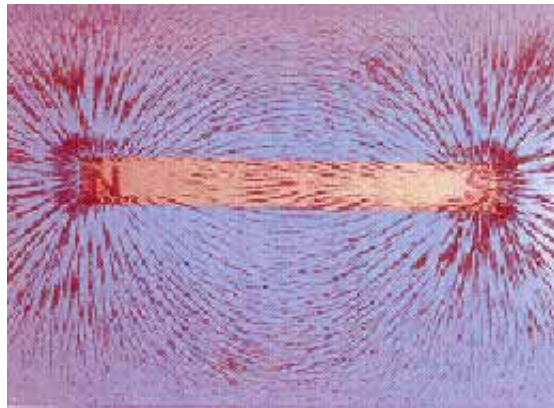


# Magnetic Particle Testing (MPT) [8]

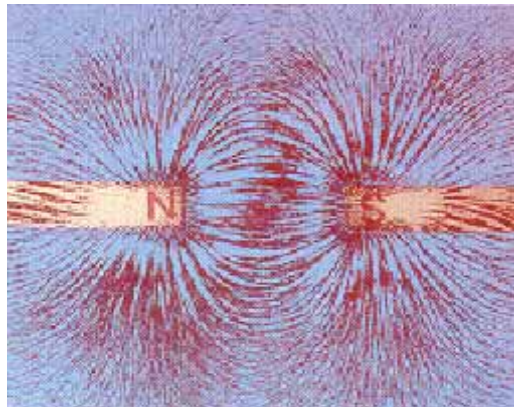
**Magnetism** is the ability of matter to attract other matter to itself. Objects that possess the property of magnetism are said to be magnetic or magnetized and magnetic lines of force can be found in and around the objects. A magnetic pole is a point where the a magnetic line of force exits or enters a material.

**Magnetic field lines:**

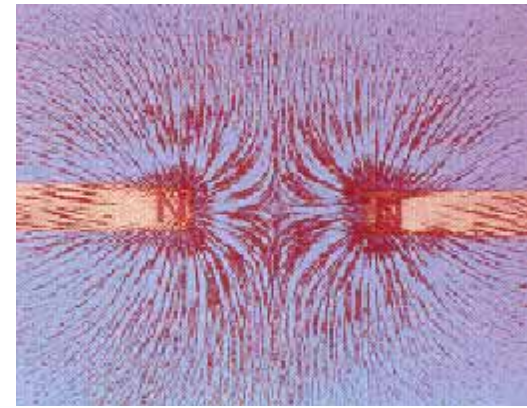
- Form complete loops.
- Do not cross.
- Follow the path of least resistance.
- All have the same strength.
- Have a direction such that they cause poles to attract or repel.



Magnetic lines of force around a bar magnet



Opposite poles attracting



Similar poles repelling

# Magnetism of the Materials

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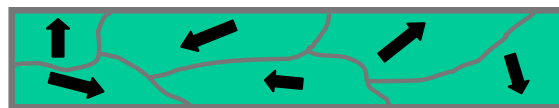
**Diamagnetic materials** are slightly repelled by a magnetic field and the material does not retain the magnetic properties when the external field is removed. Most elements in the periodic table, including copper, silver, and gold, are diamagnetic.

**Paramagnetic materials** are slightly attracted by a magnetic field and the material does not retain the magnetic properties when the external field is removed. Paramagnetic materials include magnesium, molybdenum, lithium, and tantalum..

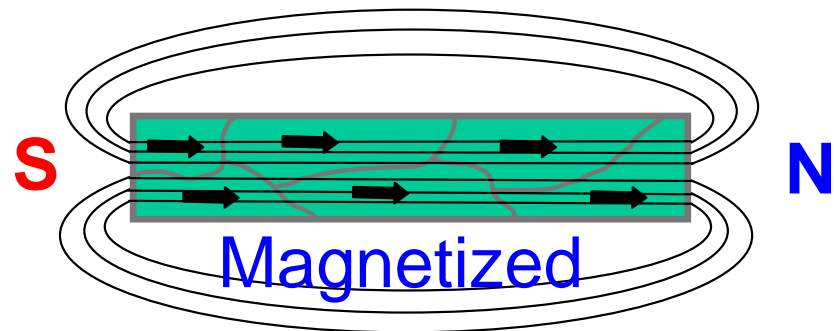
**Ferromagnetic materials** exhibit a strong attraction to magnetic fields and are able to retain their magnetic properties after the external field has been removed. When a magnetizing force is applied, the domains become aligned to produce a strong magnetic field within metals such as iron, nickel, and cobalt.

