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.

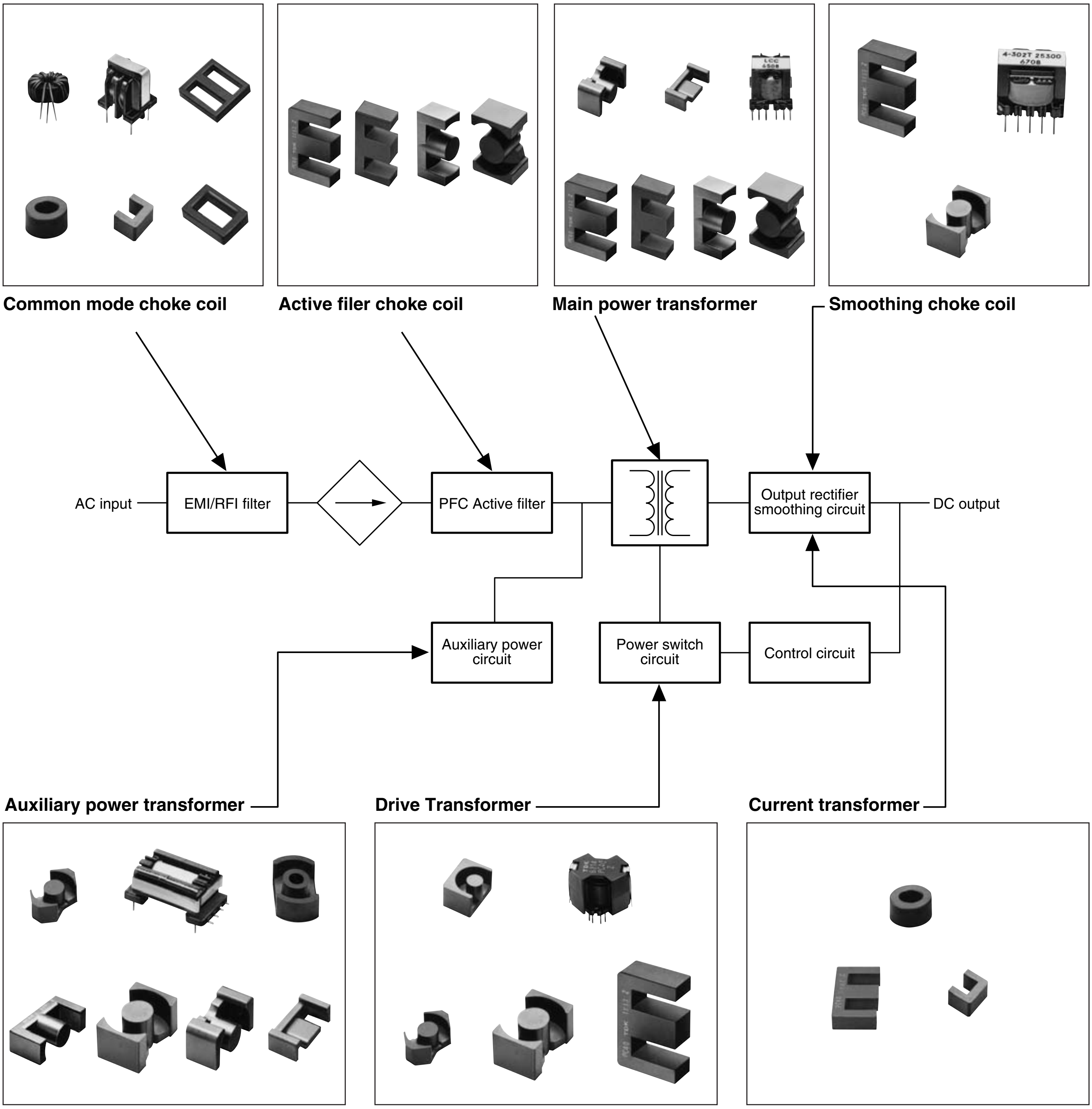
As a result of pursuing the numerous potentials of these ferrite elements, we have been able to develop high-frequency power ferrite material that deliver among the world's highest levels of reliability and magnetic properties. These products include PC33, PC40, PC44, PC45, PC46, PC47, and PC50. They 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, and HS10 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. We also manufacture peripheral items including bobbins and various accessories.

CIRCUIT EXAMPLE

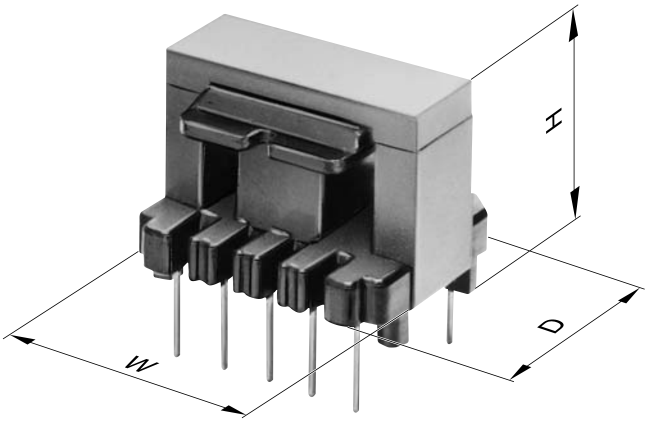
SINGLE FORWARD CONVERTER

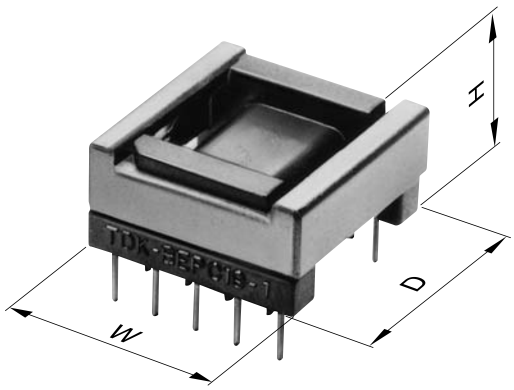


Notes:
- LP and EPC cores are ideal for use in thin transformers.
- LP cores are available in .5 and .7 inches in height (when mounted).
- EP cores are available in .5 and .65 inches in height (when mounted).

SELECTED ITEMS OF LEGEND

$C_1=\Sigma\frac{\ell}{A}$	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





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MATERIAL CHARACTERISTICS

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For Transformer and Choke

Material					PC40	PC44	PC47	PC50
Initial permeability	μi				2300±25%	2400±25%	2500±25%	1400±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	130**
				60°C	450	400	400	80**
				100°C	410	300	250	80**
				120°C	500	380	360	110**
Saturation magnetic flux density* [H=1194A/m]	Bs	mT		25°C	510	510	530	470
				60°C	450	450	480	440
				100°C	390	390	420	380
				120°C	350	350	390	350
Remanent flux density*	Br	mT		25°C	95	110	180	140
				60°C	65	70	100	110
				100°C	55	60	60	98
				120°C	50	55	60	100
Coercive force*	Hc	A/m		25°C	14.3	13	13	36.5
				60°C	10.3	9	9	31.0
				100°C	8.8	6.5	6	27.2
				120°C	8	6	7	26.0
Curie temperature	Tc	°C			>215	>215	>230	>240
Density*	db	kg/m³			4.8×10³	4.8×10³	4.9×10³	4.8×10³
Electrical resistivity*	ρv	Ω•m			6.5	6.5	4.0	30

Material					PC33	PC90	PC95
Initial permeability	μi				1400±25%	2200±25%	3300±25%
Amplitude permeability	μa						
Core loss volume density (Core loss)* [B=200mT]	Pcv	kW/m³	100kHz sine wave	25°C	1100	680	350
				60°C	800	470	
				100°C	600	320	290
				120°C	680	460	350
Saturation magnetic flux density* [H=1194A/m]	Bs	mT		25°C	510	540	530
				60°C	490	500	480
				100°C	440	450	410
				120°C	420	420	380
Remanent flux density*	Br	mT		25°C	220	170	85
				60°C	150	95	70
				100°C	100	60	60
				120°C	100	65	55
Coercive force*	Hc	A/m		25°C	23	13	9.5
				60°C	17	9	7.5
				100°C	14	6.5	6.5
				120°C	14	7	6.0
Curie temperature	Tc	°C			>290	>250	>215
Density*	db	kg/m³			4.8×10³	4.9×10³	4.9×10³
Electrical resistivity*	ρv	Ω•m			2.5	4.0	6.0

