The most effective magnetic shielding enclosures are designed and fabricated to meet specific requirements.

Magnetic field interference usually is discovered when the completed assembly is tested. Shielding becomes imperative but not enough space has been allowed by the designer. Jamming some shielding into the inadequate area helps but doesn't produce the full performance desired.

In accordance with the time-tested "ounce of prevention," the shield should be incorporated at the equipment manufacturing stage whenever possible. CRTs are a good example. Retrofitting the optimum shield is often expensive and sometimes impossible if the designer hasn't allowed sufficient space. If the shield is designed into the assembly at the very beginning, optimum shielding is easily attained.

AN OUNCE OF DESIGN IS WORTH A POUND OF RETROFIT

Magnetic shielding techniques are most valuable and more economical in the design and prototype stages.

Without magnetic shielding much of today's sophisticated electronic gear would be larger, less efficient and in some magnetic environments, impossible to function at all. As components are made more sensitive and packaging denser, susceptibility to electromagnetic interaction increases dramatically even in the best engineered layouts.

As a final consideration, assistance with shielding problems is available from experienced reputable manufacturers of magnetic shielding.

This article was prepared by Lester Dant, Vice President, Ad-Vance Magnetics, Inc., Rochester IN, and is published with permission.

NOMOGRAPHS OF MAGNETIC SHIELDING EFFECTIVENESS

Shielding effectiveness (SE) describes the ability of a given material to act as a shield against incident magnetic fields. It is composed of three factors: reflection losses (R), absorption losses (A) and secondary reflection losses (B). These factors can be calculated separately and added as follows.

$$SE = R + A + B \text{ (dB)}$$

The R and A can be determined by using one nomograph each; however, the B is complex and requires both a nomograph and a graph.

ABSORPTION LOSSES

Absorption losses (A) are a function of the physical characteristics of the shield and are independent of the type of source field. For a given thickness, magnetic material (steel) provides higher absorption losses than non-magnetic material (copper). When reflection losses are low, thicker, high-permeability materials are employed to increase shielding effectiveness. The nomograph in Figure 1 is used to determine A.

REFLECTION LOSSES

The computation of reflection losses can be greatly simplified by considering shielding effectiveness for incident electric fields as a separate problem from that of magnetic fields or plane waves. The nomograph in Figure 2 solves the equation for R.

SECONDARY REFLECTION LOSSES

When absorption losses are very low (less than 6 dB), the magnetic shielding effectiveness due to reflection losses changes. The B can be found by using Figure 3.

PERMEABILITY INFLUENCES SHIELDING EFFECTIVENESS

Magnetic shielding effectiveness calculations are highly dependent on the permeability (μ) of the shield. It has long been thought that permeability decreased at higher frequencies, and that saturation due to exposure to high-intensity magnetic fields also produced a loss of shield permeability.

This is not entirely true. The more common building metals (i.e., cold-rolled steel, galvanized steel, hot-rolled steel) do not change permeability with frequency, and show only one to 3 dB variation in SE when exposed to high intensity fields (2 Oersteds). Higher permeability materials show both a change of permeability with frequency and a 5 to 8 dB saturation loss in 2 Oersted fields.