# Ferromagnetic Materials

- A material is considered ferromagnetic if it can be magnetized. Materials with a significant Iron, nickel or cobalt content are generally ferromagnetic.
- Ferromagnetic materials are made up of many regions in which the magnetic fields of atoms are aligned. These regions are called magnetic domains.
- Magnetic domains point randomly in demagnetized material, but can be aligned using electrical current or an external magnetic field to magnetize the material.



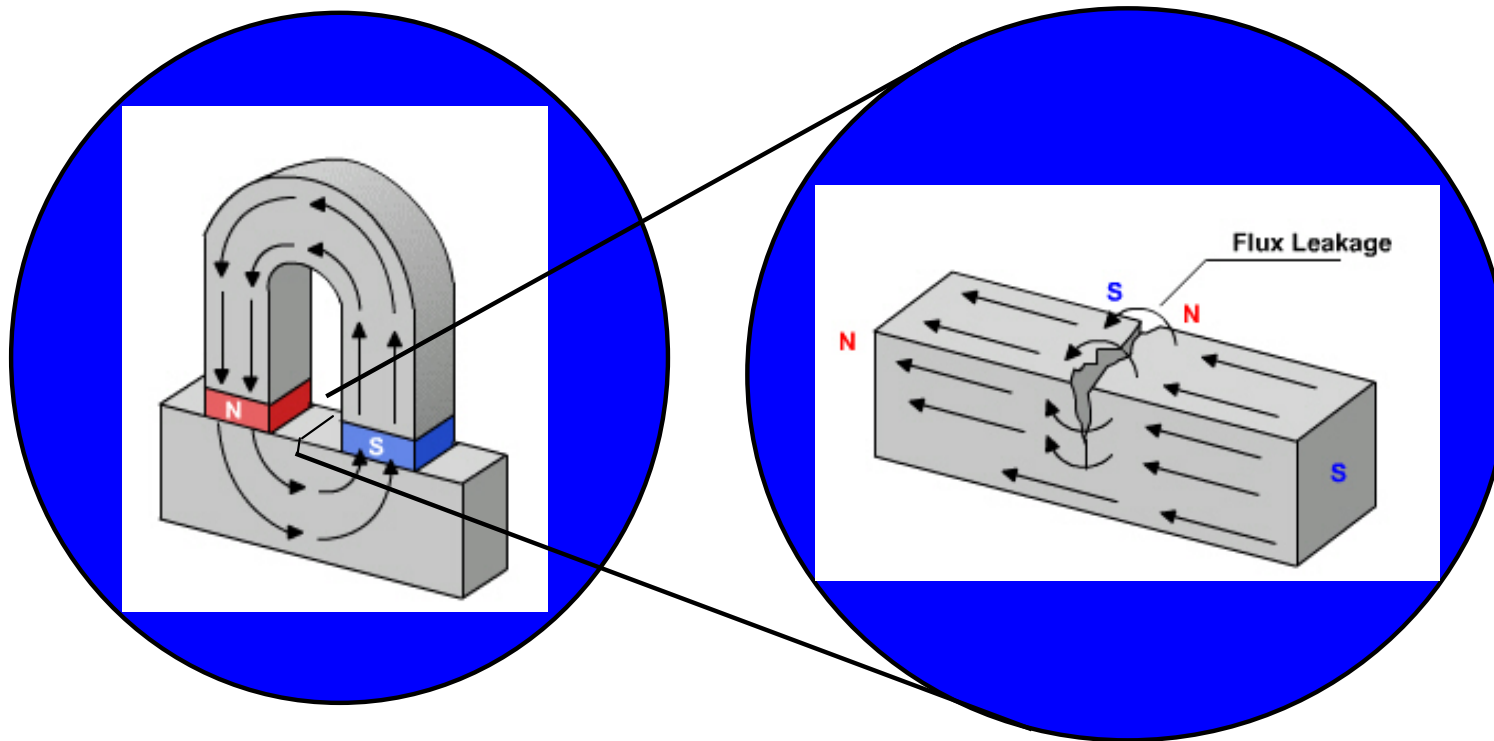
Demagnetized



Magnetized

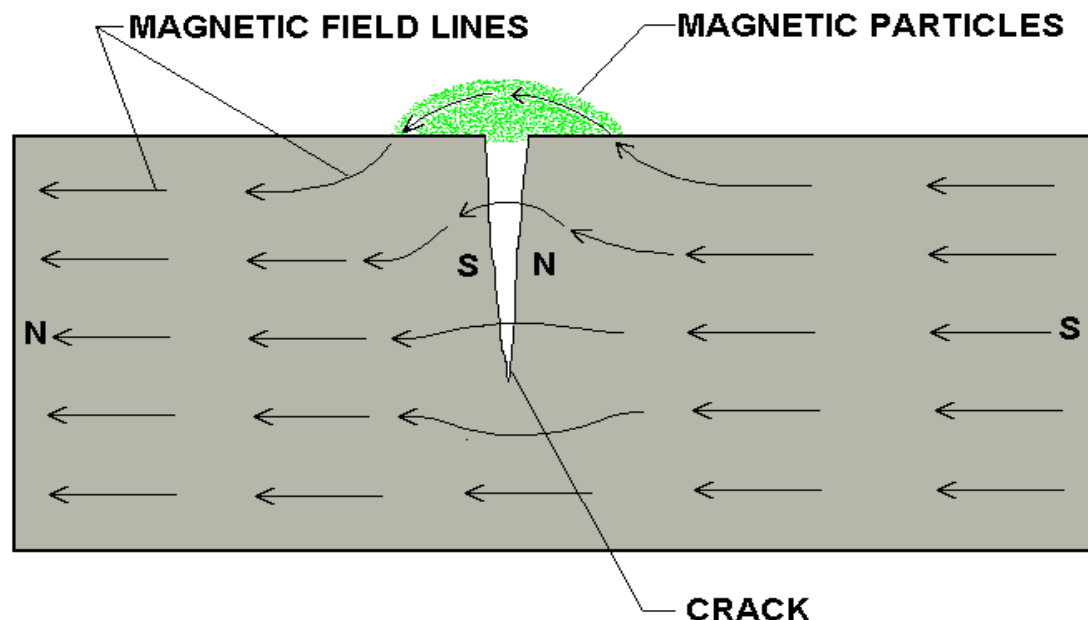
# How Does Magnetic Particle Inspection Work?

A ferromagnetic test specimen is magnetized with a strong magnetic field created by a magnet or special equipment. If the specimen has a discontinuity, the discontinuity will interrupt the magnetic field flowing through the specimen and a leakage field will occur.



# 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 Inspection Procedure

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## **Basic steps involved:**

- 1. Component pre-cleaning**
- 2. Introduction of magnetic field**
- 3. Application of magnetic media**
- 4. Interpretation of magnetic particle indications**

# Pre-cleaning – Step 1

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**When inspecting a test part with the magnetic particle method it is essential for the particles to have an unimpeded path for migration to both strong and weak leakage fields alike. The part's surface should be clean and dry before inspection.**

**Contaminants such as oil, grease, or scale may not only prevent particles from being attracted to leakage fields, they may also interfere with interpretation of indications.**





