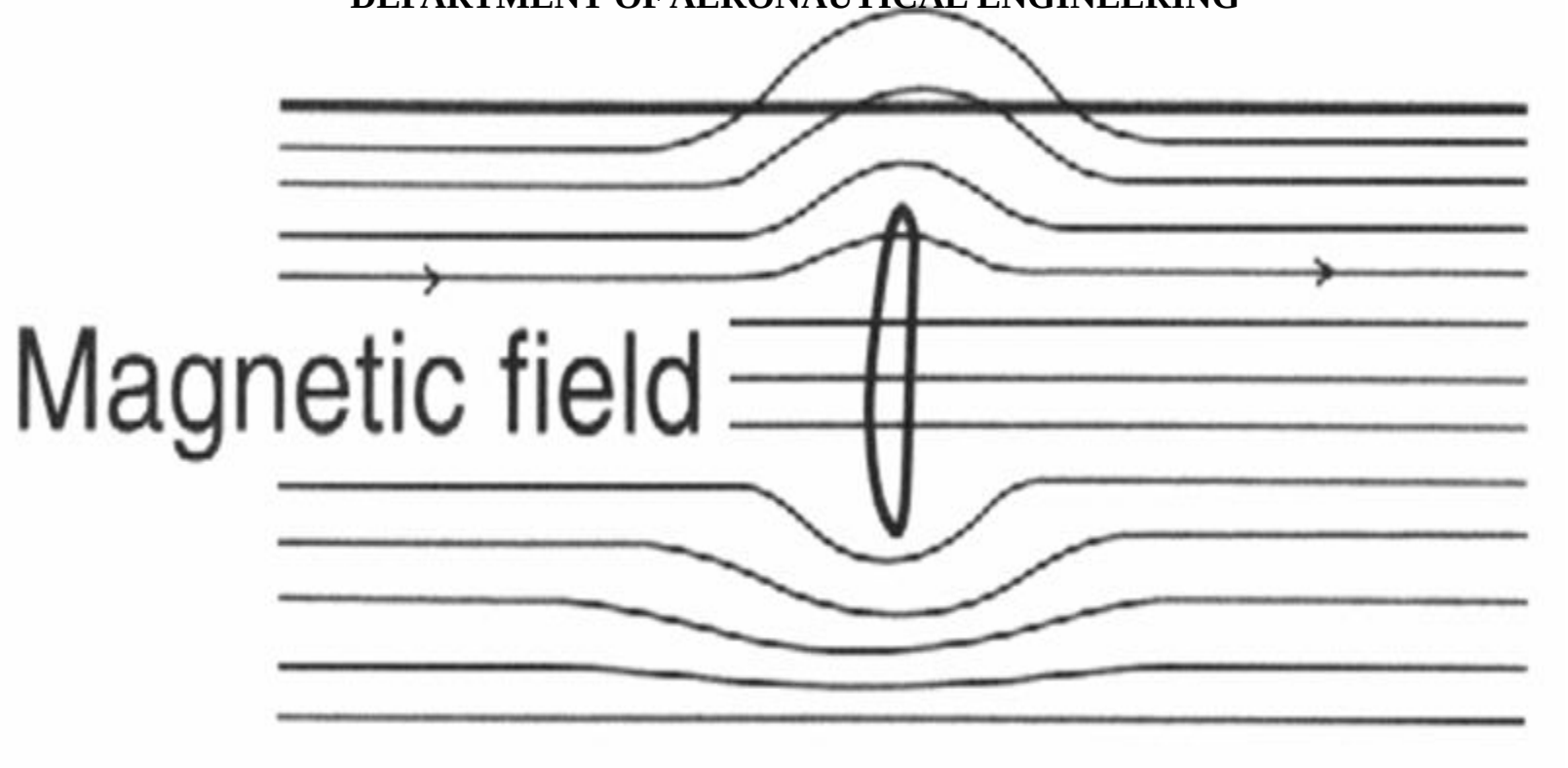
Portable video inspection unit with zoom allows inspection of large tanks and vessels, railroad tank cars, sewer lines.

