Ferrites - "The Most Important Properties"

1994 Soft Ferrite Users Conference

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Inductance - Electrical property that opposes any change in current because of a magnetic field.

$L = ((.004) (\pi) (N^2) (Ae) (10^6)) / Le$ (in Henries)

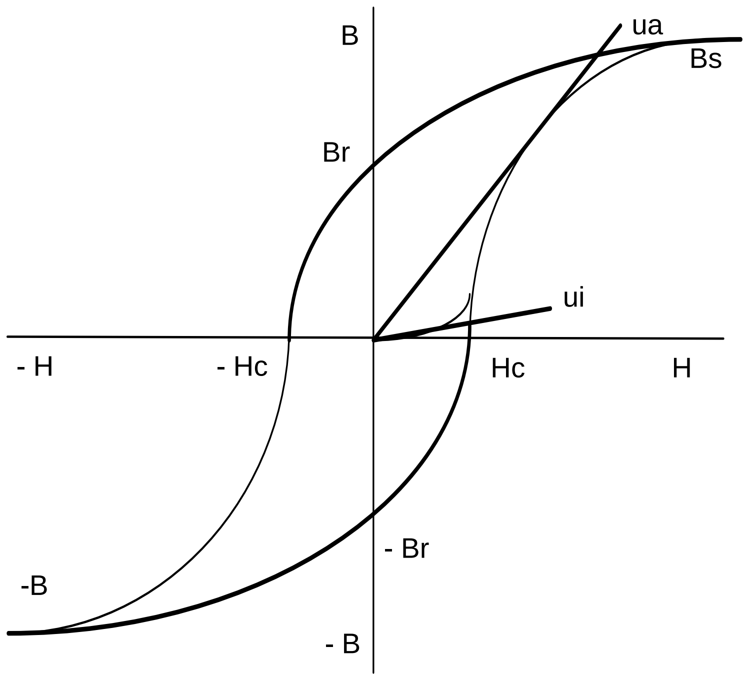
- Material Permeability, core dimensions & number of turns all affect inductance and therefor affect component size

Ae = effective cross sectional area

Le = effective magnetic path length

N = turns on coil.

Inductance Index Al is the Inductance per unit turn in nH/N^2



Hysteresis Curve

B = Magnetic Flux Density

Flux per unit area induced by a field s

H = Magnetizing Force

The externally applied force that indu
flux in a magnetic material

u = B / H = Permeability

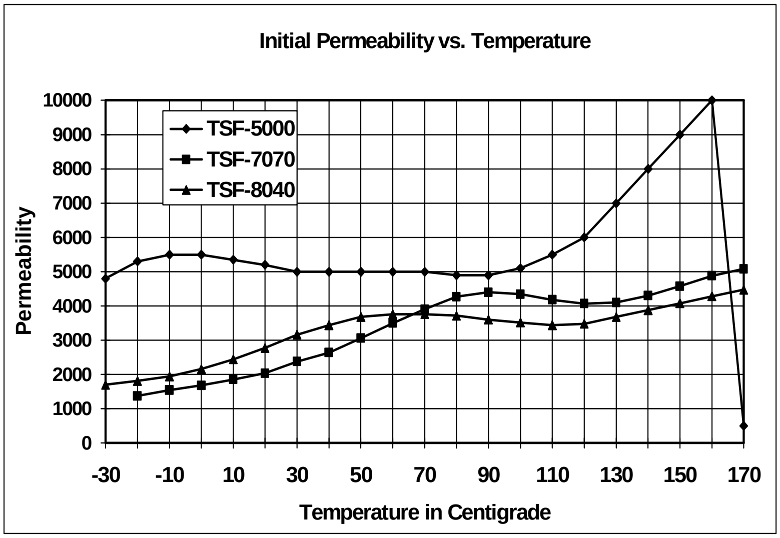
Initial Permeability at low amplitudes
Amplitude Permeability at high amplit

Bsat = Saturation Flux Density

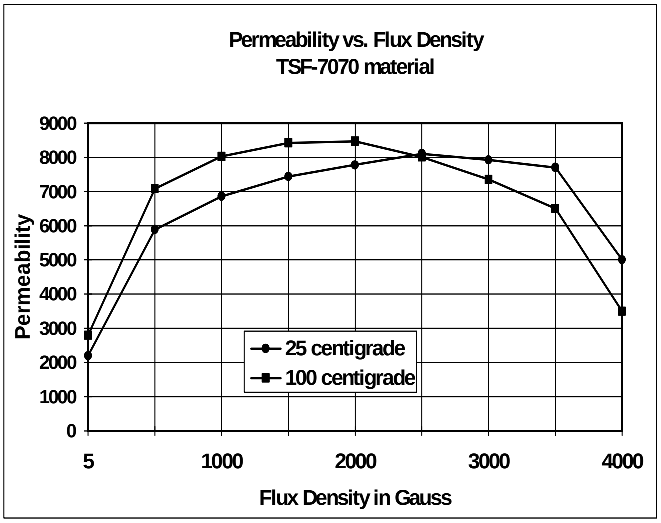
The value of magnetic flux density at

Br = Residual Induction

The magnetic Induction remaining in
material after the magnetizing force (
removed