* *Average value*
** *500kHz, 50mT*

For Common Mode Choke

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

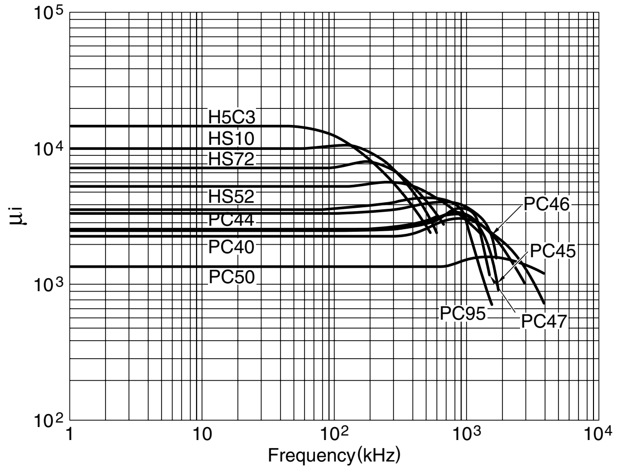
For Telecommunication

Material				H5A	H5B2	H5C2	H5C3	H5C4
Initial permeability	μi			$3300^{+40\%}_{-0\%}$	7500±25%	10000±30%	15000±30%	12000±30% 9000(–20°C)
Relative loss factor	tanδ/μi	$\times 10^{-6}$		<2.5(10kHz) <10(100kHz)	<6.5(10kHz)	<7.0(10kHz)	<7.0(10kHz)	<8(10kHz)
Temperature factor of initial permeability	αμir	$\times 10^{-6}$	–30 to +20°C	–0.5 to 2.0	0 to 1.8	–0.5 to 1.5	–0.5 to 1.5	
			0 to 20°C					
			20 to 70°C	–0.5 to 2.0	0 to 1.8	–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	380
Remanent flux density*	Br	mT	25°C	100	40	90	105	100
Coercive force*	Hc	A/m	25°C	8.0	5.6	7.2	4.4	4.4
Curie temperature	Tc	°C		>130	>130	>120	>105	>110
Hysteresis material constant	ηB	$\frac{10^{-6}}{mT}$		<0.8	<1.0	<1.4	<0.5	<2.8
Disaccommodation factor	DF	$\times 10^{-6}$		<3	<3	<2	<2	<3
Density*	db	kg/m^3		4.8×10^3	4.9×10^3	4.9×10^3	4.95×10^3	4.95×10^3
Electrical resistivity*	ρv	Ω•m		1	0.1	0.15	0.15	0.15

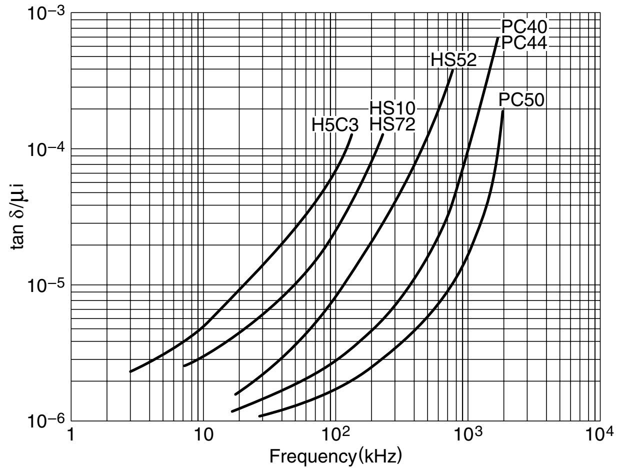
Material				H5C5	HP5	DNW45	DN40	DN70
Initial permeability	μi			30000±30%	5000±20%	4200±25%	4000±25%	7500±25%
Relative loss factor	tanδ/μi	$\times 10^{-6}$	25°C, 10kHz	<15	<3.5	<3.5	<2.5	<2.0
Temperature factor of initial permeability	αμir	$\times 10^{-6}$	–30 to +20°C	–0.5 to 1.5			–0.5 to 2.0	–0.5 to 1.5
			0 to 20°C		±12.5%			
			20 to 70°C	–0.5 to 1.5	±12.5%		–0.5 to 2.0	–0.5 to 1.5
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	380	400	450	405	390
Remanent flux density*	Br	mT	25°C	120	65	50	95	45
Coercive force*	Hc	A/m	25°C	4.2	7.2	6.5	8.0	3.5
Curie temperature	Tc	°C		>110	>140	>150	>130	>105
Hysteresis material constant	ηB	$\frac{10^{-6}}{mT}$		<1.5	<0.4	<0.8	<0.8	<0.2
Disaccommodation factor	DF	$\times 10^{-6}$		<2	<3	<3	<3	<2.5
Density*	db	kg/m^3		4.95×10^3	4.8×10^3	4.85×10^3	4.8×10^3	5.0×10^3
Electrical resistivity*	ρv	Ω•m		0.15	0.15	0.65	1.0	0.3

* *Average value*

μi vs. Frequency Characteristics

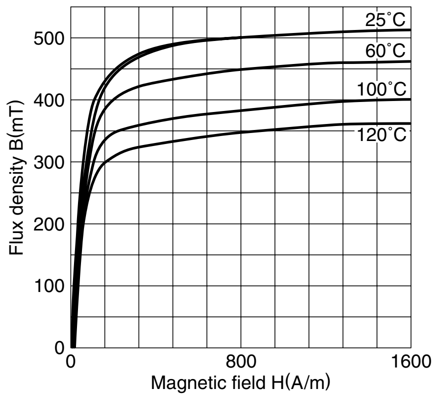


tanδ/μi vs. Frequency Characteristics

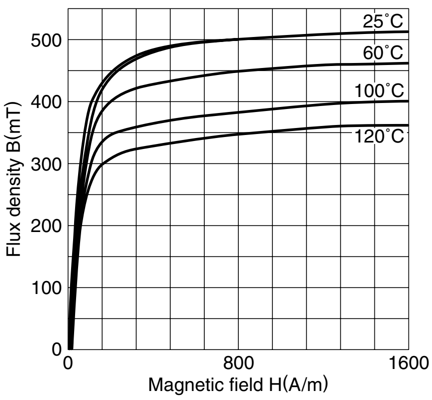


Magnetization Curves (Typical)

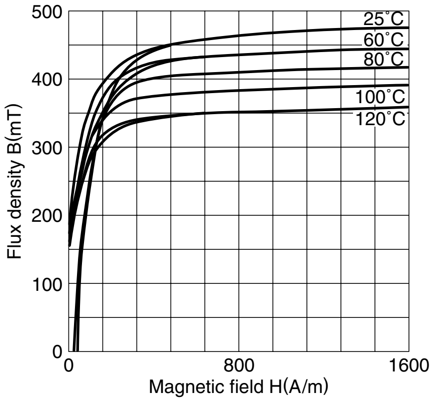
Material: PC40



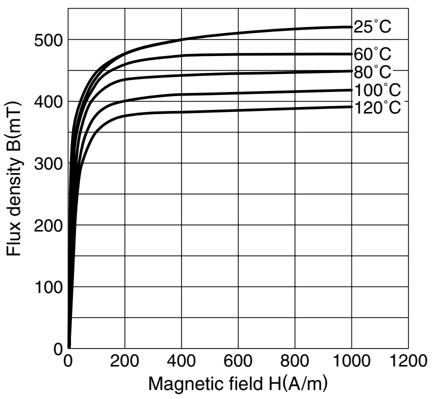
Material: PC44



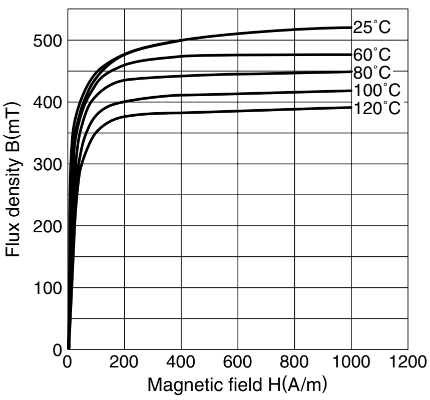
Material: PC50



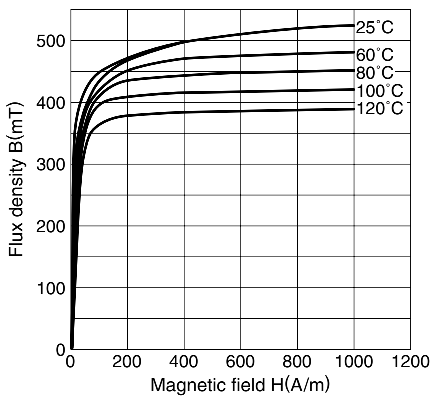
Material: PC45



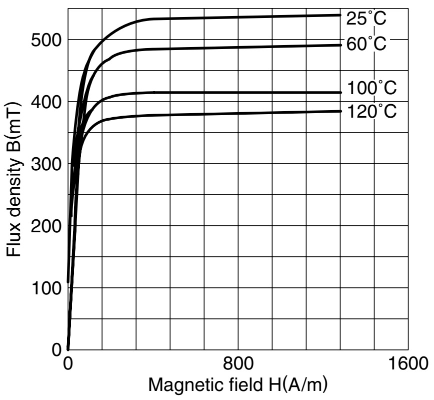
Material: PC46



Material: PC47



Material: PC95



• All specifications are subject to change without notice.

