Ferrite for Switching Power Supplies

Summary

Issue date: February 2010

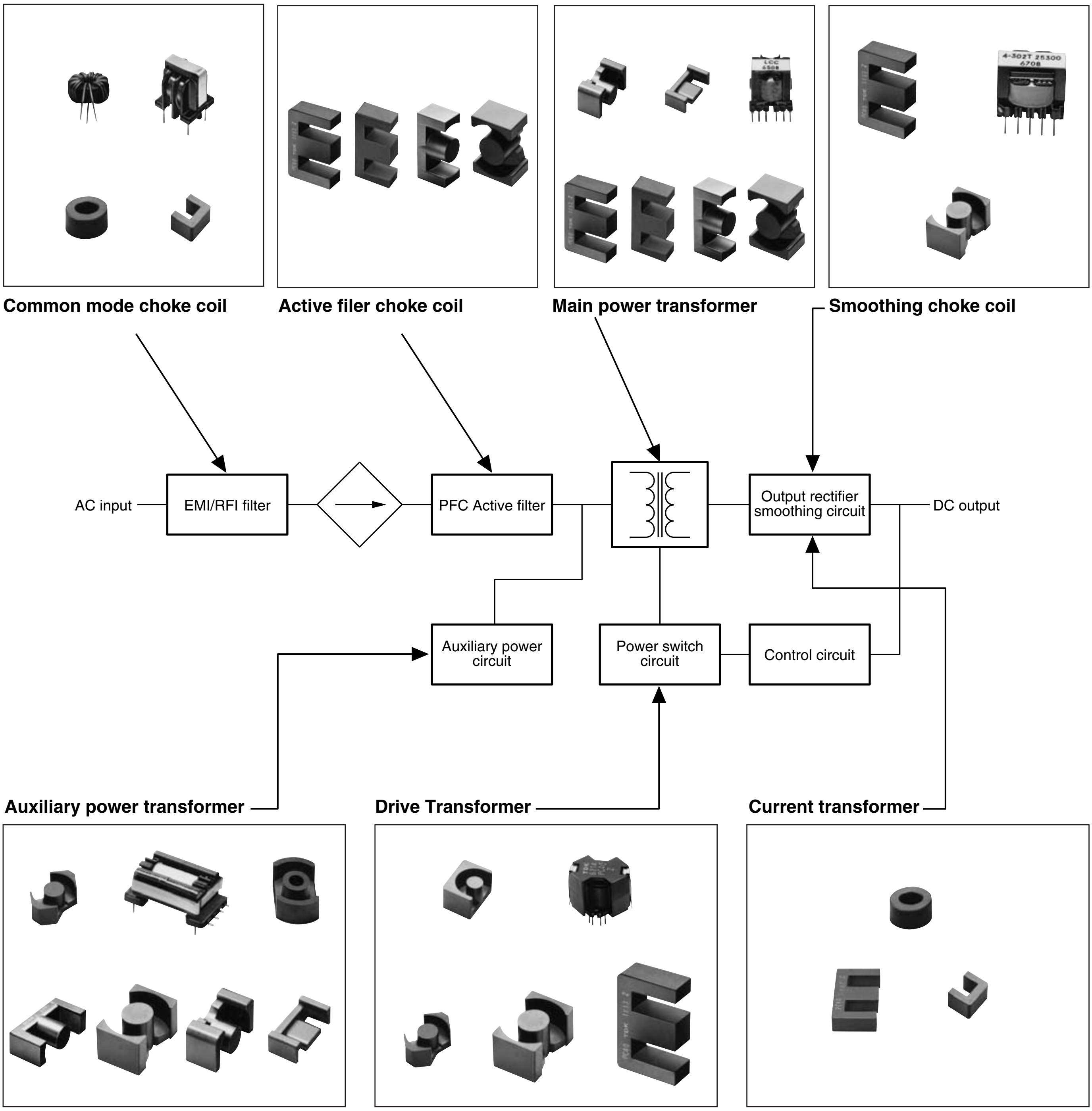
- All specifications are subject to change without notice.
- Conformity to RoHS Directive: This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used, except for exempted applications.

Ferrite for Switching Power Supplies
Summary

Our foremost mission is to develop unique and advanced electronics technologies. As such, ever since TDK was founded in 1935 when its researchers invented ferrite, we have been involved in a wide range of technological and product development efforts. Particularly, our high-performance ferrite elements, which result from our accumulated expertise and excellent microstructure control technologies, have become essential in reducing the weight and improving the performance of advanced electronic devices that are transforming the world around us.
As a result of pursuing the numerous potentials of these ferrite elements, we have been able to develop high-frequency power ferrite material that deliver among the world's highest levels of reliability and magnetic properties. These products include PC40, PC44 and PC47. They contribute to achieving even greater size reductions and performance improvements of high-performance switching power supplies and DC to DC converters -- products considered to constitute the heart of microelectronic devices. We have also developed the PC95, which delivers a saturated magnetic flux density equivalent to that of PC44 and low loss in a wide temperature range. This materials is expected to improve the efficiency of power supplies in DC to DC converters used in electric vehicles.
Additionally, we have been conducting research in ferrite that delivers permeability close to the theoretical limit in high frequency ranges. These ferrite materials are designed for EMC solutions. The materials HS52, HS72, HS10 and HS12 deliver frequency responses with excellent permeability - a prerequisite for EMC magnetic material such as EMI filters and common mode choke coils - and higher impedance compared to existing material in the high frequency ranges.
In parallel with material development, we have been working to reduce sizes and improve the performance of our switching power supplies and DC to DC converters. To this end, we have been developing optimum core shape designs and creating an extensive line up of these products to accommodate a wide range of specific needs.

