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# How to shield the magnetic field of permanent magnets

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How to shield the magnetic field of permanent magnets? The magnetic field is a kind of physical phenomenon that is invisible and intangible but truly exists. The magnetic field generated by permanent magnets has brought convenience to our lives and work in many cases, for example, playing an important role in devices such as motors and speakers.

However, in some scenarios, the magnetic field generated by permanent magnets needs to be shielded or weakened, such as in the manufacturing process of precision instruments, during the transportation of permanent magnets, or to protect electronic devices. So, how can this be achieved? This

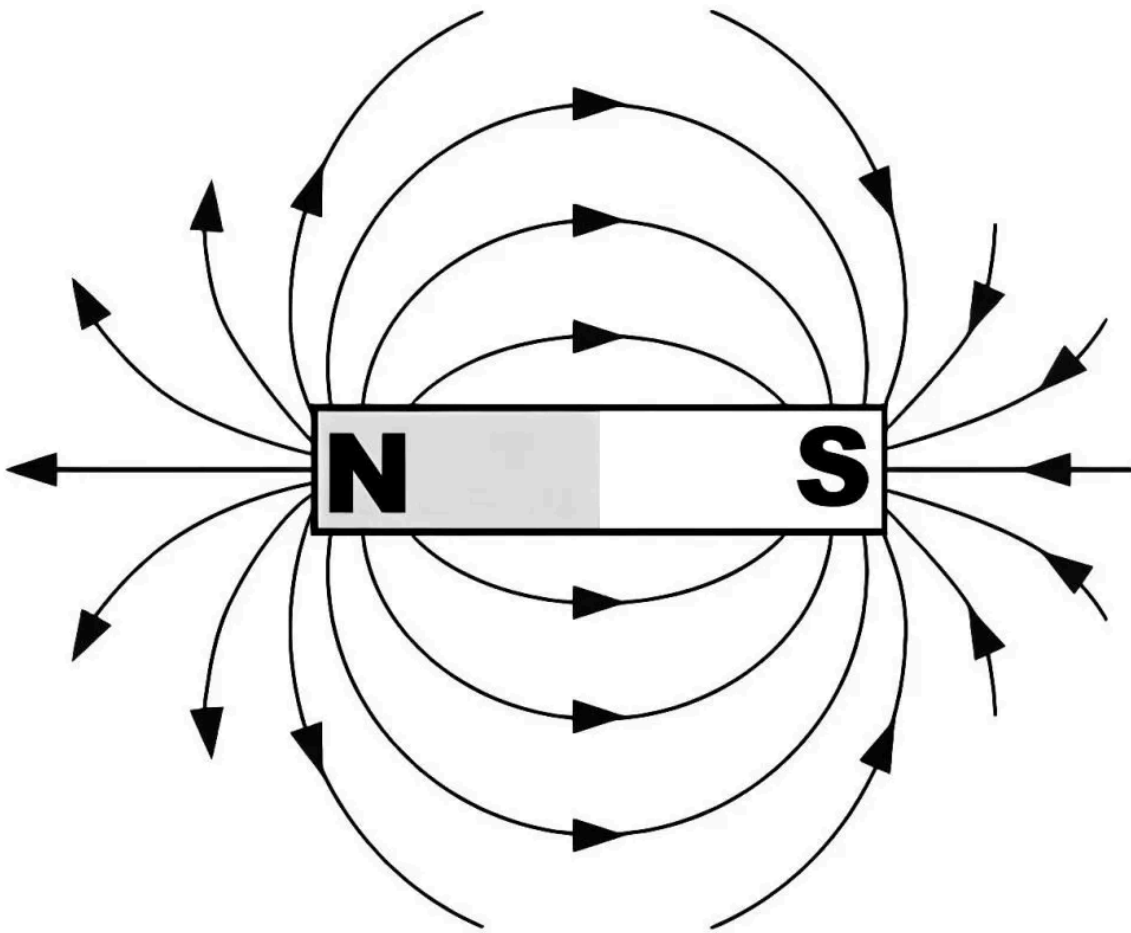
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requires not only an in-depth understanding of the characteristics of the magnetic field but also the use of some specialized methods and materials.

## The magnetic field type of permanent magnets

The type of magnetic field generated by permanent magnets is the static magnetic field.



The magnetic field strength and direction of the static magnetic field do not change with time. In contrast, the dynamic magnetic field changes over time, which may be periodic (such as an alternating current electromagnetic field) or randomly changeable. The static magnetic field is generated by the stationary charge distribution (such as a permanent magnet) or a constant current (such as the current in a direct current circuit).

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# Magnetostatic shielding

Magnetostatic shielding is a technique to reduce or eliminate the influence of static magnetic fields on specific areas. This technique is mainly achieved by using ferromagnetic materials with high magnetic permeability. These materials can guide and concentrate magnetic field lines, thereby forming a low magnetic field environment within the protected space.

