

NEOREC(NEODYMIUM-IRON-BORON) MAGNETS

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Neodymium-Iron-Boron Magnets NEOREC Series

INTRODUCTION

In recent years, small, high-performance rare-earth magnets have been in increasing demand for use in electronics equipment.

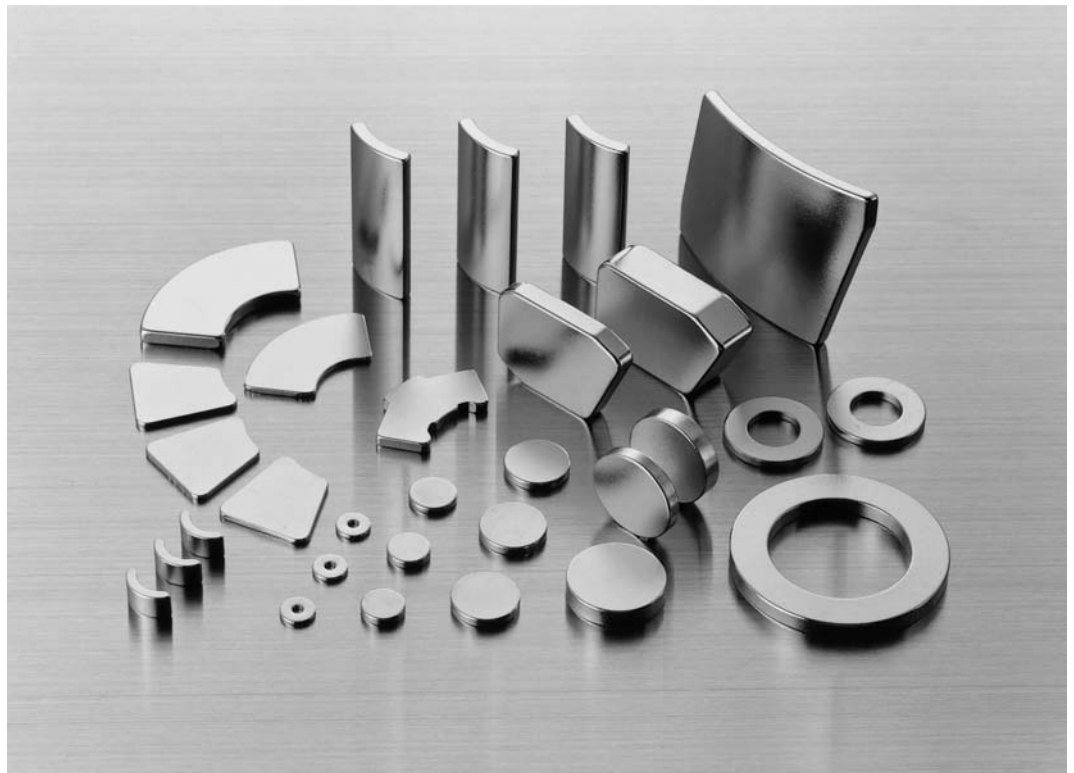
In 1977, TDK commercialized a 2-17 type REC magnet, solving the problem of high cost, the main drawback with conventional samarium-cobalt magnets. It not only achieved better cost-performance, its superior performance was appraised as being the highest in the world.

The NEOREC magnet is a new product, surpassing the REC magnet. The main raw materials are neodymium, a rare-earth element, iron and boron. Its magnetic characteristics at the mass production level reach 49MGOe in maximum energy product(BH), achieving 50 to 80% high performance with 10% reduction in specific gravity compared with samarium-cobalt magnets.

Ideal for meeting miniaturization and weight reduction needs for VCMs and other equipment. TDK offers a selection of custom magnets in any shapes and sizes to meet customers' requirements.

TDK also provides a range of technical services, including design of NEOREC magnet-applied products. For further information, please contact TDK or your nearest representatives.

- Development of this product was made under license granted for the use of proprietary techniques developed by Hitachi Metals, Ltd.



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.

- All specifications are subject to change without notice.

FEATURES/APPLICATIONS

FEATURES

- Magnetic characteristics at the mass production level reach 49MGOe in maximum energy product(BH) max, achieving 50 to 80% higher performance than rare-earth cobalt magnet.
- The specific gravity is 7.4g/cm³ more than 10% lower than that of rare-earth cobalt magnet. Ideal for meeting miniaturization and weight reduction needs.
- Higher mechanical strength such as bending and tensile strength than rare-earth cobalt magnets, making handling easier than before.
- Since the main raw materials are neodymium and iron, both abundant resources, stable supply is assured.

APPLICATIONS

Actuators for magnetic and optical disks, core-less motors, servomotors, stepping motors, MRI's printers, sensors, magnetrons, klystrons, magnetic bearings, magnetic couplings, etc.

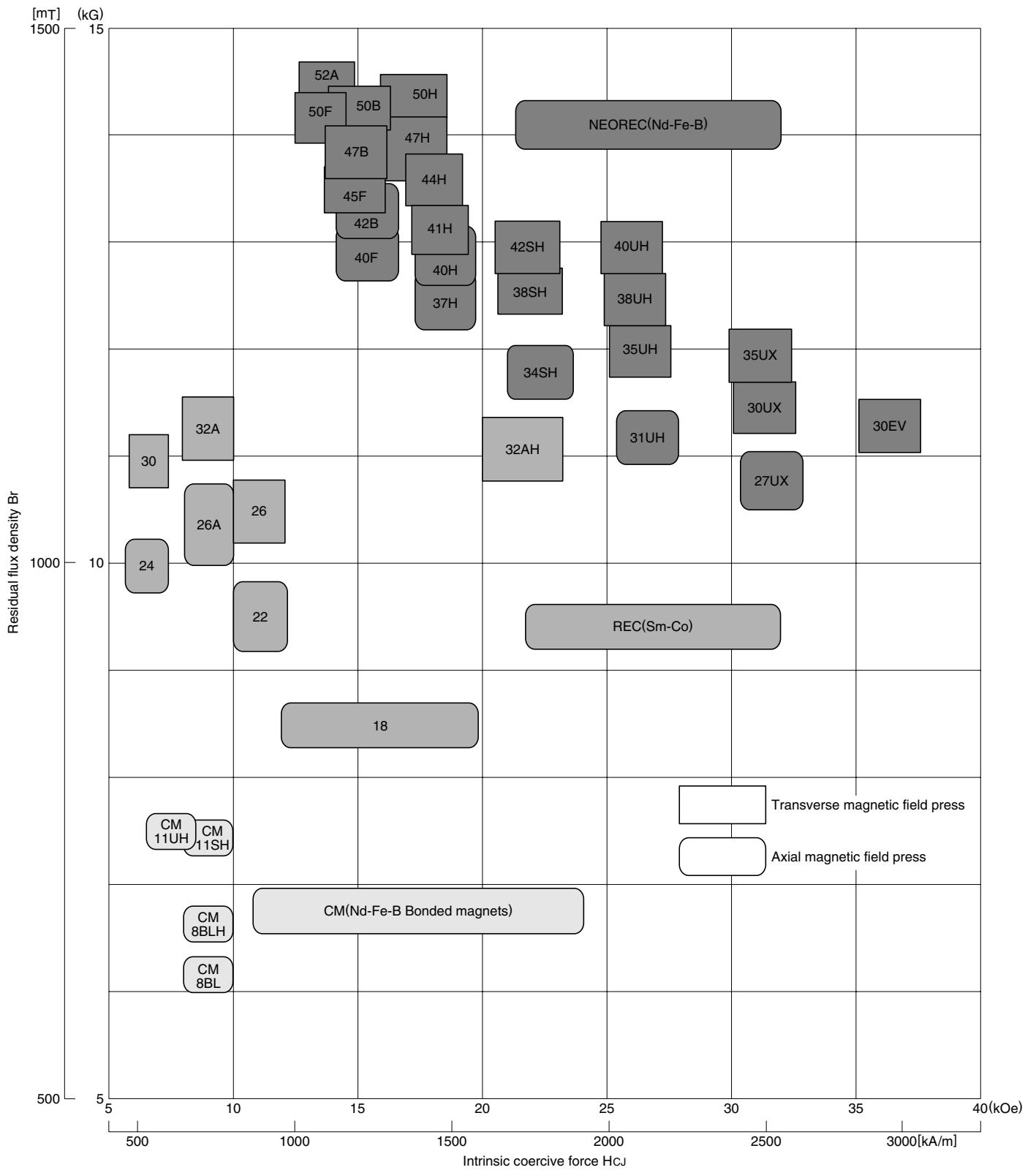
DIFFERENCES BETWEEN NdFe-MAGNET AND SmCo-MAGNET

Item	NdFe-magnet	SmCo-magnet
Composition	Nd, Fe, B, and other additives	Sm, Co, Fe, Cu, and other additives
Manufacturing method	Sintering	Sintering
Magnetic characteristics		
Maximum energy product (BH)max	28 to 49MGOe	16 to 32MGOe
Residual flux density Br	10.3 to 13.0kG	8.2 to 11.6kG
Intrinsic coercive force H _{cj}	11.0 to 25.0kOe	6.2 to 20.0kOe
Recoil permeability	1.05	1.05
Reversible temperature coefficient of Br	-0.11 to -0.13%/°C	-0.03 to -0.04%/°C
Temperature coefficient of H _{cj}	-0.55 to -0.65%/°C	-0.15 to -0.30%/°C
Physical characteristics		
Curie temperature	320°C	800°C
Density	7.3 to 7.5g/cm ³	8.2 to 8.4g/cm ³
Thermal expansion coefficient		
C//*(0 to 100°C)	5.2× 10 ⁻⁶ /°C	8× 10 ⁻⁶ /°C
C⊥*(0 to 100°C)	-0.8× 10 ⁻⁶ /°C	11× 10 ⁻⁶ /°C
Mechanical characteristics		
Deflection strength	25kg/mm ²	15kg/mm ²
Compressive strength	110kg/mm ²	82kg/mm ²
Tensile strength	7.5kg/mm ²	3.6kg/mm ²
Vickers hardness	550 to 650	500 to 550
Electric resistance	130× 10 ⁻⁶ Ωcm	86× 10 ⁻⁶ Ωcm
Required magnetizing field	25kOe min.	15kOe min. (SmCo ₅ system) 25kOe min. (Sm ₂ Co ₁₇ system)
Resistance to cracking	Solid, hard to break	Brittle easily
Resistance to rust	Relatively easy to rust	Relatively resistant to rust

* C// is the value measured in the easy magnetization direction.

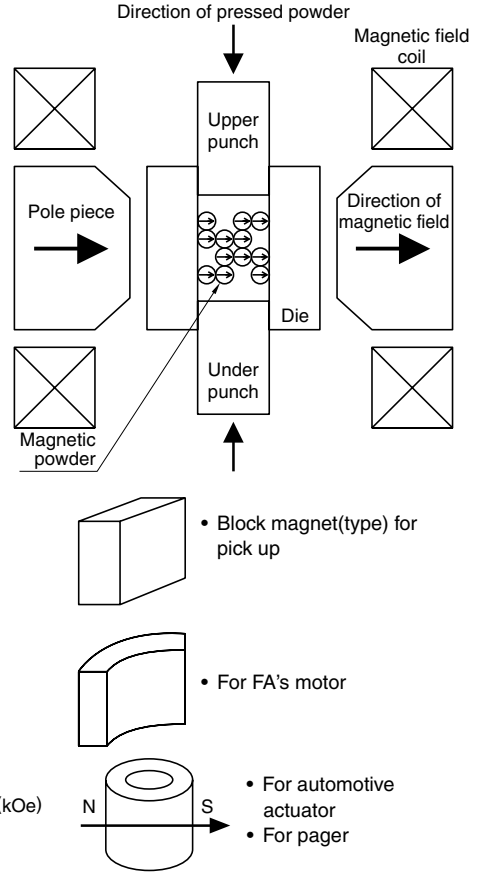
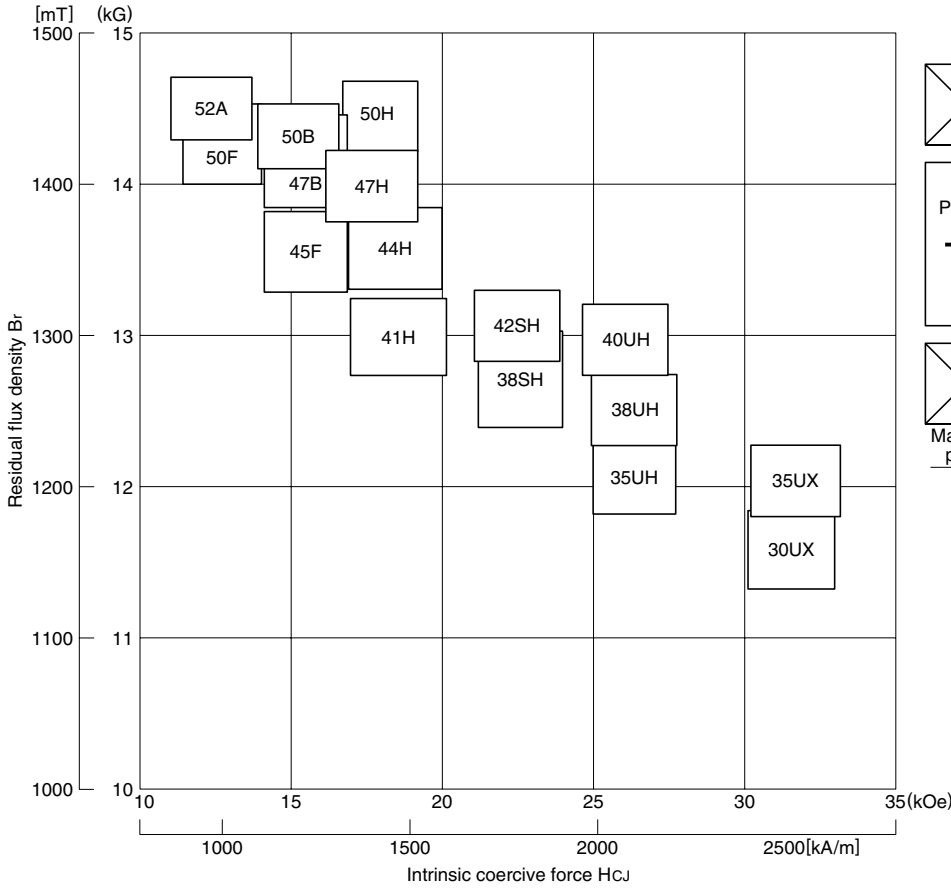
C⊥ is the value measured in the vertical direction to the easy magnetization direction.

