AeroCheck2 & AeroCheck+ Eddy Current Flaw Detector

WeldCheck2 & WeldCheck+ Eddy Current Flaw Detector

SigmaCheck Eddy Current Conductivity meter

ETi-200 Advanced Eddy Current Flaw Detector

VeeScan Eddy Current Aircraft Wheel Inspection System

ETHER NDE

Useful Technical Information concerning Eddy Current NDT

Ohms Law

V = I x R Where V = Voltage in volts, I = Current in Amps and R = Resistance in Ohms

Impedance

$Z = \sqrt{R^2 + X_L^2}$ Where Z = Impedance in ohms, R = Resistance in ohms and XL = Reactance in ohms.

Phase Angle

$Tan\phi = \frac{X_L}{R}$ Where ϕ = Phase Angle in degrees, X_L = Inductive Reactance in ohms and R = Resistance in ohms.

Magnetic Permeability

$\mu = \frac{B}{H}$ Where μ = Magnetic Permeability in Henries per meter (mu), B = Magnetic Flux Density in Tesla, H = Magnetising Force in Amps/meter.

Relative Magnetic Permeability

$\mu_r = \frac{\mu}{\mu_o}$

μ_r = Relative magnetic permeability (mu) = 1 if the material is non-ferrous.
μ_o = Magnetic permeability of free space (Henries per meter = 1.257 * 10^{-6})
μ = Magnetic permeability (Henries per meter) = μ_r * μ_o

Conductivity and Resistivity

$\sigma = \frac{1}{\rho}$

Conductivity can be measured in Siemens per m (S/m) or more commonly in Aerospace NDT in % IACS (International Annealed Copper Standard). 1 Siemen is the inverse of an ohm. Another common measurement unit is Siemen per cm (S/cm). 100S/m=1S/cm and 100%IACS = 58 *10^6 S/m = 58 MS/m = 0.58 MS/cm.
σ = Conductivity (sigma)
ρ = Resistivity (rho)

Resistance and Conductivity

$R = \frac{l}{A\sigma}$ Where R = the resistance of a uniform cross section conductor in ohms (Ω), l= the length of the conductor in the same linear units as the conductivity or resistivity is measured in e.g.

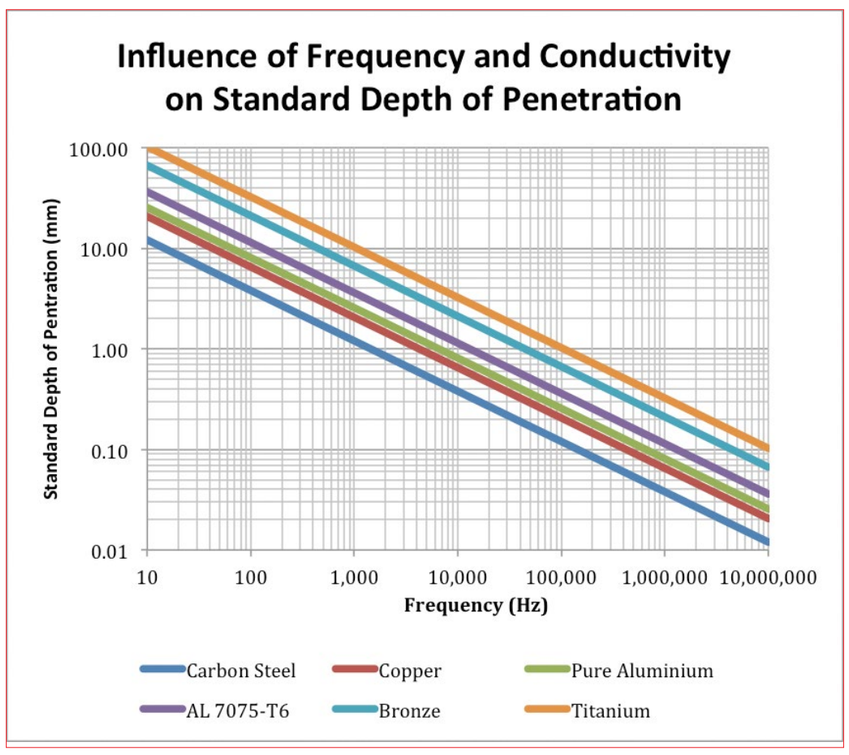
or

$R = \frac{\rho l}{A}$ S/m or ohm.m, A = Cross Sectional area, = conductivity S/m and = Resistivity (Ωm)

Standard Depth of Penetration

$\delta = \frac{1}{\sqrt{2\pi\mu\sigma}}$

δ = standard depth of penetration in metres (m) or skin depth.
π = pi (3.1415)
f = frequency (Hz)
μ = Magnetic Permeability (Henries per meter). As =1 for non-ferrous material then = 4 * 10 - 7 = 1.257 * 10^{-6}
σ = Conductivity (Siemens/metre)



Depth of Penetration and probe size

Smith et al have introduced the idea of spatial frequency.

$$\delta = \frac{1}{\sqrt{\frac{4^2}{D^2} + 2\pi f\mu\sigma}}$$

Where D = the effective diameter of the probe field in metres. This limits the depth of penetration to D/4. In the usual equation the probe effective diameter is assumed to be infinite.