CIRCUIT EXAMPLE

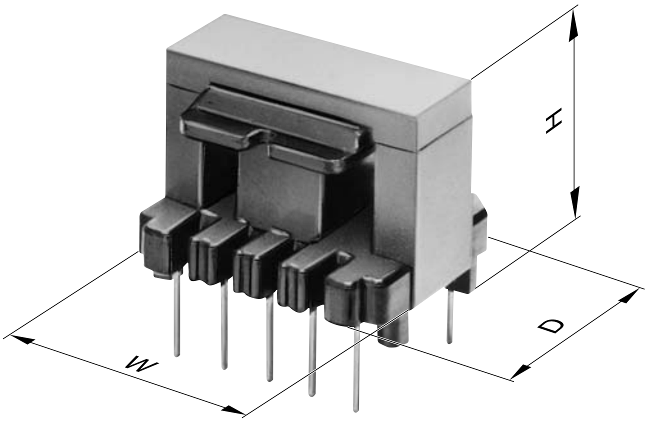
SINGLE FORWARD CONVERTER

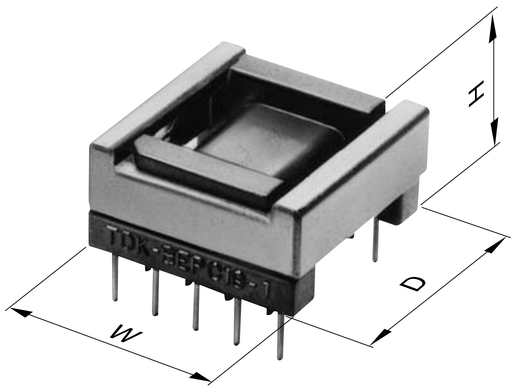


Notes:
- LP and EPC cores are ideal for use in thin transformers.
- LP cores are available in .5 and .7 inches in height (when mounted).
- EP cores are available in .5 and .65 inches in height (when mounted).

SELECTED ITEMS OF LEGEND

$C_1 = \sum \frac{\ell}{A}$	Core constant mm^{-1}
Ae	Effective cross-sectional area, mm^2
ℓe	Effective magnetic path length, mm
Ve	Effective core volume mm^3
Acp	Cross-sectional center leg/pole area, mm^2
Acp min.	Minimum cross-sectional center pole area, mm^2
Acw	Cross-sectional winding area of core, mm^2
Aw	Cross-sectional winding area of bobbin, mm^2
ℓw	Average length of turns around bobbin, mm
t	Minimum thickness of bobbin inside which core is placed, including flanges, mm
W	Bobbin-core assembly dimensions
D	Bobbin-core assembly dimensions
H	Bobbin-core assembly dimensions





MATERIAL CHARACTERISTICS

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For Transformer and Choke

Material					PC40	PC44	PC47
Initial permeability	μi				2300±25%	2400±25%	2500±25%
Amplitude permeability	μa				3000 min.	3000 min.	
Core loss volume density (Core loss)* [B=200mT]	Pcv	kW/m3	25kHz sine wave	25°C	120		
				60°C	80		
				100°C	70		
				120°C	85		
			100kHz sine wave	25°C	600	600	600
				60°C	450	400	400
				100°C	410	300	250
				120°C	500	380	360
Saturation magnetic flux density* [H=1194A/m]	Bs	mT		25°C	510	510	530
				60°C	450	450	480
				100°C	390	390	420
				120°C	350	350	390
Remanent flux density*	Br	mT		25°C	95	110	180
				60°C	65	70	100
				100°C	55	60	60
				120°C	50	55	60
Coercive force*	Hc	A/m		25°C	14.3	13	13
				60°C	10.3	9	9
				100°C	8.8	6.5	6
				120°C	8	6	7
Curie temperature	Tc	°C			>215	>215	>230
Density*	db	kg/m3			4.8×10[3]	4.8×10[3]	4.9×10[3]
Electrical resistivity*	ρv	Ω • m			6.5	6.5	4.0

Material					PC90	PC95
Initial permeability	μi				2200±25%	3300±25%
Amplitude permeability	μa					
Core loss volume density (Core loss)* [B=200mT]	Pcv	kW/m3	100kHz sine wave	25°C	680	350
				60°C	470	
				100°C	320	290
				120°C	460	350
Saturation magnetic flux density* [H=1194A/m]	Bs	mT		25°C	540	530
				60°C	500	480
				100°C	450	410
				120°C	420	380
Remanent flux density*	Br	mT		25°C	170	85
				60°C	95	70
				100°C	60	60
				120°C	65	55
Coercive force*	Hc	A/m		25°C	13	9.5
				60°C	9	7.5
				100°C	6.5	6.5
				120°C	7	6.0
Curie temperature	Tc	°C			>250	>215
Density*	db	kg/m3			4.9×10[3]	4.9×10[3]
Electrical resistivity*	ρv	Ω • m			4.0	6.0