Br/HcJ CHARACTERISTICS DISTRIBUTION OF NEOREC MAGNETS

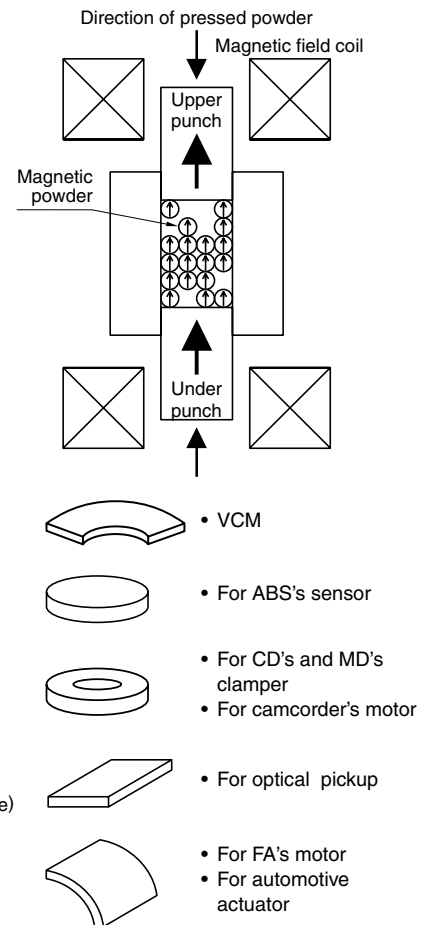
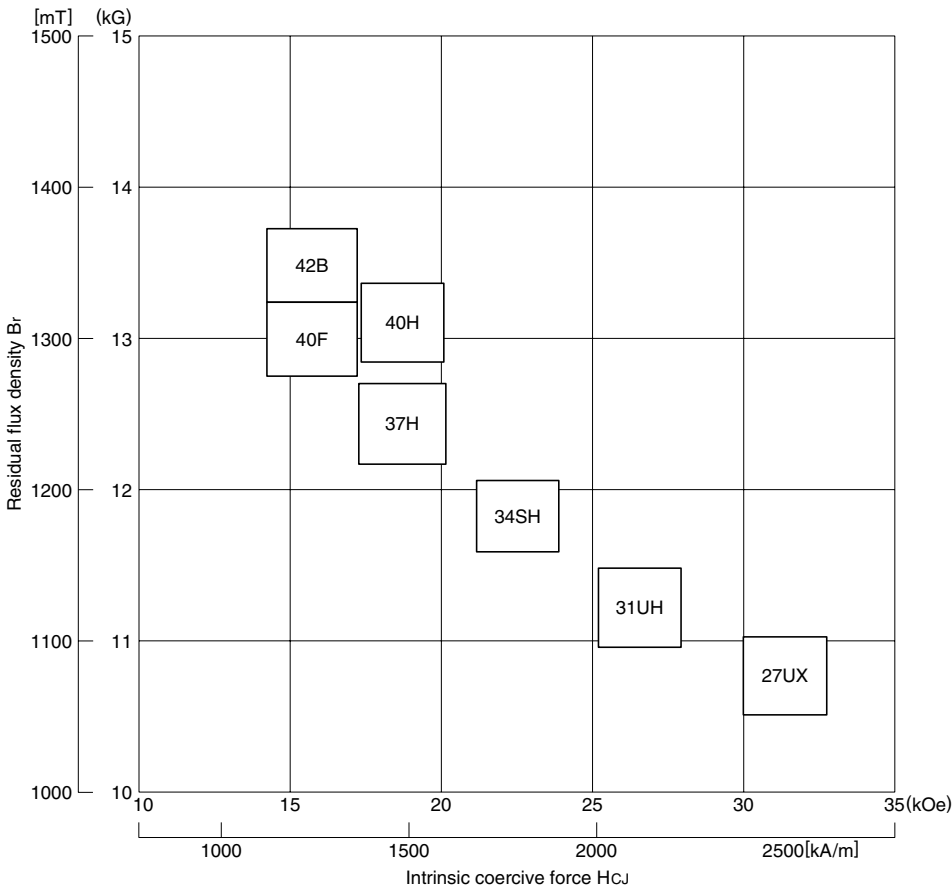


• All specifications are subject to change without notice.

TRANSVERSE MAGNETIC FIELD PRESS



AXIAL MAGNETIC FIELD PRESS

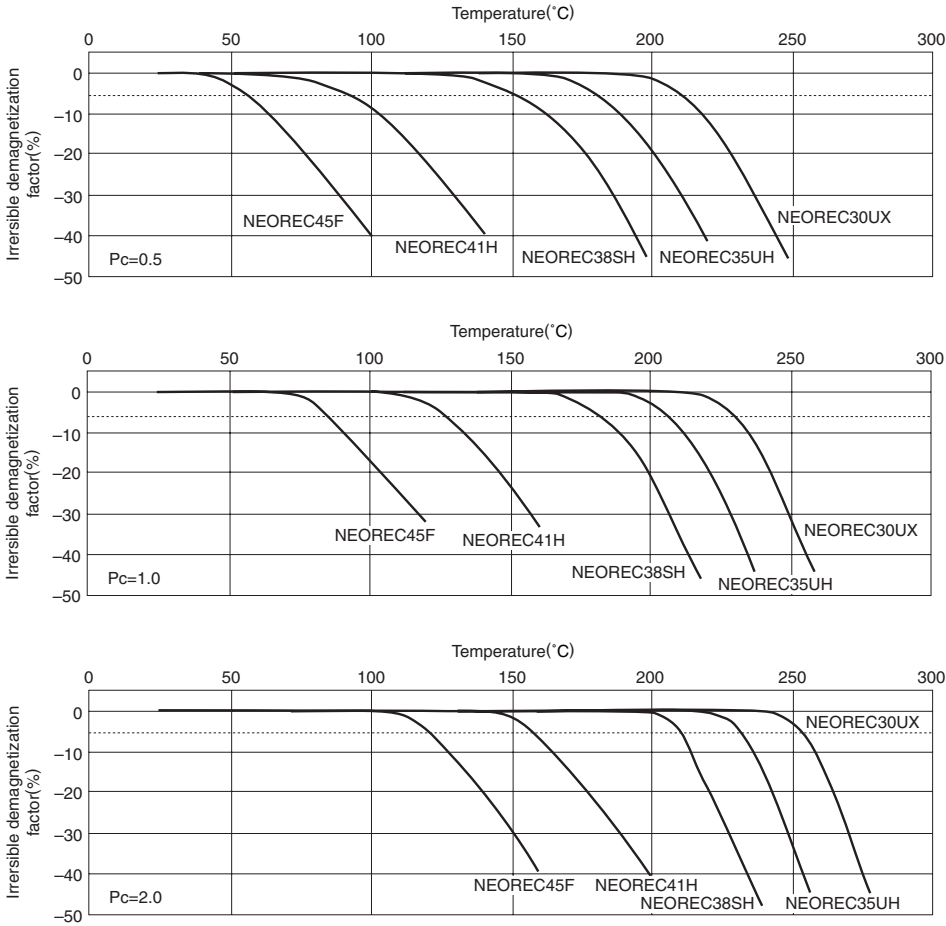


• All specifications are subject to change without notice.

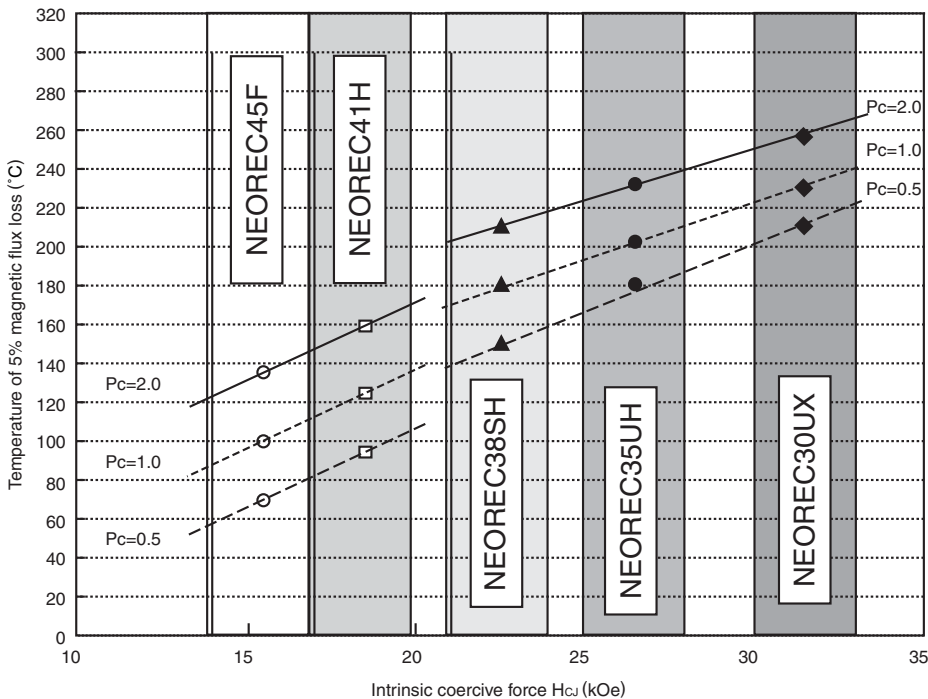
IRREVERSIBLE DEMAGNETIZATION CHARACTERISTICS

The irreversible demagnetization characteristics of NEOREC magnets are dependent on their coercive forces and are not due to their residual flux densities. There is no difference between the irreversible demagnetization characteristics of transversely and longitudinally magnetized products.

TEMPERATURE DEPENDENCE OF IRRERISBLE DEMAGNETIZATION FACTOR



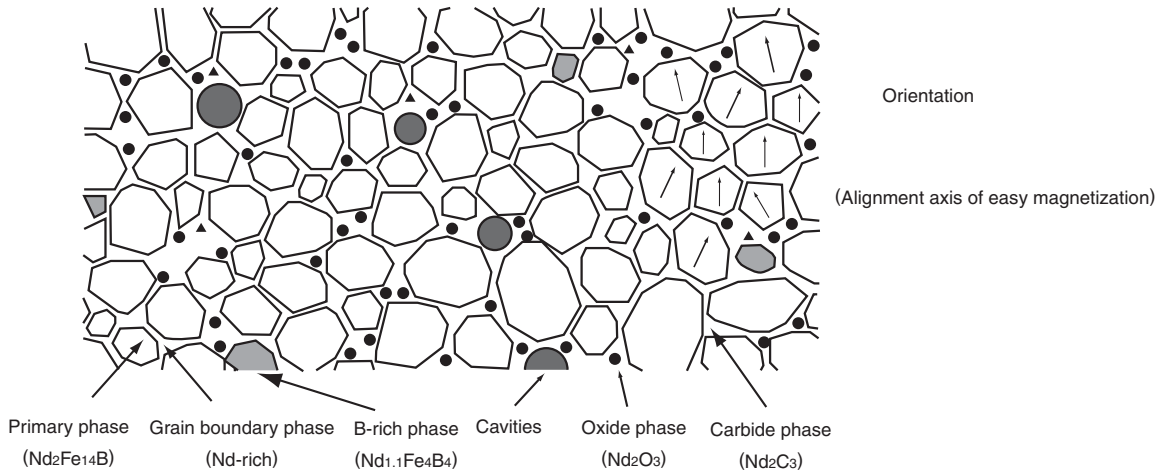
TEMPERATURE OF 5% MAGNETIC FLUX LOSS vs. COERCIVE FORCE



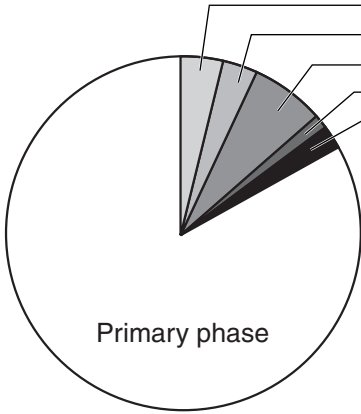
• All specifications are subject to change without notice.

MAGNET STRUCTURES/MAGNETIC CHARACTERISTICS/RUST PREVENTION TREATMENTS

CROSS SECTION OF A MAGNET (MODEL ILLUSTRATION)



PHASE PROPORTIONS AND MAGNETIC CHARACTERISTICS



NEOREC Series

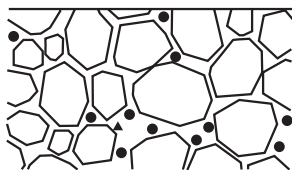
(%)	38's	41's	45's	50's
Primary phase	84	88	92	94
Grain boundary phase	4	4	2	2
B-rich phase	3	2	1	0.5
Oxide phase	7	4	3	2.5
Carbide phase	1	1	1	0.5
Cavities	1	1	1	0.5
Orientation (%)	93	93	94	95
Br (kG)	12.7	13.2	13.6	14.2

CORROSION RESISTANCE OF MAGNET MATERIALS (MODEL ILLUSTRATION)

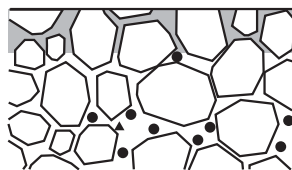
Before corrosion

Corrosion (early stage)

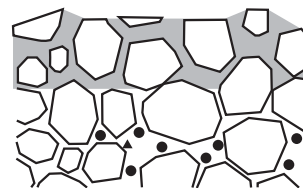
Corrosion (late stage)



Primary phase crystal grains (Nd₂Fe₁₄B)
Grain boundary phase (Nd-rich)



- 1) Corrosion on the surface of the primary phase
→ Fe₂O₃ • H₂O
- 2) Corrosion in the grain boundary phase (Nd-rich)
→ (Nd₂O₃, Nd(OH)₃)



- Drop-off of primary phase crystal grains
↓
Corrosion on the surface of the primary phase
Corrosion in the grain boundary phase

RUST PREVENTION TREATMENTS FOR NEOREC

		Ni plating		
Surface treatment technique		Electrolytic plating	Electrolytic plating with good throwing power	Improvements to corrosion resistance and adhesion
	Element Ni	Ni	Ni/Sn	
Film structure	Spontaneous potential (mV: standard electrode)	-250 to -300	-220 to -170	-100 to -150
	Internal stress (Mpa)	-150 to -100	-50 to 0	-50 to 0
	Vickers hardness (Hv)	400 to 600	200 to 300	200 to 300
	Organic brightener	Used	Not used	Not used
Film thickness	Range (µm)	10 to 20	10 to 20	10 to 20/1 to 3
	Uniformity	Acceptable	Good	Good
Adhesion	Room temperature	Good	Excellent	Excellent
	200°C	Acceptable	Good	Good
	Adhesiveness	Acceptable	Good	Excellent
Reliability	Temperature resistance test (60°C, 90%RH)	>2500 (hr)	>2500 (hr)	>2500 (hr)
	Humidity resistance test (85°C, 85%RH)	>500 (hr)	>500 (hr)	>500 (hr)
	Salt spray test (35°C, 5% NaCl)	<24 (hr)	<24 (hr)	>24 (hr)
	SO ₂ gas test (40°C, 75%RH)	<96 (hr)	<96 (hr)	>96 (hr)
Examples of applications		HDD Motors for hard disk drives, audio visual equipment and office automation equipment. (electrical household appliances)	Optical pickups, sensors and motors (electrical household appliances, factory automation and automobiles)	Actuators, sensors and motors (factory automation and automobiles)
Maximum operating temperature (°C)		120	220	220

• Please consult us for the different types of surface treatments.