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

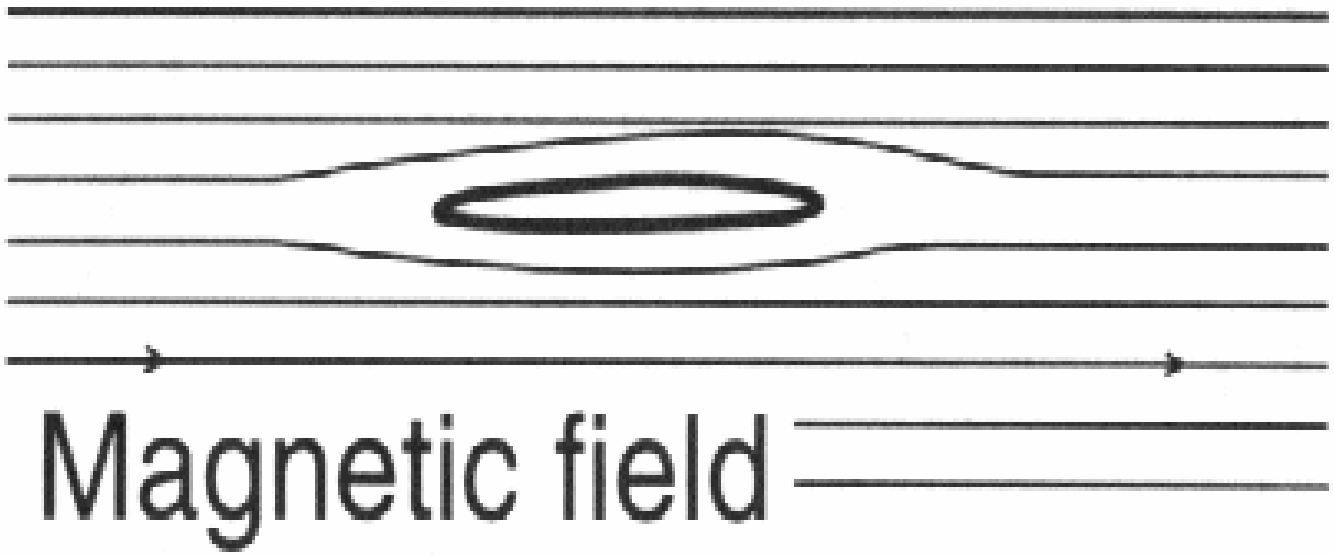
2. MAGNETIC PARTICLE INSPECTION



Distortion of the magnetic flux lines due to a surface crack in a magnetic material



Distortion of the magnetic flux lines due to a subsurface defect



Little distortion of the magnetic flux lines when the length of the defect is parallel to the applied magnetic field will not

Magnetic Particle Testing

Magnetic particle testing is a **nondestructive** method for locating surface and subsurface discontinuities (cracks or defects) in ferromagnetic materials such as steel. The parts are magnetized by passing a strong electric current through or around them. An electric current is always accompanied by a magnetic field. The magnetic lines of flux travel through the part when it is magnetized. A crack or **discontinuity** will create a flux leakage. A **flux leakage** occurs where the lines of flux leave the surface of the material, resulting in a concentration of magnetic strength at the discontinuity, as shown in Fig. 10–8.

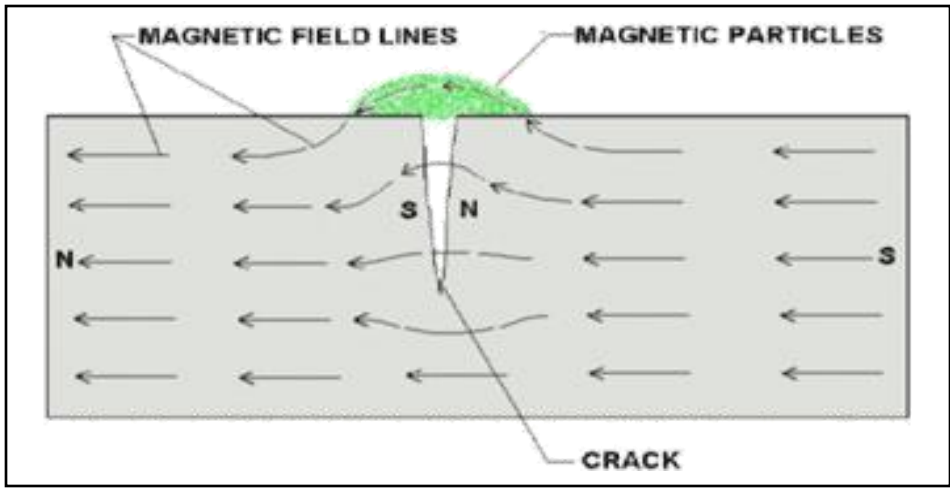
Magnetic particles are applied to the magnetized part and concentrate in the areas of flux leakage, giving a visible sign of a discontinuity.