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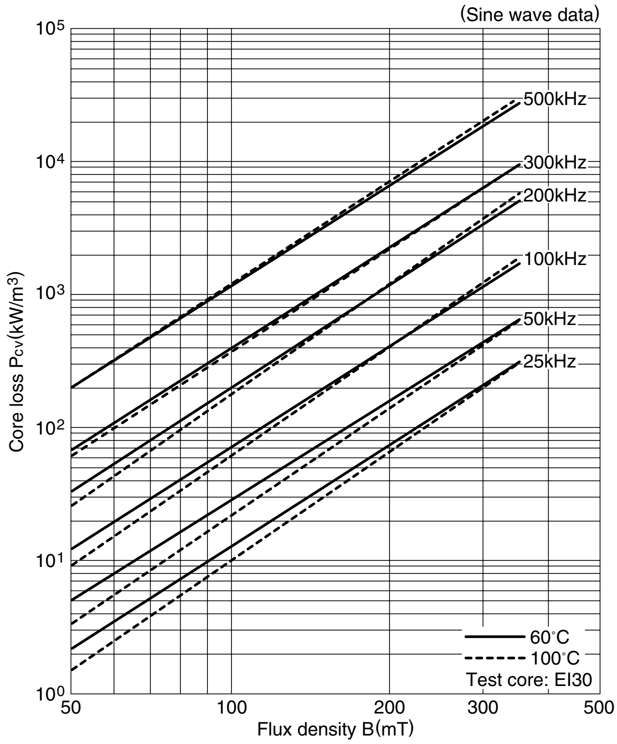
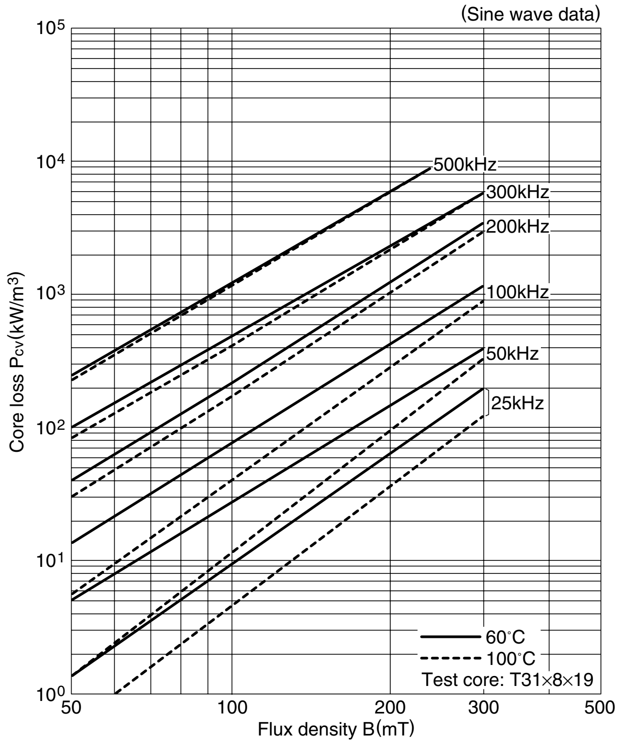
Core Loss (Typical)