CORRELATION IN HUMIDITY RESISTANCE TESTS

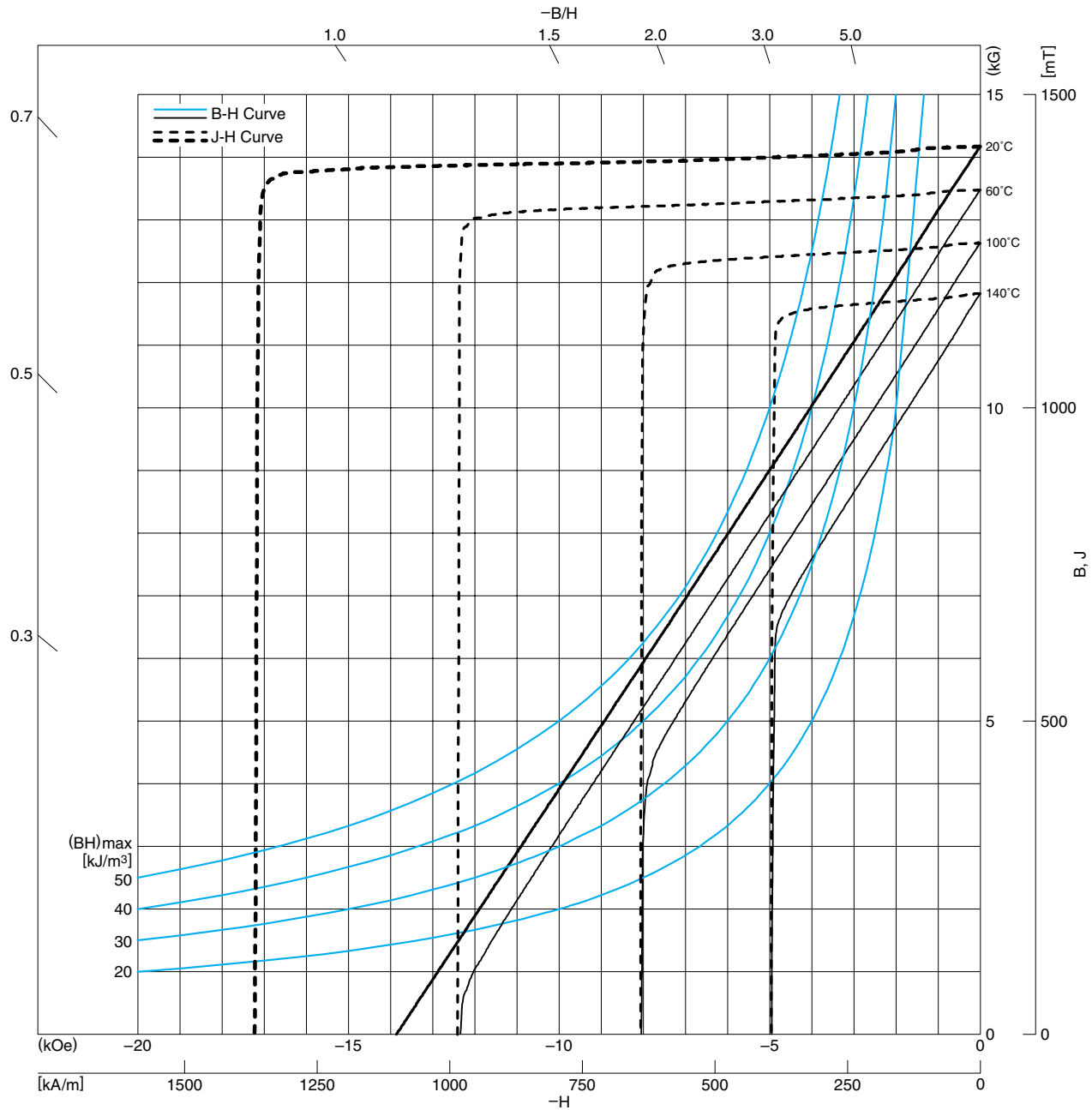
Test items	Conditions	Times					
Pressure cooker test	120 °C	25 (hours)	50	75	100	125	
	2atm, 100%RH						
Humidity resistance test	85°C, 85%RH	250 (hours)	500	750	1000	1250	
	60 °C, 90 %RH	1500 (hours)	3000	4500	6000	7500	
Cycle test	MIL202F-106E	50 (cycles)	100	150	200	250	
	23.8°C 78%RH	Rust (blisters)	4.5 (years)	9.0	13.5	18.0	22.5
Operating environment (estimated)	Bangkok	Breaking	18 (years)	36	54	72	90
	16.2°C 67%RH	Rust (blisters)	22.5 (years)	45	67.5	90	113
	Osaka	Breaking	90 (years)	180	270	360	450

(↑ 20hr: Pre-shipment inspection)

DEMAGNETIZATION CURVES/MAGNETIC CHARACTERISTICS

NEOREC50H

DEMAGNETIZATION CURVE

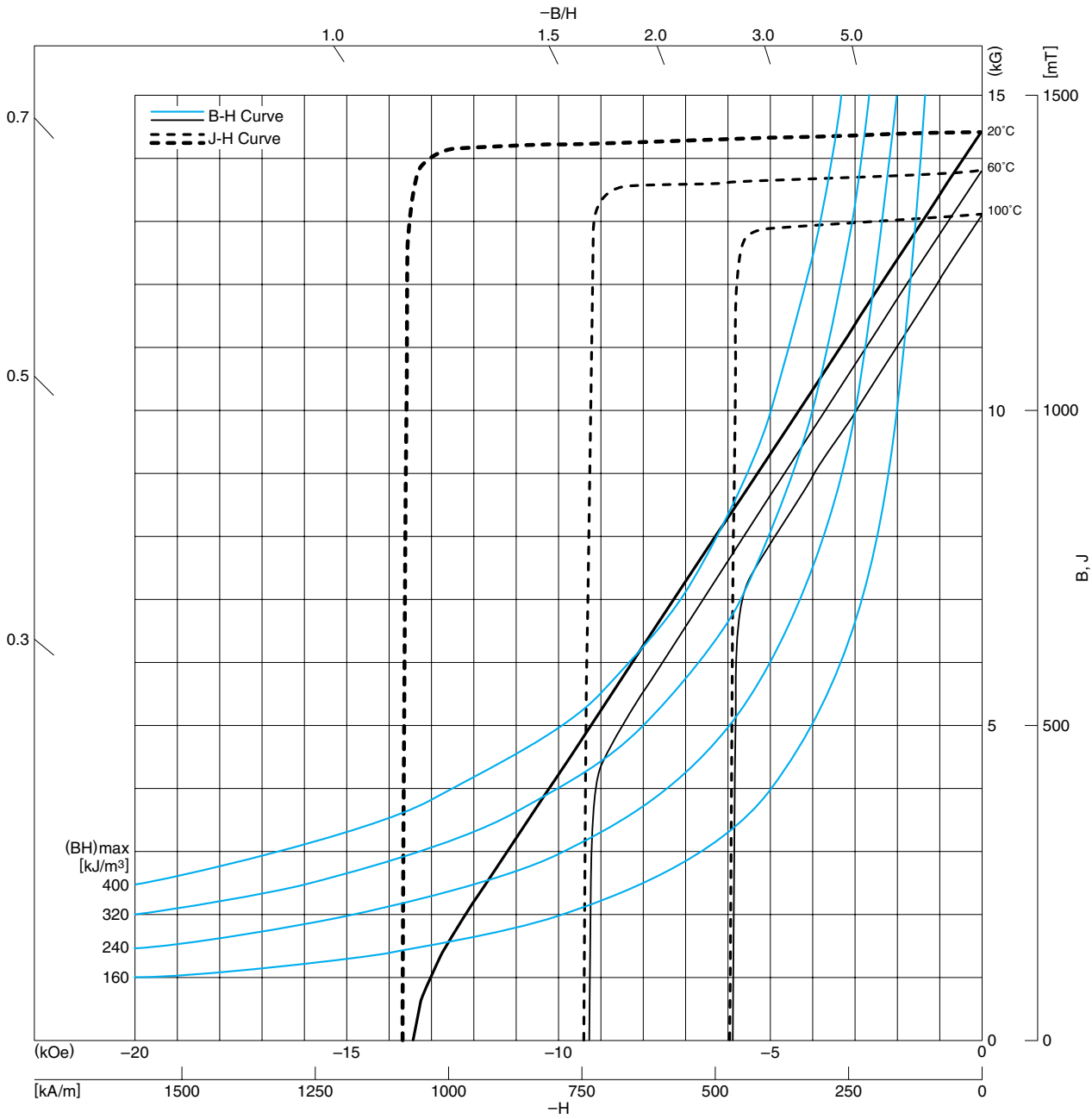


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1420±20
B_r	(kG)	14.2±0.2
Coercive force	[kA/m]	1090±56
H_{cB}	(kOe)	13.7±0.7
Intrinsic coercive force	[kA/m]	≥ 1353
H_{cJ}	(kOe)	≥ 17.0
Maximum energy product	[kJ/m^3]	390±16
$(BH)_{max}$	(MGOe)	49.0±2.0

- []: in the unit of SI
- (): in the unit of CGS

NEOREC52A DEMAGNETIZATION CURVE

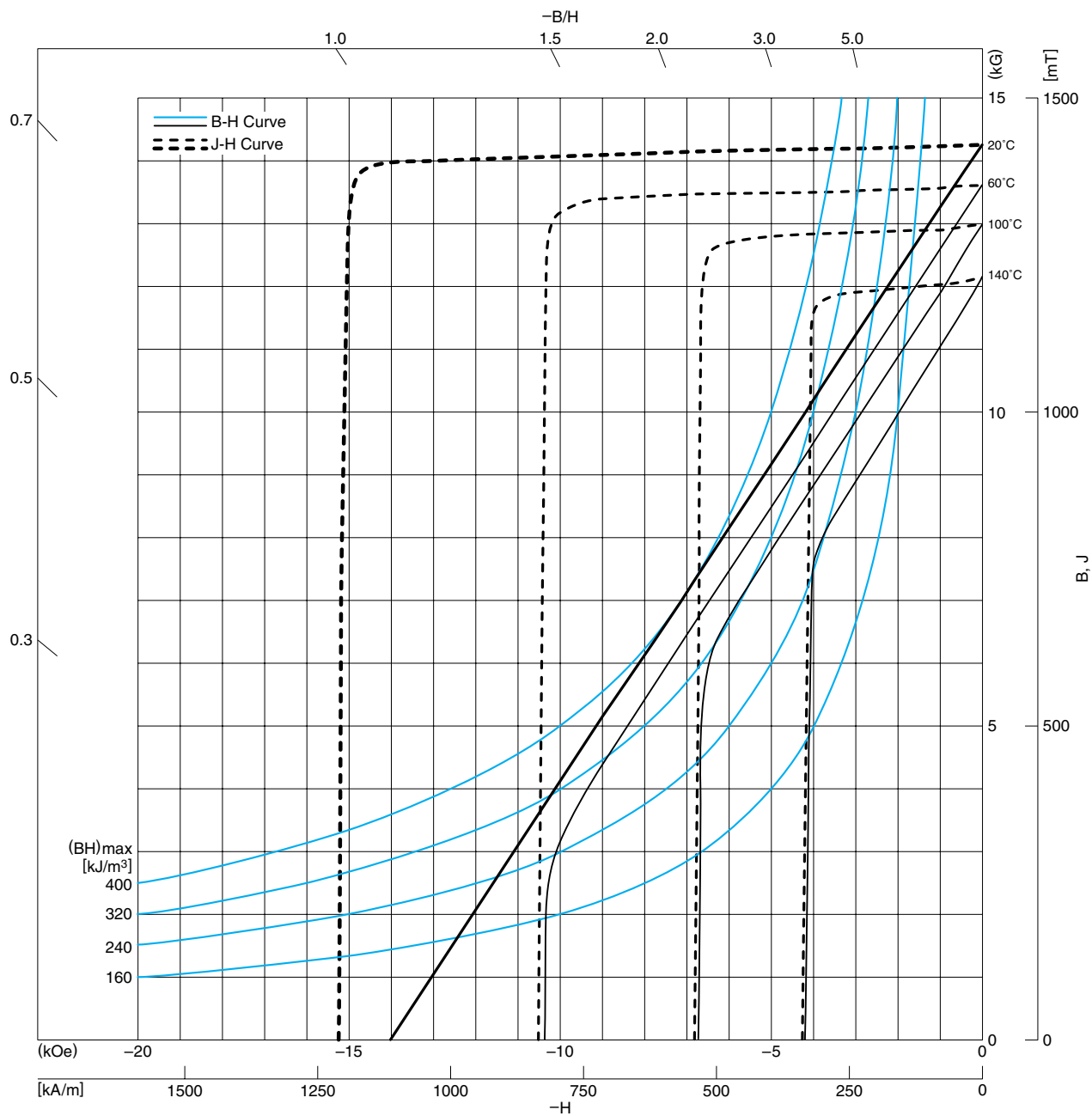


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1440±20
Br	(kG)	14.4±0.2
Coercive force	[kA/m]	1035±72
H _{cB}	(kOe)	13.0±0.9
Intrinsic coercive force	[kA/m]	≥ 995
H _{cJ}	(kOe)	≥ 12.5
Maximum energy product	[kJ/m³]	398±16
(BH) _{max}	(MGOe)	50.0±2.0

- []: in the unit of SI
- (): in the unit of CGS

NEOREC50B
DEMAGNETIZATION CURVE

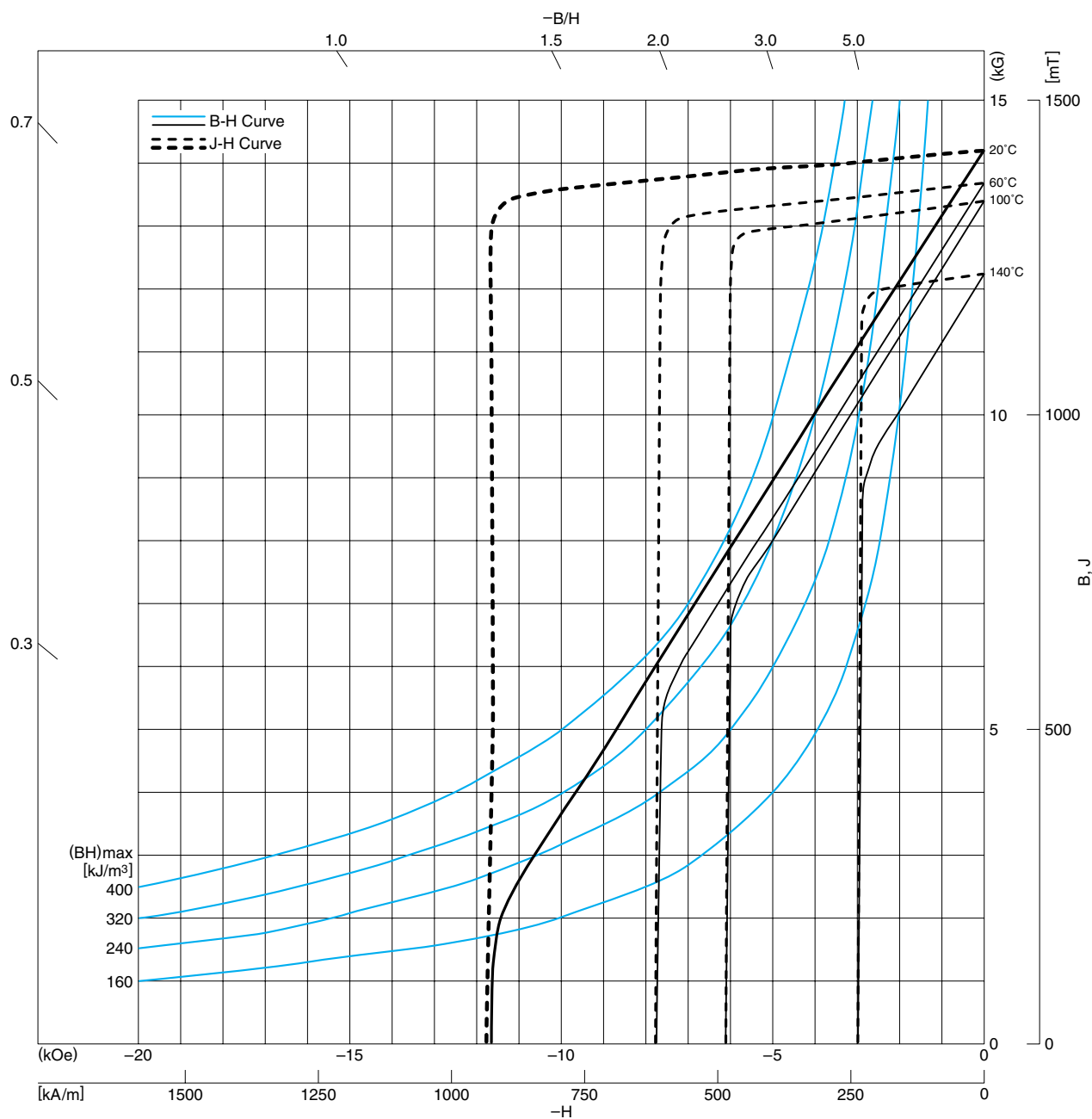


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1420±20
Br	(kG)	14.2±0.2
Coercive force	[kA/m]	1074±48
H _{CB}	(kOe)	13.5±0.6
Intrinsic coercive force	[kA/m]	≥ 1114
H _{CJ}	(kOe)	≥ 14.0
Maximum energy product	[kJ/m³]	390±16
(BH) _{max}	(MGOe)	49.0±2.0