* Average value
** 500kHz, 50mT

For Common Mode Choke

Material				HS52	HS72	HS10	HS12
Initial permeability	μi			5500±25%	7500±25% (2000min. at 500kHz)	10000±25%	12000±25% (at 150kHz)
Relative loss factor*	tanδ/μi	$\times 10^{-6}$		10(100kHz)	30(100kHz)	30(100kHz)	20(100kHz)
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	410	410	380	430
Remanent flux density*	Br	mT	25°C	70	80	120	80
Coercive force*	Hc	A/m	25°C	6	6	5	6
Curie temperature	Tc	°C		>130	>130	>120	>130
Density*	db	kg/m^3		4.9×10^3	4.9×10^3	4.9×10^3	4.9×10^3
Electrical resistivity*	ρv	Ω • m		1	0.2	0.2	0.5

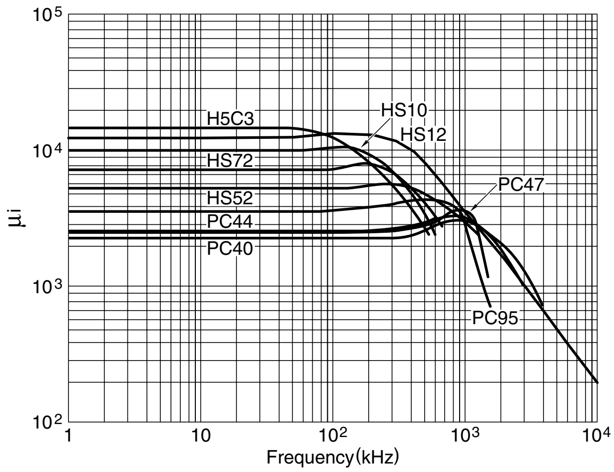
For Telecommunication

Material				H5A	H5B2	H5C2	H5C3
Initial permeability	μi			$3300^{+40\%}_{-0\%}$	7500±25%	10000±30%	15000±30%
Relative loss factor	tanδ/μi	$\times 10^{-6}$		<2.5(10kHz) <10(100kHz)	<6.5(10kHz)	<7.0(10kHz)	<7.0(10kHz)
Temperature factor of initial permeability	αμir	$\times 10^{-6}$	–30 to +20°C 0 to 20°C 20 to 70°C	–0.5 to 2.0 –0.5 to 2.0	0 to 1.8 0 to 1.8	–0.5 to 1.5 –0.5 to 1.5	–0.5 to 1.5 –0.5 to 1.5
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	410	420	400	360
Remanent flux density*	Br	mT	25°C	100	40	90	105
Coercive force*	Hc	A/m	25°C	8.0	5.6	7.2	4.4
Curie temperature	Tc	°C		>130	>130	>120	>105
Hysteresis material constant	ηB	$\frac{10^{-6}}{mT}$		<0.8	<1.0	<1.4	<0.5
Disaccommodation factor	DF	$\times 10^{-6}$		<3	<3	<2	<2
Density*	db	kg/m^3		4.8×10^3	4.9×10^3	4.9×10^3	4.95×10^3
Electrical resistivity*	ρv	Ω • m		1	0.1	0.15	0.15

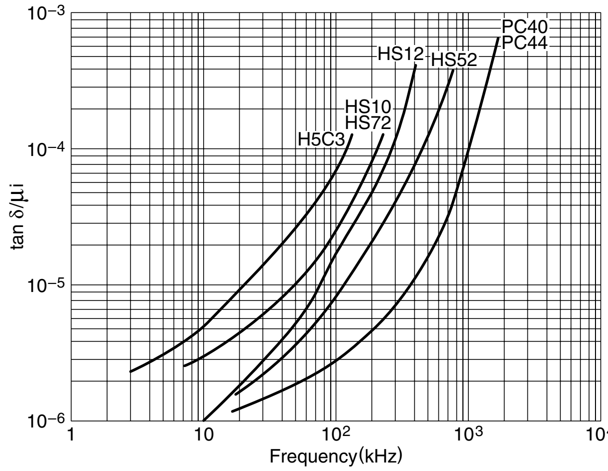
Material				H5C4	HP5	DNW45	DN70
Initial permeability	μi			12000±30% 9000(–20°C)	5000±20%	4200±25%	7500±25%
Relative loss factor	tanδ/μi	$\times 10^{-6}$	25°C, 10kHz	<8(10kHz)	<3.5	<3.5	<2.0
Temperature factor of initial permeability	αμir	$\times 10^{-6}$	–30 to +20°C 0 to 20°C 20 to 70°C		 ±12.5% ±12.5%		–0.5 to 1.5 –0.5 to 1.5
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	380	400	450	390
Remanent flux density*	Br	mT	25°C	100	65	50	45
Coercive force*	Hc	A/m	25°C	4.4	7.2	6.5	3.5
Curie temperature	Tc	°C		>110	>140	>150	>105
Hysteresis material constant	ηB	$\frac{10^{-6}}{mT}$		<2.8	<0.4	<0.8	<0.2
Disaccommodation factor	DF	$\times 10^{-6}$		<3	<3	<3	<2.5
Density*	db	kg/m^3		4.95×10^3	4.8×10^3	4.85×10^3	5.0×10^3
Electrical resistivity*	ρv	Ω • m		0.15	0.15	0.65	0.3

