Specification for Soft Magnetic Material

kOr 120 / kOr 120HF / kOr 120LP

Material selection (first block in part number, see page 2)

120: standard material for transformers, common mode chokes (CMC), RCD cores, CT cores without DC tolerance available with linear flat hysteresis loop (F-loop), round loop (R-loop), rectangular loop (Z-loop)

120HF: optimised for transformers for f > 30 kHz and CMCs with improved high frequency impedance

120LP: high linearity / low permeability version for DC tolerant CT cores or CMCs with very high unbalanced current

Nominal data

	Symbol	Unit	Value	Conditions	
General material data					
Chemical composition		at%	$Fe_{73,5}Cu_1Nb_3Si_{15,5}B_7$		
Saturation flux density (saturation induction)	B_{sat}	mT	1200 1120	H > 100 A/m H > 100 A/m	25°C 100°C
Curie temperature	T_c	°C	600		
Resistance	ρ	µΩm	1,15		
Density	d	g / cm³	7,35	annealed	
Thermal expansion coefficient	α	1 / K	8×10^{-6}		
Saturation magnetostriction	$\lvert\lambda_S\rvert$	ppm	<1	annealed	
Tape thickness[2)]	d	µm	~18 ~14	kOr 120, kOr 120LP kOr 120HF	
Tape width	b	mm	3 - 72		
Filling factor (stacking factor)	FF	%	>80 >76	kOr 120: b ≤ 25 mm kOr 120: b>25 mm; all kOr 120HF	
recommended max. operational temperature		°C	85 - 200	depending on specification and operational conditions	

For kOr 120 / kOr 120HF with flat hysteresis loop (nominal values, cores in protection case or Epoxy coated):

Initial permeability	μ_i'		25.000 - 200.000	adjustable[1)]	25°C
Nominal permeability (10 kHz)	µ'		25.000 - 120.000	adjustable[1)]	
Remanence	B_r	mT	50 150	µ = 30.000, 50 Hz µ = 100.000, 50 Hz	
Power losses (in protection case)	P_{Fe}	W/kg	4,5 60 40	10 kHz / 0,6 T 100 kHz / 0,3 T (kOr 120) 100 kHz / 0,3 T (kOr 120HF)	

For kOr 120 with round hysteresis loop (in protection case):

Initial permeability	μ_i'		100.000 - 250.000		25°C
Maximum permeability	μ'_{max}		150.000 - 500.000	adjustable[1)]	50 Hz
Remanence	B_r	mT	500 - 900		

For kOr 120 with rectangular hysteresis loop (in protection case):

Remanence ratio	B_r / B_S		0,90 - 0,96	f = 1 kHz, saturation - saturation

For kOr 120LP with high linear flat hysteresis loop (in protection case or Epoxy coated):

Initial permeability	μ_i'		1000 - 2500	adjustable[1)]	25°C
permeability decay at 0,9 T		%	6 - 10		50 Hz

Remarks:

1) Permeability μ can be adjusted.

A_L-values are calculated according to $A_L = \mu_r \mu_0 \frac{A_{Fe}}{l_{Fe}}$

(A_L in mH, effective cross section A_{Fe} in mm^2, magnetic path length l_{Fe} in mm, $\mu_0 = 4\pi \cdot 10^{-7}$ Vs/Am)
μ_r in this formula is identical with μ' in this document.
A_{Fe} and l_{Fe} depend on the core dimensions and are indicated in the core datasheets.

2) Effective tape thickness, calculated from length, width and density of a tape sample.
Geometrical tape thickness (measured with a tape stack using a gauge) is higher by 10% - 15% due to roughness.

Material data of specific product specifications may differ due to geometry and dimension.