• []: in the unit of SI
(): in the unit of CGS

NEOREC50F
DEMAGNETIZATION CURVE

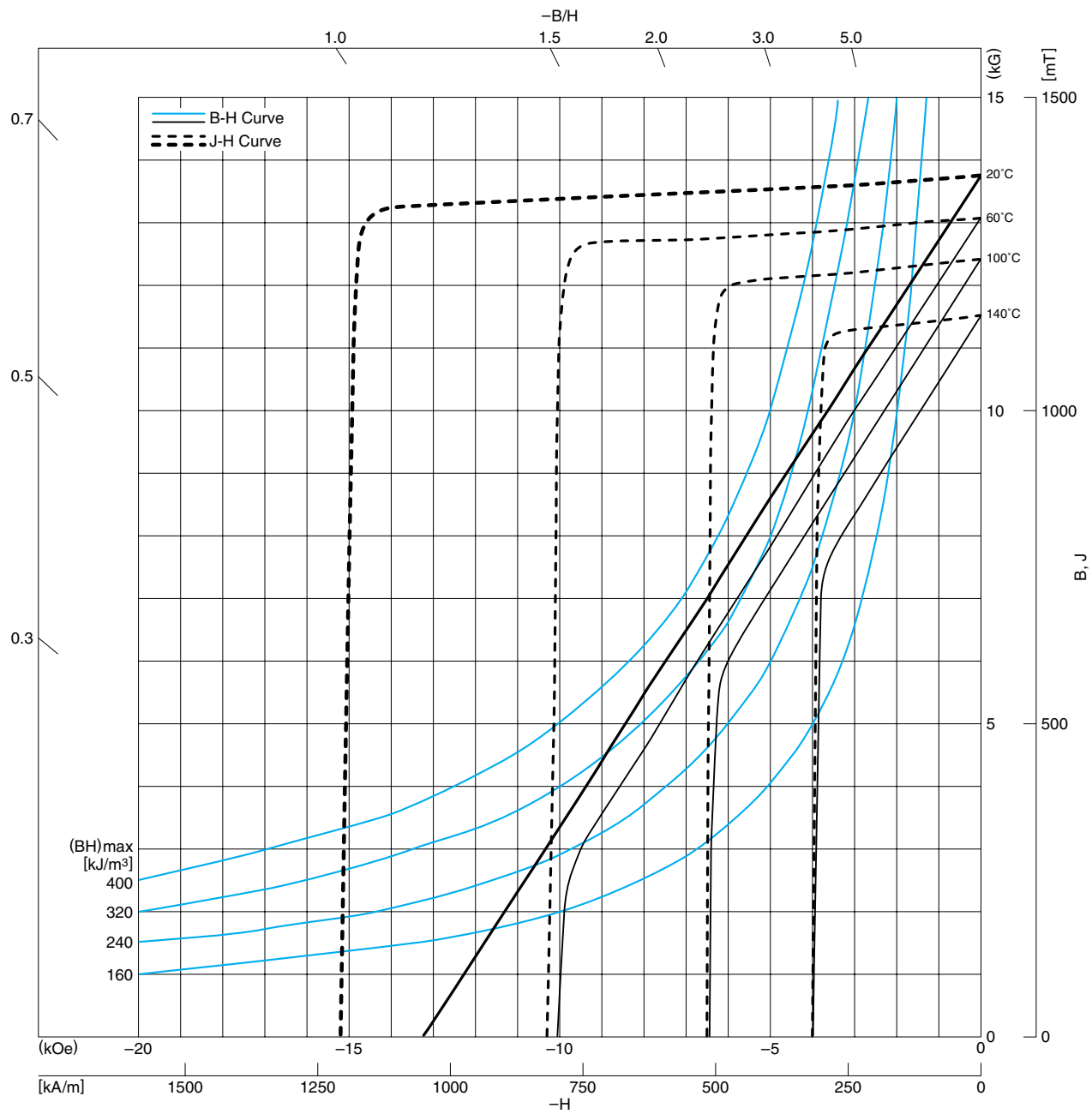


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1430±30
Br	(kG)	14.3±0.3
Coercive force	[kA/m]	876±56
H _{CB}	(kOe)	11.0±0.7
Intrinsic coercive force	[kA/m]	>876
H _{CJ}	(kOe)	>11.0
Maximum energy product	[kJ/m ³]	390±16
(BH) _{max}	(MGOe)	49±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC47B DEMAGNETIZATION CURVE

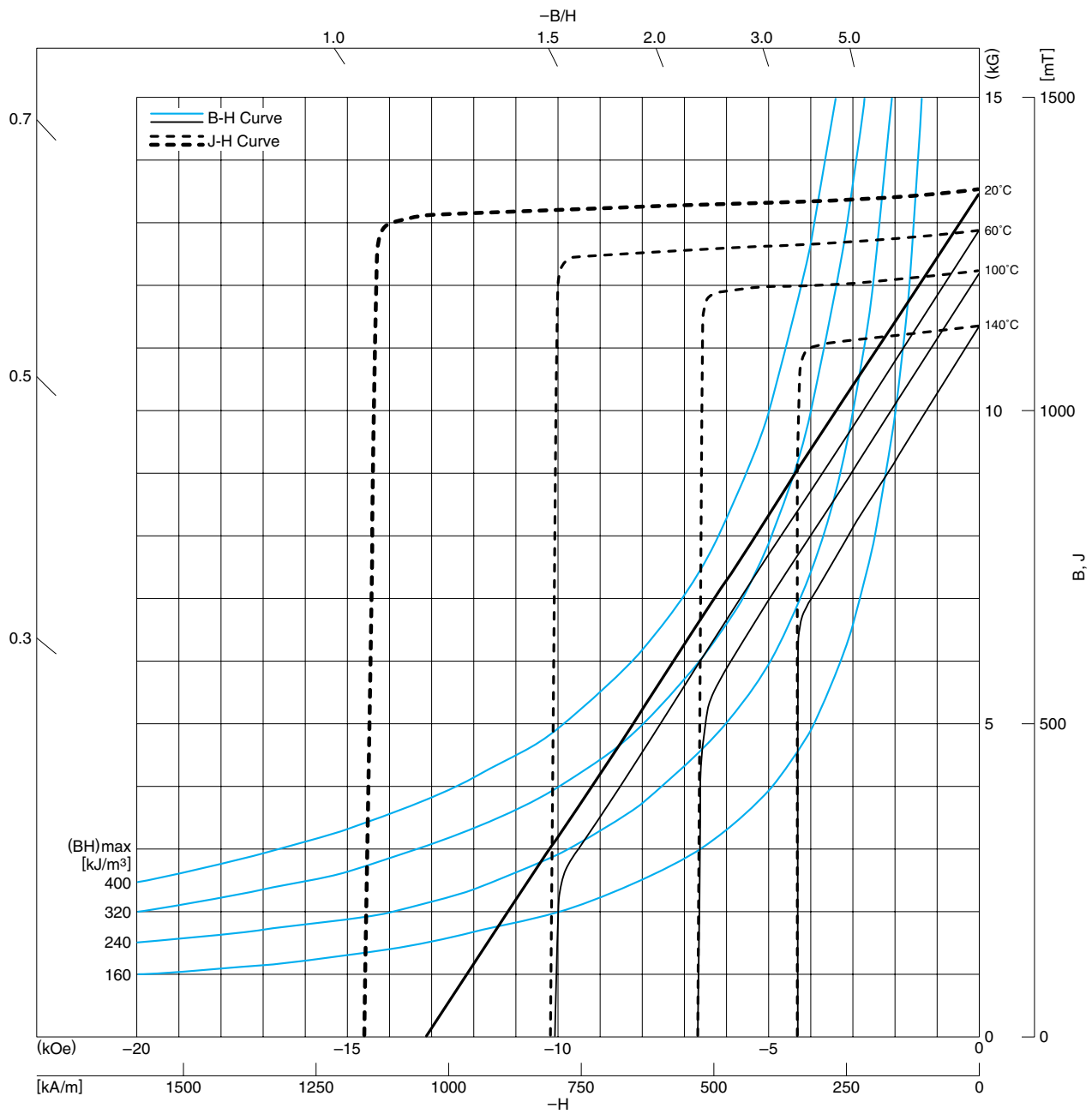


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1390±30
Br	(kG)	13.9±0.3
Coercive force	[kA/m]	1035±56
H _{CB}	(kOe)	13.0±0.7
Intrinsic coercive force	[kA/m]	>1114
H _{CJ}	(kOe)	>14.0
Maximum energy product	[kJ/m³]	366±16
(BH)max	(MGOe)	46±2

- []: in the unit of SI
- (): in the unit of CGS

NEOREC45F DEMAGNETIZATION CURVE

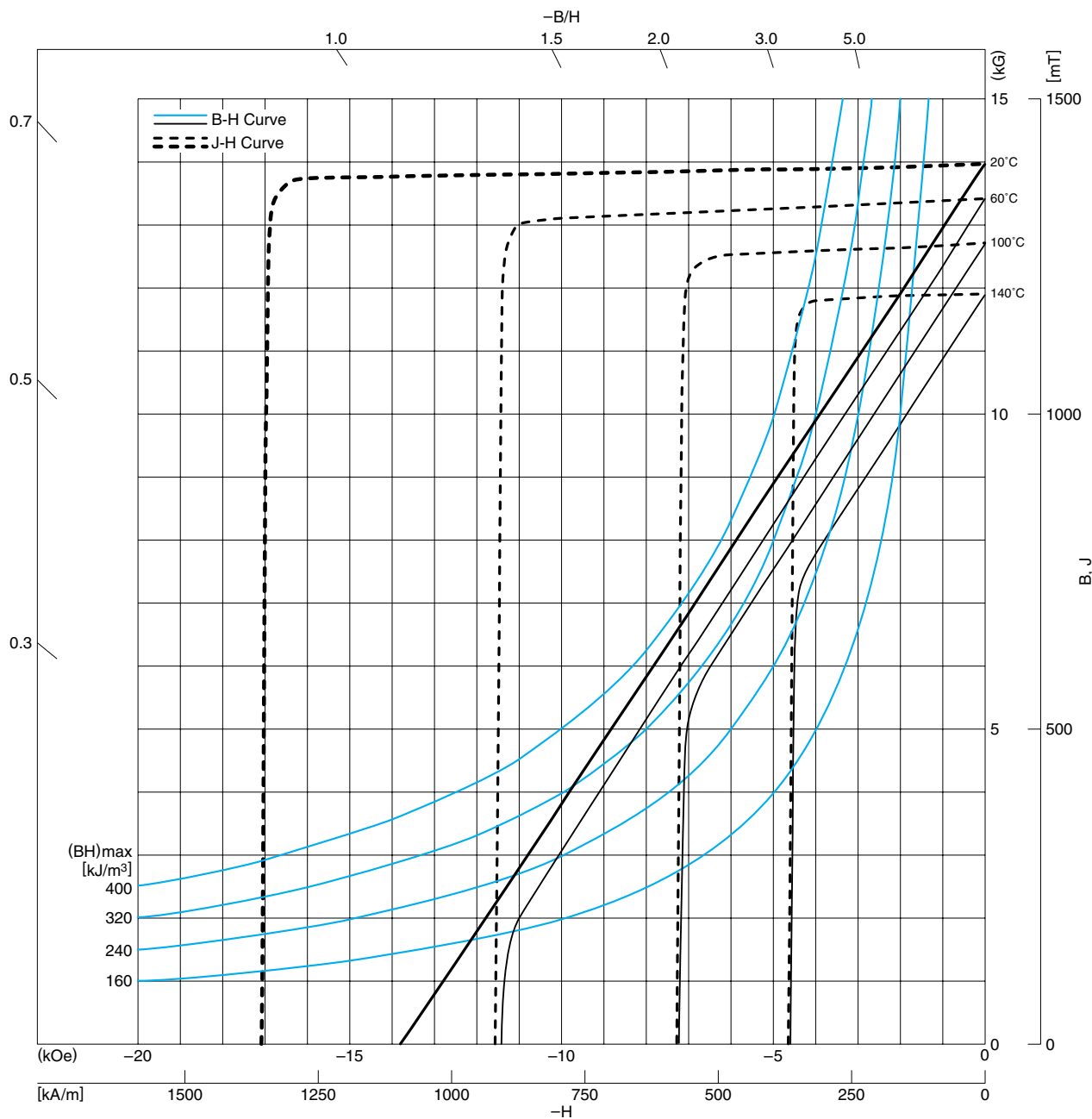


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1360±30
Br	(kG)	13.6±0.3
Coercive force	[kA/m]	1011±56
H _{CB}	(kOe)	12.7±0.7
Intrinsic coercive force	[kA/m]	>1114
H _{CJ}	(kOe)	>14.0
Maximum energy product	[kJ/m³]	350±16
(BH) _{max}	(MGOe)	44±2

- []: in the unit of SI
- (): in the unit of CGS

NEOREC47H
DEMAGNETIZATION CURVE

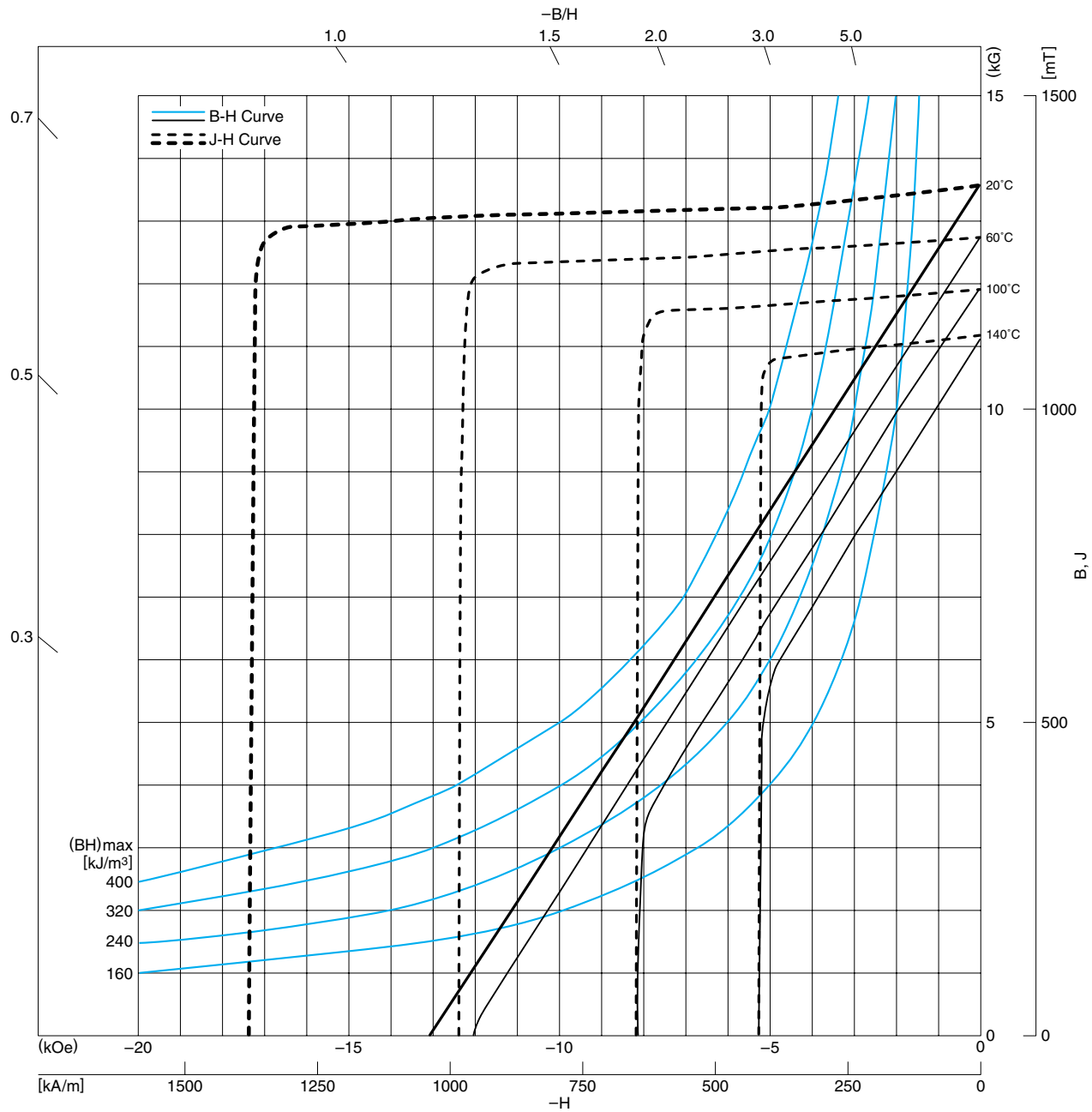


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1390±20
Br	(kG)	13.9±0.2
Coercive force	[kA/m]	1067±48
H _{CB}	(kOe)	13.4±0.6
Intrinsic coercive force	[kA/m]	≥ 1273
H _{CJ}	(kOe)	≥ 16.0
Maximum energy product	[kJ/m³]	374±16
(BH) _{max}	(MGOe)	47.0±2.0