* Average value

μi vs. Frequency Characteristics

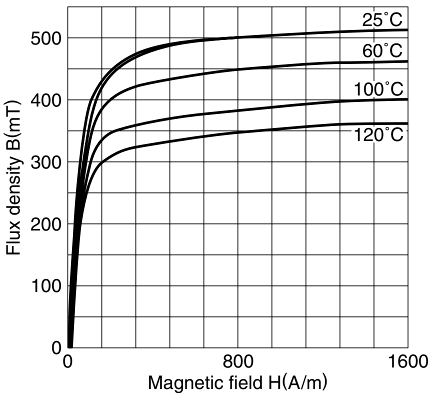


tanδ/μi vs. Frequency Characteristics

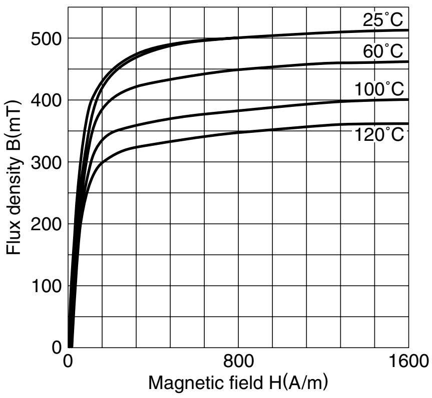


Magnetization Curves (Typical)