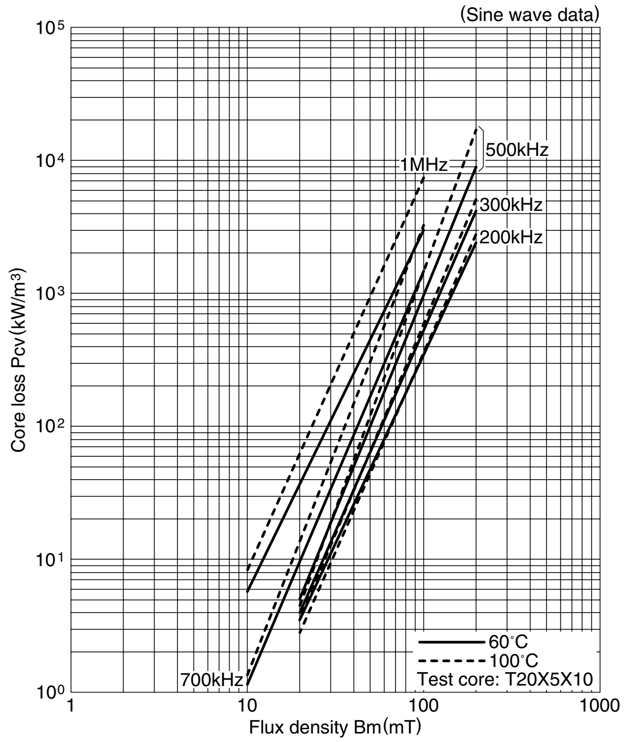
Material: PC40



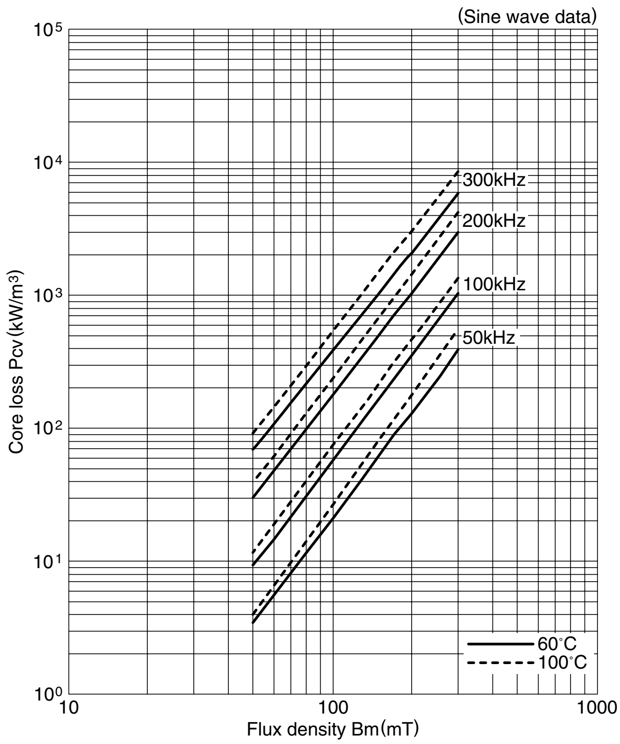
Material: PC44



Material: PC50

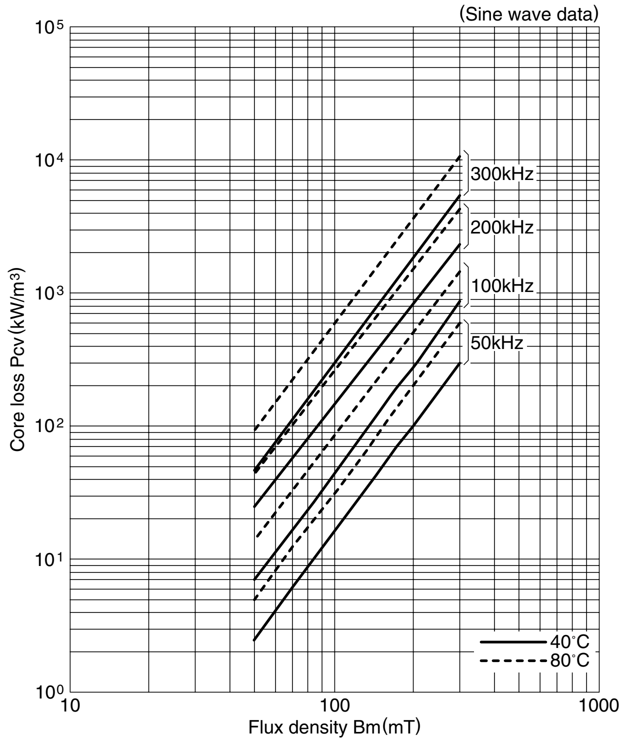


Material: PC45

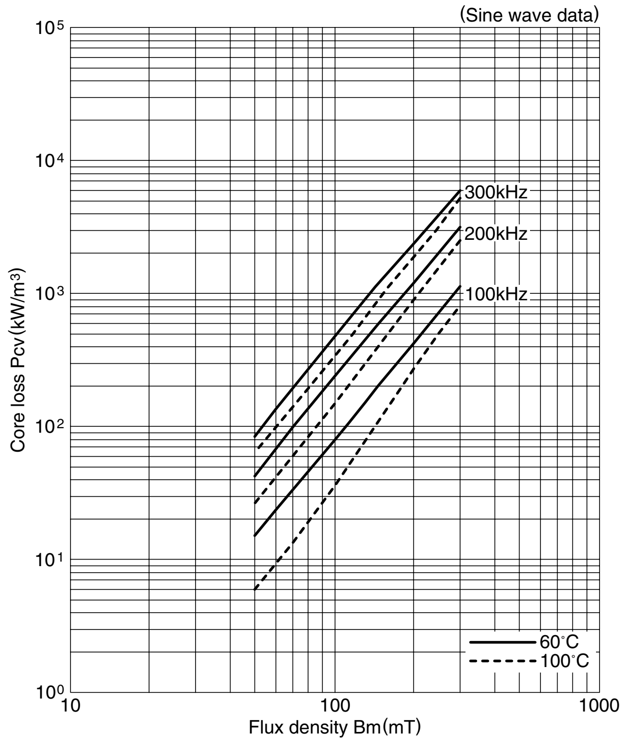


Core Loss (Typical)

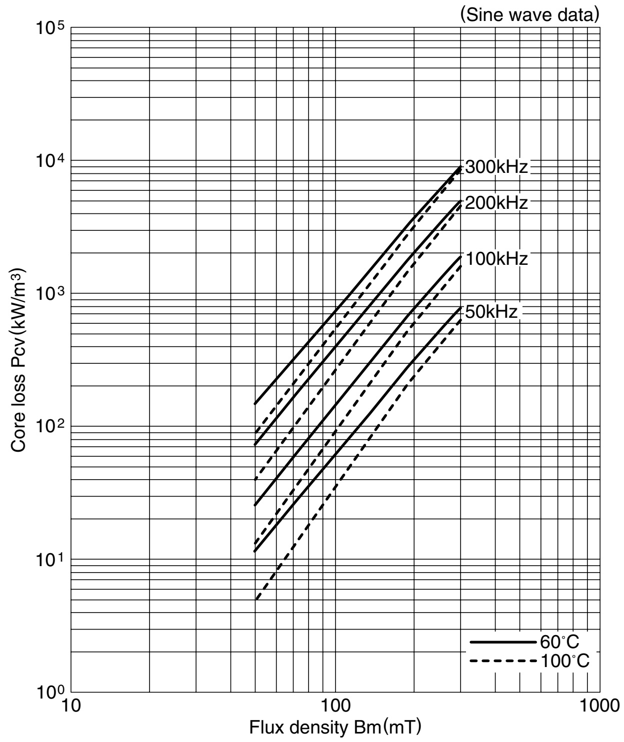
Material: PC46



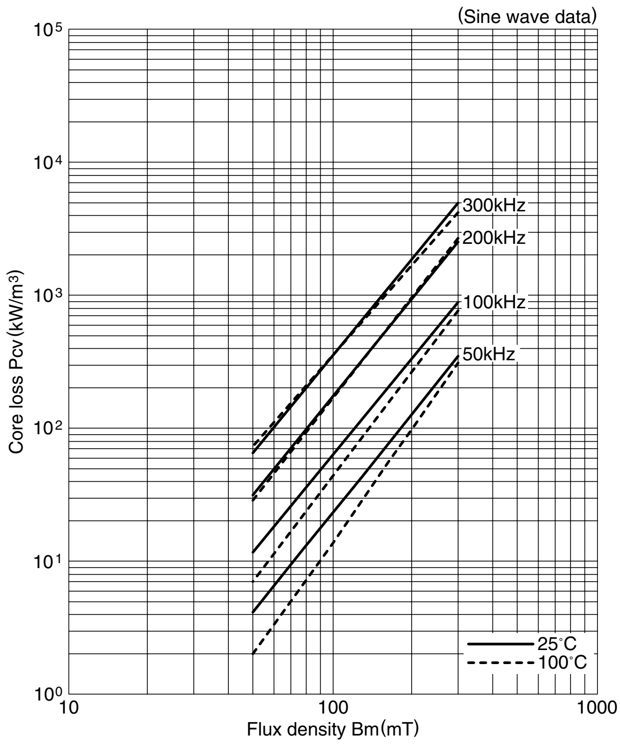
Material: PC47



Material: PC33

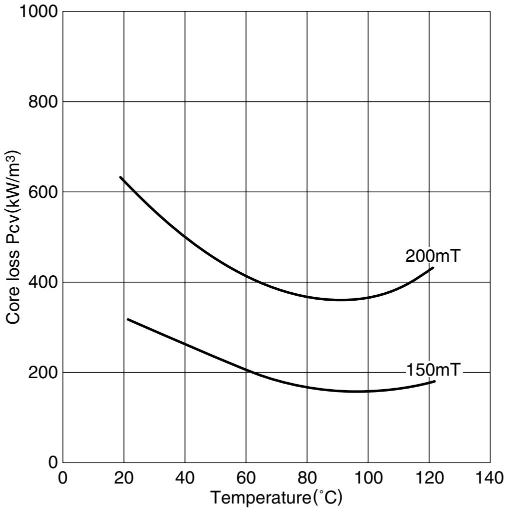


Material: PC95

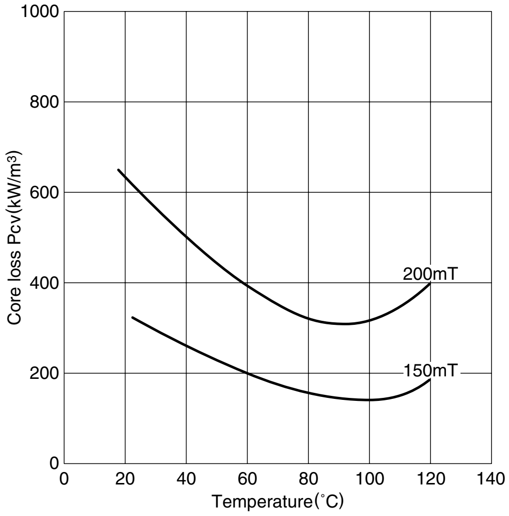


Temperature Dependence of Core Loss (Typical)

Material: PC40 (Frequency: 100kHz)

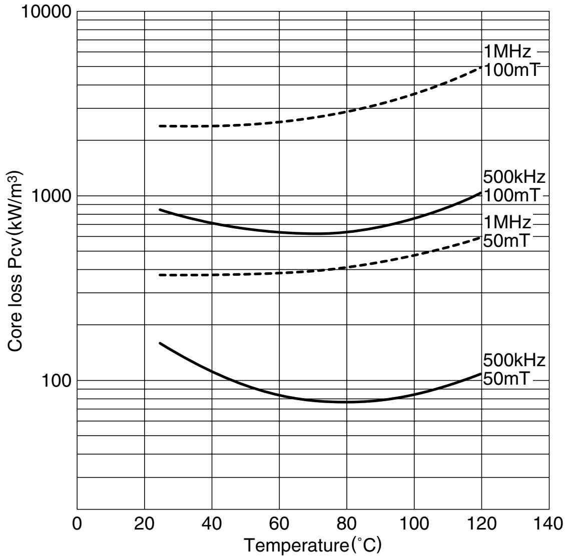


Material: PC44 (Frequency: 100kHz)