• []: in the unit of SI
(): in the unit of CGS

NEOREC44H DEMAGNETIZATION CURVE

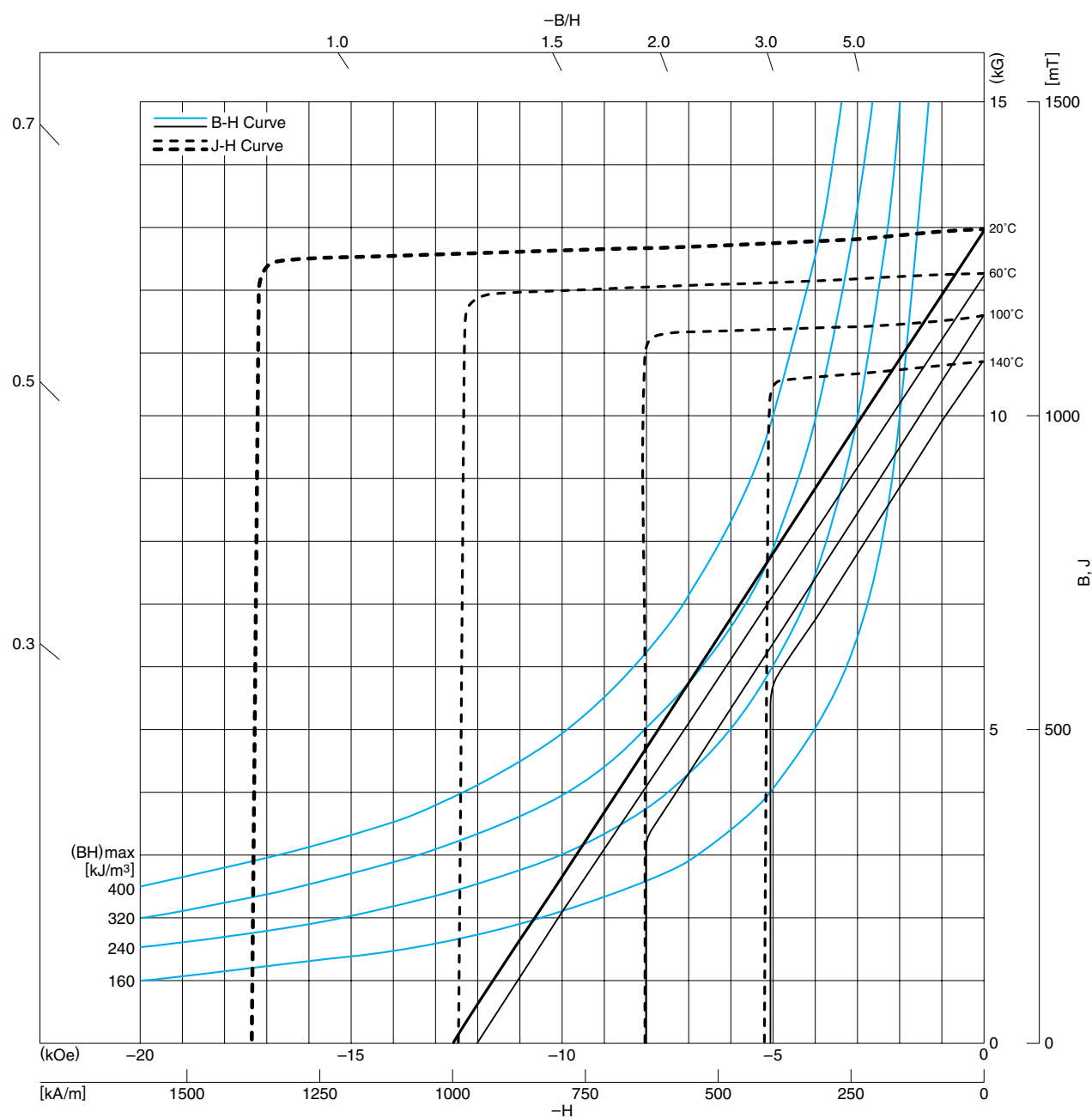


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1360±30
Br	(kG)	13.6±0.3
Coercive force	[kA/m]	1003±56
H _{CB}	(kOe)	12.6±0.7
Intrinsic coercive force	[kA/m]	>1353
H _{CJ}	(kOe)	>17.0
Maximum energy product	[kJ/m³]	350±16
(BH) _{max}	(MGOe)	44±2

- []: in the unit of SI
- (): in the unit of CGS

NEOREC41H DEMAGNETIZATION CURVE

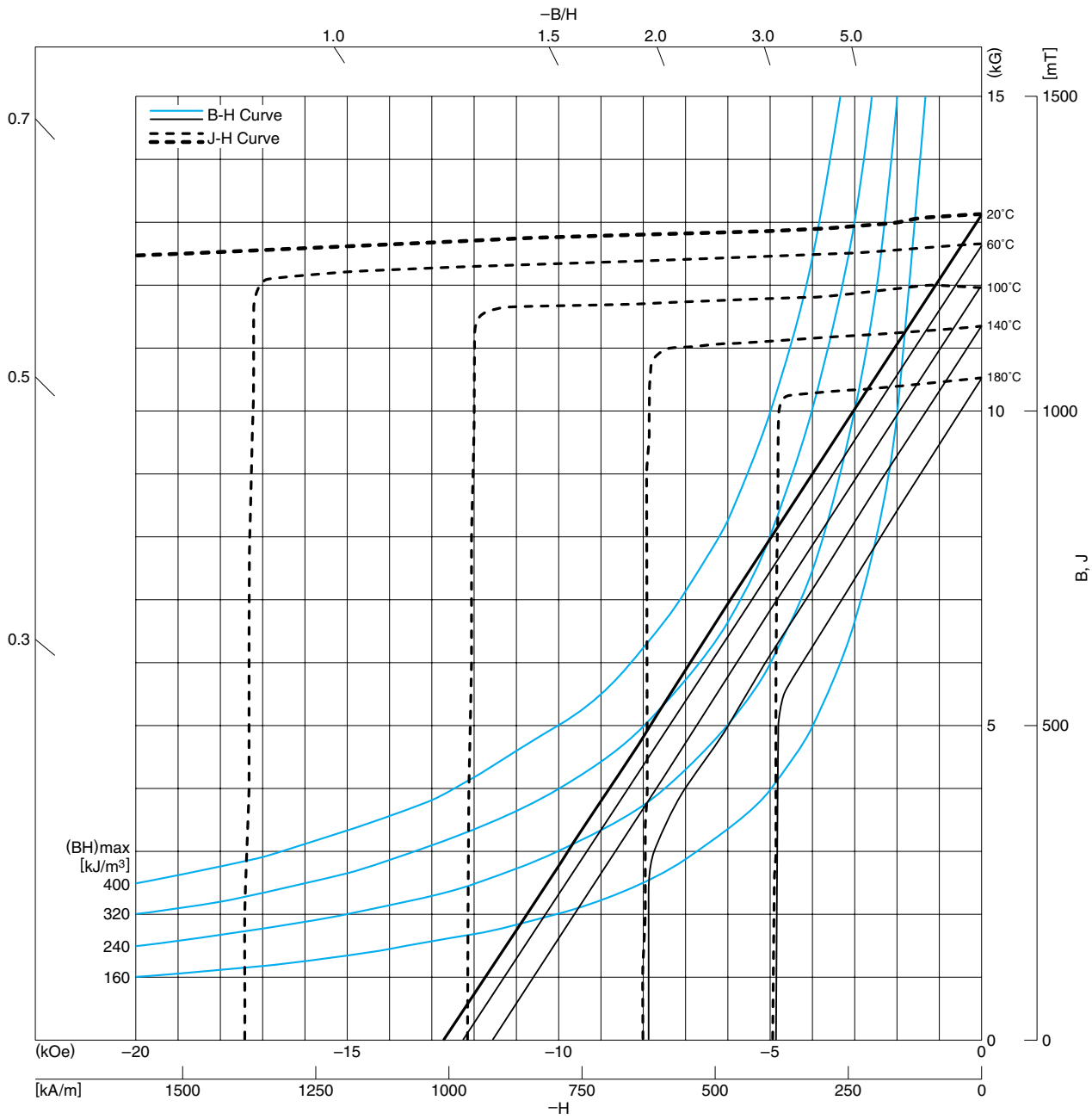


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1300±30
Br	(kG)	13.0±0.3
Coercive force	[kA/m]	971±56
H _{CB}	(kOe)	12.2±0.7
Intrinsic coercive force	[kA/m]	>1353
H _{CJ}	(kOe)	>17.0
Maximum energy product (BH) _{max}	[kJ/m³]	326±16
	(MGOe)	41±2

- []: in the unit of SI
- (): in the unit of CGS

NEOREC42SH DEMAGNETIZATION CURVE

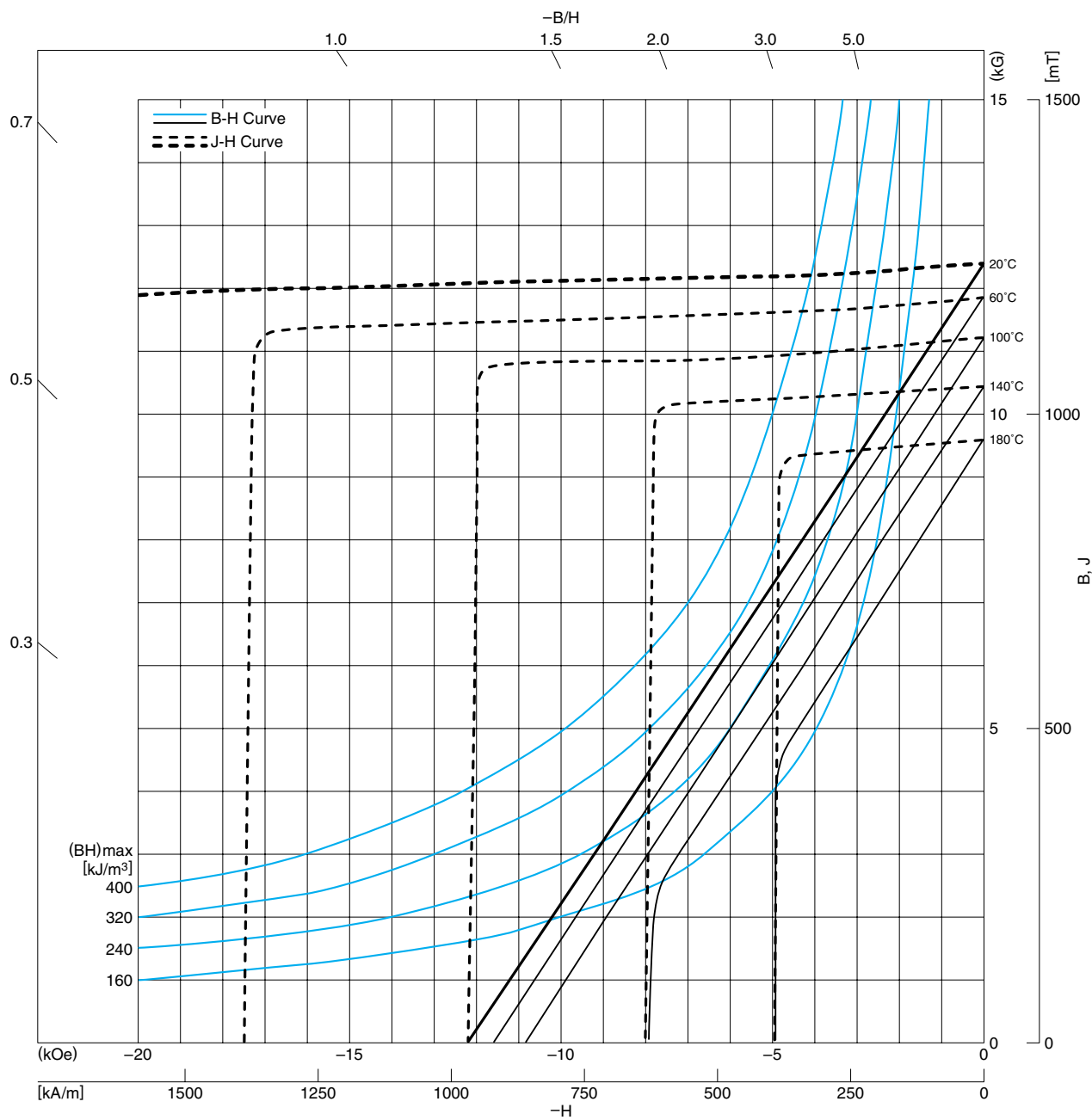


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1300±30
Br	(kG)	13.0±0.3
Coercive force	[kA/m]	979±56
H _{CB}	(kOe)	12.3±0.7
Intrinsic coercive force	[kA/m]	>1671
H _{CJ}	(kOe)	>21.0
Maximum energy product	[kJ/m³]	326±16
(BH)max	(MGOe)	41±2

• []: in the unit of SI
 (): in the unit of CGS

NEOREC38SH
DEMAGNETIZATION CURVE

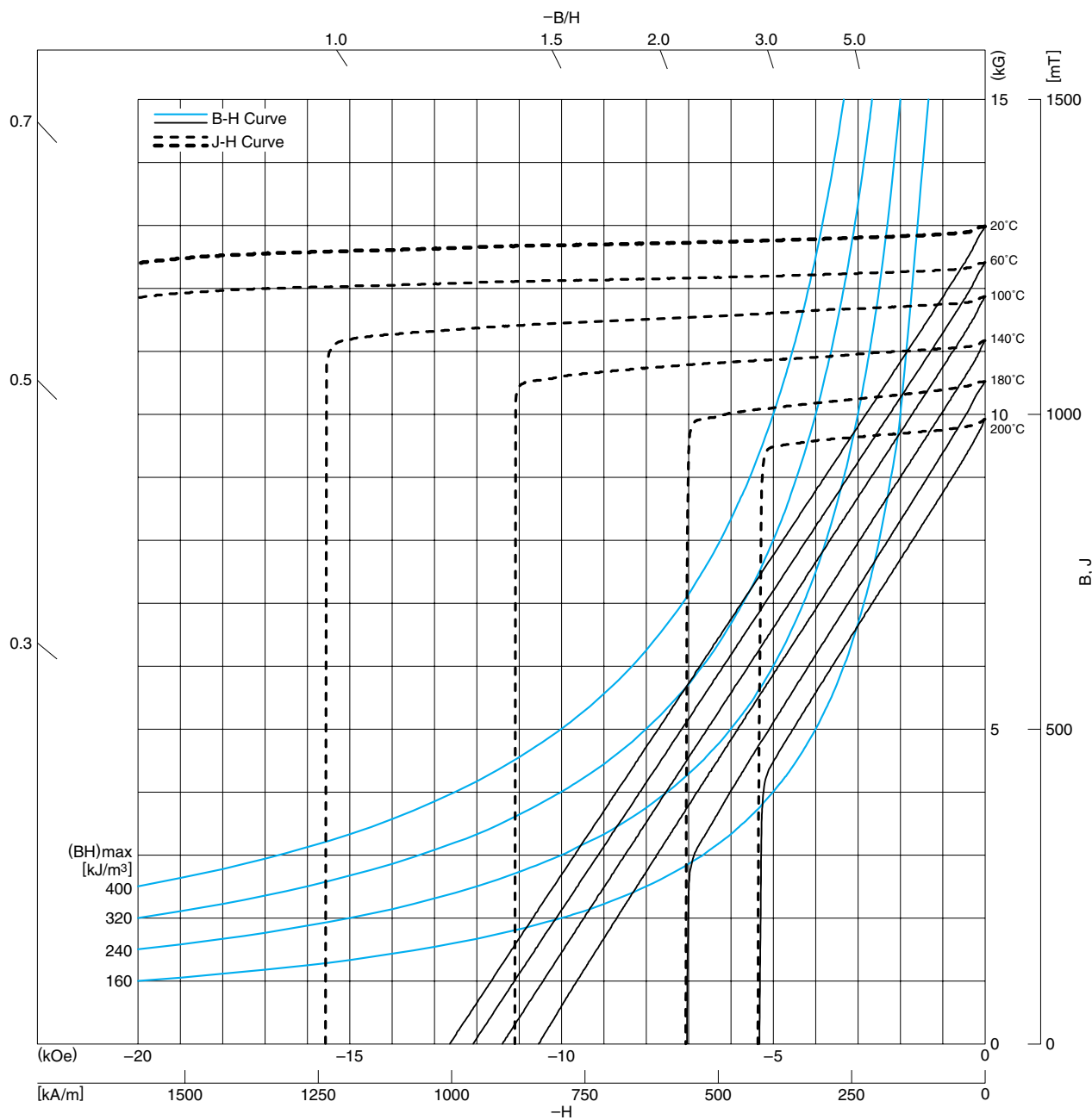


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1260±30
Br	(kG)	12.6±0.3
Coercive force	[kA/m]	939±56
H _{CB}	(kOe)	11.8±0.7
Intrinsic coercive force	[kA/m]	>1671
H _{CJ}	(kOe)	>21.0
Maximum energy product	[kJ/m³]	302±16
(BH) _{max}	(MGOe)	38±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC40UH
DEMAGNETIZATION CURVE