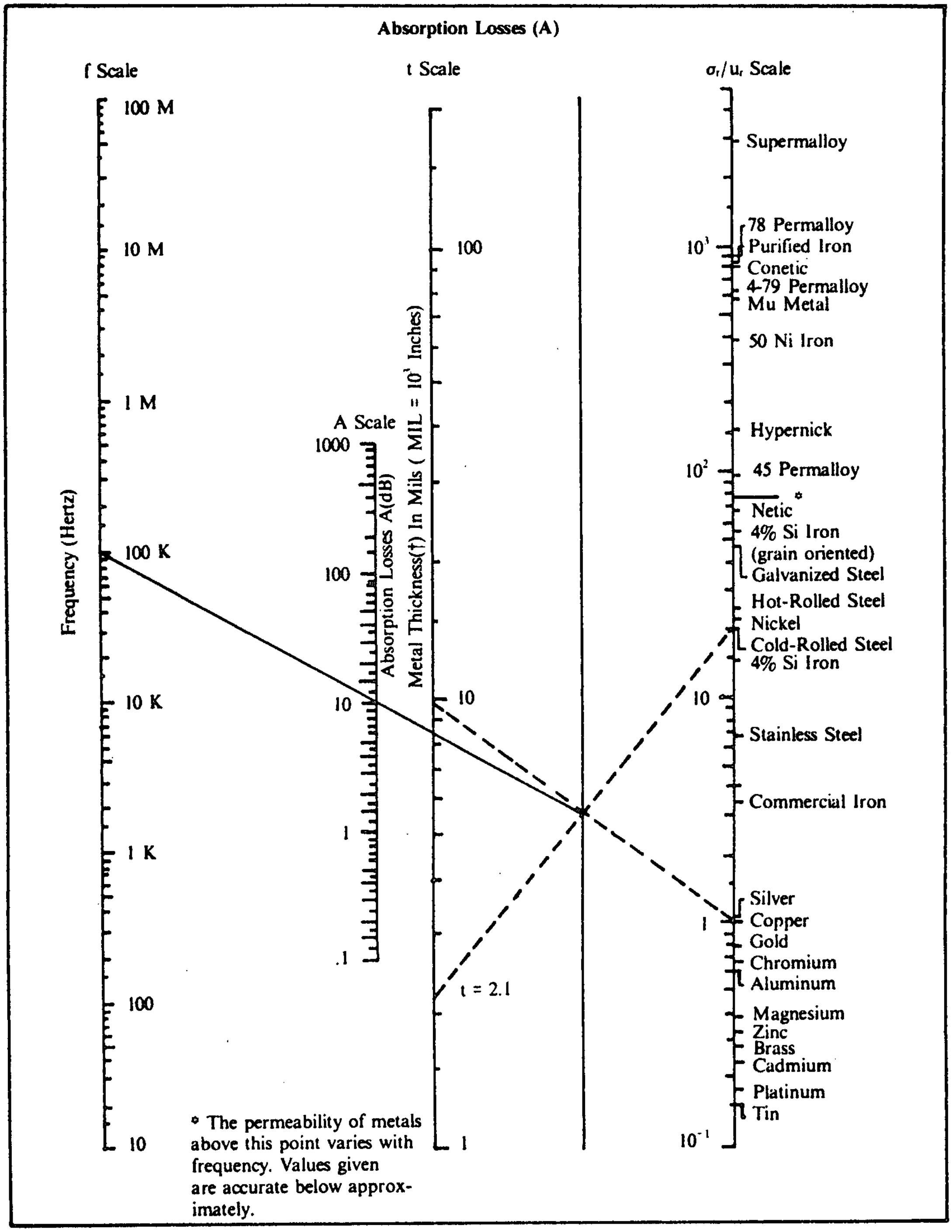

Figure 1.

How to use the Absorption Loss nomograph.

Given a desired amount of absorption loss at a known frequency, determine the required thickness for a known metal.

1) Locate the frequency of the **f scale** and the desired absorption loss on the **A scale.** Place a straightedge across these points and locate a point on the unmarked scale. (Example: A = 10 dB, f = 100 kHz.)
2) Pivot the straightedge about the point on the unmarked scale to various metals noted on the σ_r/μ_r **scale.** A line connecting the σ_r/μ_r **scale.** and the point on the unmarked scale will give the required thickness on the **t scale.** (Example: for copper t = 9.5 mils, for cold rolled steel t = 2.1 mils.)
3) The absorption loss nomograph can also be used in reverse of the above order.