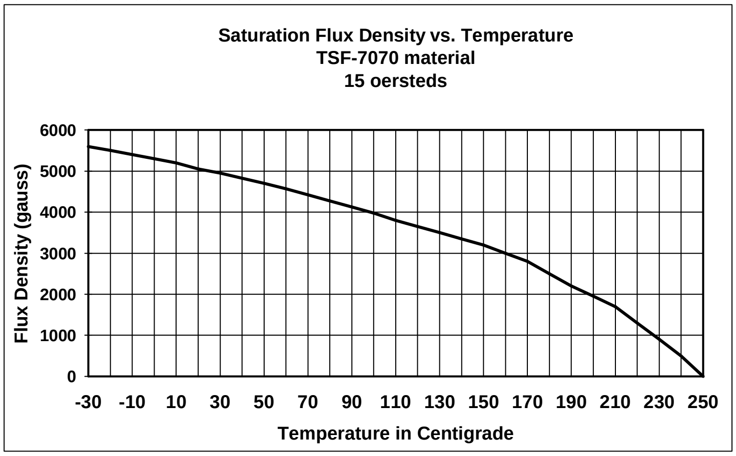
- Permeability varies with temperature and drops to unity above the curie temperature.



- Permeability varies with Flux Density and drops to unity when saturated. Soft Ferrite materials saturate sooner at elevated temperatures.

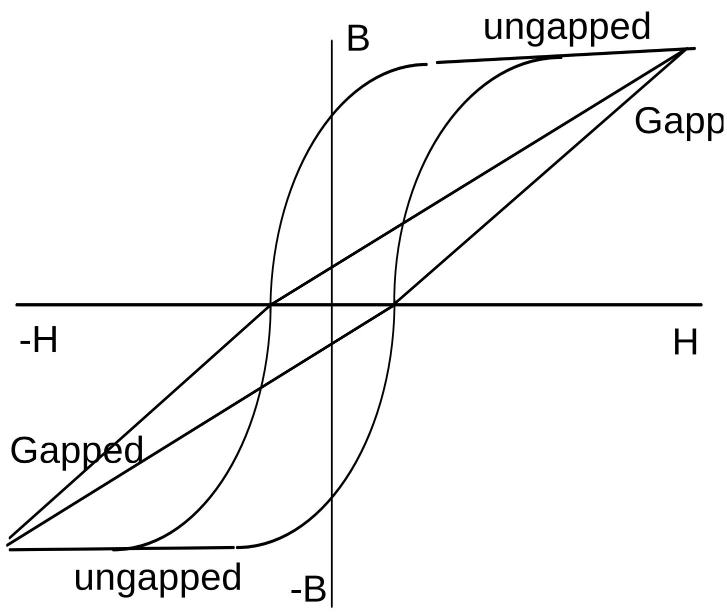
Saturation Flux Density - The value of magnetic flux density at saturation. A materials maximum magnetic induction.

$B = (Erms)(10^8) / (4.44)(f)(N)(Ae)$



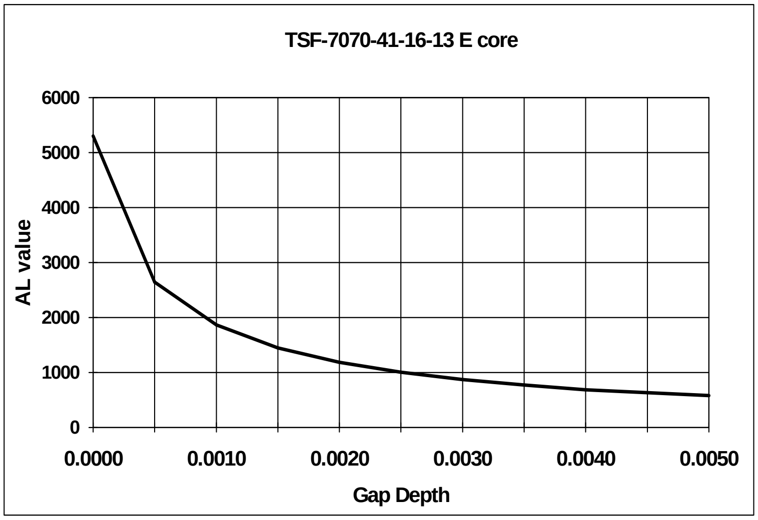
- Saturation Flux Density decreases with increasing temperature. Often a material's Saturation Flux Density is a constraint on the minimum core size.