## Permeability and magnetic saturation point of shielding materials

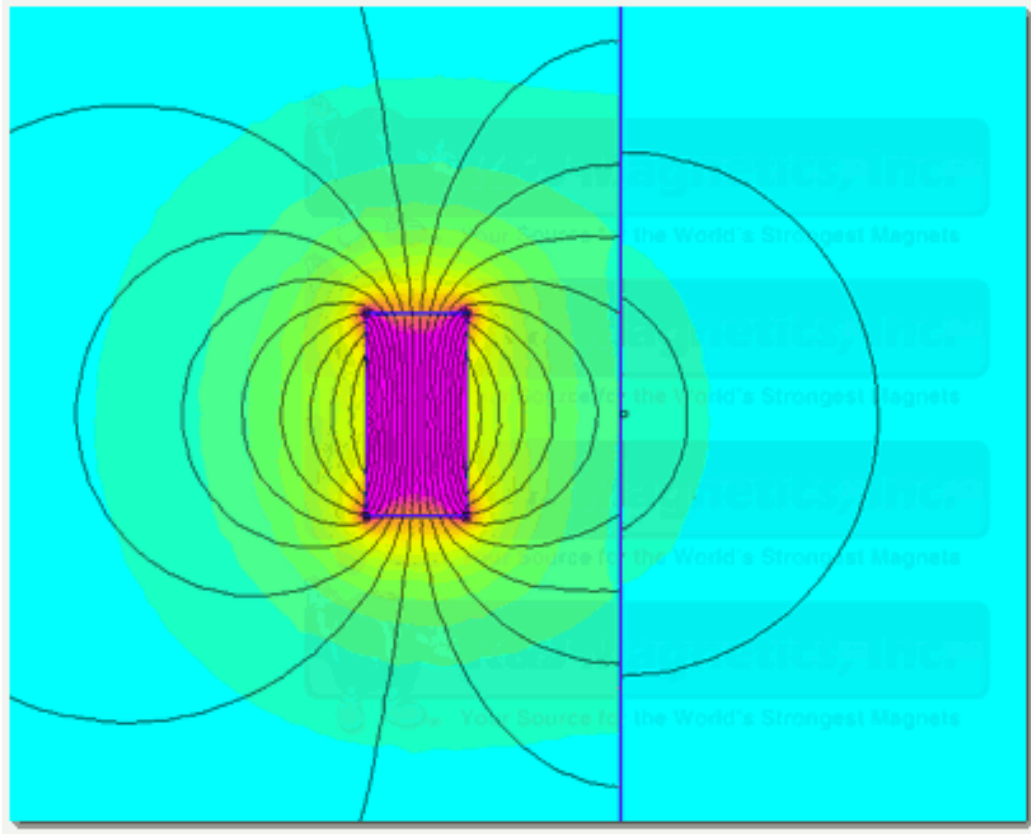
The performance of shielding materials depends on their permeability and magnetic saturation point.

**Permeability** refers to the ability of a material to guide a magnetic field. Materials with high permeability can effectively attract magnetic field lines and direct them in a specific direction. Common materials with high permeability include soft iron, permalloy, silicon steel, etc. Because ferromagnetic materials with high permeability are often used as the shielding layer, static magnetic shielding is also known as ferromagnetic shielding.

The **magnetic saturation point** refers to the maximum magnetic field strength that a material can withstand. If this value is exceeded, the material can no longer effectively guide more magnetic field lines, and its permeability will significantly decrease. Different materials have different magnetic saturation points. For example, soft iron has a higher magnetic saturation point, while permalloy has a higher permeability but a relatively lower magnetic saturation point.

# Shielding methods of permanent magnets

## 1. Single-layer shielding



***As the shielding layer thickens, more magnetic lines are attracted until they are completely shielded.***

Usually, as long as a piece of iron plate is placed in the direction where the magnetic field needs to be shielded, most of the magnetic field in this direction can be effectively shielded. Besides, we can further enhance the shielding effect by increasing the thickness of the shielding plate or replacing it with a material with higher magnetic permeability.

It can be seen from the figure that with the increase of the thickness of the iron plate, the shielding layer can guide more magnetic force lines through the shielding layer and finally achieve effective shielding on one side of the

magnetic field. The higher the magnetic permeability of the material and the thicker the shielding layer, the better the shielding effect.

## ***2.Multi-layer shielding:***

According to the characteristics of different shielding materials, we can also combine them for use to achieve a better shielding effect.

### **The first layer: Iron plate**

Due to the high magnetic saturation point of pure iron, it can effectively absorb a large number of magnetic field lines on the first layer. The main purpose of this layer is to capture most of the magnetic field lines and relieve the pressure on the subsequent materials. The high magnetic saturation point of the iron plate can prevent the entire system from reaching saturation prematurely and ensure the effectiveness of the entire shielding structure.