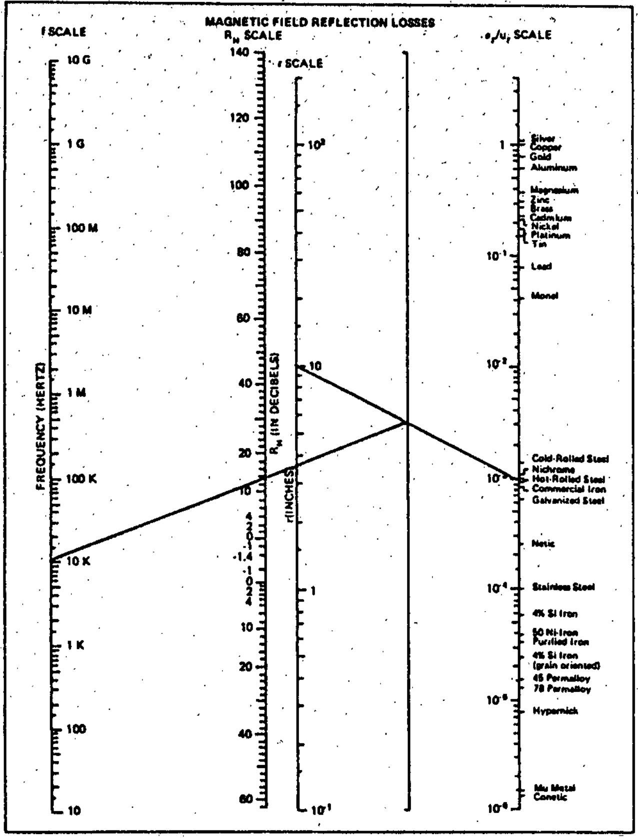

Figure 2.

How to use the Reflection Loss nomograph.

1) Locate a point on the σ_r/μ_r **scale.** for one of the metals listed. If the metal is not listed, compute σ_r/μ_r and locate a point on the numerical scale.

2) Locate the distance between the energy source and the shield on the **r scale.**

3) Place a straightedge between r and $\sigma_r/\ \mu_r$ and locate a point on the blank scale (Example: r = 10 inches for hot rolled steel).

4) Place a straightedge between the point on the blank scale and the desired frequency on the **f scale.**

5) Read the reflection loss from the $\mathbf{R_H}$ **scale.** (For f = 10 kHz, R_H = 13 dB).

6) By sweeping the f scale while holding the point on the blank scale, R_H versus frequency can be obtained. (For f = 1 kHz, R_H = 3.5 dB).

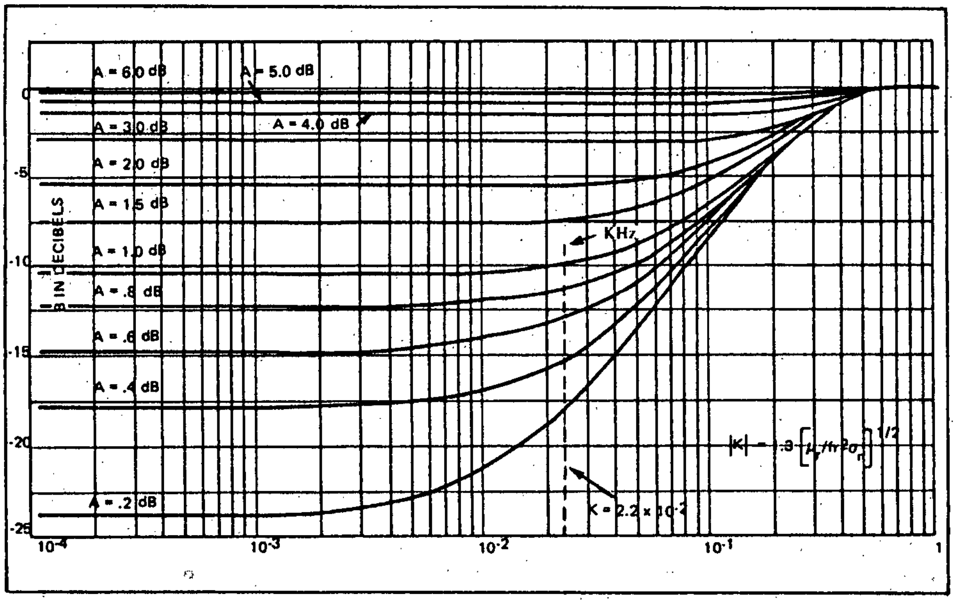

Figure 3.

Use graph to locate B.

1) Locate |K| = 2.2 x 10^{-2} on the horizontal scale.
2) Move vertically to intersect the A = 1.3 curve (interpolate), and then horizontally to the left to find B = 8.5 dB.

Condensed from works prepared by Robert B. Cowdell, EMC Consultant.