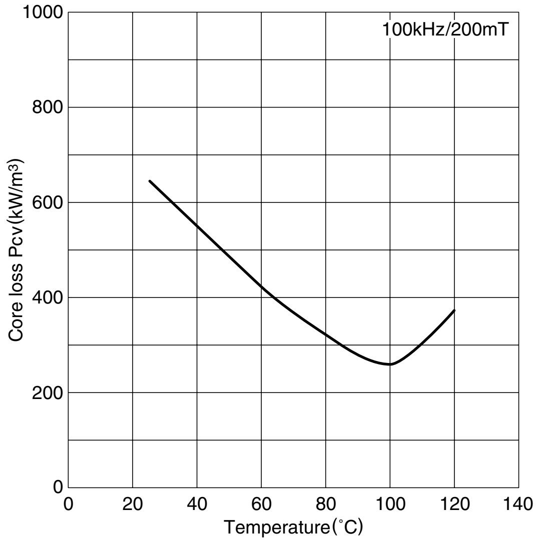


Test core: Toroidal
OD=31mm
TH=8mm
ID=19mm

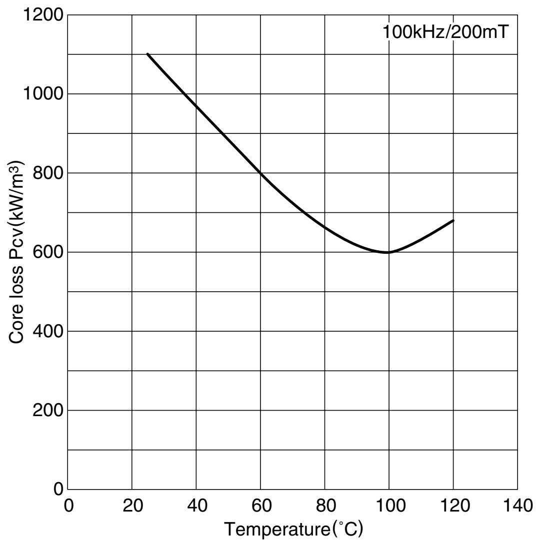
Material: PC50



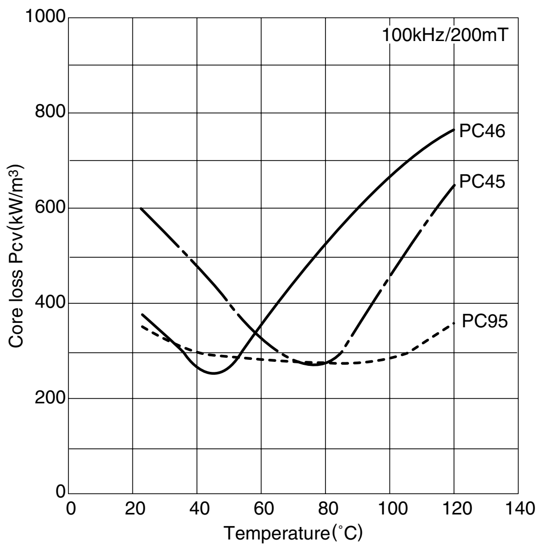
Material: PC47



Material: PC33

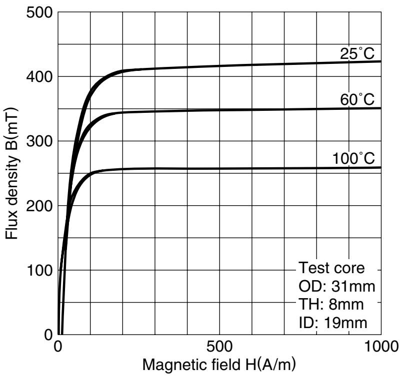


Material: PC95, PC45, PC46

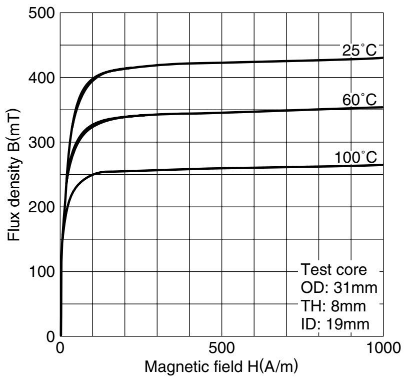


Magnetization Curves (Typical)

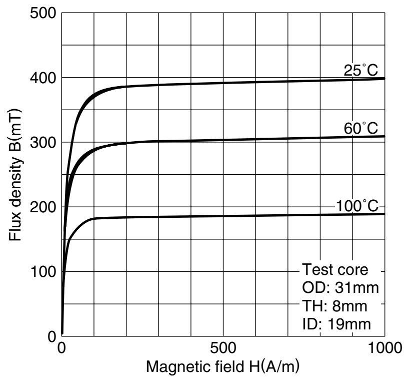
HS52



HS72

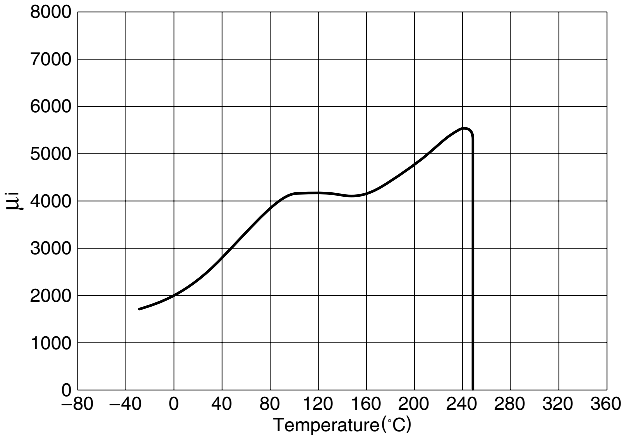


HS10

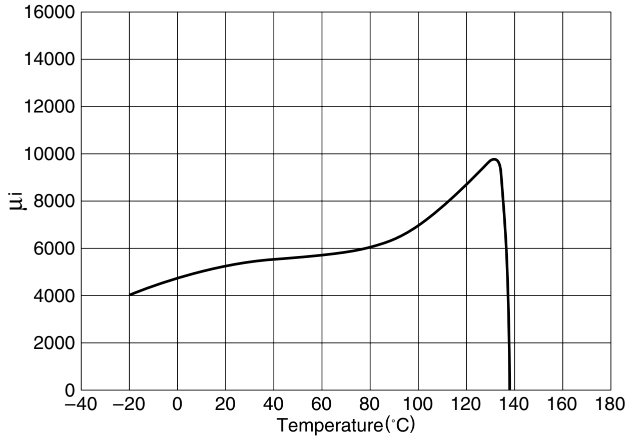


µi vs. Temperature Characteristics (Typical)