f = frequency
N= turns
Ae = effective core area



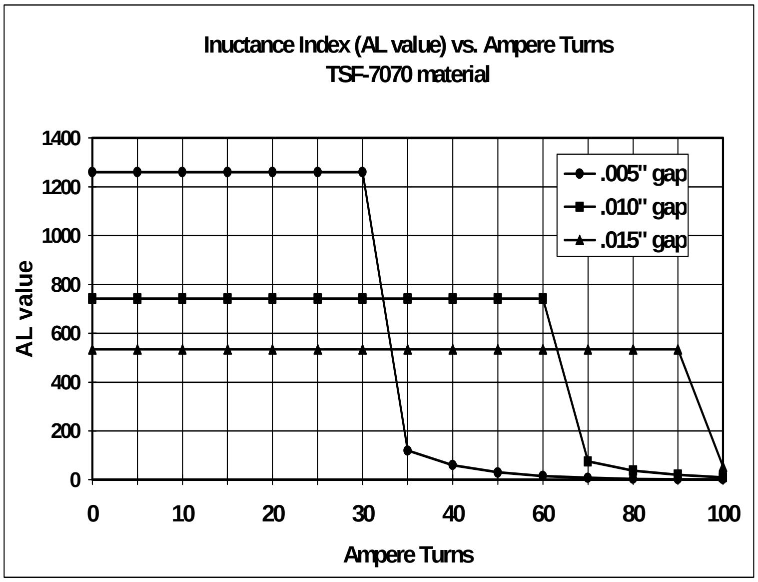
- The hysteresis loop shears over with increasing gap depths. The gapped structure results in lower effective permeabilities but requires more magnetizing force to saturate the core.

Inductance Index AL vs. Gap Depth



- Inductance decays exponentially as the air gap increases.
  The slope is steep for small gaps which have large AL values. For this reason larger tolerances are needed compared to the AL tolerances for deep gaps that have shallow slopes and small AL values.

  AL=(4πμAeAg)/(μAeLe)+Ag(Le-LG) times (1+Lg/Square root Ae ln(2G/Lg)) to account for fringing flux



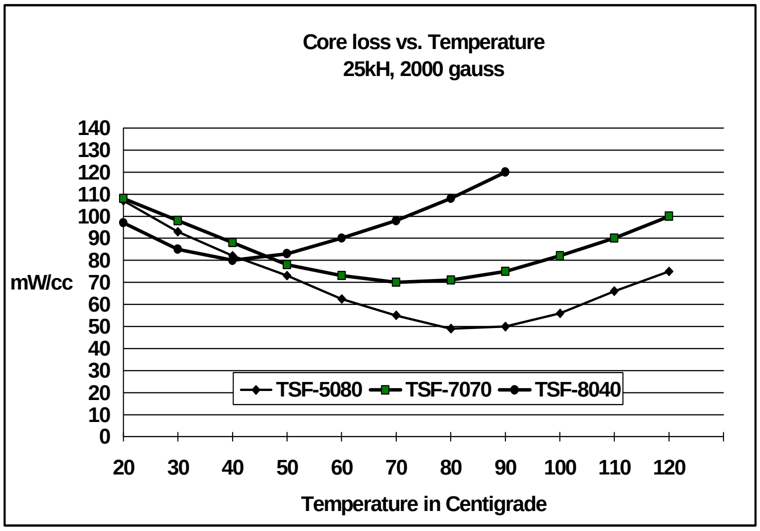
- Inductance rolls-off as the material saturates. Small gaps (Large AL values) saturate sooner than large gaps (small AL values)

