

Target thickness with eddy current sensors

The principle of eddy current displacement measurement requires a minimum thickness for stable results. This minimum thickness depends on the target material used and the sensor frequency. The sensor generates an alternating electromagnetic field (see Fig. 1) which penetrates the target. Eddy currents then form in the target causing a secondary magnetic field which attenuates the primary field.

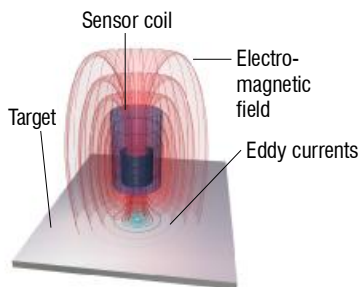


Fig. 1: Schematic illustration of an eddy current measurement

Skin or penetration depth

Electromagnetic fields are attenuated on entering an electrically or magnetically conducting material. The reduction in the field strength and therefore the current density is accompanied by losses which occur in the vicinity of the material surface. The characteristic length at which the current density reduces to the value 1/e or to 37% is known as the skin depth (see Fig. 2).

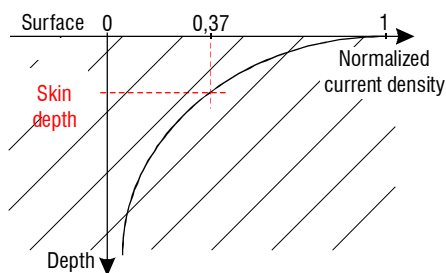


Fig. 2: Current density distribution in the target

Calculating the skin depth

The skin depth can be calculated with the following formula (it applies to the ideal case of a plane boundary layer and an infinitely extended object).

$$\delta = \frac{1}{\sqrt{\sigma \cdot f \cdot \mu \cdot \pi}}$$

δ = Skin depth

σ = electrical conductivity

f = Sensor frequency

μ = $\mu_0 \cdot \mu_r$ = Permeability

μ_0 = $12,566 \cdot 10^{-7} \frac{Vs}{Am}$

You can determine the permeability for some materials from Fig. 3. Or you can read off the skin depth directly from Table 1.

Target material	Skin depth in μm at	
	250 kHz	1MHz
Aluminium	168	84
Brass	249	124
Copper	134	67
Gold	149	74
Graphite	2700	1350
Lead	459	230
Magnesium	209	104
Nickel	27	14
Permalloy	4	2
Phosphor Bronze	302	151