Finishing selection

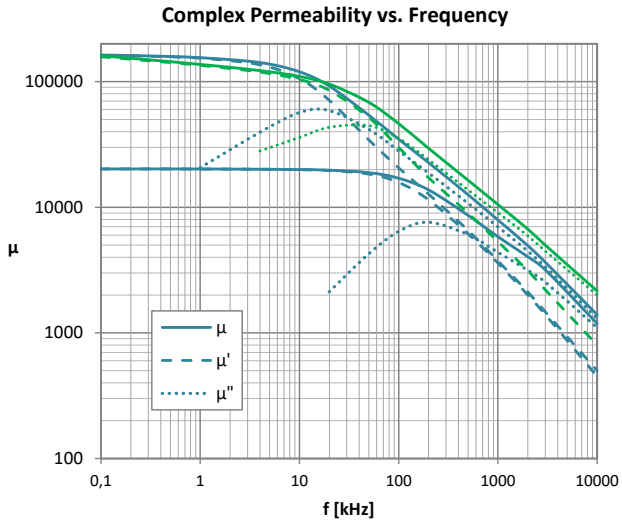
B	protection box (case):	standard plastic: PBT + 20-30% GF (class B) or PET + 30% GF (class F)
		higher temperature classes or metal cases on demand
E	Epoxy coated, ~0,3 mm	standard: class F; winding can be applied on coated core
I	Epoxy impregnated	core becomes machinable
EI	Epoxy impregnated and coated	
S	Epoxy soft impregnation	core solidified, not machinable, usually wrapped with glas fiber tape
V	Varnish sprayed	only transport protection, winding can't be applied directly

Part number system

	material	-	shape	finish	-	size	-	perm./cuts	-version
example:	120HF	-	T	B	-	252010	-	70	-1
	120	-	R	I	-	016A	-	2C	-2

material:	number denotes B_S in 10 mT; available materials see page 1
shape:	T = toroid, R = rectangular, O = oval, E = E-shape, U = U-shape, I = bar
finish:	B, E, I, EI, S, or V - see above
size:	toroid: OD ID H; rectangular: standard number or B C H; bar: A B C; all dimesnions in mm
permeability:	for non-cut cores of kOr 120 and kOr 120HF: minimum permeability in 1000
	for non-cut cores of kOr 120LP: minimum permeability
	for cores with rectangular hysteresis loop (Z-loop): "Z"
cuts:	for standard cut cores: number of cuts + "C"
	for premium cut cores: number of cuts + "PC"
	for bars: empty
version:	version number (e.g. different coatings). This is not the revision state!

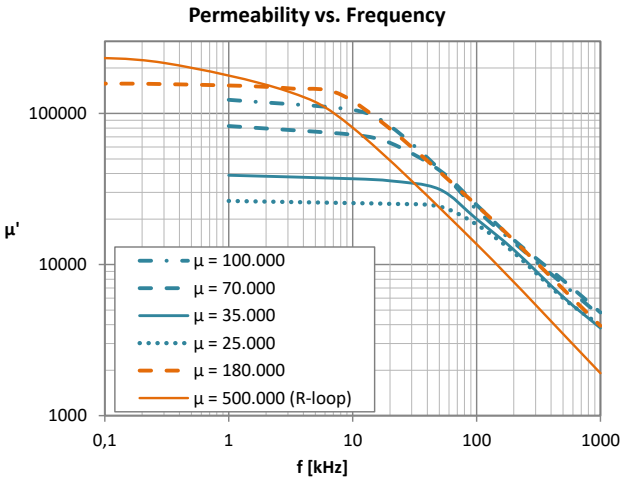
Frequency and bias current dependence of permeability



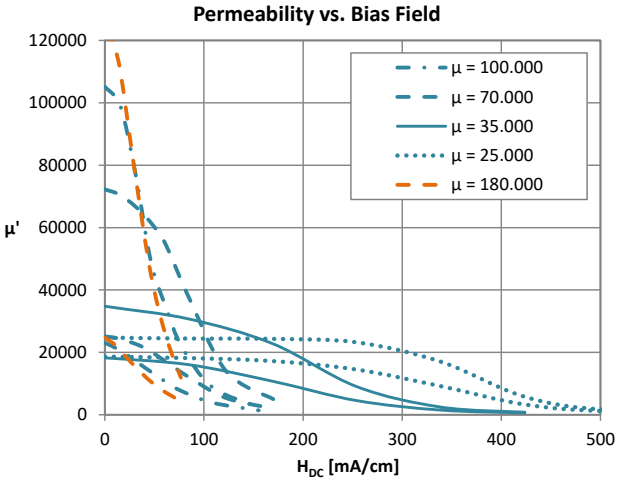
Notes:

Typical curves are given for cores with nominal permeability (10 kHz) of 20.000 and 100.000. Data for other permeabilities may be approximated using these data.
Green curves are for kOr 120HF with nominal permeability (10 kHz) of 100.000.

