Guidelines For Installing Magnetic Shielding

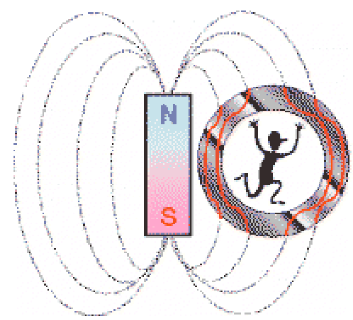
Designing magnetic shielding is not a hard science, and sometimes only experience, careful attention to detail, and some trial and error testing are available to produce the desired outcome.

Many factors affect shield performance. Naturally, the permeability and saturation induction of the shield material itself must be chosen carefully… as well as the type of anneal. But that is only the beginning. Remember that magnetic shielding is not really “shielding” in the traditional sense. One cannot stop or block magnetic field lines. They ***will*** travel from the N pole of the source to the S pole. What we can do is to alter the *path* that these magnetic fields lines take on their journey. Magnetic shielding materials “conduct” magnetic field lines better than air (and most other materials). In a sense, they create a “path of least resistance” in which the magnetic field lines can travel. But the magnetic field lines will travel in this alternate path if it is a lower energy path. Not just because we want it to.

Following is an incomplete list of other factors which must be considered, along with comments about each:

Shape of the shield

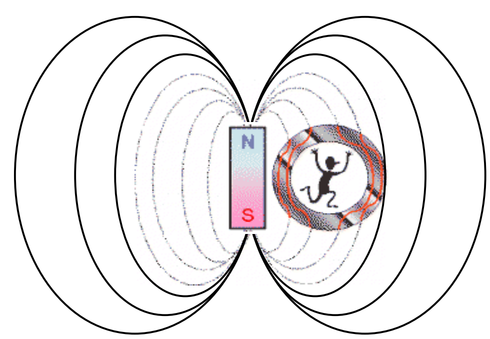
In general, spherical and cylindrical shaped shields work best. This is because magnetic field lines resist making sharp turns. When spherical and cylindrical shapes are not possible it is always best to make bends with a curve, rather than a sharp crease. Note however, that a cylinder shield around a straight wire does not prevent the magnetic field from emitting. It will however, protect the wire inside from fields originating outside the shield. See diagram at right.



Pay careful attention to bending the material. Because the magnetic properties are highly dependant on size/shape of the metal crystals, any manipulation such as bending or high heating which alters crystal size/shape will adversely affect the ability of magnetic field lines to travel through that area. Often bending is absolutely necessary. One can either accept some decreased performance, or re-anneal the material after forming to achieve peak performance.

Size of the shield

In general, the larger the shield, the more magnetic field lines it will “attract”. However, magnetic field lines which travel at a distance from the shield location will not have an incentive to travel through the shield. See diagram at right. On the other hand, larger shields will also “conduct” more of the Earth’s magnetic field. At about 400 mG, the Earth’s field can saturate high permeability shields, if large enough, or thin enough.



A general recommendation for a typical application in a home environment where one is shielding a circuit box with flat shielding is to shield an area which extends about 2-3 feet beyond the dimensions of the source. So a shield about 6 ft x 6 ft is recommended. If the presence of a side wall, floor, or ceiling restricts the size of the shield, the shielding material can be continued around the corner, but the metal must be continuous, or properly joined.

Number of layers (or thickness) of the shield
Shield performance increases with increased thickness of number of layers. The relationship is non-linear. Ultimately, the required thickness will depend on how much attenuation is needed, and cost.

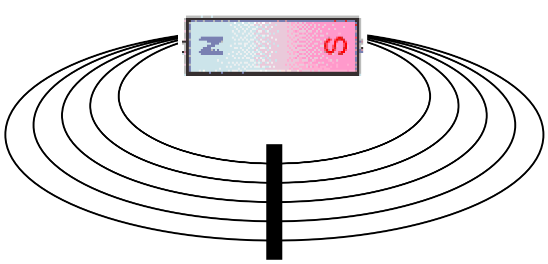
A general recommendation for a typical application in a home environment where one is shielding a circuit box with flat shielding is to use at least 0.020 inch thick high permeability material.

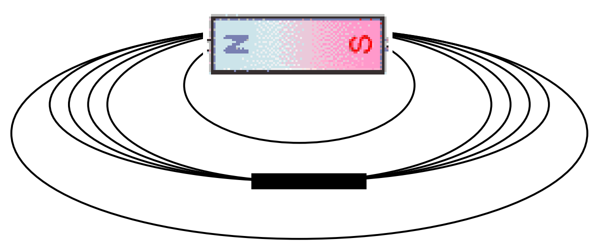
A general recommendation for a typical speaker magnet application is to make 3 concentric cup-shaped shields from high saturation alloy. Use cardboard spacers between layers. Place the stacked cups over the back of the speaker magnet.

