

Fig. 4 Hysteresis loops of 80 Ni 5 Mo Re Fe cores annealed to square the loop a) 3h at 420°C, H// to lm b) Normal material to flatten the loop c) 20 min.) 1 h) at 310°C, H ⊥ lm 3 h)

Inductors and electronic transformers for the telephone industry make use of Ni-Fe alloys containing 50 and 80% nickel, because these alloys have high permeability at low flux densities of .1 to 10 mT. It is well understood today how to influence the permeability and hysteresis loop of such alloys by changing the crystal anisotropies through controlled ordering, so that today flat or very square hysteresis loop materials can be made. In the 80% Ni-Fe alloys, the variation of initial permeability with temperature can be precisely controlled so that inductors and current transformers of great temperature stability can be made. Figure 4 shows the hysteresis loop of 80% Ni-Fe after various heat treatments in magnetic fields applied in the direction or perpendicular to the direction of the operating magnetic field, to either square or flatten the loop by introducing uniaxial atomic anisotropies.

Gapped Magnetic Core Structures

High permeability core structures are often out of necessity or deliberately gapped, which flattens the loop and makes the permeability lower, but more constant over B and over a wide temperature range. Figure 5

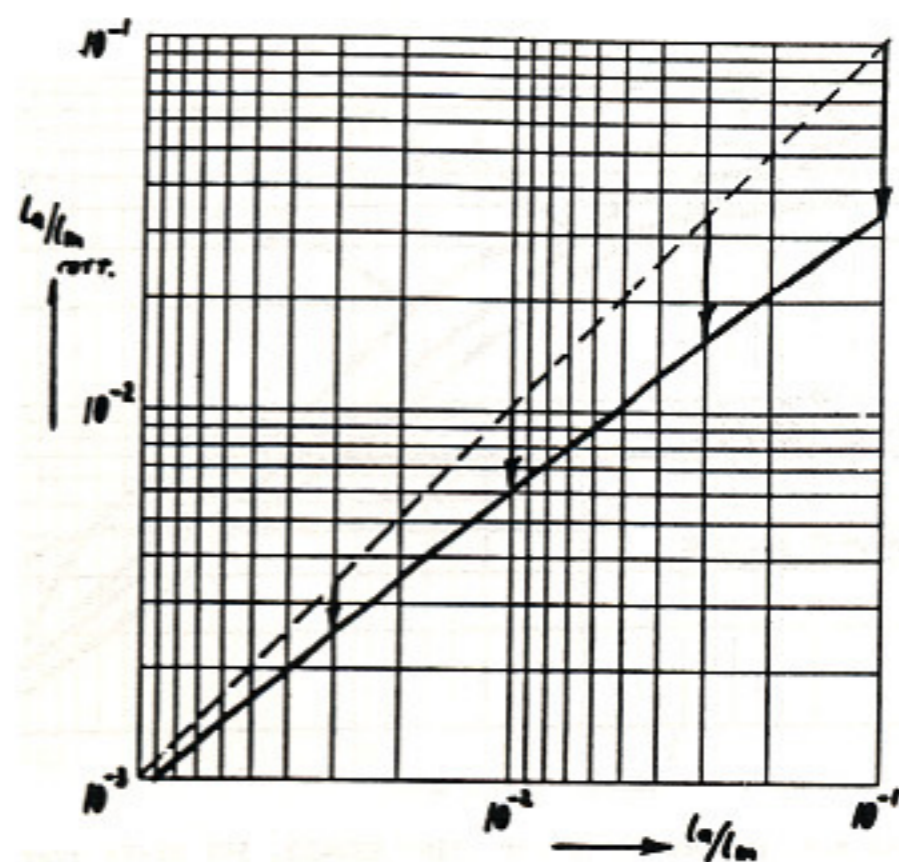


Fig. 6 Corrected effective air gap ratios la/lm for core structure with larger air gaps.