N = 1, H = 10 mA/cm



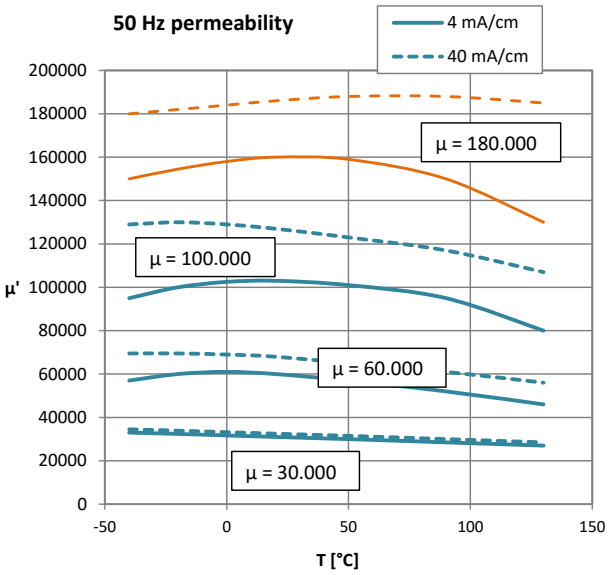
Typical curves.
Blue curves:
Nominal permeability refers to 10 kHz value.
Orange curves (highest permeabilities):
Nominal permeability refers to μ_{max} at 50 Hz, curves are measured at H_{AC} = 4 mA/cm.

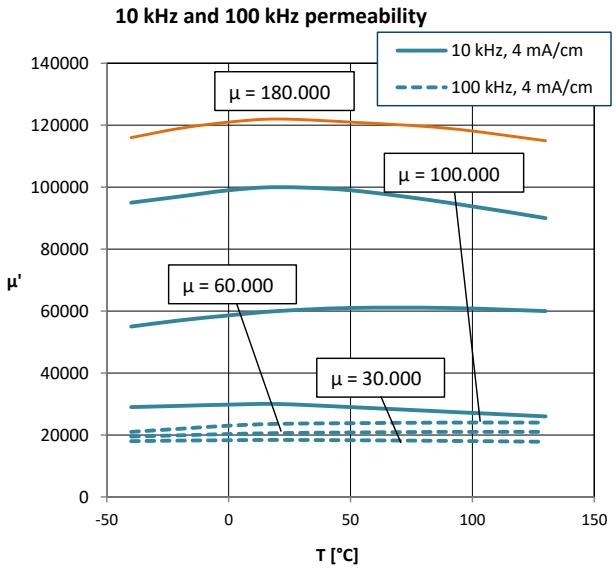


Typical curves.
Upper curve: 10 kHz
Lower curve: 100 kHz
Blue curves:
Nominal permeability refers to 10 kHz value.
orange curves:
Nominal permeability refers to μ_{max} at 50 Hz, curves are measured at H_{AC} = 4 mA/cm.

$$I_{DC} = H_{DC} \cdot l_{Fe}$$

Temperature dependence of permeability





Notes:

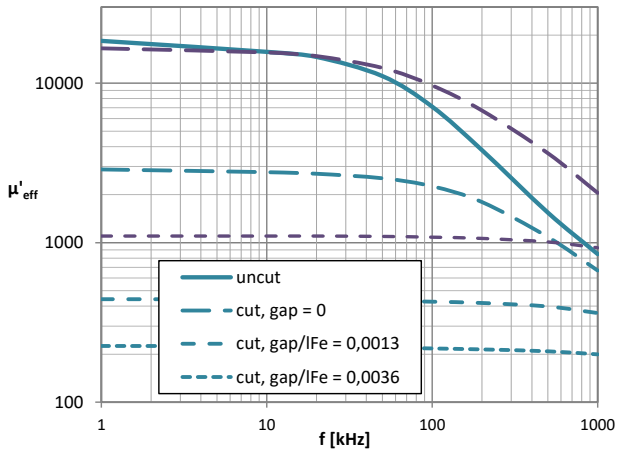
Typical curves for cores without or with low residual stress, for example in protection case fixed with some silicone glue or foam rings.

Permeability of Epoxy coated cores decreases in relation to shown curves below 50°C.

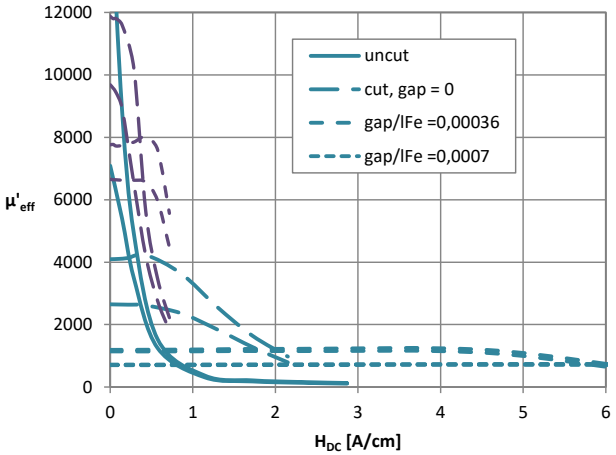
Blue curves:
Nominal permeability refers to 10 kHz value.
Orange curves:
Nominal permeability refers to μ_{max} at 50 Hz.