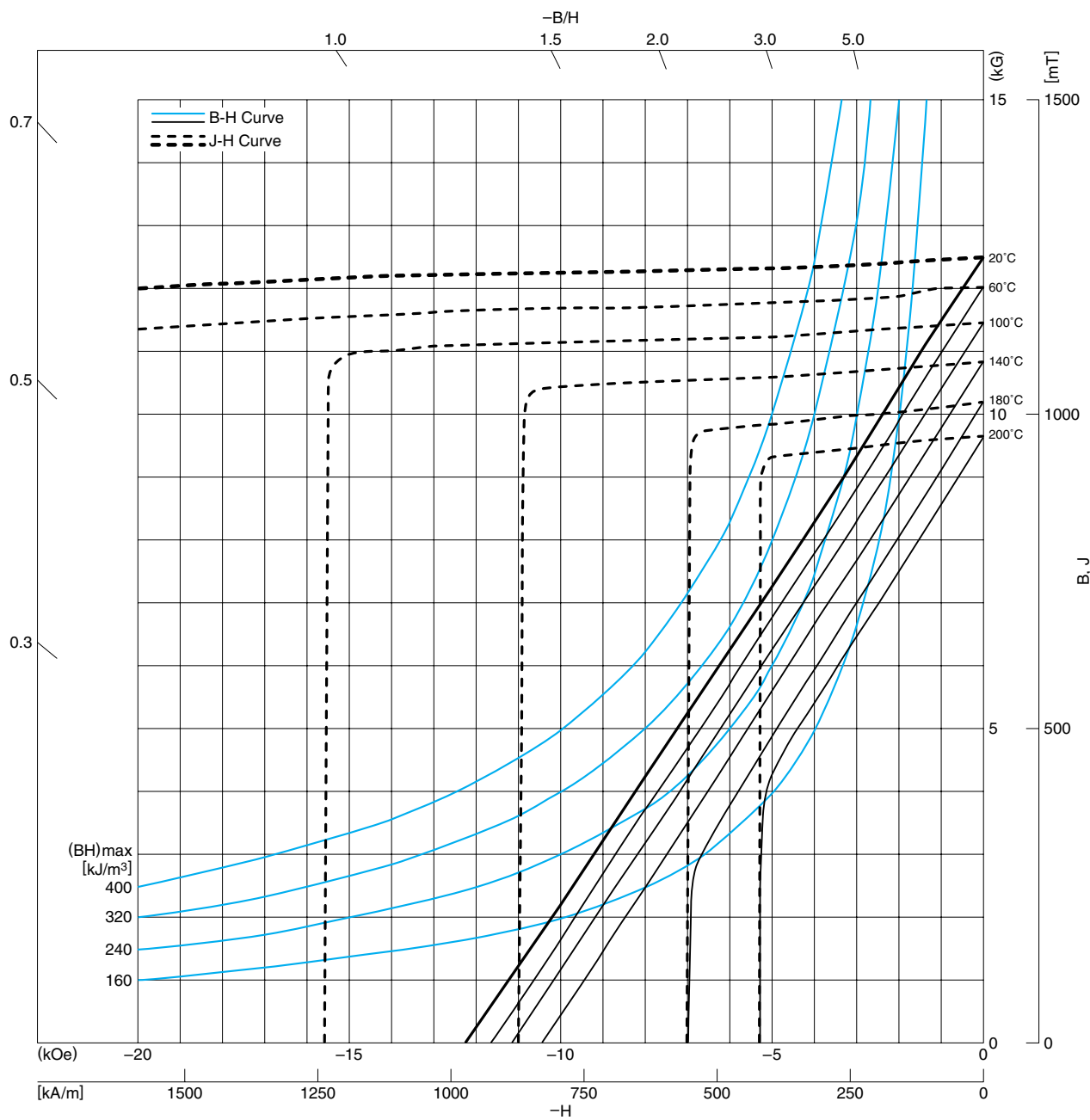


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1290±30
Br	(kG)	12.9±0.3
Coercive force	[kA/m]	995±56
H _{CB}	(kOe)	12.5±0.7
Intrinsic coercive force	[kA/m]	≥ 1990
H _{CJ}	(kOe)	≥ 25
Maximum energy product	[kJ/m³]	310±16
(BH) _{max}	(MGOe)	39±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC38UH
DEMAGNETIZATION CURVE

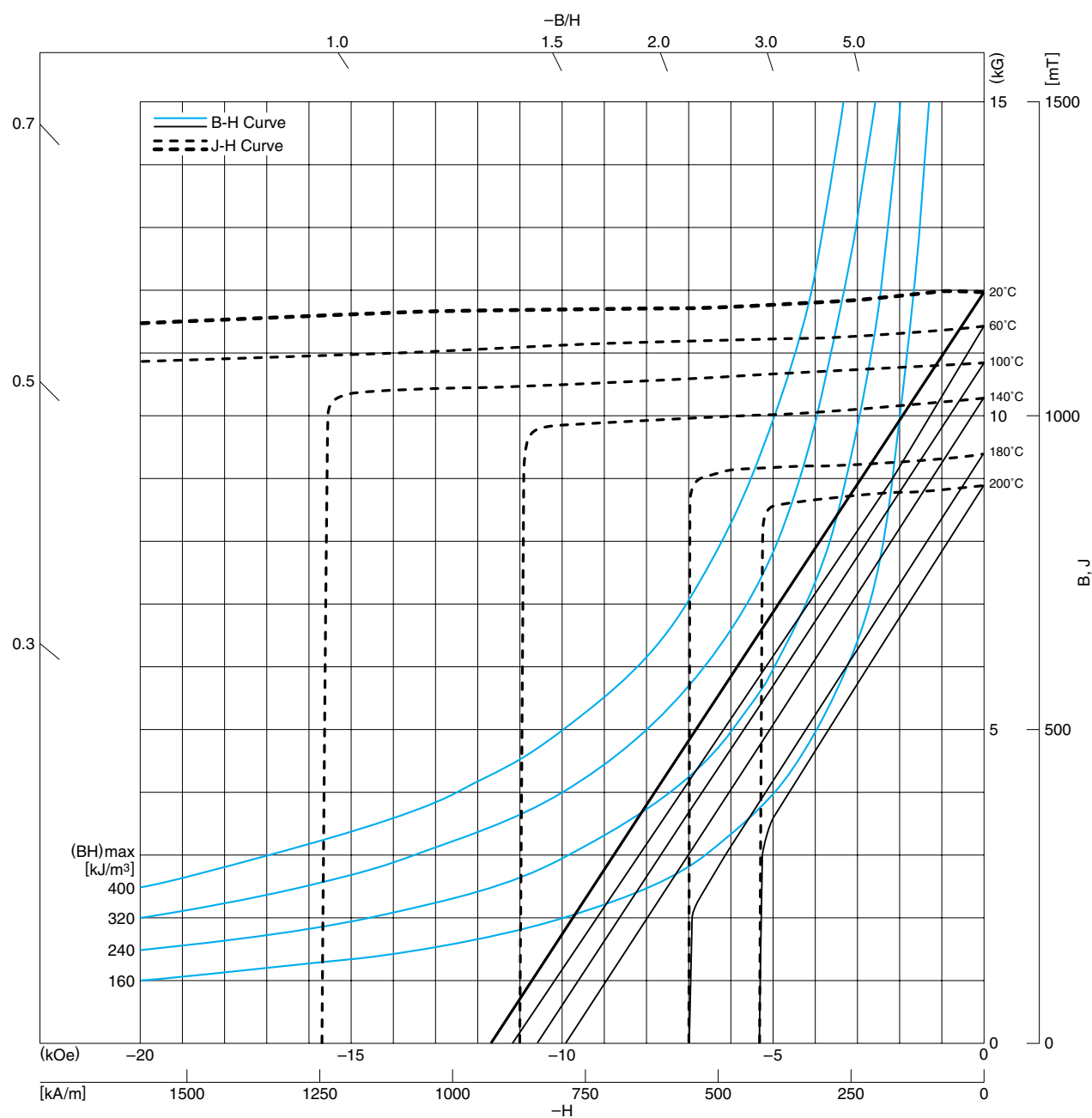


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1260±30
Br	(kG)	12.6±0.3
Coercive force	[kA/m]	963±56
H _{CB}	(kOe)	12.1±0.7
Intrinsic coercive force	[kA/m]	≥ 1990
H _{CJ}	(kOe)	≥ 25
Maximum energy product	[kJ/m³]	294±16
(BH) _{max}	(MGOe)	37±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC35UH
DEMAGNETIZATION CURVE

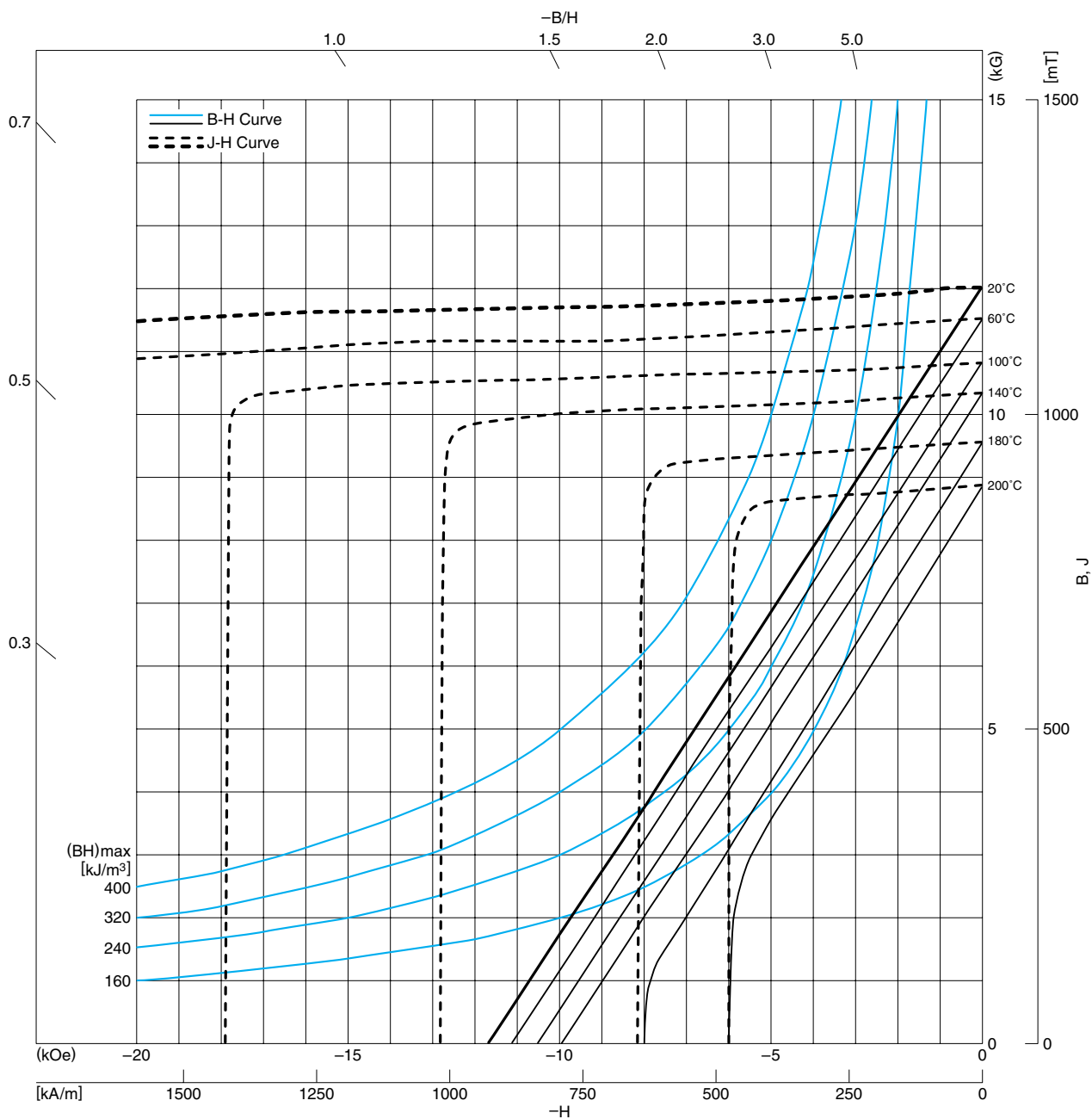


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1200±30
Br	(kG)	12.0±0.3
Coercive force	[kA/m]	931±48
H _{CB}	(kOe)	11.7±0.6
Intrinsic coercive force	[kA/m]	>1990
H _{CJ}	(kOe)	>25.0
Maximum energy product	[kJ/m³]	279±24
(BH) _{max}	(MGOe)	35±3