# Introduction of the Magnetic Field – Step 2

**The required magnetic field can be introduced into a component in a number of different ways.**

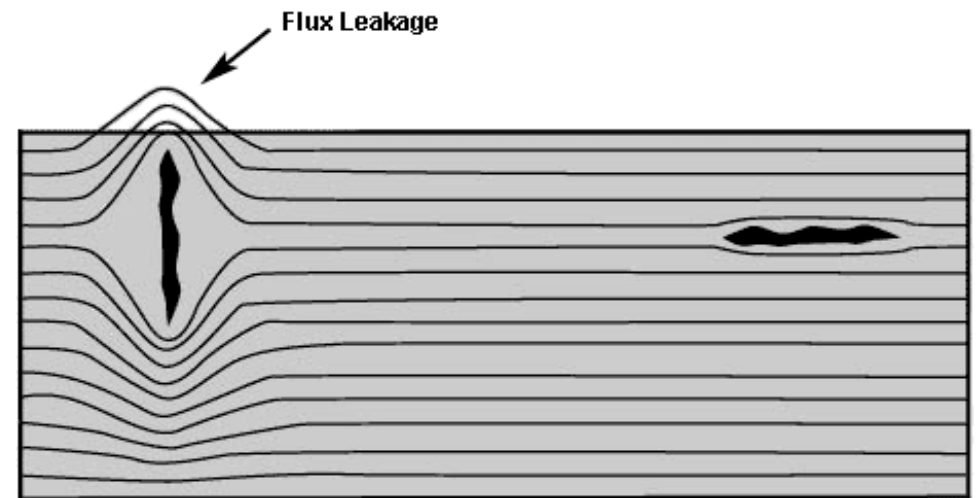
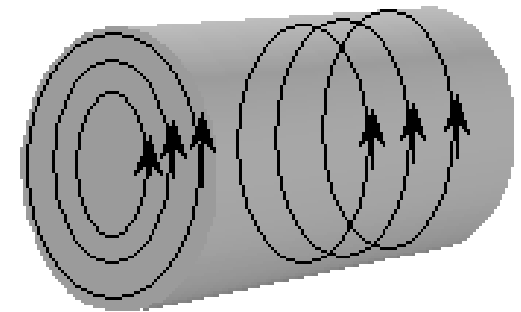
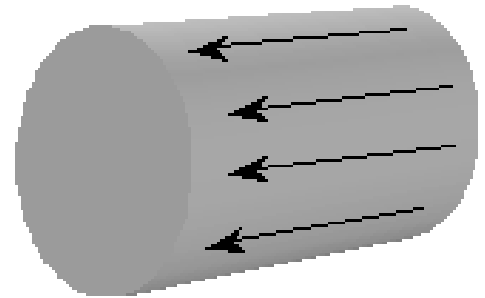
- 1. Using a permanent magnet or an electromagnet that contacts the test piece**
- 2. Flowing an electrical current through the specimen**
- 3. Flowing an electrical current through a coil of wire around the part or through a central conductor running near the part.**





