

[Home](#) - [Education Resources](#) - [NDT Course Material](#) - [MPI](#) [Back](#)[Next](#) 

Diamagnetic, Paramagnetic, and Ferromagnetic Materials

When a material is placed within a magnetic field, the magnetic forces of the material's electrons will be affected. This effect is known as Faraday's Law of Magnetic Induction. However, materials can react quite differently to the presence of an external magnetic field. This reaction is dependent on a number of factors, such as the atomic and molecular structure of the material, and the net magnetic field associated with the atoms. The magnetic moments associated with atoms have three origins. These are the electron motion, the change in motion caused by an external magnetic field, and the spin of the electrons.

In most atoms, electrons occur in pairs. Electrons in a pair spin in opposite directions. So, when electrons are paired together, their opposite spins cause their magnetic fields to cancel each other. Therefore, no net magnetic field exists.

Alternately, materials with some unpaired electrons will have a net magnetic field and will react more to an external field. Most materials can be classified as diamagnetic, paramagnetic or ferromagnetic.

Diamagnetic materials have a weak, negative susceptibility to magnetic fields. Diamagnetic materials are slightly repelled by a magnetic field and the material does not retain the magnetic properties when the external field is removed. In diamagnetic materials all the electron are paired so there is no permanent net magnetic moment per atom. Diamagnetic properties arise from the realignment of the electron paths under the influence of an external magnetic field. Most elements in the periodic table, including copper, silver, and gold, are diamagnetic.

Paramagnetic materials have a small, positive susceptibility to magnetic fields. These materials are slightly attracted by a magnetic field and the material does not retain the magnetic properties when the external field is removed. Paramagnetic properties are due to the presence of some unpaired electrons, and from the realignment of the electron paths caused by the external magnetic field.

Introduction to Magnetic Particle Inspection

Introduction

- [Introduction](#)
- [Basic Principles](#)
- [History of MPI](#)

Physics

- [Magnetism](#)
- [Magnetic Mat'l's](#)
- [Magnetic Domains](#)
- [Magnetic Fields](#)
- [Electromag. Fields](#)
- [Field From a Coil](#)
- [Mag Properties](#)
- [Hysteresis Loop](#)
- [Permeability](#)
- [Field Orientation](#)
- [Magnetization of Mat'l's](#)
- [Magnetizing Current](#)
- [Longitudinal Mag Fields](#)
- [Circular Mag Fields](#)
- [Demagnetization](#)
- [Measuring Mag Fields](#)

Equipment & Materials

- [Portable Equipment](#)
- [Stationary Equipment](#)
- [Multidirectional Equipment](#)
- [Lights](#)
- [Field Strength Indicators](#)
- [Magnetic Particles](#)
- [Suspension Liquids](#)

Testing Practices

- [Dry Particles](#)
- [Wet Suspension](#)
- [Magnetic Rubber](#)
- [Continuous & Residual Mag](#)
- [Field Direction & Intensity](#)
- [L/D Ratio](#)

Process Control

- [Particle Concentration](#)
- [Suspension Contamination](#)
- [Electrical System](#)
- [Lighting](#)
- [Eye Considerations](#)

Example Indications

- [Visible Dry Powder](#)
- [Fluorescent Wet](#)

Quizzes

Paramagnetic materials include magnesium, molybdenum, lithium, and tantalum.

Ferromagnetic materials have a large, positive susceptibility to an external magnetic field. They exhibit a strong attraction to magnetic fields and are able to retain their magnetic properties after the external field has been removed. Ferromagnetic materials have some unpaired electrons so their atoms have a net magnetic moment. They get their strong magnetic properties due to the presence of magnetic domains. In these domains, large numbers of atom's moments (10^{12} to 10^{15}) are aligned parallel so that the magnetic force within the domain is strong. When a ferromagnetic material is in the unmagnetized state, the domains are nearly randomly organized and the net magnetic field for the part as a whole is zero. When a magnetizing force is applied, the domains become aligned to produce a strong magnetic field within the part. Iron, nickel, and cobalt are examples of ferromagnetic materials. Components with these materials are commonly inspected using the magnetic particle method.

BackNext