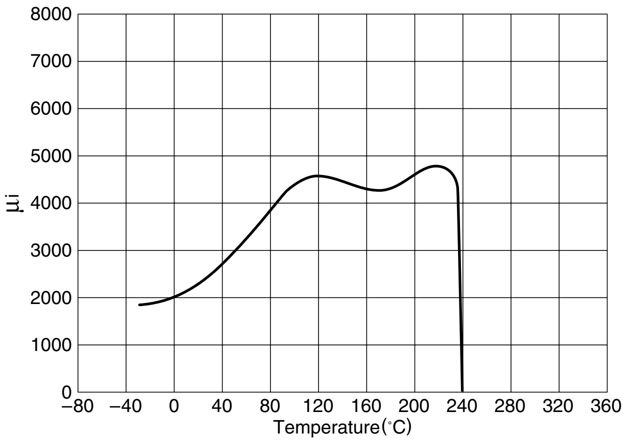
PC40



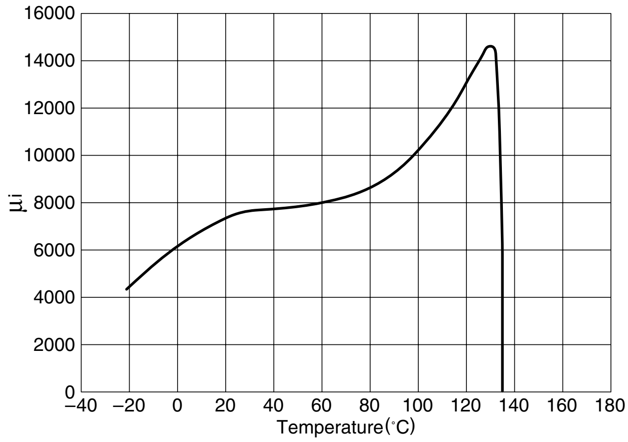
HS52



PC44

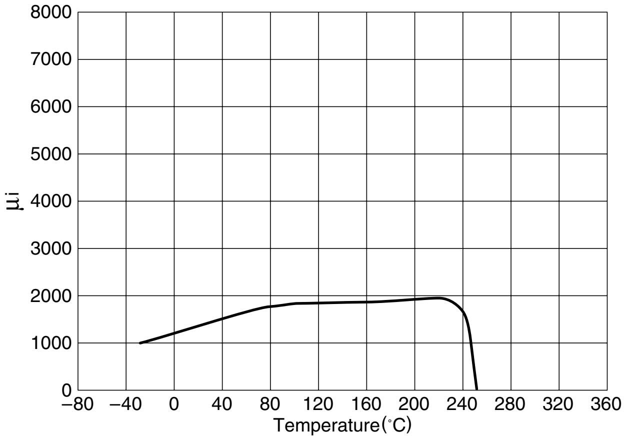


HS72

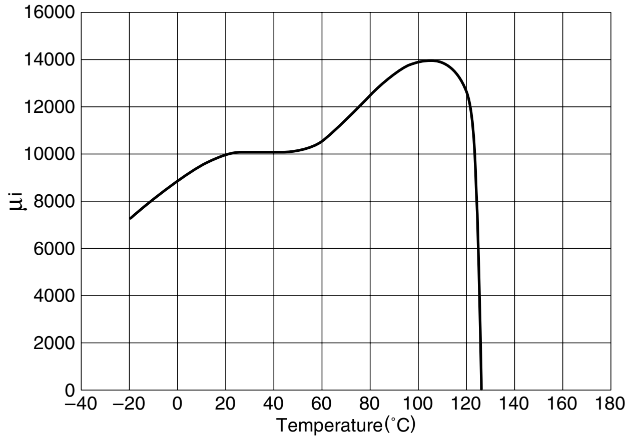


μi vs. Temperature Characteristics (Typical)

PC50

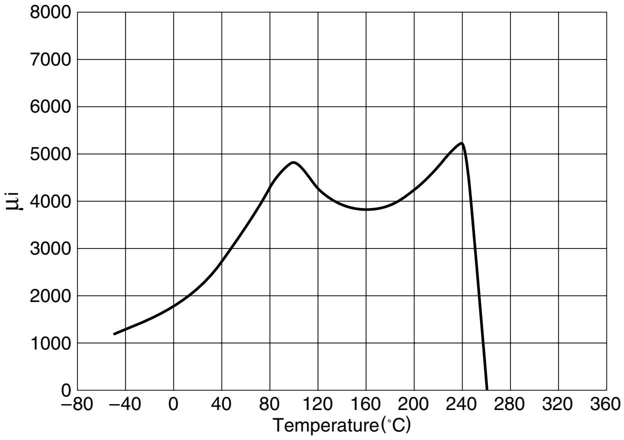


HS10

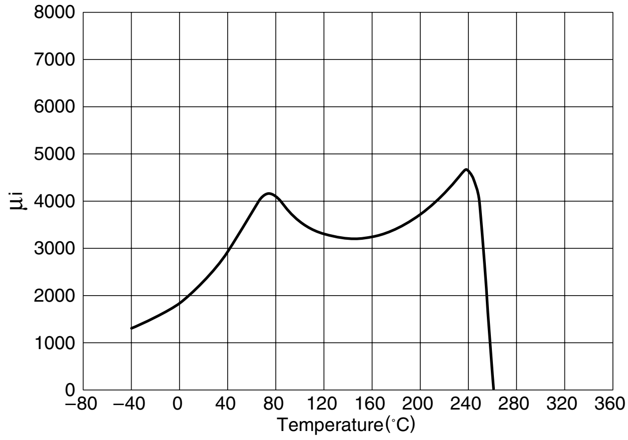


Test core: OD=31mm
TH=8mm
ID=19mm

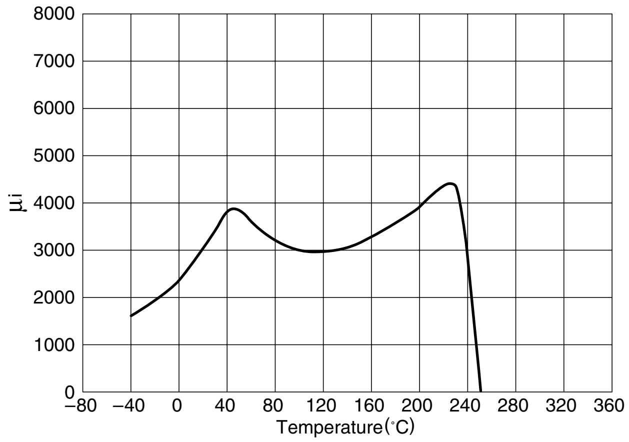
PC47



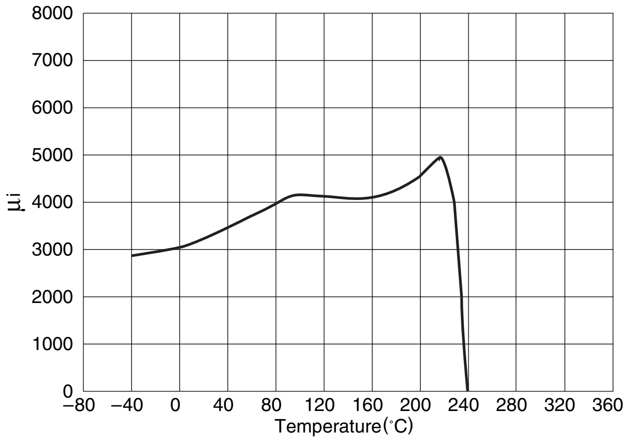
PC45



PC46



PC95



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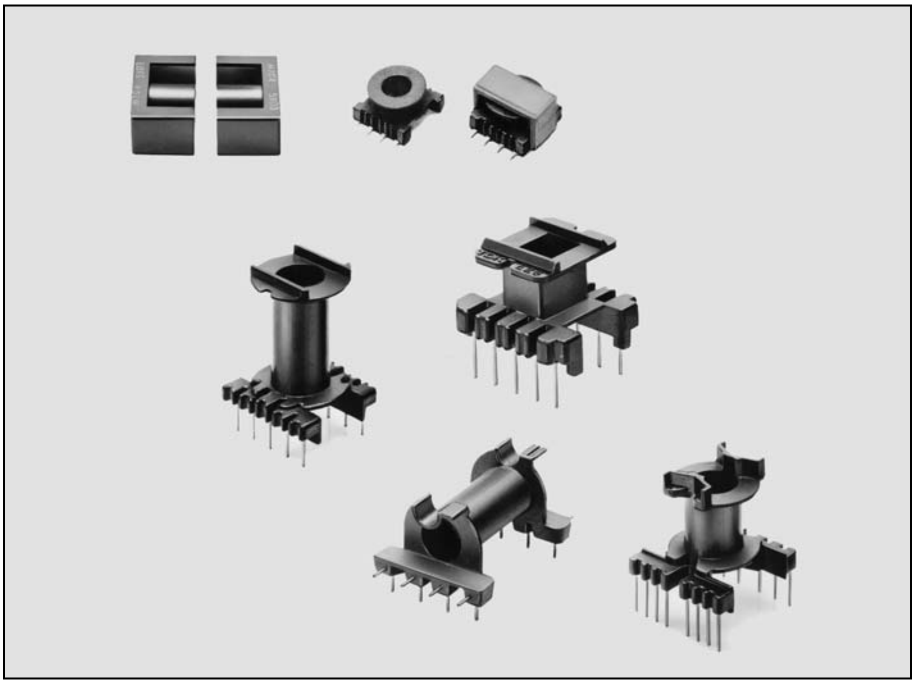
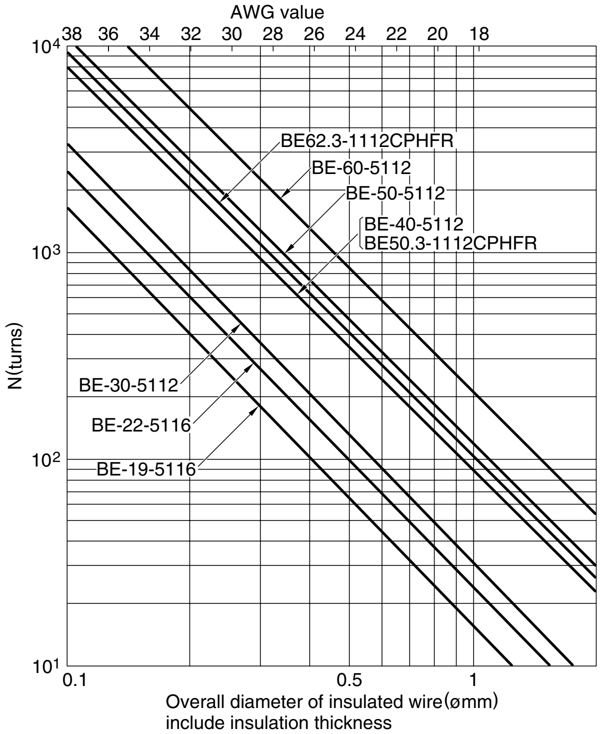
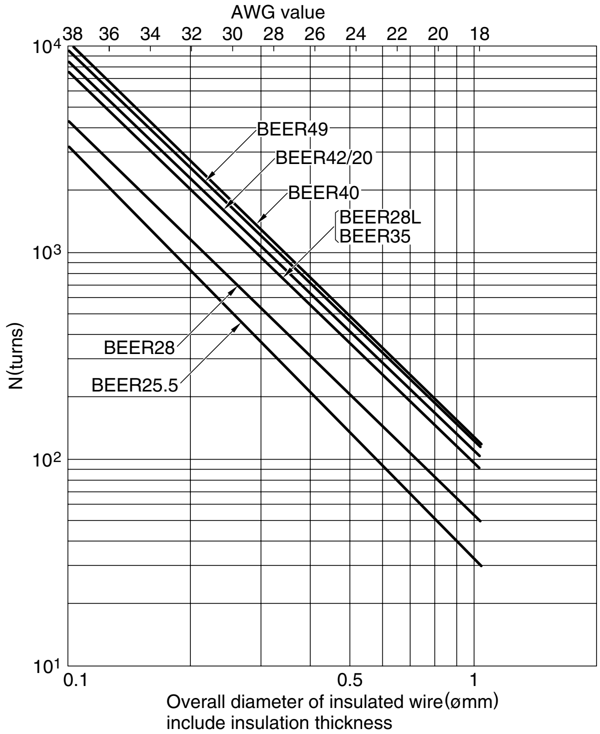
MAXIMUM NUMBER OF TURNS ON BOBBINS