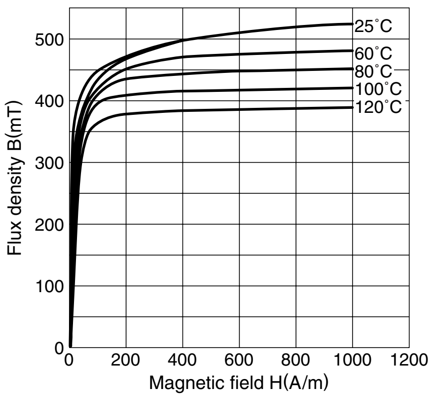
Material: PC40



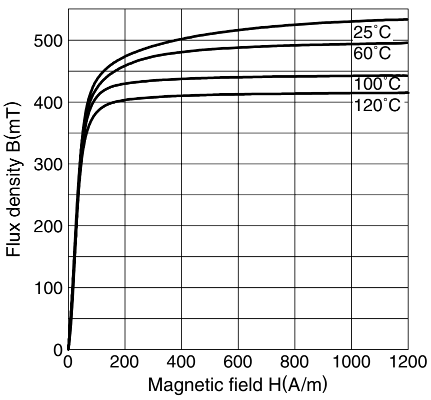
Material: PC44



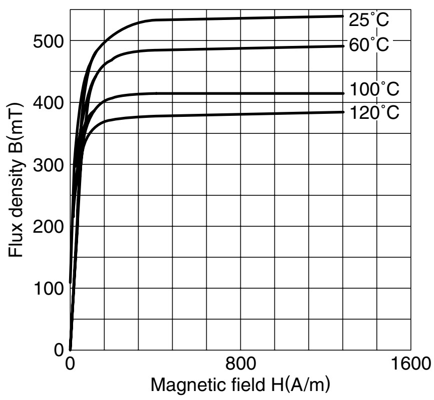
Material: PC47



Material: PC90

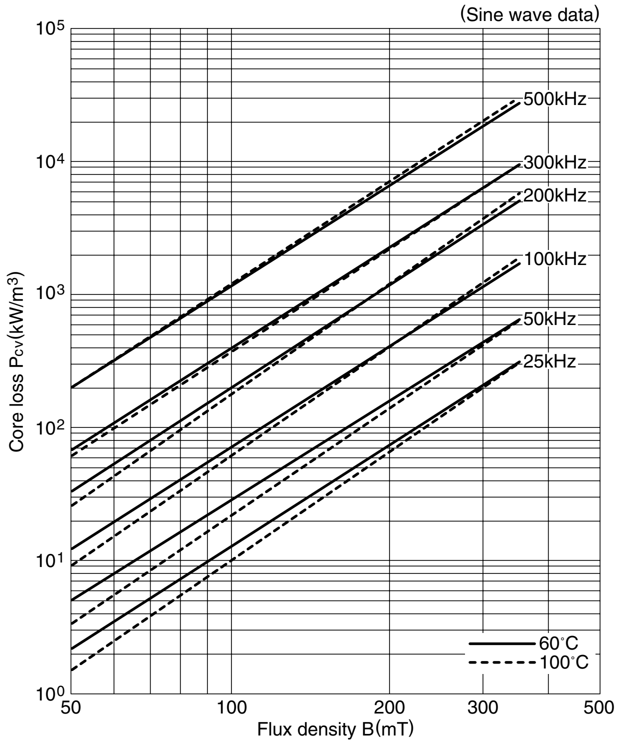


Material: PC95

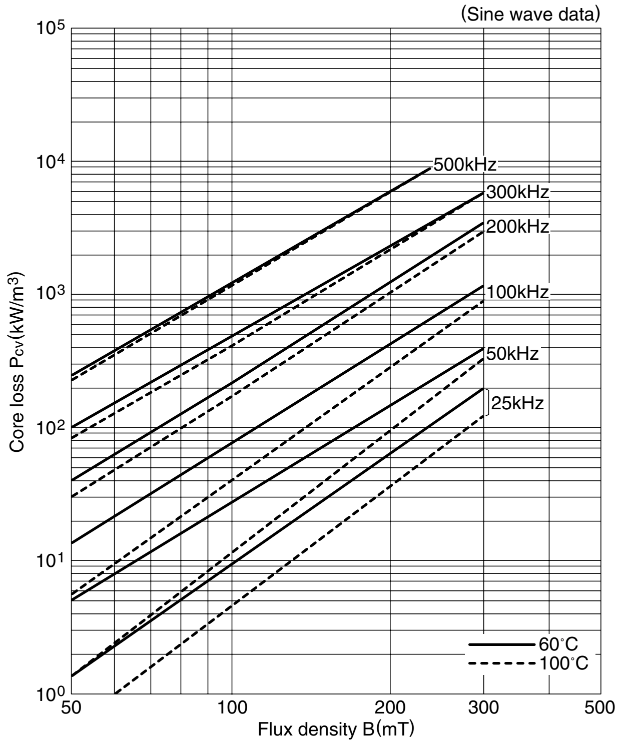


Core Loss (Typical)