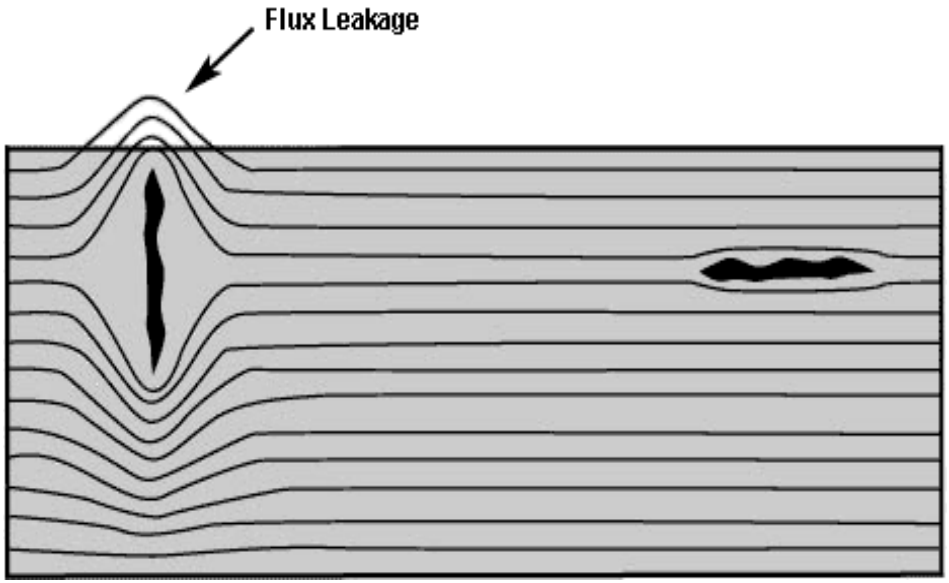
Magnetic particle testing is done with special equipment, such as that manufactured by Magnaflux Cor-

Magnetic Particle Inspection

- The magnetic flux line close to the surface of a ferromagnetic material tends to follow the surface profile of the material
- Discontinuities (cracks or voids) of the material perpendicular to the flux lines cause fringing of the magnetic flux lines, i.e. flux leakage
- The leakage field can attract other ferromagnetic particles

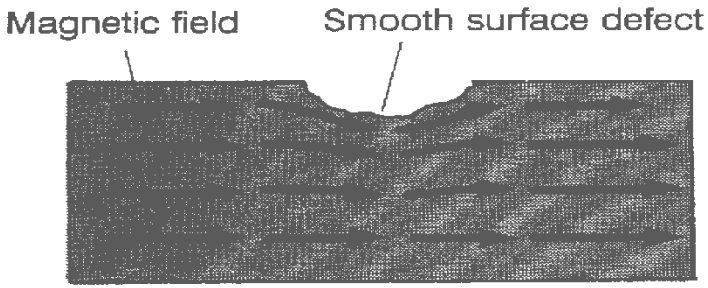
The magnetic particles form a ridge many times wider than the crack itself, thus making the otherwise invisible crack visible