• []: in the unit of SI
(): in the unit of CGS

NEOREC35UX
DEMAGNETIZATION CURVE

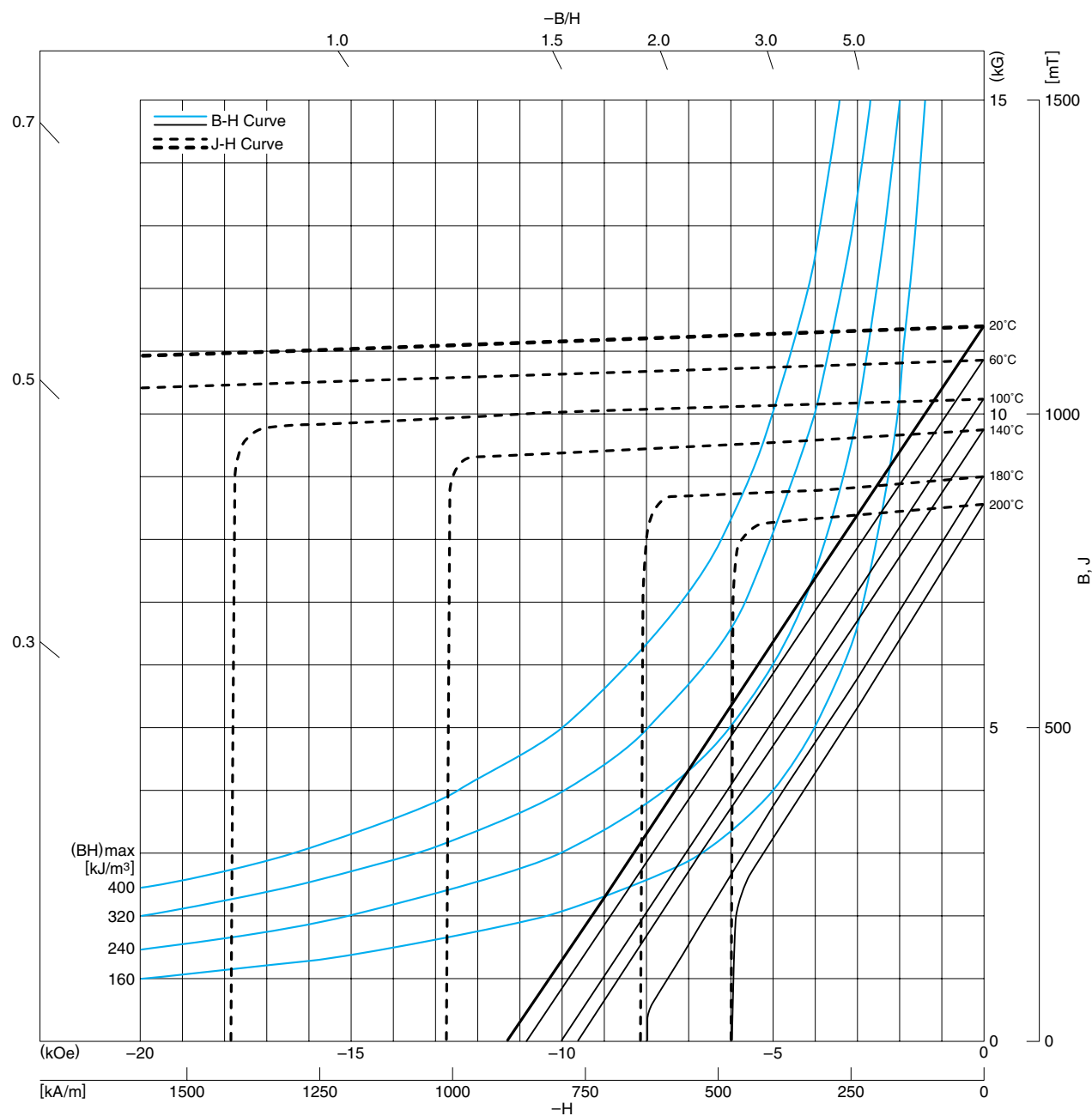


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1200±30
Br	(kG)	12.0±0.3
Coercive force	[kA/m]	923±56
H _{CB}	(kOe)	11.6±0.7
Intrinsic coercive force	[kA/m]	≥ 2388
H _{CJ}	(kOe)	≥ 30
Maximum energy product	[kJ/m³]	271±16
(BH) _{max}	(MGOe)	34±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC30UX
DEMAGNETIZATION CURVE

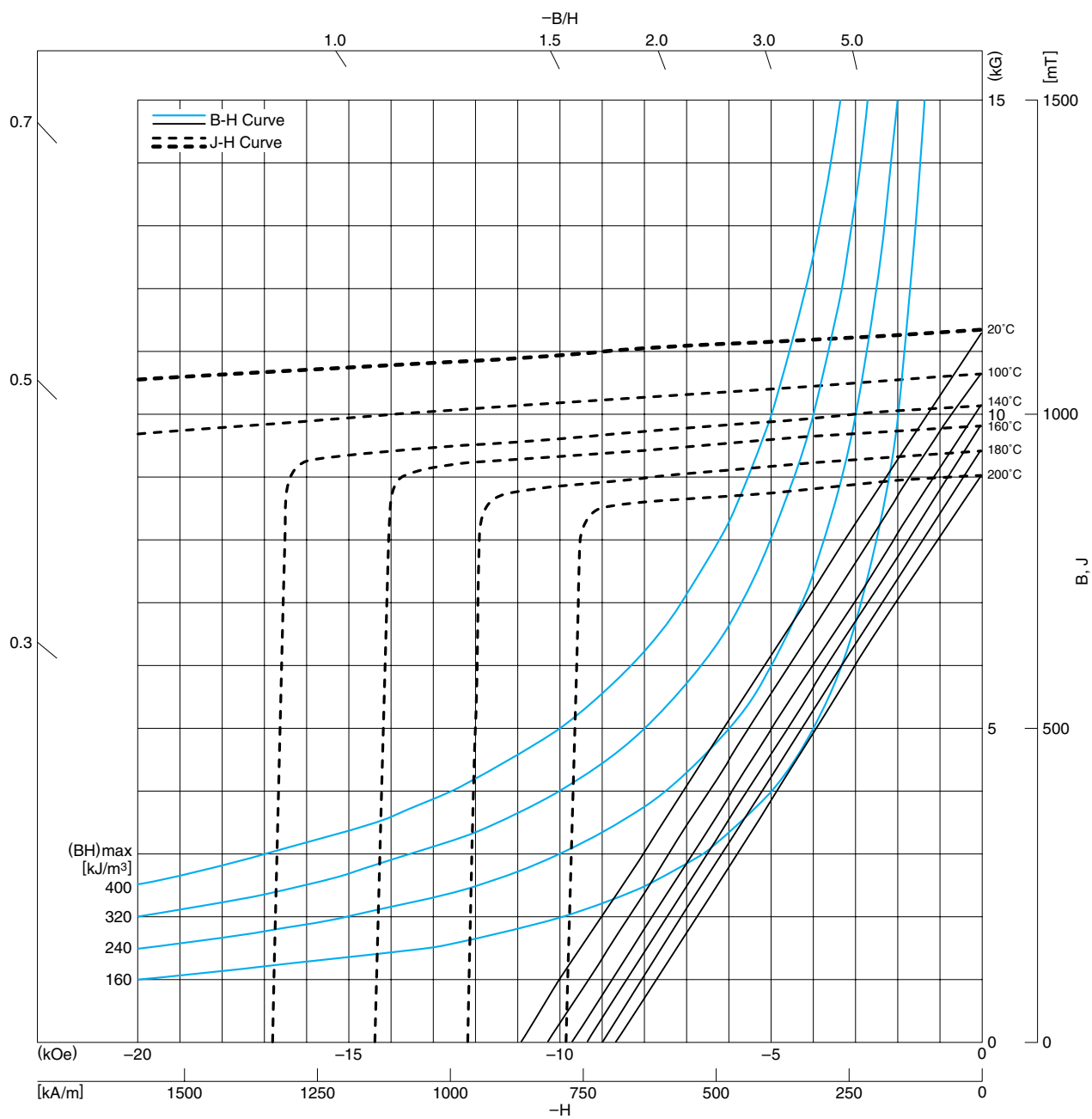


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1150±30
Br	(kG)	11.5±0.3
Coercive force	[kA/m]	876±56
H _{CB}	(kOe)	11.0±0.7
Intrinsic coercive force	[kA/m]	>2388
H _{CJ}	(kOe)	>30.0
Maximum energy product	[kJ/m³]	255±16
(BH) _{max}	(MGOe)	32±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC30EV
DEMAGNETIZATION CURVE



MAGNETIC CHARACTERISTICS

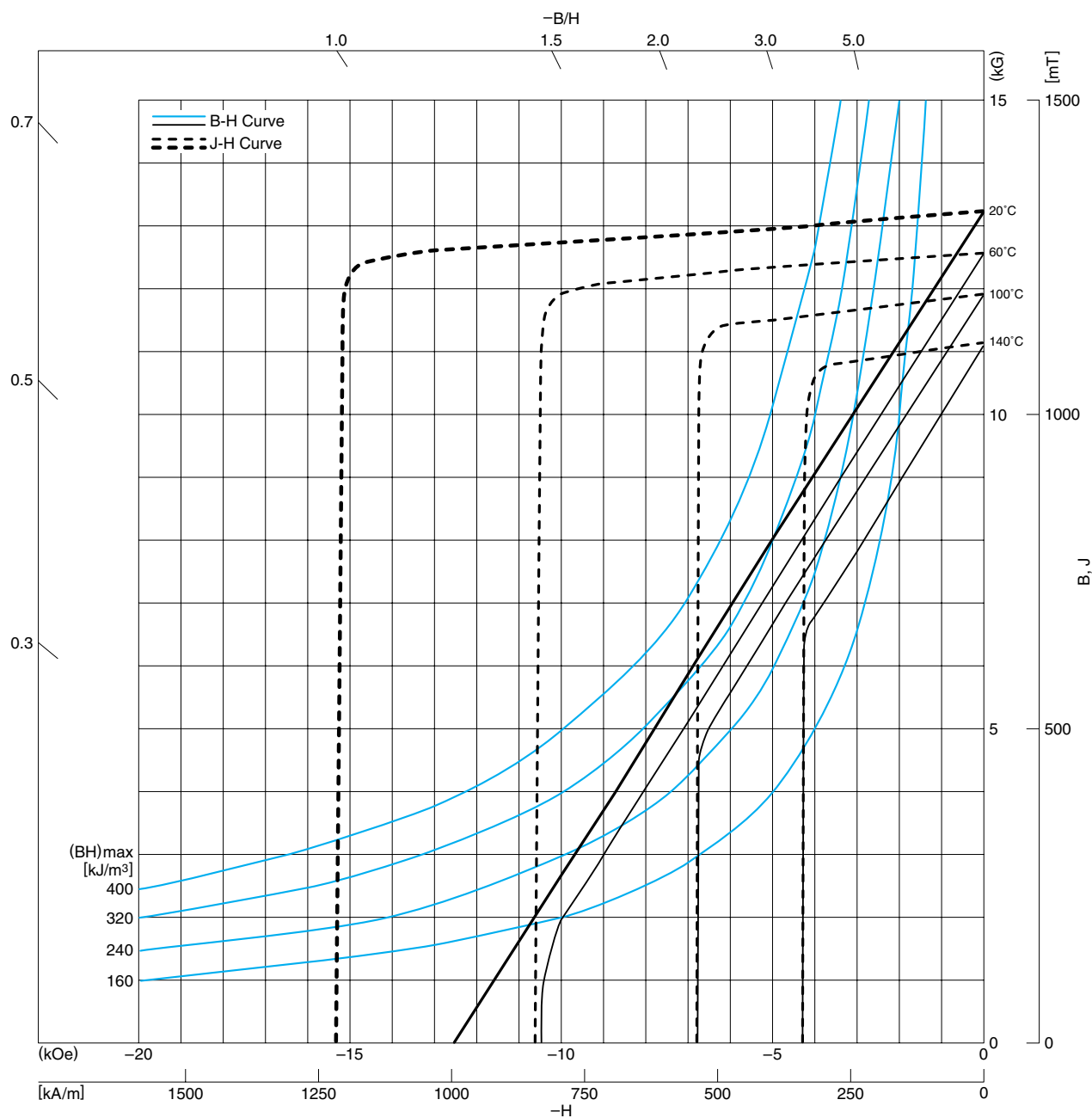
Residual flux density	[mT]	1140±30
Br	(kG)	11.4±0.3
Coercive force	[kA/m]	867±56
H _{CB}	(kOe)	10.9±0.7
Intrinsic coercive force	[kA/m]	≥ 756*
H _{CJ}	(kOe)	≥ 9.5*
Maximum energy product	[kJ/m³]	231±16
(BH) _{max}	(MGOe)	29±2

* at 200 °C

• []: in the unit of SI

(): in the unit of CGS

NEOREC42B
DEMAGNETIZATION CURVE

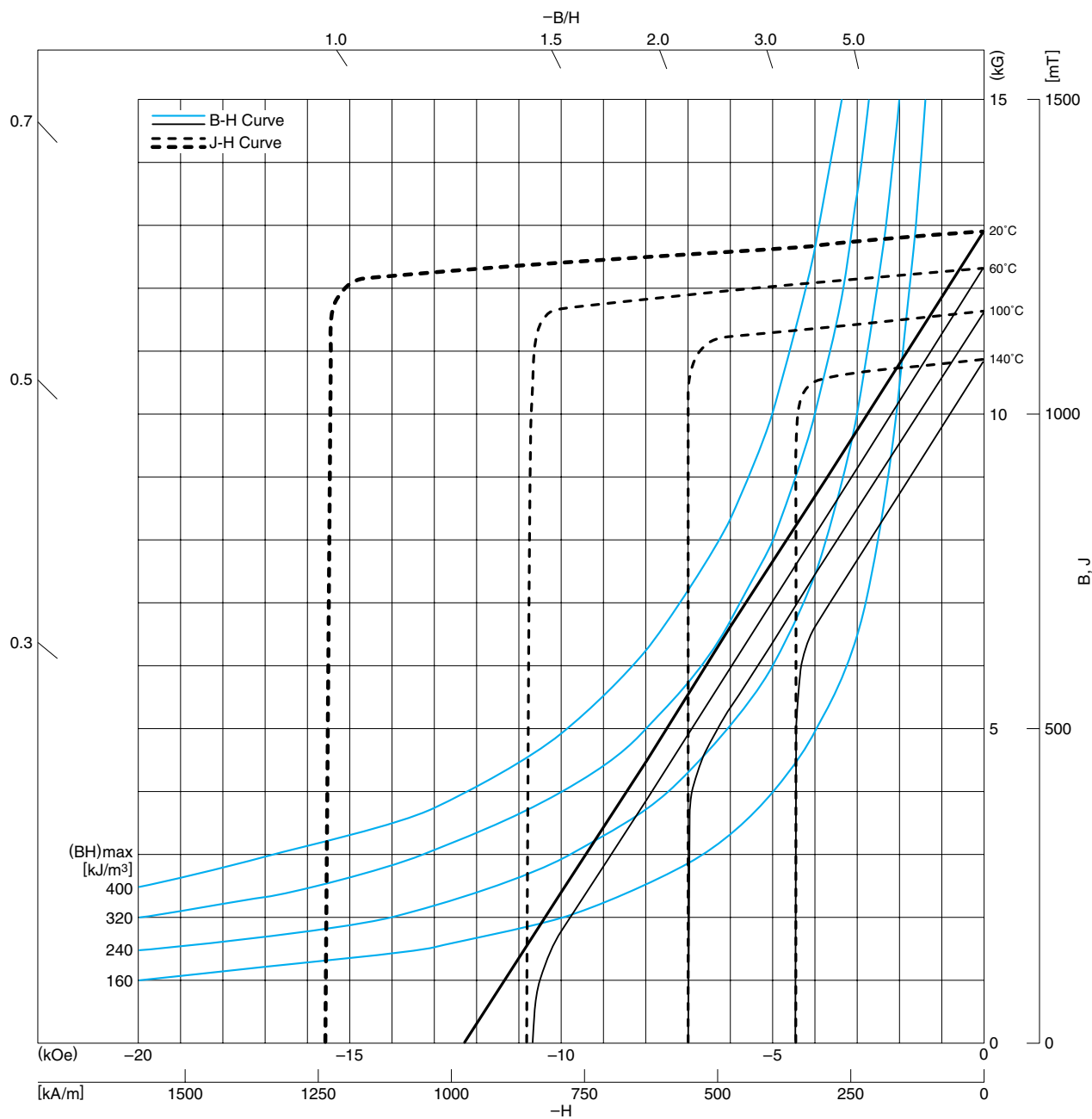


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1330±30
Br	(kG)	13.3±0.3
Coercive force	[kA/m]	987±56
H _{CB}	(kOe)	12.4±0.7
Intrinsic coercive force	[kA/m]	>1114
H _{CJ}	(kOe)	>14.0
Maximum energy product	[kJ/m ³]	334±16
(BH) _{max}	(MGOe)	42±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC40F
DEMAGNETIZATION CURVE