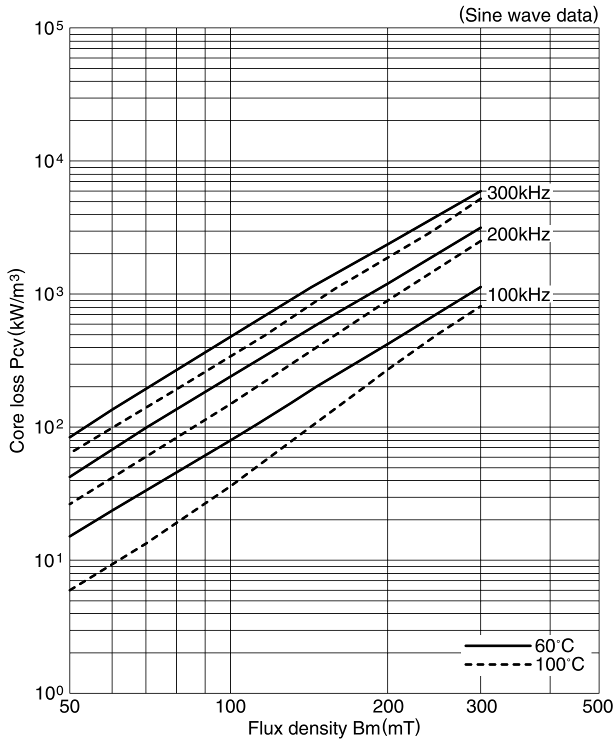
Material: PC40



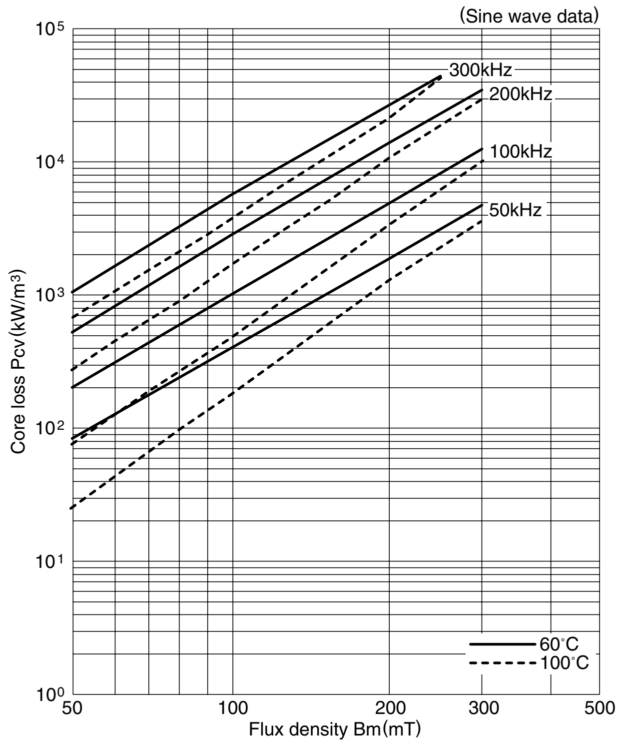
Material: PC44



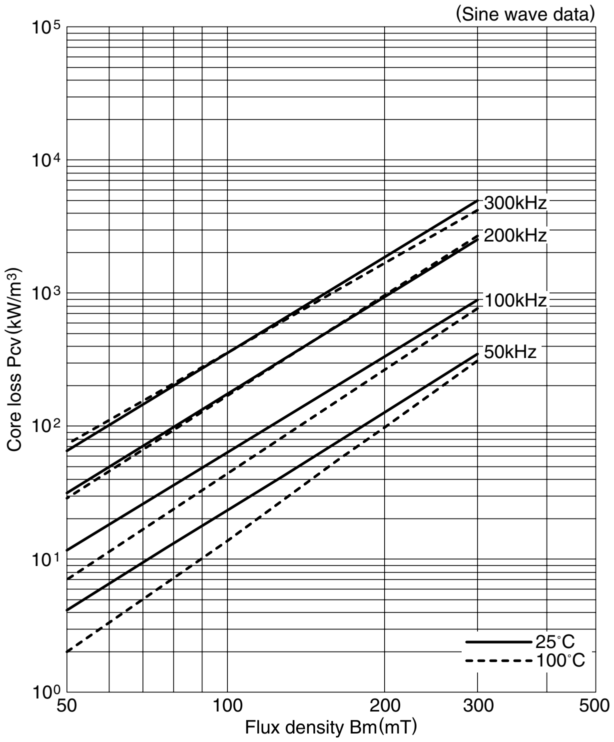
Material: PC47



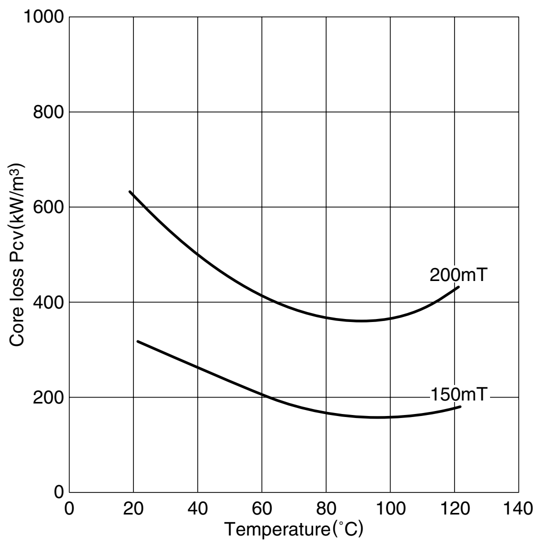
Material: PC90



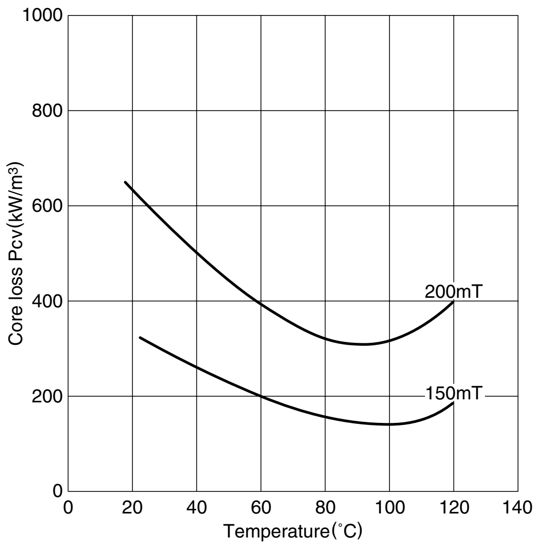
Core Loss (Typical)
Material: PC95



Temperature Dependence of Core Loss (Typical)
Material: PC40 (Frequency: 100kHz)



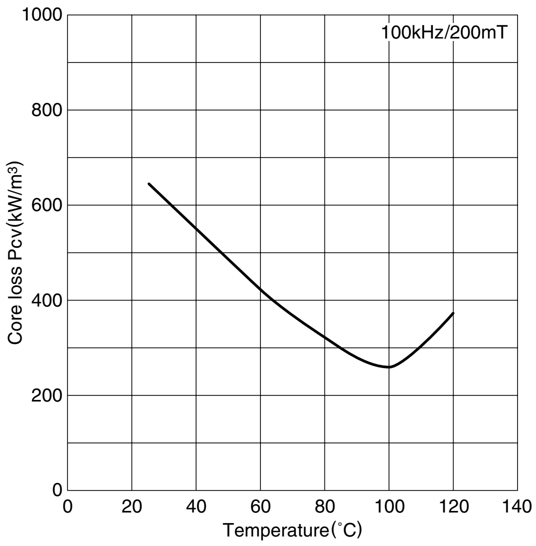
Material: PC44 (Frequency: 100kHz)



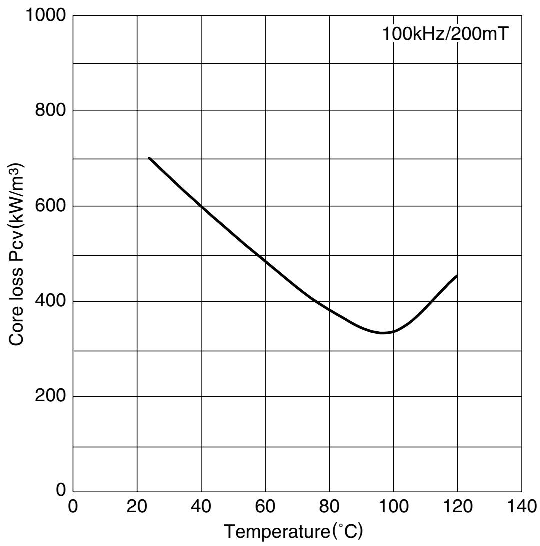
Test core: Toroidal
OD=31mm
TH=8mm
ID=19mm

Temperature Dependence of Core Loss (Typical)