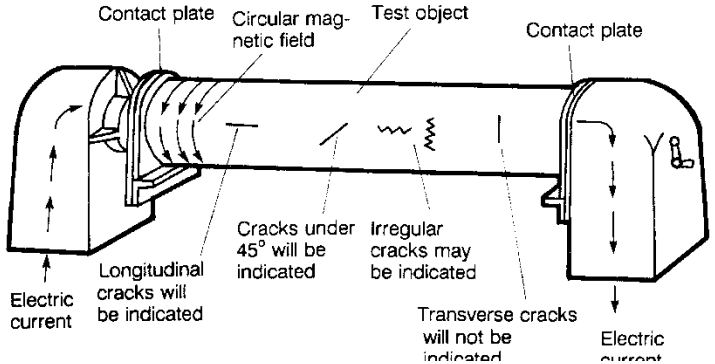




Cracks just below the surface can also be revealed

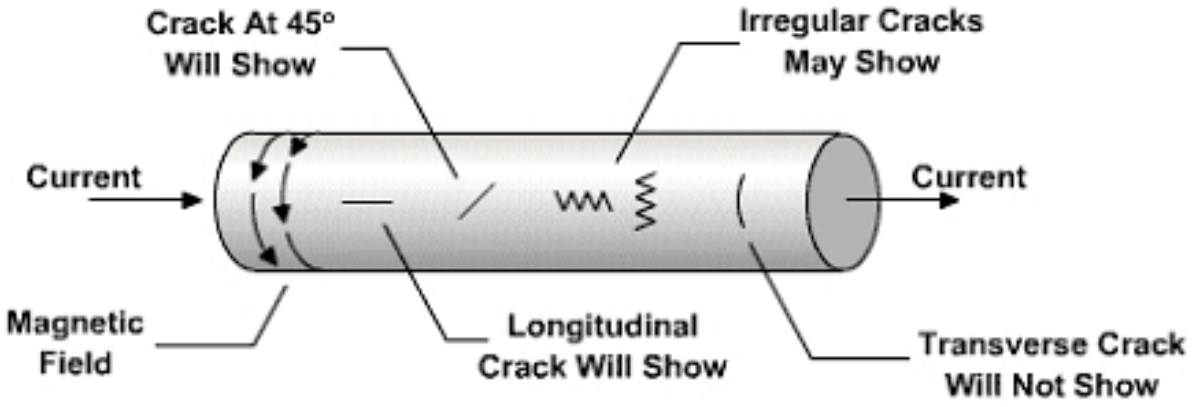
MPI is not sensitive to shallow and smooth surface defects





Stationary bench unit. The impor
relation to the magnetic field line

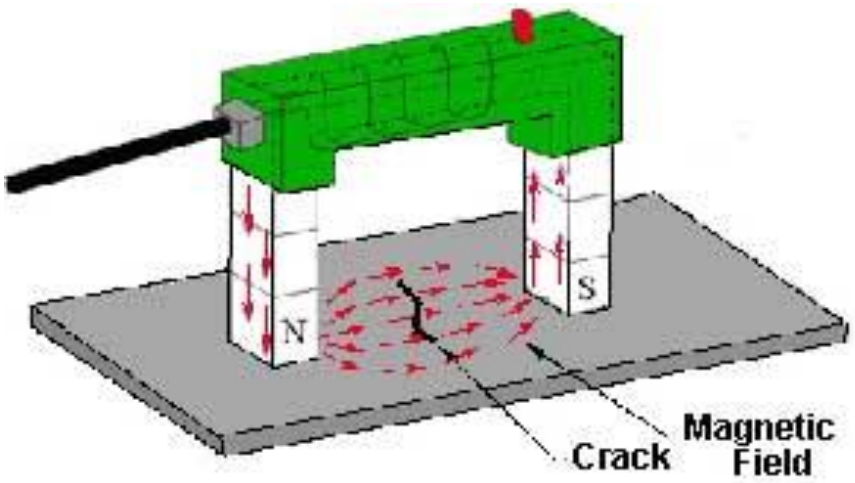
The effectiveness of MPI depends strongly on the orientation of the crack related to the flux lines