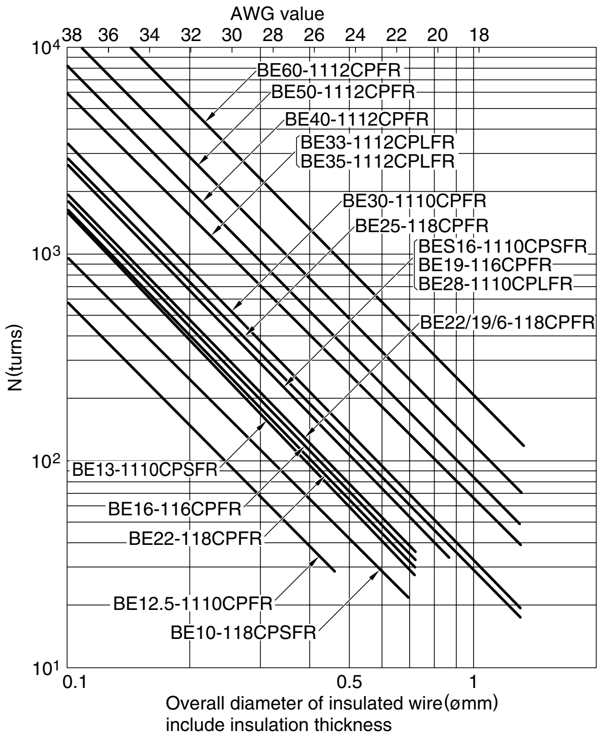
EI and EE Series (without terminal pin)



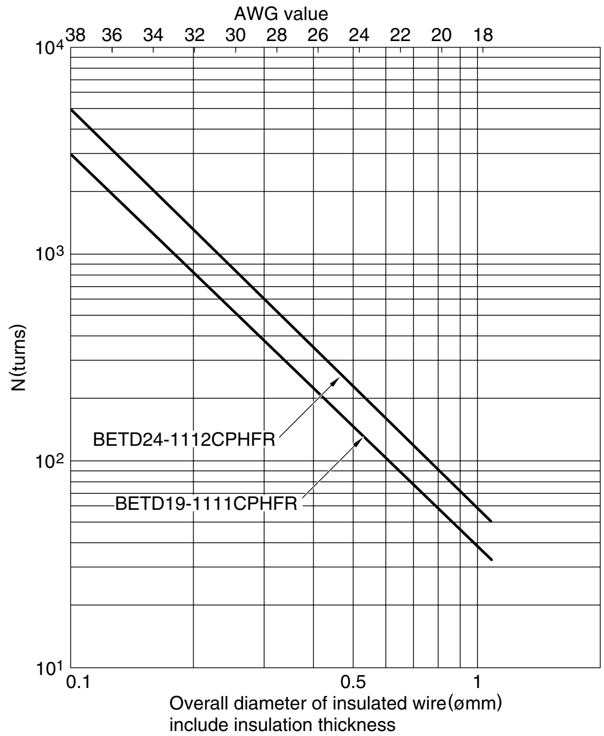
EER Series



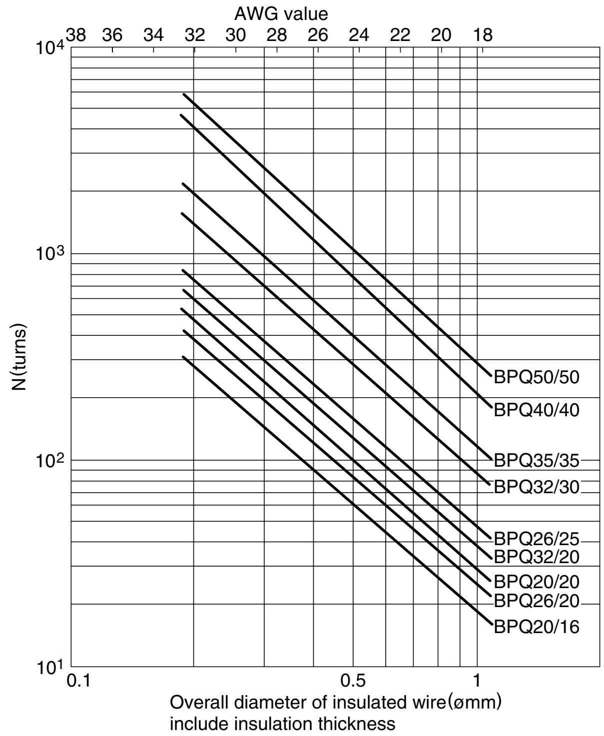
EI and EE Series (with terminal pin)



