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Selecting magnetic shielding metals

High-permeability shielding materials prevent interference from driving sensitive circuits crazy.

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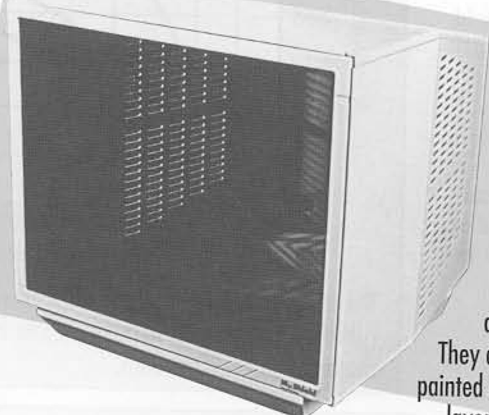


This magnetic shield from MuShield Co. fits snugly around monitor enclosures to eliminate distorted images caused by electromagnetic interference from power lines, strong magnets, transformers, and other monitors and computers. Installations include medical, educational, and governmental facilities where high-resolution monitors (color and grayscale) are exposed to magnetic fields to 20 gauss. They are custom made or available off the shelf, painted to match most monitors, and consist of two layers of MuMetal and an optional glare guard.

Magnetic shielding protects electronic circuits from magnetic-field interference. Usually, sources of this interference include permanent magnets, transformers, motors, solenoids, and cables. Magnetic shields provide a path around sensitive areas to deflect magnetic flux. In addition, shielding may contain magnetic flux around a component that generates flux.

The ability to conduct magnetic lines of force is called permeability, and in a magnetic shield, the degree of permeability is expressed numerically. The standard or base line is free space with a rating of one, compared to shield materials which range from about 200 to 350,000.

Shields handle two basic needs. One prevents strong field radiation from sources such as transformers, magnets, and motors. The second shields instruments and devices from magnetic fields in an environment or prevents emanation from other sources. Three general types of materials are used for these — high permeability, medium permeability, and high saturation.

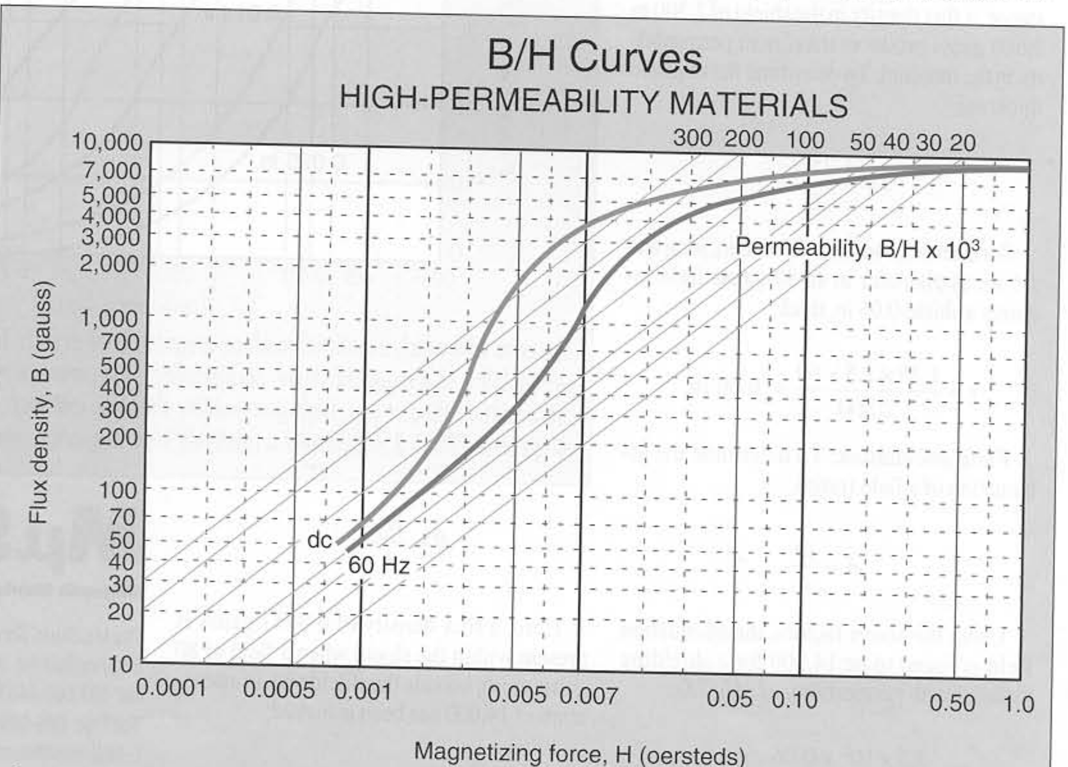
High-permeability materials have a minimum value of 80,000 at B-40 and a maximum of 350,000 with a saturation point of about 7,500 gauss after heat treating.

Medium-permeability materials are usually used with high-permeability materials and have values of 12,500 to 150,000 with a saturation point of about 15,500 gauss. High-saturation materials have permeability ranging from 200 to 50,000 with saturation points between 18,000 and 21,000 gauss.