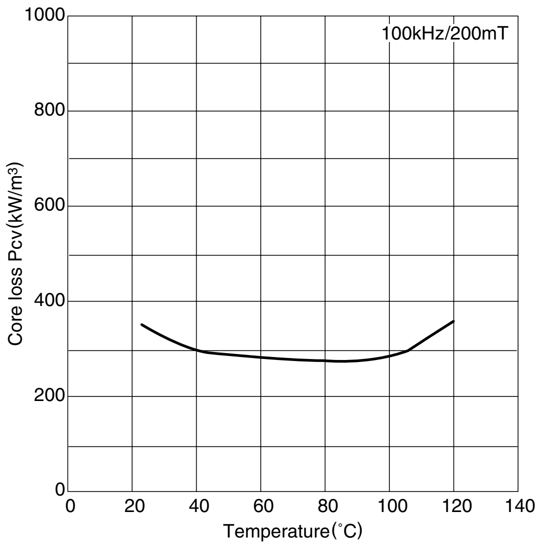
Material: PC47



Material: PC90

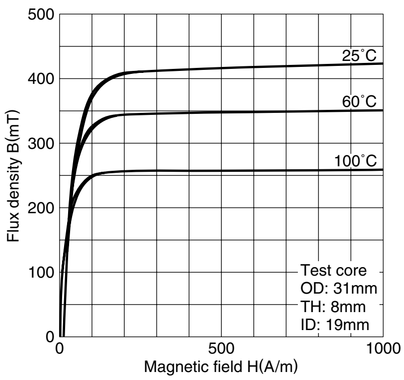


Material: PC95

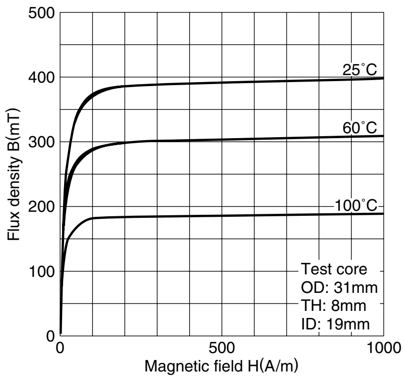


Magnetization Curves (Typical)

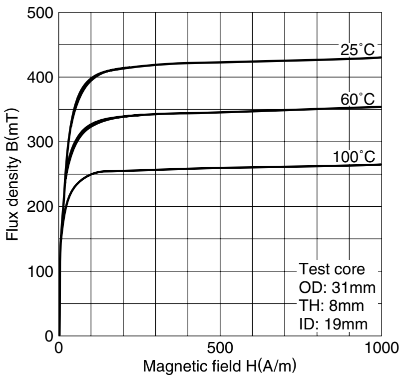
HS52



HS72

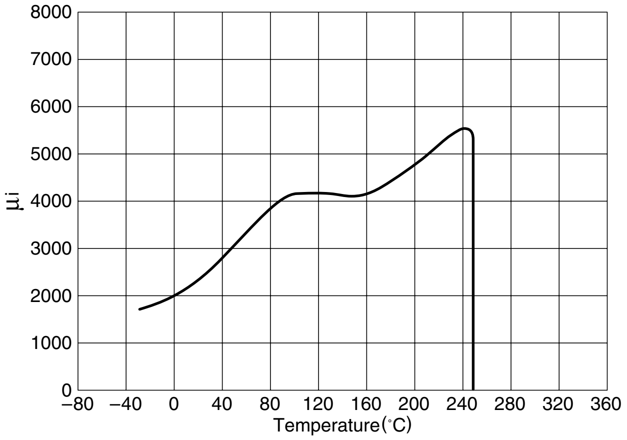


HS10

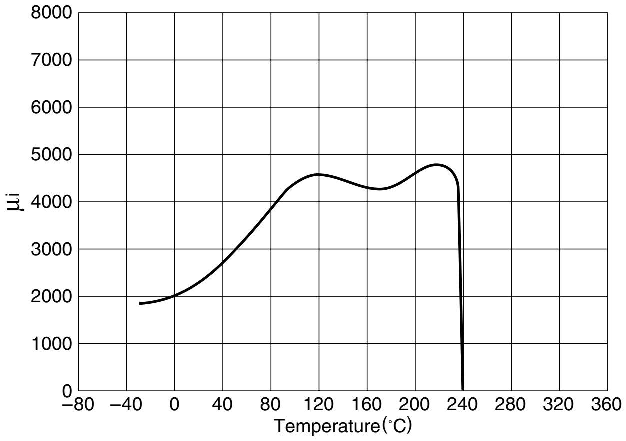


μi vs. Temperature Characteristics (Typical)