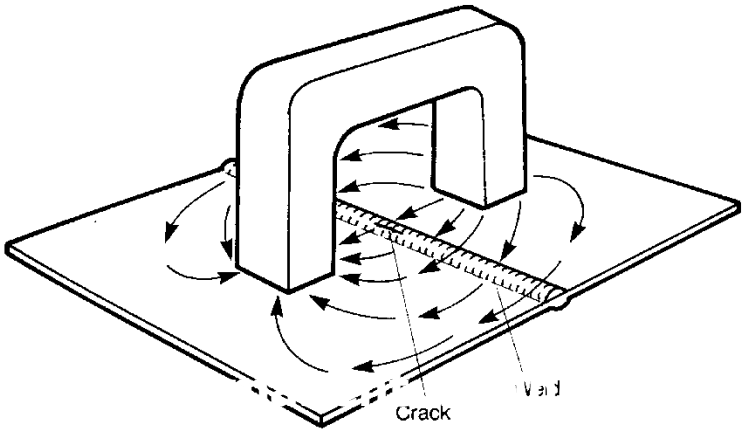


Testing Procedure of MPI

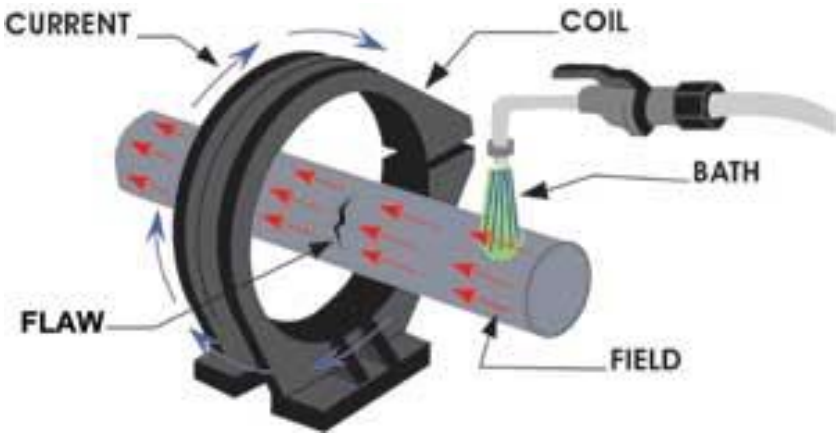
- Cleaning
- Demagnetization
- Contrast dyes (e.g. white paint for dark particles)
- Magnetizing the object
- Addition of magnetic particles
- Illumination during inspection (e.g. UV lamp)
- Interpretation
- Demagnetization - prevent accumulation of iron particles or influence to sensitive instruments

• Indirect magnetization: using a strong external magnetic field to establish a magnetic field within the component





Magnetization using a permanent magnet.



Advantages of magnetic particle testing

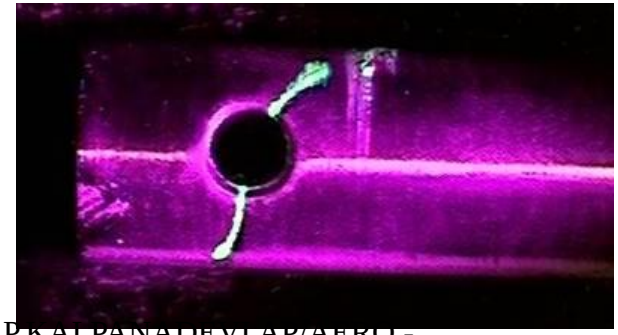
- ✓Best method for the detection of fine, shallow surface cracks in ferromagnetic material
- ✓Fast and relatively simple NDT method
- ✓Generally inexpensive
- ✓One of the most dependable and sensitive methods for surface defects
- ✓Fast, simple and inexpensive
- ✓Direct, visible indication on surface
- ✓Can be used on painted objects
- ✓Surface preparation not required
- ✓Results readily documented with photo or tape impression

Limitations Of Magnetic Particle Testing

- ✓ Material must be ferromagnetic
- ✓ Large currents sometimes required
- ✓ Orientation and strength of magnetic field is critical
- ✓ Sub-surface defects will not always be indicated
- ✓ Relative direction between the magnetic field and the defect line is important
- ✓ Objects must be demagnetized before and after the examination
- ✓ The current magnetization may cause burn scars on the item examined

3. DYE PENETRANT INSPECTION

Liquid penetrant inspection (LPI) is one of the most widely used nondestructive evaluation (NDE) methods. Its popularity can be attributed to two main factors, which are its relative ease of use and its flexibility. LPI can be used to inspect almost any material provided that its surface is not extremely rough or porous. Materials that are commonly inspected using LPI include metals (aluminum, copper, steel, titanium, etc.), glass, many ceramic materials, rubber, and plastics.