Magnetic fields: To determine the approximate magnetic field in the shield

$$B = \frac{2.5d\,H_o}{2t}$$

For example, a shield 1.5 in. in diameter



The ratio of flux density in the field, B, to the magnetizing force, H, is a measure of the ability of the material to absorb magnetic interference to its point of saturation. The amount of absorption is based on its permeability rating, B/H.

made of material 0.06 in. thick in a field of 80 gauss has a flux density of 2,500.

$$B = \frac{2.5 \times 1.5 \times 80}{2 \times 0.06} = 2{,}500 \text{ gauss}$$

Shield thickness: For selection of shield thickness for fields of less than 2 gauss,

$$t = \frac{Ad}{\mu}$$

A shield 1.5 in. in diameter with a permeability of 80,000 and attenuation field of 1,000 to 1.0 would need a shield 0.019-in. thick.

$$t = \frac{1{,}000 \times 1.5}{80{,}000} = 0.019 \text{ in.}$$

Efficient shielding: When considering the price of materials, maintaining the correct thickness keeps costs to a minimum. The magnetic-shielding material must have an initial permeability of at least 80,000, otherwise the shield thickness is compromised.

When a strong field is encountered, a thickness can be selected that develops maximum permeability in the material. For instance, a flux density in the shield of 2,300 to 2,500 gauss produces maximum permeability in the material. To determine the required thickness

$$t = \frac{1.25 H_o}{B}$$

For a sense of scale, a shield 6 in. long and 1.5 in. in diameter in an 80-gauss field requires a shield 0.06 in. thick;

$$t = \frac{1.25 \times 1.5 \times 80}{2{,}500} = 0.06 \text{ in.}$$

Field attenuation: To determine the attenuation of a field (ratio),

$$A = \frac{\mu t}{d}$$

Using the above factors, the attenuation field is found to be 14,000 for a shielding material with permeability of 350,000.

$$A = \frac{3.5 \times 10^5 \times 0.06}{1.5} = 14{,}000$$

Flux density: To determine the flux density within the shield in gauss

$$B = \frac{H_o}{A}$$

Here, a flux density of 0.0057 gauss is present within the shield when a field of 80 gauss exists outside the shield and an attenuation of 14,000 has been achieved;

$$B = \frac{80}{14{,}000} = 0.0057 \text{ gauss}$$

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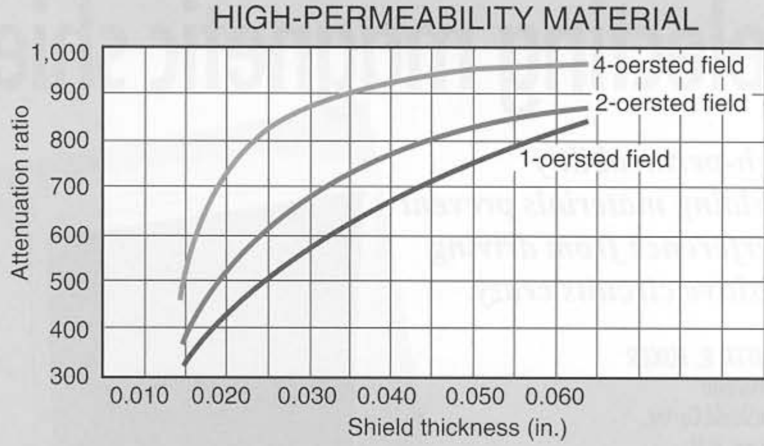
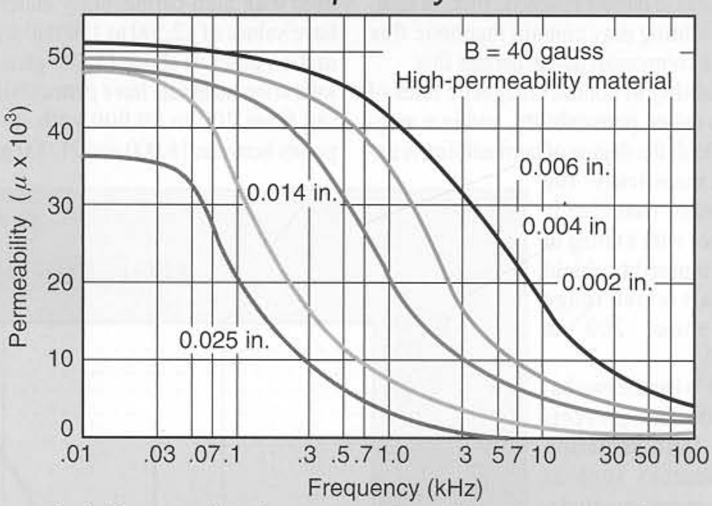
Shield thickness versus attenuation ratio (60 Hz)



The amount of attenuation a material provides is proportional to its thickness up to a critical point. Increasing thickness further becomes less effective by producing smaller changes in attenuation ratios.

Permeability versus frequency



The ease with which a material conducts magnetic lines of force is a measure of its permeability. In a magnetic shield, permeability is expressed numerically, compared to free space with a rating of one. High-permeability shielding materials, such as these, typically range from 200 to 350,000 over a relatively wide frequency range.