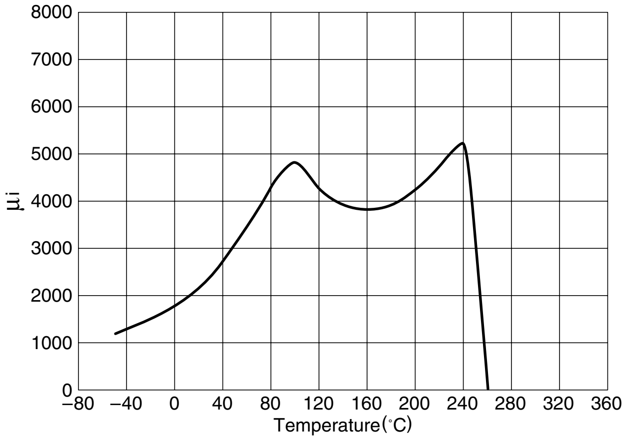
PC40



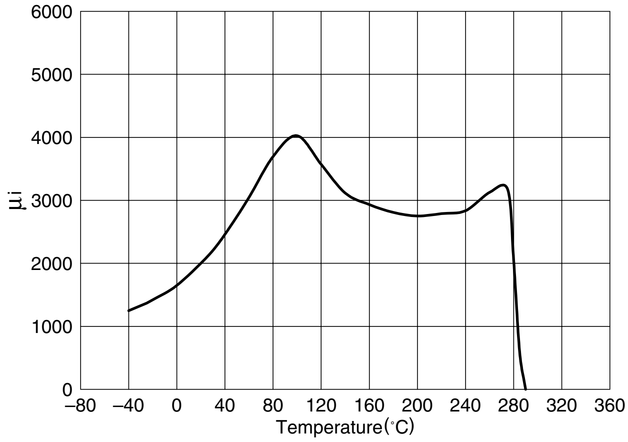
PC44



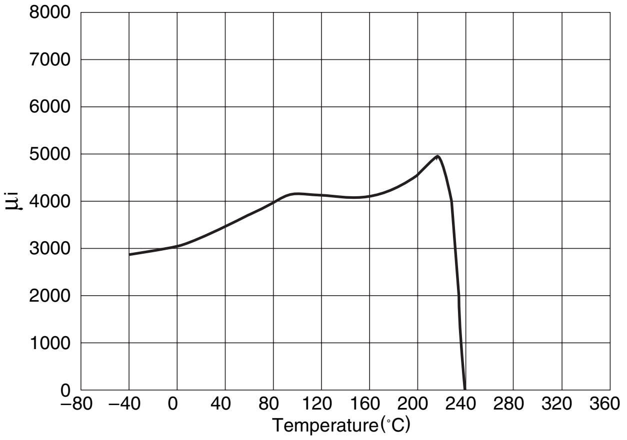
PC47



PC90



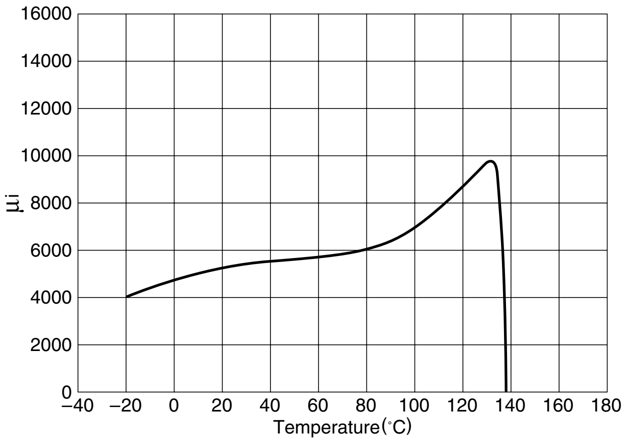
PC95



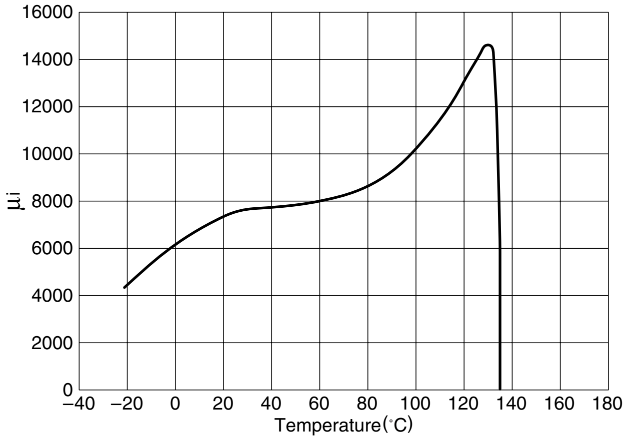
TDK

μi vs. Temperature Characteristics (Typical)

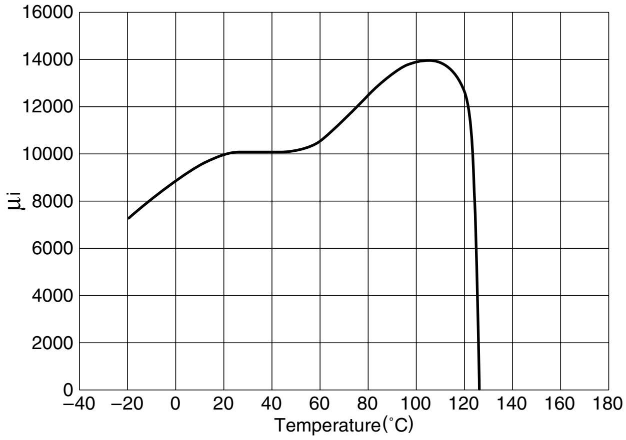
HS52



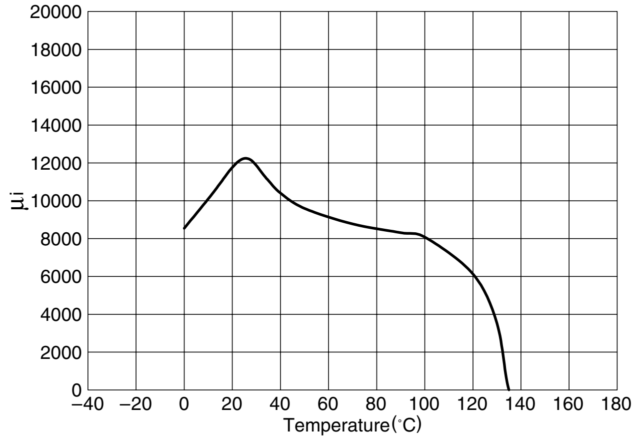
HS72



HS10



HS12



Test core: OD=31mm
TH=8mm
ID=19mm