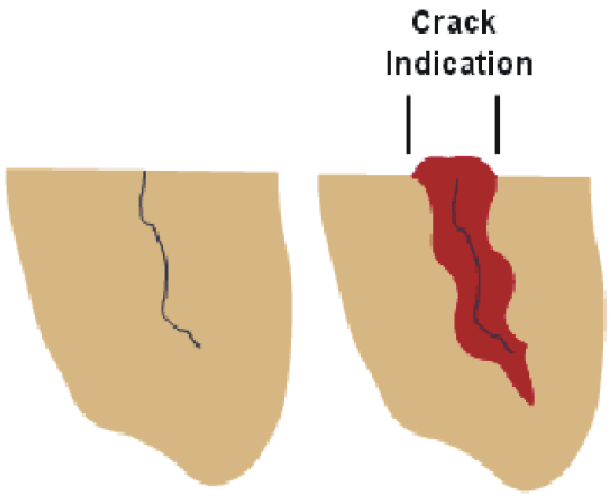


INTRODUCTION

- Liquid penetration inspection is a method that is used to reveal surface breaking flaws by bleed out of a colored or fluorescent dye from the flaw.
- The technique is based on the ability of a liquid to be drawn into a "clean" surface breaking flaw by capillary action.
- After a period of time called the "dwell," excess surface penetrant is removed and a developer applied. This acts as a "blotter." It draws the penetrant from the flaw to reveal its presence.
- Colored (contrast) penetrants require good white light while fluorescent penetrants need to be used in darkened conditions with an ultraviolet "black light". Unlike MPI, this method can be used in non-ferromagnetic materials and even non-metals
- Modern methods can reveal cracks 2μm wide

Why Liquid Penetrant Inspection?

- To improves the detectability of flaws



There are basically two ways that a penetrant inspection process makes flaws more easily seen.

(1) LPI produces a flaw indication that is much larger and easier for the eye to detect than the flaw itself.

(2) LPI produces a flaw indication with a high level of contrast between the indication and the background.

The advantage that a liquid penetrant inspection (LPI) offers over an unaided visual inspection is that it makes defects easier to see for the inspector.

Basic processing steps of LPI

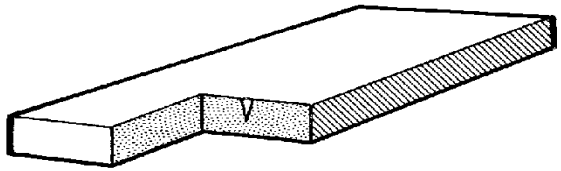
1. **Surface Preparation:** One of the most critical steps of a liquid penetrant inspection is the surface preparation. The surface must be free of oil, grease, water, or other contaminants that may prevent penetrant from entering flaws. The sample may also require etching if mechanical operations such as machining, sanding, or grit blasting have been performed. These and other mechanical operations can smear the surface of the sample, thus closing the defects.
2. **2.Penetrant Application:** Once the surface has been thoroughly cleaned and dried, the penetrant material is applied by spraying, brushing, or immersing the parts in a penetrant bath.

3. Penetrant Dwell: The penetrant is left on the surface for a sufficient time to allow as much penetrant as possible to be drawn from or to seep into a defect. The times vary depending on the application, penetrant materials used, the material, the form of the material being inspected, and the type of defect being inspected. Generally, there is no harm in using a longer penetrant dwell time as long as the penetrant is not allowed to dry.

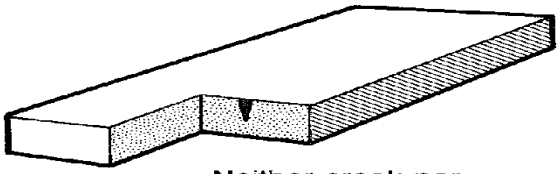
4. **Excess Penetrant Removal:** This is the most delicate part of the inspection procedure because the excess penetrant must be removed from the surface of the sample while removing as little penetrant as possible from defects. Depending on the penetrant system used, this step may involve cleaning with a solvent, direct rinsing with water, or first treated with an emulsifier and then rinsing with water.
5. **Developer Application:** A thin layer of developer is then applied to the sample to draw penetrant trapped in flaws back to the surface where it will be visible. Developers come in a variety of forms that may be applied by dusting (dry powdered), dipping, or spraying (wet developers).
6. **Indication Development:** The developer is allowed to stand on the part surface for a period of time sufficient to permit the extraction of the trapped penetrant out of any surface flaws. This development time is usually a minimum of 10 minutes and significantly longer times may be necessary for tight cracks.

7. Inspection: Inspection is then performed under appropriate lighting to detect indications from any flaws which may be present.