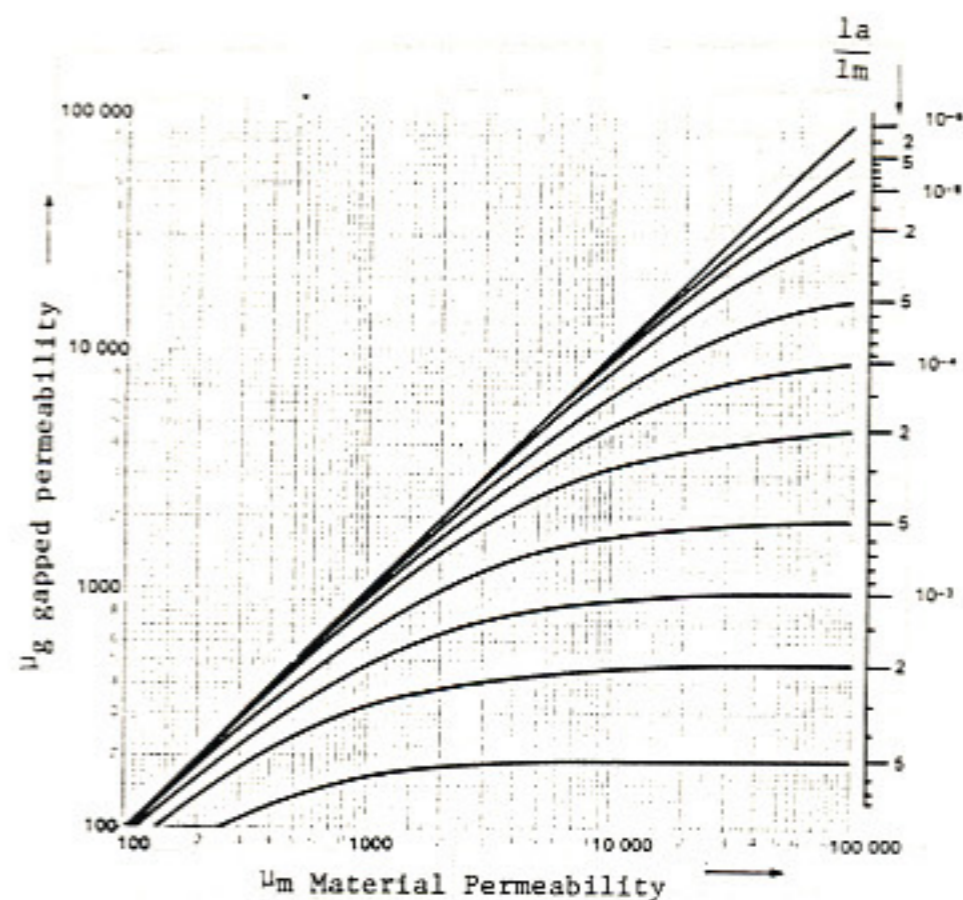


Fig. 5 Effect of air gap upon the gapped core permeability for various ratios of air gap la to mean path length lm .

shows the gapped permeability μ_g over the material permeability μ_m , as calculated by

$$\mu_g = \frac{\mu_m}{1 + \frac{la}{lm} \mu_m} \quad (6)$$

in which la/lm is the ratio of air gap over mean path length for a given core. For larger air gaps, the B field at the air gap fringes over a larger area and the above equations have to be corrected, as shown in Figure 6.

In nickel iron alloys, for instance, the initial permeability of 80% Ni-Fe (Super Perm 80) normally varies from -30 to +60°C by more than 30%. It can be made temperature stable by appropriate heat treatment (Super Therm 80) so that it will not vary by more than 15%. In laminations such as F-shaped laminations, the stability can be further improved by choosing an appropriate air gap la/lm . This is shown in Figure 7. With this method, lamination stacks can be made temperature stable to a variation of less than 1%.

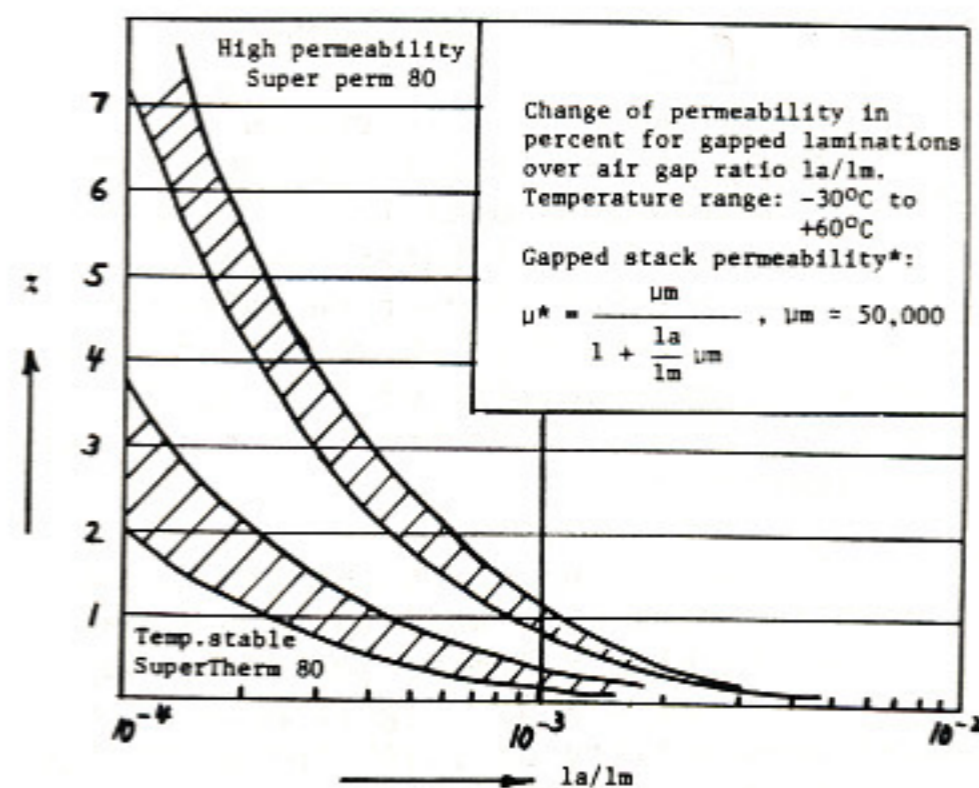


Fig. 7 Change of initial permeability for gapped core structure.