Impregnated uncut and single cut cores

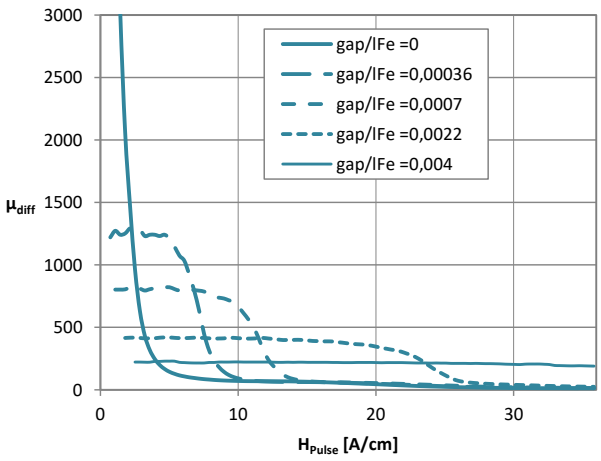
Effective Permeability vs. Frequency



Effective Permeability vs. Bias Field



Differential Permeability vs. Pulse Field



Notes:

Cores are impregnated with Epoxy.

Typical curves are shown:

blue: standard quality

violet: premium quality

gap/lFe denotes single gap width in relation to mean path length l_{Fe} for l_{Fe} = 100 - 500 mm

N = 1, U_{eff} = 100 mV

Nominal / minimum permeability (10 kHz) for single cut cores without additional gap:

standard quality:

10 kHz: 2500 / 1600

100 kHz: 1900 / 1200

premium quality:

10 kHz: 12.000 / 8000

100 kHz: 8000 / 6000

N = 1, U_{eff} = 100 mV

Upper curves: 10 kHz; lower curves: 100 kHz

blue: standard quality

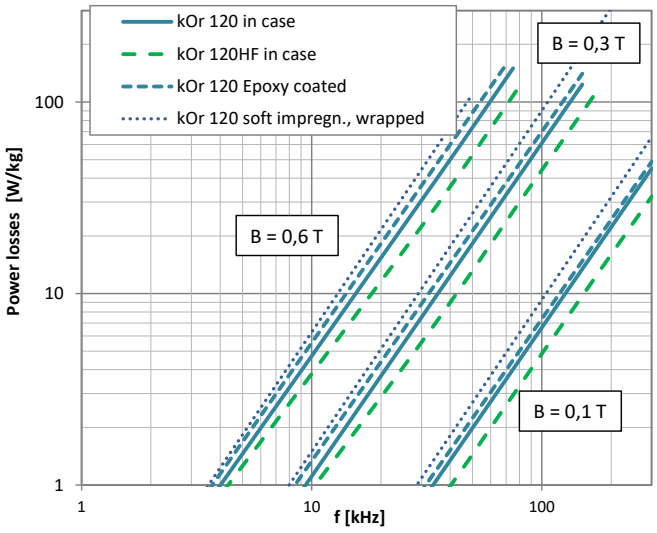
violet: premium quality

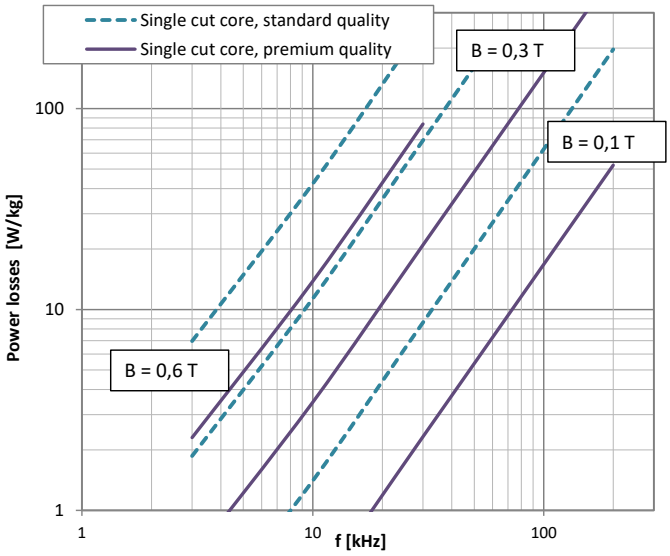
$$I_{DC} = H_{DC} \cdot l_{Fe}$$

μ_{diff} monitored during pulse

Nominal power losses

Power Losses vs. Frequency and Induction Amplitude





Notes:

Excitation with sinusoidal voltage of an amplitude corresponding to the indicated peak induction.