Spacing between layers of shielding
Spacing between layers of shielding increases shield performance. The larger the space, the better the performance. Almost any material can be used as a spacer: wood, plastic, drywall, glass, air, cardboard, other metals, etc. Other considerations such as cost, strength, flammability, weight, etc must be taken into account.

Distance from the shield to the source of the field
As the distance from the source increase, the concentration of magnetic field lines decreases. Saturation may be less of an issue, unless shield size must also be increased.

Orientation of the magnetic field as it encounters the shield
Aligning the shield surface parallel or nearly parallel to the orientation of the magnetic field lines will yield the best shielding. Magnetic field lines perpendicular the shield will not change their course as they travel through the material. See diagrams below.



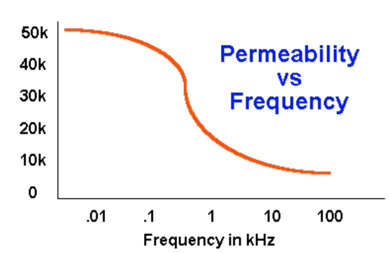


This can be used to advantage. For example, orienting a flat shield perpendicular to the Earth's magnetic field can minimize saturation problems due to Earth's field.

Note also how the magnetic field is concentrated at the edges of the shield pictured on the right. Gaussmeter readings at these edges will be higher than if no shield was present. Shield design should take into account the positioning of these edges.

Strength of the magnetic field where it encounters the shield
The strength of the magnetic field at the source is not relevant to shield design. The strength of the field at the proposed location of the shield is relevant. The stronger the field at the location of the shield, the thicker the shield should be.

Frequency of the magnetic field
Magnetic shielding performance decreases as frequency of the field increases. Attenuation is proportional to permeability, all other factors being equal. Note that permeability drops dramatically over 1kHz



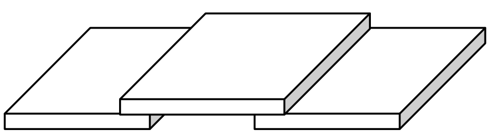
The effect of the Earth's magnetic field (and other ambient magnetic fields).
The omnipresence of the Earth's magnetic becomes an important factor in shield design when shields are large. Saturation is the instantaneous and reversible process whereby the shielding material is "conducting" all the magnetic field that it can. Additional magnetic field will not be affected by the presence of the shield. The higher the permeability of the material, the lower the saturation point.

There are several strategies for overcoming saturation:
1] increase material thickness/layers. This will be useful if the magnetic field is only slightly more than saturating the initial shield design.

2] use a multi-material approach: Use a high saturation material on the side closest to the source of the field, and high saturation material on the other side.

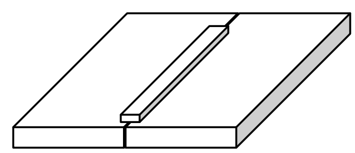
3] orient the shield to avoid the saturating field, if possible (as discussed above in the section on orientation)

Handling joints and seams
When using multiple pieces of shielding material to make a larger shield, care should be taken at the seams/joints. Magnetic field lines will "jump" an air gap between two adjoining pieces of shield, but since introducing such an air gap increases the overall "resistance" of the shield design, it will compromise shield performance. Good metal to metal contact at the seams/joints is important. One can achieve this in several ways:



1] Overlap. Two edges of shield can overlap, 1-2 inches typically. Compression, such as between layers of drywall or plywood will help to make good metal to metal contact.

2] Tape. Two edges can be butt joined, then use a high permeability tape (such as Joint-Shield™) to tape the joint. Naturally, the shield pieces should be adequately fixed in place by mechanical means to avoid separation of the pieces.



Magnetic shielding plates and foil can be fixed in place with nails, staples, screws, glue, rivets or any other suitable mechanical means that will support the weight and prevent annoying vibration or shifting. Small perforations due to a few nail or screw holes will not significantly affect shield performance (unlike radiofrequency shielding). Exposure of sharp edges should be avoided to prevent injury from contact.

Other factors to consider, such as:
Temperature of the shield location, vibration, sharp edges, corrosion resistance, structural strength, support for the weight of the shield, method of fixation, venting, perforations, ability to clean, durability with respect to scratches/dents/handling/etc., available space, and of course: cost. Finally, magnets will *always* be attracted to magnetic shielding alloys.

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