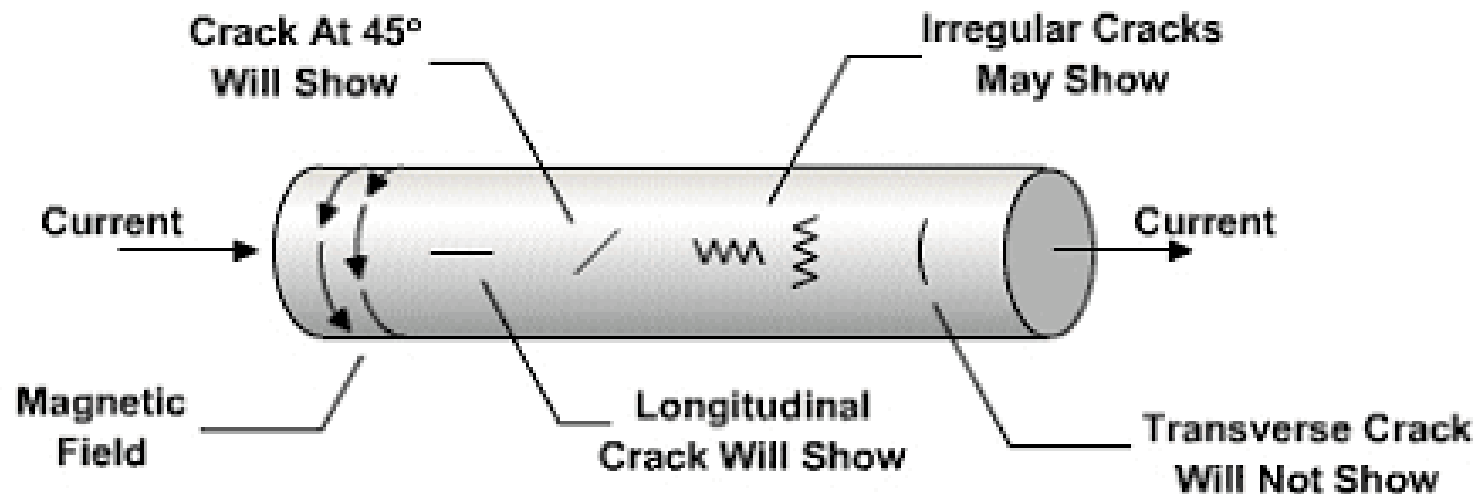
# Direction of the Magnetic Field

- A longitudinal magnetic field has magnetic lines of force that run parallel to the long axis of the part.
- A circular magnetic field has magnetic lines of force that run circumferentially around the perimeter of the part.
- Being able to magnetize the part in two directions is important because the best detection of defects occurs when the lines of magnetic force are established at right angles to the longest dimension of the defect.

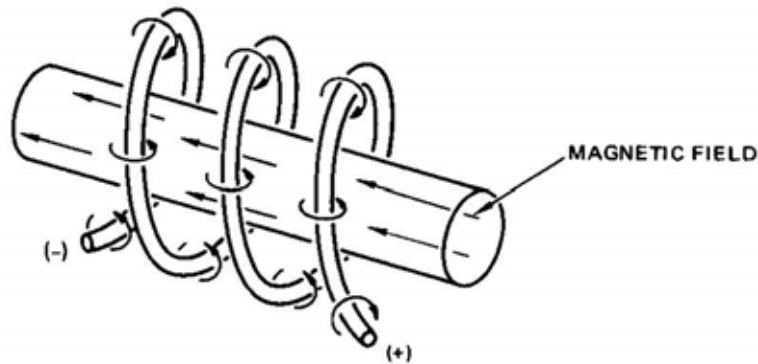


# Magnetic Field Orientation and Defect Detectability

- Defects that have a significant dimension in the direction of the current (longitudinal defects) should be detectable. Alternately, transverse-type defects will not be detectable with circular magnetization.



# Producing a Longitudinal Magnetic Field Using a Coil



**A longitudinal magnetic field is usually established by placing the part near the inside or a coil's annulus. This produces magnetic lines of force that are parallel to the long axis of the test part.**



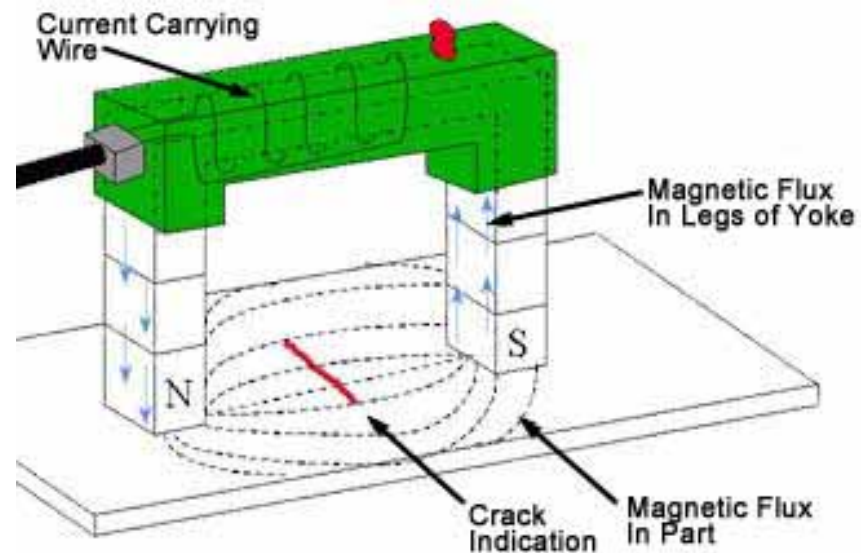
**Coil on Wet Horizontal Inspection Unit**