Current Density Change with depth

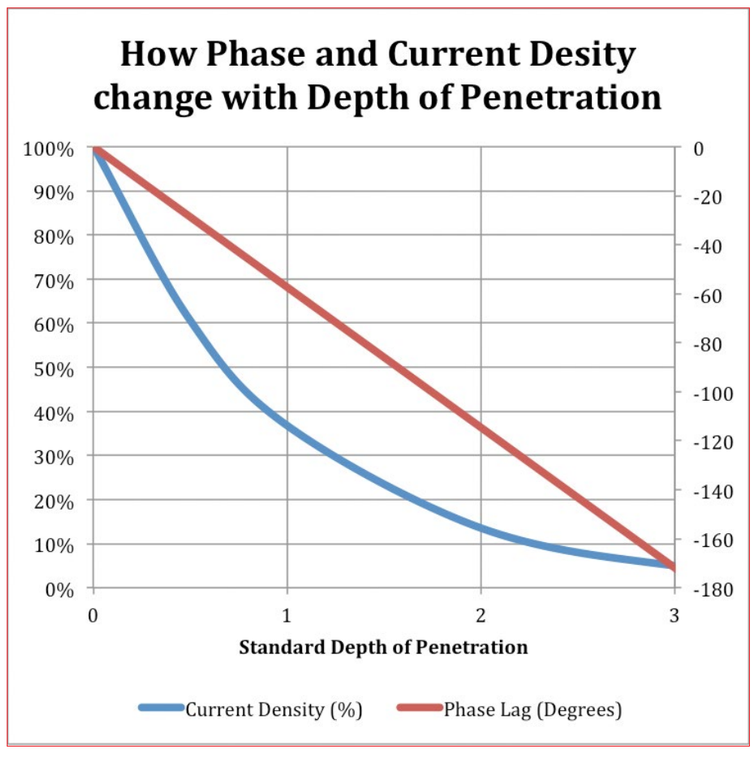
$J_x = J_0 e^{\frac{-x}{\delta}}$

J_x = Current Density at distance x below the surface (amps/m2)
J_0 = Current Density at the surface (amps/m2)
e = the base of the natural logarithm (Euler's number) = 2.71828
x = Distance below the surface
δ = Standard depth of penetration

Phase change with Depth

$\theta = \frac{57.3x}{\delta}$

θ = Phase lag (degrees) 57.3 = 1 radian expressed in degrees
x = Distance below the surface
δ = Standard depth of penetration



Some Conversion Factors

1m = 100 cm = 1000 mm 1inch = 2.54 cm
1% IACS = 0.58MS/m = 5,800S/cm 1 Siemen = $\frac{1}{\Omega}$

Frequency Calculations

Wall Thickness equals skin depth:

$f = \frac{1}{x^2\pi\mu\sigma}$

f = frequency (Hz)
π = material thickness in meters
x = pi (3.1415)
μ = Magnetic Permeability (Henries per meter). As μ_r = 1 for non-ferrous material then = 1.257 *10^{-6}
σ = Conductivity (Siemens/metre)

Frequency for Wobble v thickness Change = 90 degrees $f = \frac{0.64}{x^2\pi\mu\sigma}$

Frequency for ID to OD = 90 degrees $f = \frac{1.2}{x^2\pi\mu\sigma}$

Frequency for Through Wall to OD 20 % =120 degrees $f = \frac{2.56}{x^2\pi\mu\sigma}$

End Point 3 skin depths $f = \frac{9}{x^2\pi\mu\sigma}$

Knee point (point where optimum phase shift for surface breaking defect to lift off achieved):