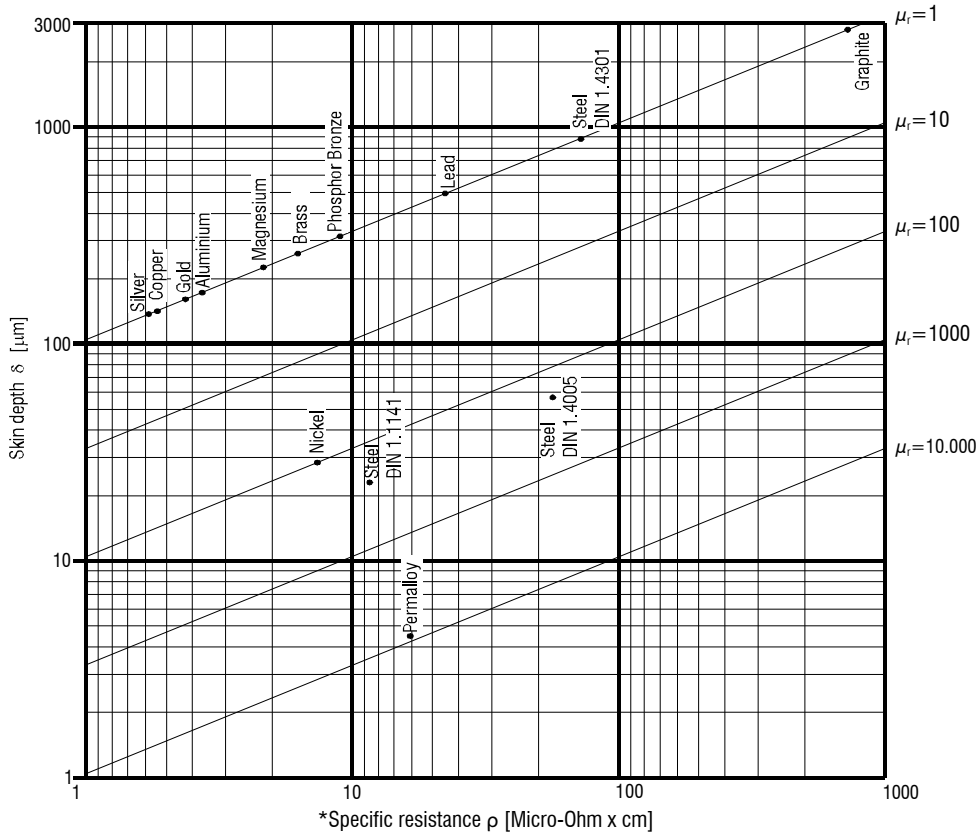
Tab. 1: Various skin depths

Calculating the minimum thickness

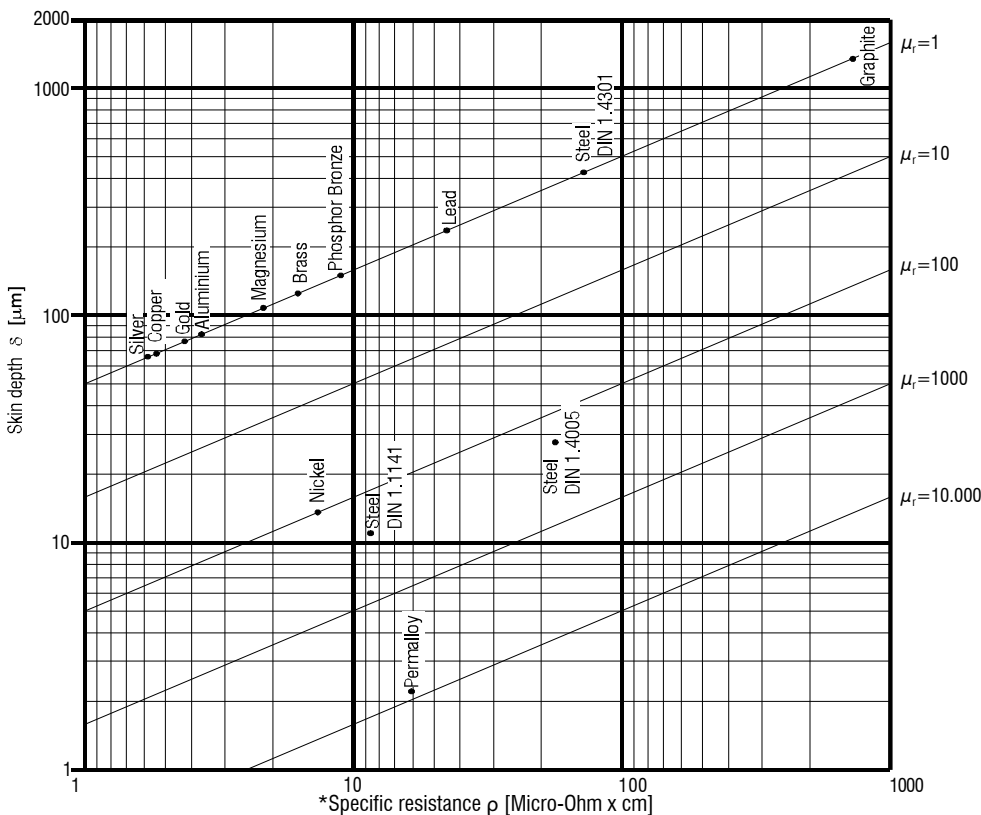
To calculate the minimum thickness of a material, take the appropriate skin depth from Table 1 or read off the skin depth from Fig. 3. Then you find the minimum thickness with the approximation value from Table 2. This calculation only applies when using a sensor with a frequency of 250 kHz or 1 MHz.

Measurement application	Minimum target thickness
Object detection (without displacement measurement)	"Skin depth" x 0,25
Displacement measurement at approx. Constant (room)temperature	"Skin depth" x 1,00
Displacement measurement with changing temperature	"Skin depth" x 3,00
Thickness measurement with two opposing sensors	"Skin depth" x 6,00

Tab. 2: Approximation values for simple determination of the minimum thickness



Tab. 3a: Skin depth at 250kHz



Tab. 3b: Skin depth at 1MHz