**Portable Coil**

# Producing a Longitudinal Field Using Electromagnetic Magnets

**Permanent magnets and electromagnetic yokes are also often used to produce a longitudinal magnetic field. The magnetic lines of force run from one pole to the other, and the poles are positioned such that any flaws present run normal to these lines of force.**



# Application of Magnetic Media – Step 3

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**MPI can be performed using either dry particles, or particles suspended in a liquid. With the dry method, the particles are lightly dusted on to the surface. With the wet method, the part is flooded with a solution carrying the particles.**

**The dry method is more portable. The wet method is generally more sensitive since the liquid carrier gives the magnetic particles additional mobility.**



**dry particles**

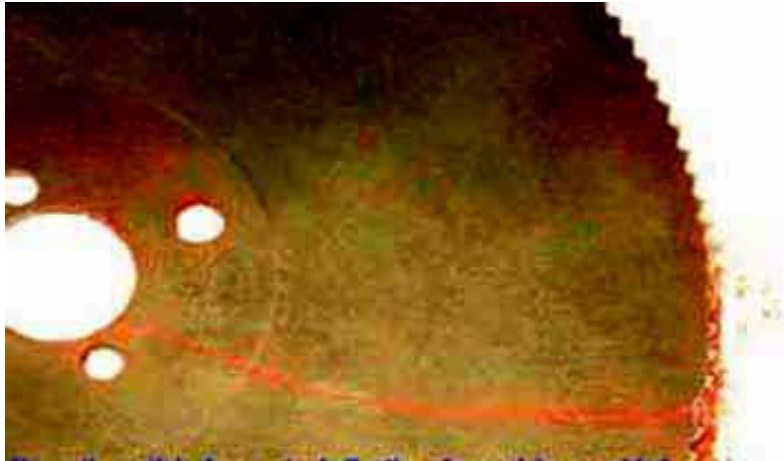


**wet particles**



# Interpretation of Magnetic Particle Indications – Step 4

## ➤ Examples of Visible Dry Magnetic Particle Indications:



**Indication of a crack in a saw blade**



**Before and after inspection pictures of cracks emanating from a hole**



**Indication of cracks originating at a fastener hole**



# Interpretation of Magnetic Particle Indications

## ➤ Examples of Visible Dry Magnetic Particle Indications



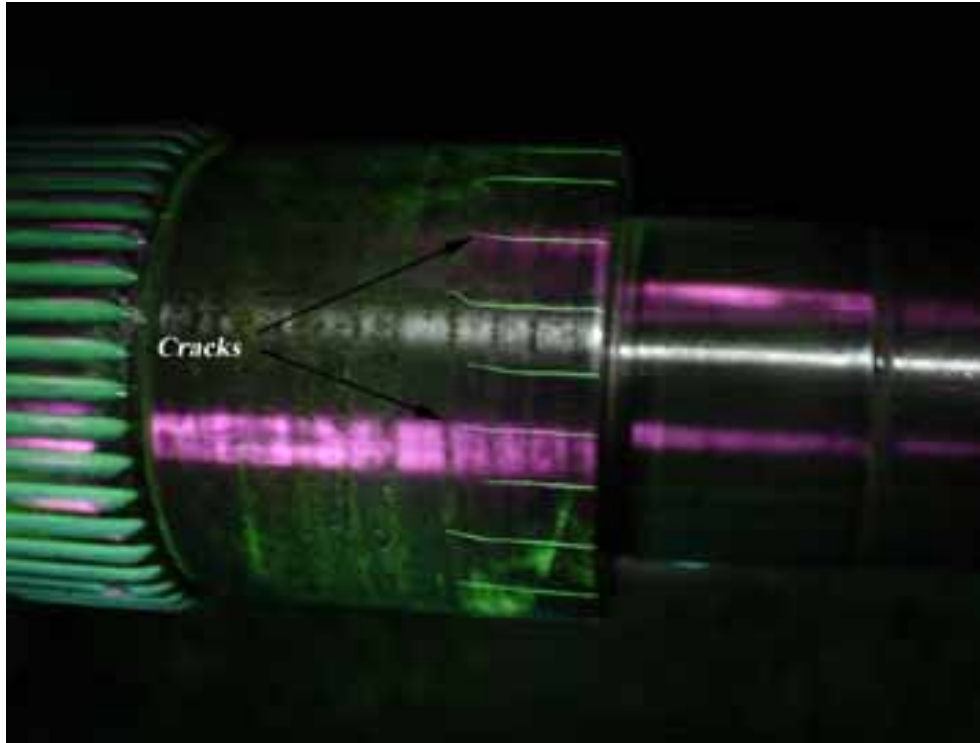
**Indication of cracks in a weldment**



**Indication of cracks running between attachment holes in a hinge**

# Interpretation of Magnetic Particle Indications

## ➤ Examples of Fluorescent Wet Magnetic Particle Indications



**Magnetic particle wet fluorescent indication of a cracks in a drive shaft**



**Magnetic particle wet fluorescent indication of a crack in a bearing**

# Advantages of Magnetic Particle Inspection

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- **Can detect both surface and near sub-surface defects.**
- **Can inspect parts with irregular shapes easily.**
- **Precleaning of components is not as critical as it is for some other inspection methods. Most contaminants within a flaw will not hinder flaw detectability.**
- **Fast method of inspection and indications are visible directly on the specimen surface.**
- **Considered low cost compared to many other NDT methods.**
- **Is a very portable inspection method especially when used with battery powered equipment.**