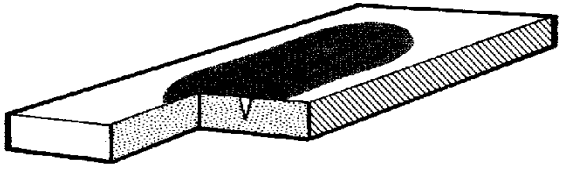
8.Clean Surface: The final step in the process is to thoroughly clean the part surface to remove the developer from the parts that were found to be acceptable.



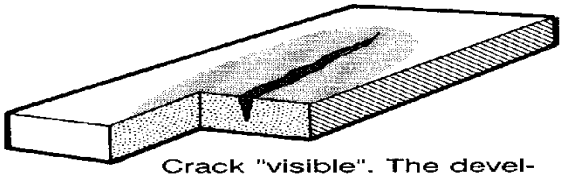
Crack not visible on surface



Neither crack nor penetrant is visible on the surface



Penetrant enters any cracks and porosities

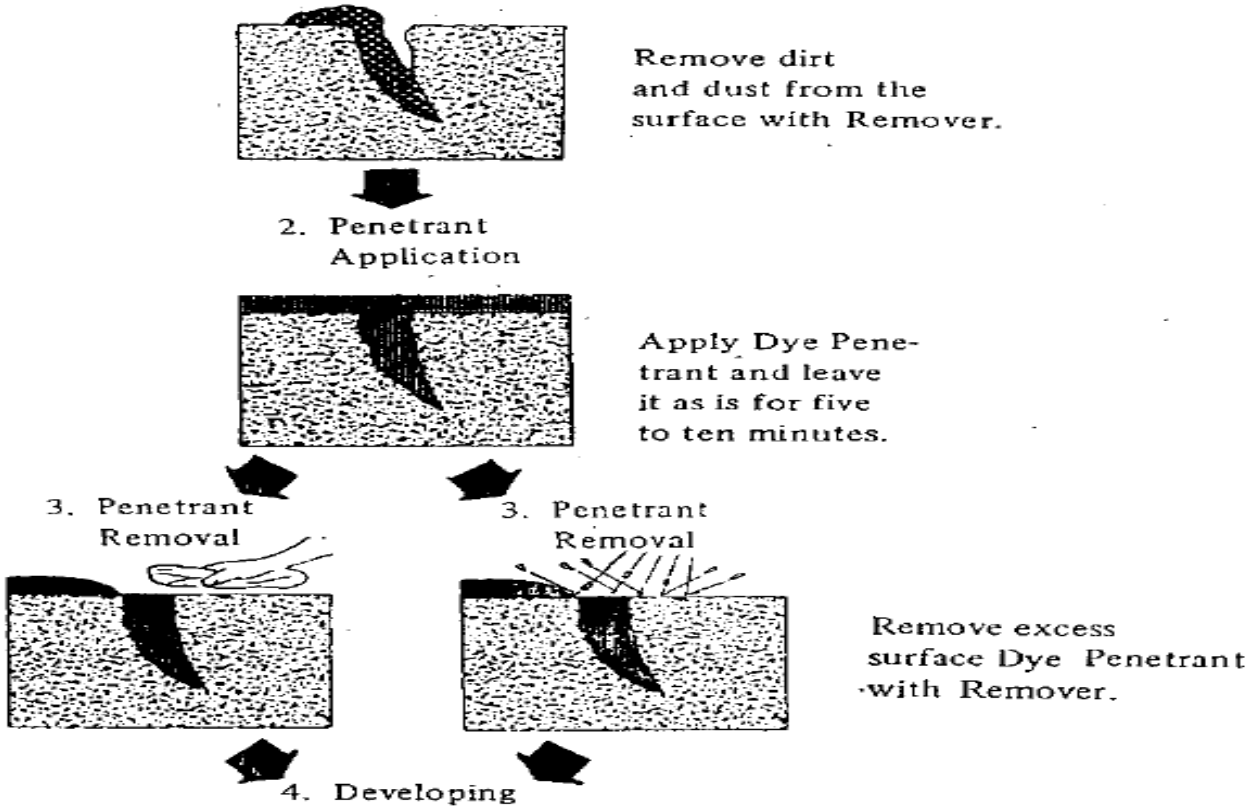


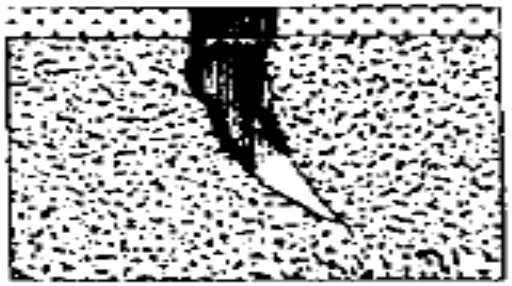
Crack "visible". The developer has drawn the liquid out of the crack and formed a broad indication on top of the crack

The procedure used when performing an examination with a penetrant.