$$f = \frac{9*10^{11}}{\sigma}$$

Short Form Conductivity List

Types and/ or Description	Conductivity % IACS	Mega Siemen per m (MSm-1)
Aluminium		
Pure Aluminium (A1)	65.86%	38.20
Aluminium Alloy 1100-0	59.45%	34.48
Aluminium Alloy 2024-0	50.71%	29.41
Aluminium Alloy 2024-T4	30.25%	17.55
Aluminium Alloy 7075-T6	33.16%	19.23
Aluminium Alloy 355.0-T6	27.81%	16.13
Aluminium Alloy 356.0-T6	25.35%	14.70
Nickel and Alloys		
Nickel - (Pure) (Ni)	25.00%	14.50
Monel K-500	2.83%	1.64
Hastelloy B	1.28%	0.74
Inconel 600	1.67%	0.97
Inconel 625	1.34%	0.78
Inconel X-750	1.41%	0.82
Inconel 800	1.74%	1.01
Nichrome - Ni 61%, Cr 15%, Fe 24%	1.54%	0.89
Nichrome V - Ni 80% + 20% Cr	1.60%	0.93
Stainless Steels		
Stainless Steel Type 420	3.13%	1.82
Stainless Steel Type 403, 410 & 416	3.02%	1.75
Stainless Steel Type 430, 430-F, 434 & 436	2.87%	1.66
Stainless Steel Type 405 & 409	2.83%	1.64
Stainless Steel Type 442	2.69%	1.56
Stainless Steel Type 446	2.57%	1.49
Stainless Steel Type 201 & 202	2.50%	1.45
Stainless Steel Type 304 & 304L	2.46%	1.43
Stainless Steel Type 321	2.43%	1.41
S/S Type 301,302, 302-B, 303, 305, 308, 347, 414 & 431	2.39%	1.39
Stainless Steel Type 316, 316L & 317	2.33%	1.35
S/St Type 2522 (V/soft nr 1.4466) Similar to 316	1.01%	0.59
Stainless Steel Type 309	2.21%	1.28
Stainless Steel Type 310	2.18%	1.26
Copper		
99.995% Min (Vacuum Cast Pure Copper) (Cu)	102.00%	59.16
Phosphorized Arsenical Copper	45.00%	26.1
Cu + 0.03 to 0.06% Mg; +0.08 to 0.15% Zr; 0.40 to 0.80% Cr	85.00%	49.3
Cu +0.7 to 1.2% Cr	82.00%	47.56
Cu +2.0% Ni + 1.0% Ti	60.00%	34.8
Cu +5.0% Ni + 2.5% Ti	55.00%	31.9
C10300 +0.001 to 0.005% P	98.20%	56.96
C14700 +0.3% S	96.00%	55.68

Types and/ or Description	Conductivity % IACS	Mega Siemen per m (MSm-1)
Miscellaneous		
Brass 95% Cu + 5% Zn	55.00%	31.9
95.7% Cu + 4.3% Ti	10.00%	5.8
Admiralty Brass 70% Cu + 29% Zn + 1% Sn	2.50%	1.45
Alpha Alloy (Ti) + 5% Al + 2.5% Sn	1.10%	0.64
Alpha-Beta Alloy (Ti) + 6% Al + 4% V	1.01%	0.59
Alpha-Ti	3.20%	1.86
Aluminium Brass BSTF3	23.00%	13.34
Aluminium Brass Type B	15.50%	8.99
ASTM Bill/71 Alloy 715 (70/30 Cu/Ni)	5.00%	2.9
ASTM Bill/F1 Alloy 443 (70/30 Cu/Zn) with 1% Sn	25.00%	14.5
Barium (Ba)	2.76%	1.6
Beryllium (Be)	38.50%	22.33
Beta Alloy (Ti)	1.20%	0.7
Brass 70% Cu + 30% Zn	28.00%	16.24
Brass 85% Cu + 15% Zn	37.00%	21.46
Brass 97.5% Cu + 2.5% Ti	15.00%	8.7
Bronze 88% Cu + 12% Sn	9.70%	5.63
C36000 (Free Cutting Brass)	26.00%	15.08
C70690 90% Cu + 10% Ni	11.90%	6.9
C71590 70% Cu + 30% Ni	5.00%	2.9
C83600 (Red Brass) 0.85% Cu; 5% Zn; 5% Sn; 5% Pb	15.00%	8.7
C85200 (Yellow Brass)	18.00%	10.44
C86200 (Manganese Bronze)	7.50%	4.35
C92200 (Navy 'M' Bronze)	14.30%	8.29
C93200 (Bearing-Bronze)	12.00%	6.96
C95400 (Aluminium-Bronze)	13.00%	7.54
Cadmium (Cd) (Pure)	25.17%	14.6
Calcium (Ca)	37.60%	21.81
Carbon (Pure)	0.12%	0.07
Chromium (Cr)	13.45%	7.8
Cobalt (Co) (99.8% Pure)	17.80%	10.32
Cobalt (Co) (Pure)	27.60%	16.01
Gold (Au) 99.9% Pure	77.60%	45.01
Graphite with Elemental		
Carbon - Plain	0.03%	0.02
Lithium (Li)	19.40%	11.25
Magnesium (Mg) (Pure)	38.60%	22.39
Manganese (Mn)	9.30%	5.39
Mg Alloy AZ91B-F	13.36%	7.75
Mg Alloy ZK60A-T5	30.25%	17.55
Molybodenum (Annealed)	41.00%	23.78
Pure Lead (Pb)	7.93%	4.6

Any questions?
Email us at sales@ethernde.com and we will be happy to assist you.