### **The second layer: Low-permeability material**

Fill low-permeability materials (such as plastics or rubbers) between the iron plate and permalloy. Doing so not only enhances the stability of the overall structure but also effectively prevents the magnetic field that overflows after the iron plate saturates from being directly transmitted to the permalloy. In addition, it can also attenuate the magnetic field intensity to a certain extent, further improving the shielding effect.

### **The third layer: Permalloy**

Permalloy is a nickel-iron alloy with extremely high magnetic permeability. Although its magnetic saturation point is not as high as that of the iron plate, in the case that the soft iron plate in the previous layer has absorbed most of the magnetic field lines, permalloy can very effectively capture the

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remaining magnetic field lines and guide them away from the area that needs protection.

### ***3. Fully enclosed structure***

The fully enclosed shielding layer can effectively guide the magnetic field lines to flow along the inside of the shielding layer instead of penetrating into the space that needs protection.

Make the shielding cover with pure iron to completely enclose the permanent magnet. The majority of the magnetic induction lines of the permanent magnet are concentrated within the pure iron shielding cover. If the permanent magnet is placed outside the pure iron shielding cover, the magnetic induction lines outside the cover basically cannot enter the cover either. For objects inside the cover, they can also be protected from the magnetic field outside the cover, thus achieving the shielding purpose.

***Rounded edges are better than right angled edges***

The edges of the shielding layer are preferably rounded corners because the magnetic field lines cannot suddenly change direction at a 90° angle. At the sharp edges of the shielding layer, they may break through the shielding layer and enter the protected area. Therefore, a spherical shielding layer of the same size will have a better shielding effect than a rectangular one.

When constructing the shielding box, the seams where the iron plates are spliced must ensure good contact. Any poor contact situation may increase the magnetic resistance, thereby weakening the shielding effect. Therefore, the contact area at the seams should be increased as much as possible.

It is best to wrap sensitive items with a smaller shielding layer. A large shielding shell significantly changes the path of the magnetic field lines, and for this, it requires a higher magnetic permeability to achieve complete shielding.

## ***4. Superconducting Magnetic Shielding***

### ***Neodymium magnet suspended on a superconductor***

In addition to ferromagnetic materials, superconductors can also be used for static magnetic shielding. When a superconductor is below its critical temperature, it can completely repel the magnetic field, which is known as the Meissner effect. Superconducting shielding can provide almost perfect magnetic field isolation, but it requires a low-temperature environment to maintain the superconducting state, so the cost is high and the implementation is complex.

In practical applications, the design of static magnetic shielding needs to consider factors such as the shape, size, material selection of the shielding cover, and the distance from sensitive equipment to ensure the desired shielding effect. In addition, attention should also be paid to the mechanical stability and cost-effectiveness of the shielding cover.

# **Does the transportation of permanent magnets require shielding?**

## ***Air transportation:***

International air transportation strictly manages magnetic goods and follows the norms of the Dangerous Goods Regulations (DGR) of the International

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Air Transport Association (IATA).

Magnetic goods must be packaged with shielding to reduce the diffusion of the magnetic field. Moreover, a magnetic detection is also required to ensure that it will not interfere with the normal operation of the aircraft, and a qualified magnetic detection report issued by the testing agency is necessary.

***This is an iron box used for shielding magnet goods. It still needs to be covered with an additional layer of cardboard box or wooden box.***

According to the test results, if the magnetic field intensity of the goods at 2.1 meters does not exceed 0.159 A/m (or 200 nT), it can be transported as a regular cargo; if the magnetic field intensity at 2.1 meters exceeds this limit,

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but the magnetic field intensity at 4.6 meters (about 15 feet) is lower than 0.418 A/m (or 525 nT), the goods can be transported in accordance with the special provisions in the Dangerous Goods Regulations; if the magnetic field intensity at 4.6 meters still exceeds 0.418 A/m, the goods are usually not allowed to be transported by air.

In order to minimize the influence of the magnetic field on the external environment, the magnet should be placed in the center of the shielding packaging as much as possible. This enables a more uniform distribution of the magnetic field lines and avoids excessive concentration on any side of the packaging, causing magnetic field leakage.

Given the variability of regulations, the shipper should consult the airline or freight forwarder in advance to ensure compliance with the latest transportation standards.

### ***Land and sea transportation:***

For permanent magnets that have undergone magnetization treatment, when transported by land or sea, there are usually no mandatory requirements for magnetic field intensity. However, this premise is based on the fact that the magnetic field intensity of the magnet does not interfere with the navigation and control equipment on ships and trucks, and does not affect other co-loaded goods. If the magnetic field intensity is too strong, the goods still need to be shielded.

**Learn More: [hw\\_dungeongreek5s\\_h\\_en\\_107 \(youtube.com\)](https://www.youtube.com/watch?v=hw_dungeongreek5s_h_en_107)**

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