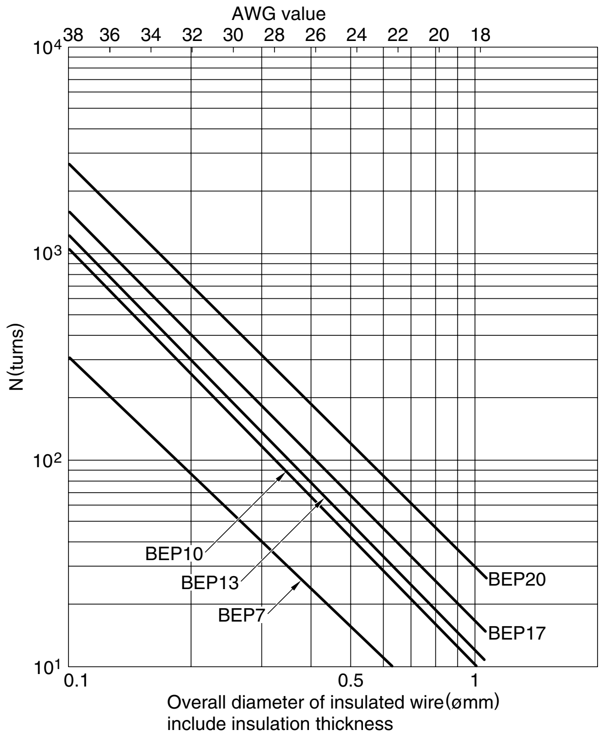
ETD Series



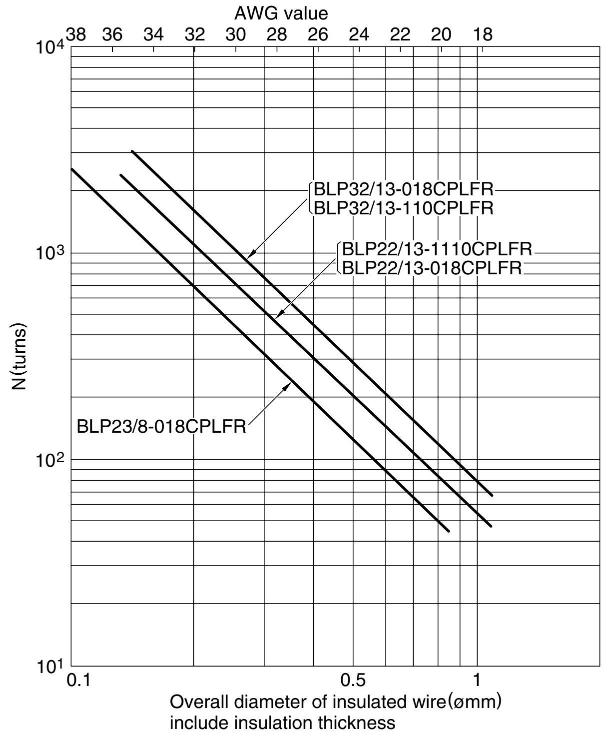
PQ Series



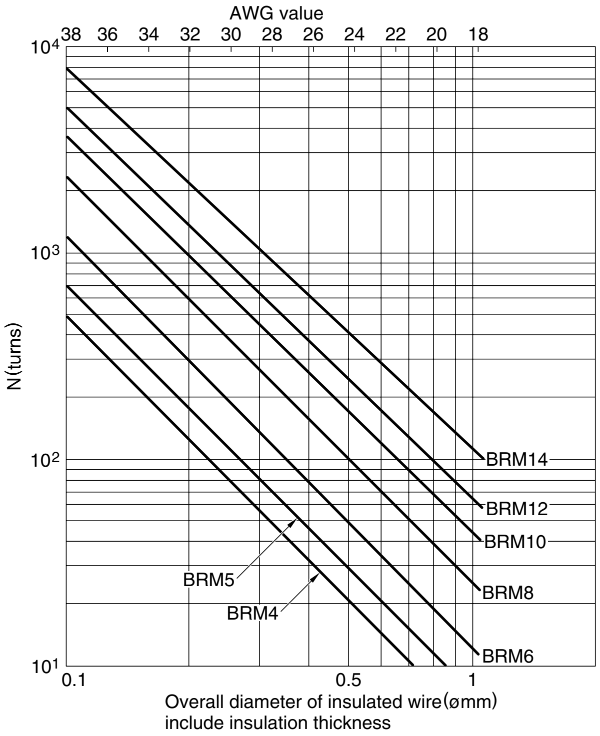
EP Series



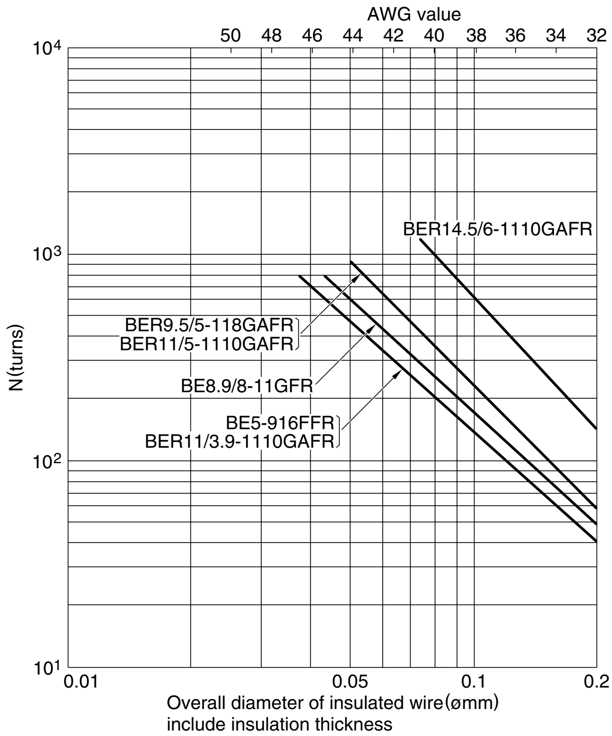
LP Series



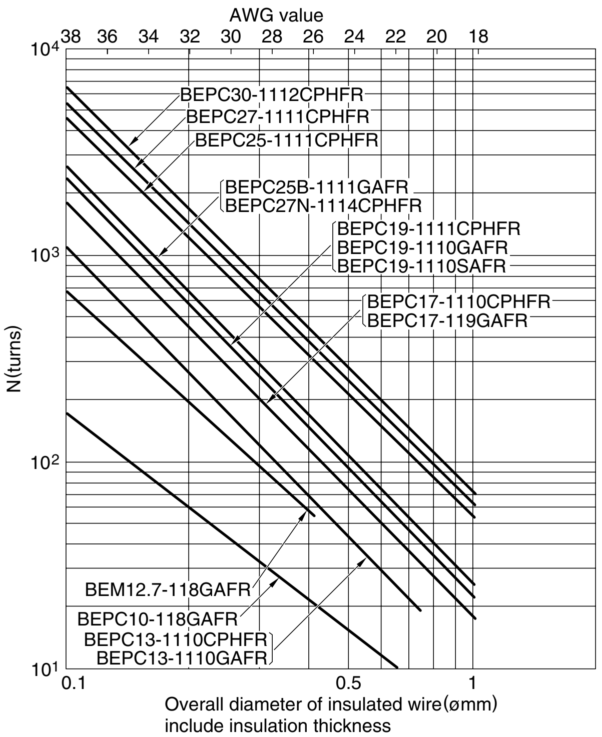
RM Series



SMD Series



EPC and EEM Series



TDK

Wire Table

AWG	AWG dia. (mm)	AWG area (mm^2)	Single dia. (mm)	Single area (mm^2)	Heavy dia. (mm)	Heavy area (mm^2)
40	0.078	0.0053	0.093	0.0068	0.100	0.0078
39	0.089	0.0066	0.104	0.0085	0.112	0.0099
38	0.102	0.0083	0.117	0.0108	0.126	0.0125
37	0.114	0.0105	0.131	0.0135	0.141	0.0156
36	0.127	0.0132	0.147	0.0169	0.158	0.0195
35	0.142	0.0166	0.164	0.0212	0.176	0.0243
34	0.160	0.0209	0.184	0.0265	0.196	0.0303
33	0.180	0.0264	0.205	0.0330	0.219	0.0376
32	0.203	0.0332	0.229	0.0412	0.244	0.0467
31	0.226	0.0418	0.256	0.0513	0.271	0.0578
30	0.254	0.0526	0.285	0.0640	0.302	0.0717
29	0.287	0.0663	0.319	0.0797	0.336	0.0888
28	0.320	0.0834	0.356	0.0993	0.374	0.1099
27	0.360	0.1050	0.397	0.1237	0.416	0.1362
26	0.404	0.1322	0.443	0.1542	0.464	0.1688
25	0.454	0.1664	0.495	0.1922	0.516	0.2093
24	0.510	0.2095	0.552	0.2397	0.575	0.2596
23	0.574	0.2638	0.617	0.2990	0.641	0.3222
22	0.642	0.3321	0.689	0.3731	0.714	0.4001
21	0.724	0.4181	0.770	0.4659	0.796	0.4972
20	0.812	0.5624	0.861	0.5820	0.887	0.6183
19	0.910	0.6627	0.962	0.7272	0.990	0.7693
18	1.024	0.8343	1.076	0.9092	1.104	0.9578
17	1.156	1.0504	1.203	1.1371	1.233	1.1933
16	1.298	1.3224	1.346	1.4228	1.376	1.4877
15	1.456	1.6648	1.506	1.7809	1.537	1.8559
14	1.634	2.0959	1.685	2.2301	1.717	2.3165
13	1.833	2.6386	1.886	2.7935	1.919	2.8931
12	2.057	3.3219	2.111	3.5006	2.145	3.6153
11	2.308	4.1821	2.364	4.3882	2.399	4.5201
10	2.589	5.2651	2.647	5.5024	2.683	5.6542
9	2.905	6.6285	2.964	6.9018	3.002	7.0763
8	3.260	8.3449	3.320	8.6594	3.359	8.8599
7	3.657	10.5059	3.720	10.8674	3.759	11.0977
6	4.104	13.2264	4.168	13.6419	4.208	13.9062