# Limitations of Magnetic Particle Inspection

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- **Cannot inspect non-ferrous materials such as aluminum, magnesium or most stainless steels.**
- **Inspection of large parts may require use of equipment with special power requirements.**
- **Some parts may require removal of coating or plating to achieve desired inspection sensitivity.**
- **Limited subsurface discontinuity detection capabilities. Maximum depth sensitivity is approximately 15 mm (under ideal conditions).**
- **Post cleaning, and post demagnetization is often necessary.**
- **Alignment between magnetic flux and defect is important**

# Standards relating to Magnetic Particle Testing

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## ➤ **American Society for Testing and Materials (ASTM):**

- **ASTM E125 - Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings (2013).**
- **ASTM E709 - Standard Guide for Magnetic Particle Examination (2015).**
- **ASTM E1444 - Standard Practice for Magnetic Particle Examination (2012).**
- **ASTM E1316 - Standard Terminology for Nondestructive Examinations (2016).**

# Magnetic Particle Inspection Video

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<https://www.youtube.com/watch?v=qpgcD5k1494>



# References

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- [https://en.wikipedia.org/wiki/Magnetic\\_particle\\_inspection](https://en.wikipedia.org/wiki/Magnetic_particle_inspection)
- NDT Resource Center. [https://www.nde-ed.org/index\\_flash.htm](https://www.nde-ed.org/index_flash.htm)
- The American Society for Nondestructive Testing. [www.asnt.org](http://www.asnt.org)
- ASTM International. ASTM E125 - Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings. West Conshohocken, 2013. (DOI: 10.1520/E0125)
- ASTM International. ASTM E709 - Standard Guide for Magnetic Particle Examination. West Conshohocken, 2015. (DOI: 10.1520/E0709-15)
- ASTM International. ASTM E1444 - Standard Practice for Magnetic Particle Examination. West Conshohocken, 2012. (DOI: 10.1520/E1444\_E1444M-12)
- ASTM International. ASTM E1316 - Standard Terminology for Nondestructive Examinations . West Conshohocken, 2016. (DOI: 10.1520/E1316-16)
- ASM International. ASM Handbook, Volume 17: Nondestructive Evaluation and Quality Control. ASM, 9th edition, 795p., 1989. (ISBN: 978-0-87170-023-0)