1. *Pre-clean, remove grease and dry the component.*
2. *Penetrant is applied to the component and acts for a brief period.*
3. *Excess penetrant is completely removed from the surface.*
4. *A developer is applied and dried off. Inspect for indication of defects.*

3. FLUORESCENT DYE PENETRANT TECHNIQUE (OR) LIQUID PENETRANT TESTING (PT)





Apply Developer uniformly over the surface.

5. Inspection

Defects will be found in a bright red indication.

Different stages of liquid penetrant process.

Penetrant testing materials

A penetrant must possess a number of important characteristics. A penetrant must

• spread easily over the surface of the material being inspected to provide complete and even coverage.

• be drawn into surface breaking defects by capillary action.

• remain in the defect but remove easily from the surface of the part.

• remain fluid so it can be drawn back to the surface of the part through the drying and developing steps.

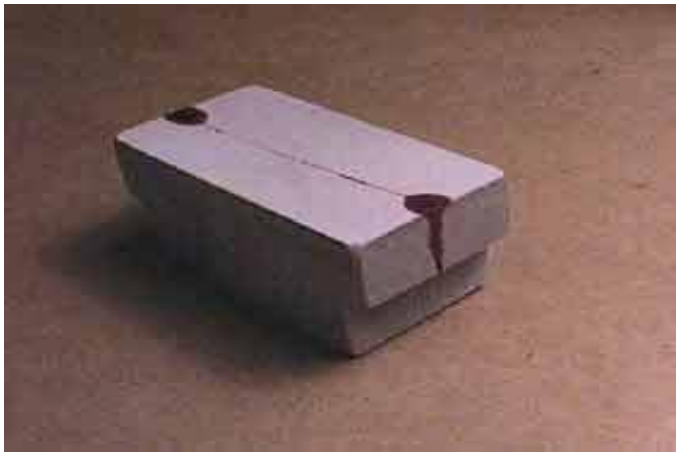
• be highly visible or fluoresce brightly to produce easy to see indications.

• must not be harmful to the material being tested or the inspector.

Penetrant Types

Dye penetrants

- The liquids are coloured so that they provide good contrast against the developer
- Usually red liquid against white developer
- Observation performed in ordinary daylight or good indoor illumination



Fluorescent penetrants

- Liquid contain additives to give fluorescence under UV
- Object should be shielded from visible light during inspection
- Fluorescent indications are easy to see in the dark

Standard: Aerospace Material Specification (AMS) 2644.

Developer Types

- **Dry powder developer** –the least sensitive but inexpensive
- **Water soluble** – consist of a group of chemicals that are dissolved in water and form a developer layer when the water is evaporated away.
- **Water suspendible** – consist of insoluble developer particles suspended in water.
- **Non aqueous** – suspend the developer in a volatile solvent and are typically applied with a spray gun.

Primary Advantages

- The method has high sensitive to small surface discontinuities.
- The method has few material limitations, i.e. metallic and nonmetallic, magnetic and nonmagnetic, and conductive and nonconductive materials may be inspected.
- Large areas and large volumes of parts/materials can be inspected rapidly and at low cost.
- Parts with complex geometric shapes are routinely inspected.
- Indications are produced directly on the surface of the part and constitute a visual representation of the flaw.
- Aerosol spray cans make penetrant materials very portable.
- Penetrant materials and associated equipment are relatively inexpensive.

Primary Disadvantages

- Only surface breaking defects can be detected.
- Only materials with a relative nonporous surface can be inspected.
- Pre cleaning is critical as contaminants can mask defects.
- Metal smearing from machining, grinding, and grit or vapor blasting must be removed prior to LPI.
- The inspector must have direct access to the surface being inspected.
- Surface finish and roughness can affect inspection sensitivity.
- Multiple process operations must be performed and controlled.
- Post cleaning of acceptable parts or materials is required.
- Chemical handling and proper disposal is required.