Losses

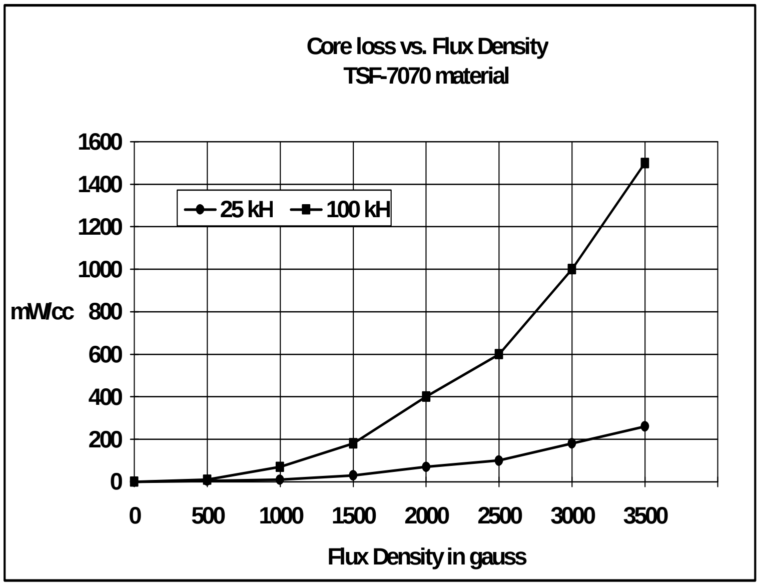
Loss Factor - Figure of merit of a material at low levels of magnetizing force (Tan δ / μQ = 1 / μQ)

- Often a materials core loss characteristics is a constraint on the minimum core size.

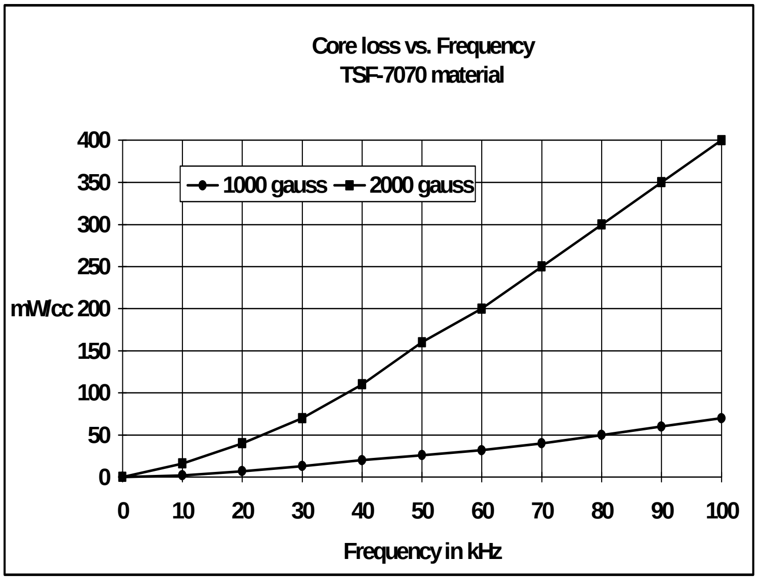
Core Loss - A measure of the efficiency of a material at high levels of magnetizing force. Dissipated energy in the form of heat.



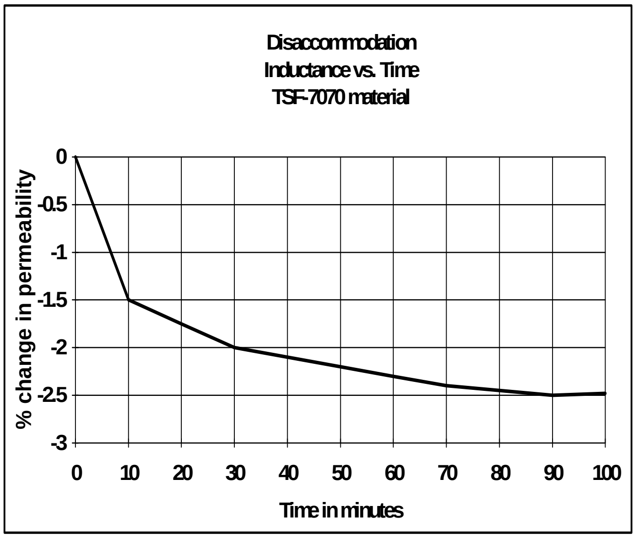
- A number of material grades have been designed so that their minimum core loss occurs at specific temperatures.



- Core Loss increases exponentially with increasing Flux Density.



- Core Loss increases exponetially with increasing frequency.



- Disaccomodation is the variation of permeability with time. Mechanical, magnetic or thermal disturbances cause the initial permeability to be raised to an unstable value from which it returns as a function of time. This process is indefinitely repeatable.

Ferrite Material Constants	
Specific Heat	0.25 cal / g / °c
Thermal Conductivity	10×10^{-3} cal / sec / cm / °c
Coefficient of Linear Expansion	8 to 10×10^{-6} / °c
Compressive Strength	60×10^{3} lbs / in^{2}
Young's Modulus	18×10^{3} lbs / in^{2}
Hardness (Knoop)	650
Density	4.6 to 4.8 gm / cm^{3}