Power losses of cores in plastic cases decrease with increasing temperature.

Power losses of coated cores converge towards those of cores in cases between 80 and 130°C.

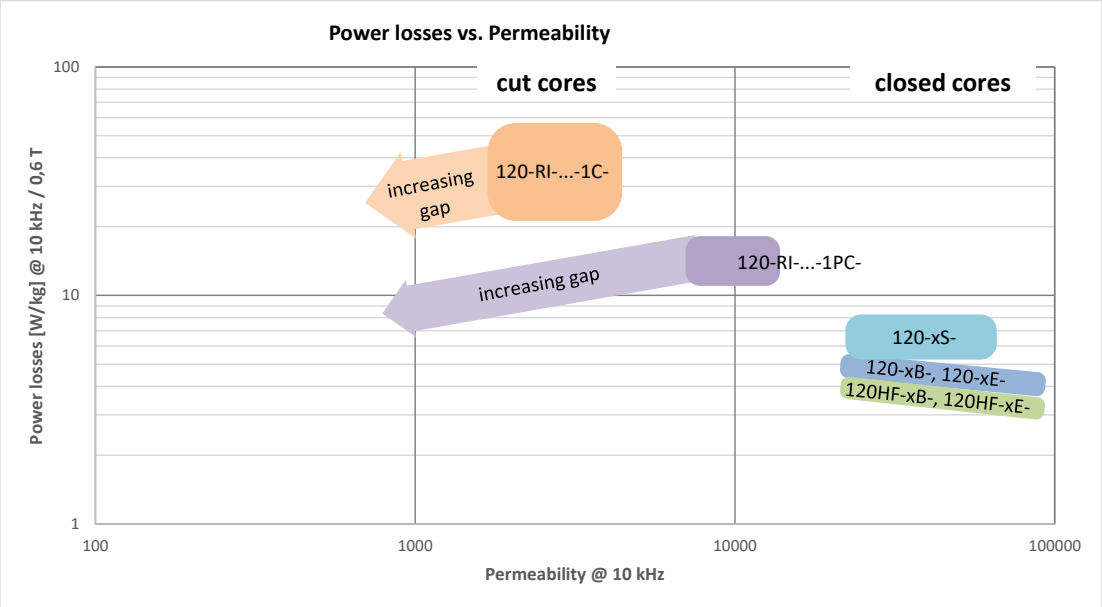
Losses of cut cores refer to rectangular shape (not E-shaped cores or other shapes) with path length l_{Fe} of 50 - 500 mm and effective cross section A_{Fe} of 100 - 3000 mm^2 without additional gap.
Losses vary with gap width and number of cuts.

Core losses are affected by forces, i.e. by assembly and fixation technologies.

Actual losses may vary in a wide range.

Soft impregnation and wrapped:
Cores are impregnated with soft Epoxy resin, and wrapped with glasfiber or Polyimide foil. They can be wire wound directly.

Nominal power losses



Steinmetz-coefficients (nominal data):

$$P_{Fe} = k\, f^{a} \hat{B}^{b}$$

P_{Fe} in W/kg, f in kHz, B in T

	Part Number	k	a	b
kOr 120 in protection case	120-TB-…	0,23	1,74	2,02
kOr 120HF in protection case	120HF-TB-…	0,18	1,72	2,01
kOr 120 Epoxy coated	120-TE-…	0,30	1,72	2,05
kOr 120HF Epoxy coated	120HF-TE-…	0,20	1,70	2,03
kOr 120 soft impregnated, wrapped	120-TS-…	0,3	1,78	2,07
kOr 120 cut core standard quality	120-RI-…-1C-…	3	1,55	2,1
kOr 120 cut core premium quality	120-RI-…-1PC-…	0,9	1,64	2,0

Valid for room temperature.
Valid for B ≤ 0,6 T, f = 10 … 150 kHz; losses are higher for f < 10 kHz and nominal B > 0,6 T.