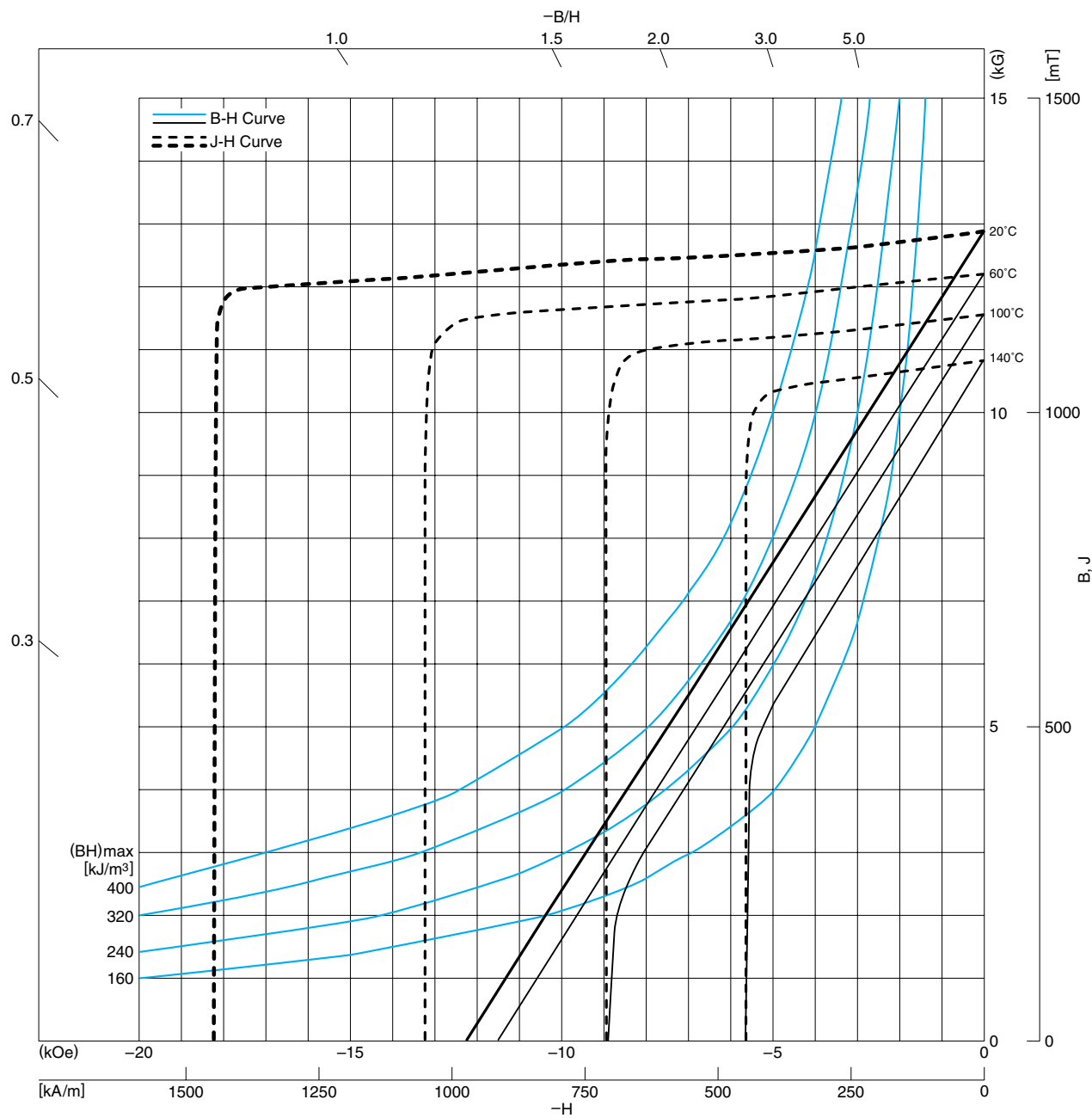


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1300±30
Br	(kG)	13.0±0.3
Coercive force	[kA/m]	963±56
H _{CB}	(kOe)	12.1±0.7
Intrinsic coercive force	[kA/m]	>1114
H _{CJ}	(kOe)	>14.0
Maximum energy product	[kJ/m³]	318±16
(BH) _{max}	(MGOe)	40±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC40H DEMAGNETIZATION CURVE

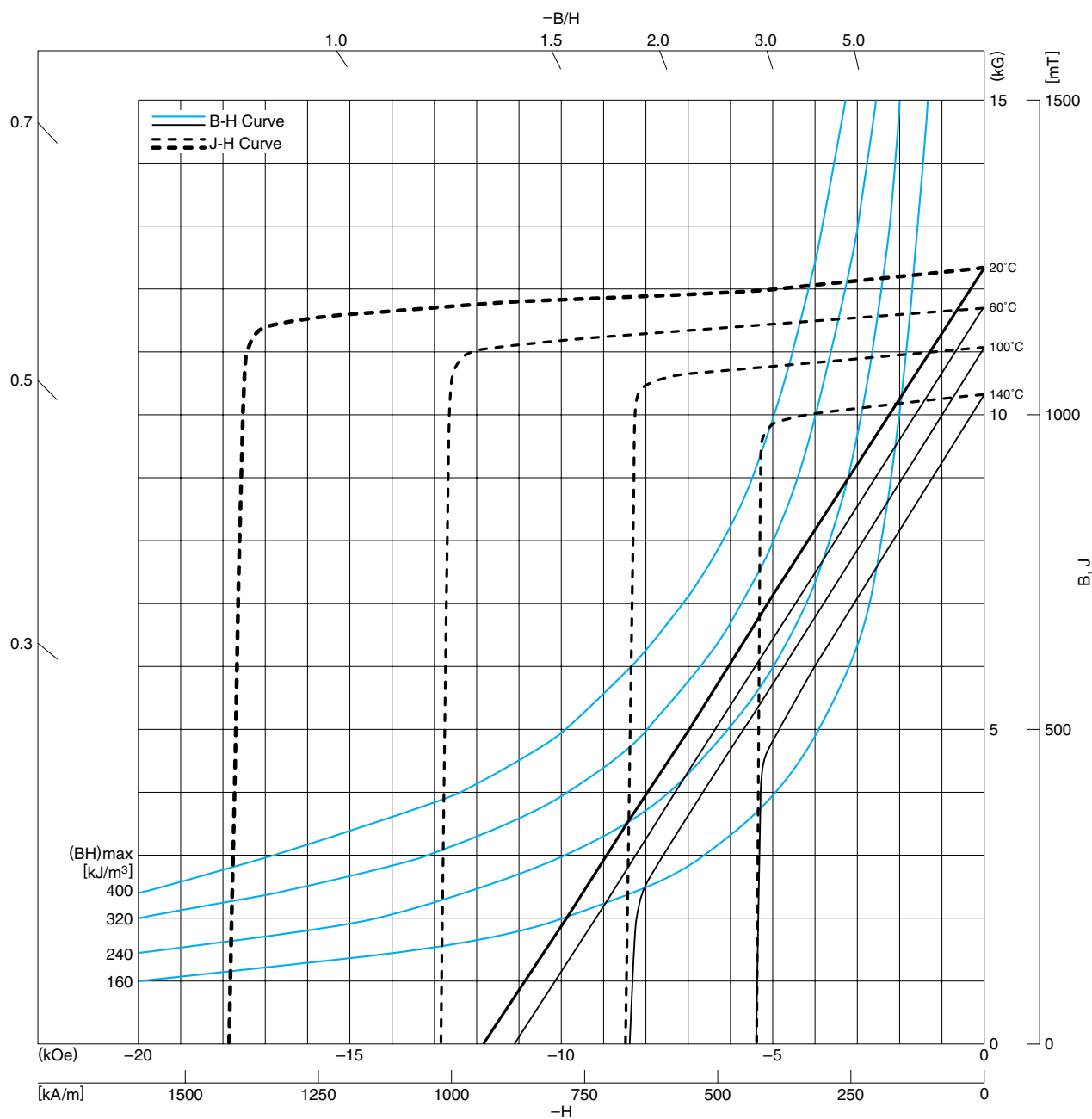


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1300±30
Br	(kG)	13.0±0.3
Coercive force	[kA/m]	971±56
H _{cb}	(kOe)	12.2±0.7
Intrinsic coercive force	[kA/m]	>1353
H _{cj}	(kOe)	>17.0
Maximum energy product	[kJ/m³]	318±16
(BH) _{max}	(MGOe)	40±2

• []: in the unit of SI
 (): in the unit of CGS

NEOREC37H
DEMAGNETIZATION CURVE

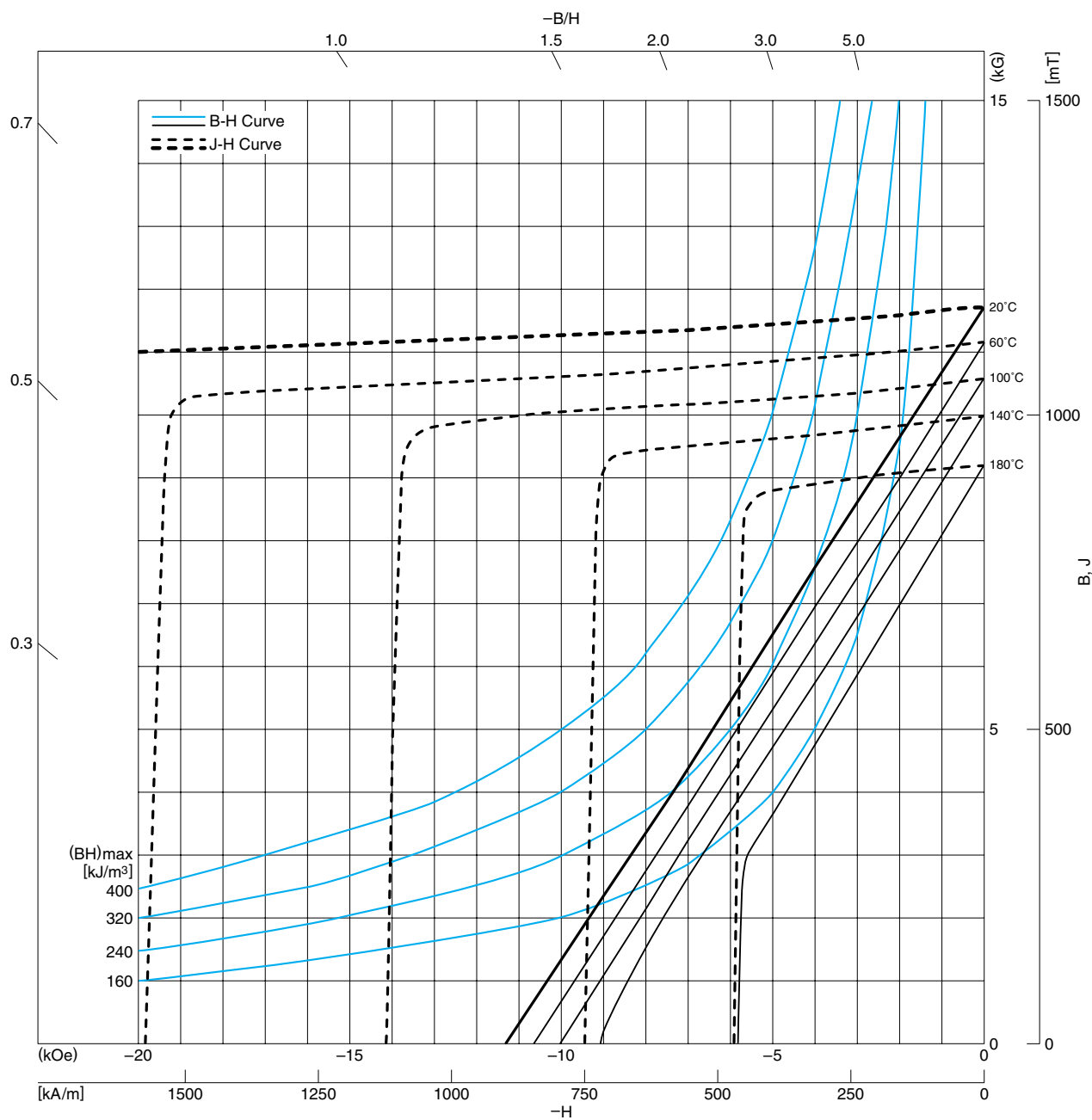


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1240±30
Br	(kG)	12.4±0.3
Coercive force	[kA/m]	923±56
H _{CB}	(kOe)	11.6±0.7
Intrinsic coercive force	[kA/m]	>1353
H _{CJ}	(kOe)	>17.0
Maximum energy product	[kJ/m³]	294±16
(BH) _{max}	(MGOe)	37±2

• []: in the unit of SI
(): in the unit of CGS

NEOREC34SH DEMAGNETIZATION CURVE

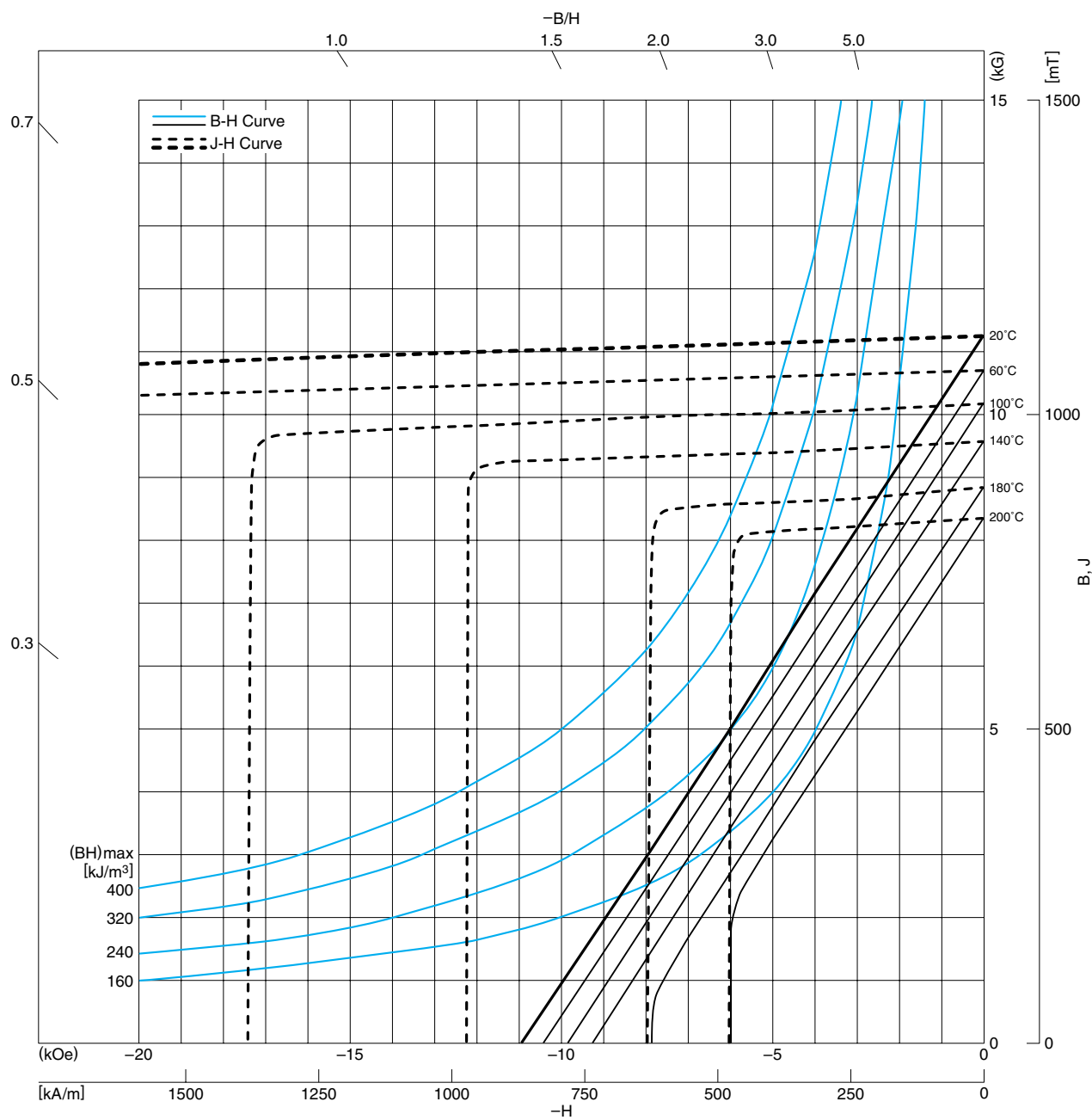


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1180±30
Br	(kG)	11.8±0.3
Coercive force	[kA/m]	876±56
H _{CB}	(kOe)	11.0±0.7
Intrinsic coercive force	[kA/m]	>1671
H _{CJ}	(kOe)	>21.0
Maximum energy product	[kJ/m³]	271±16
(BH)max	(MGOe)	34±2

• []: in the unit of SI
 (): in the unit of CGS

NEOREC31UH
DEMAGNETIZATION CURVE

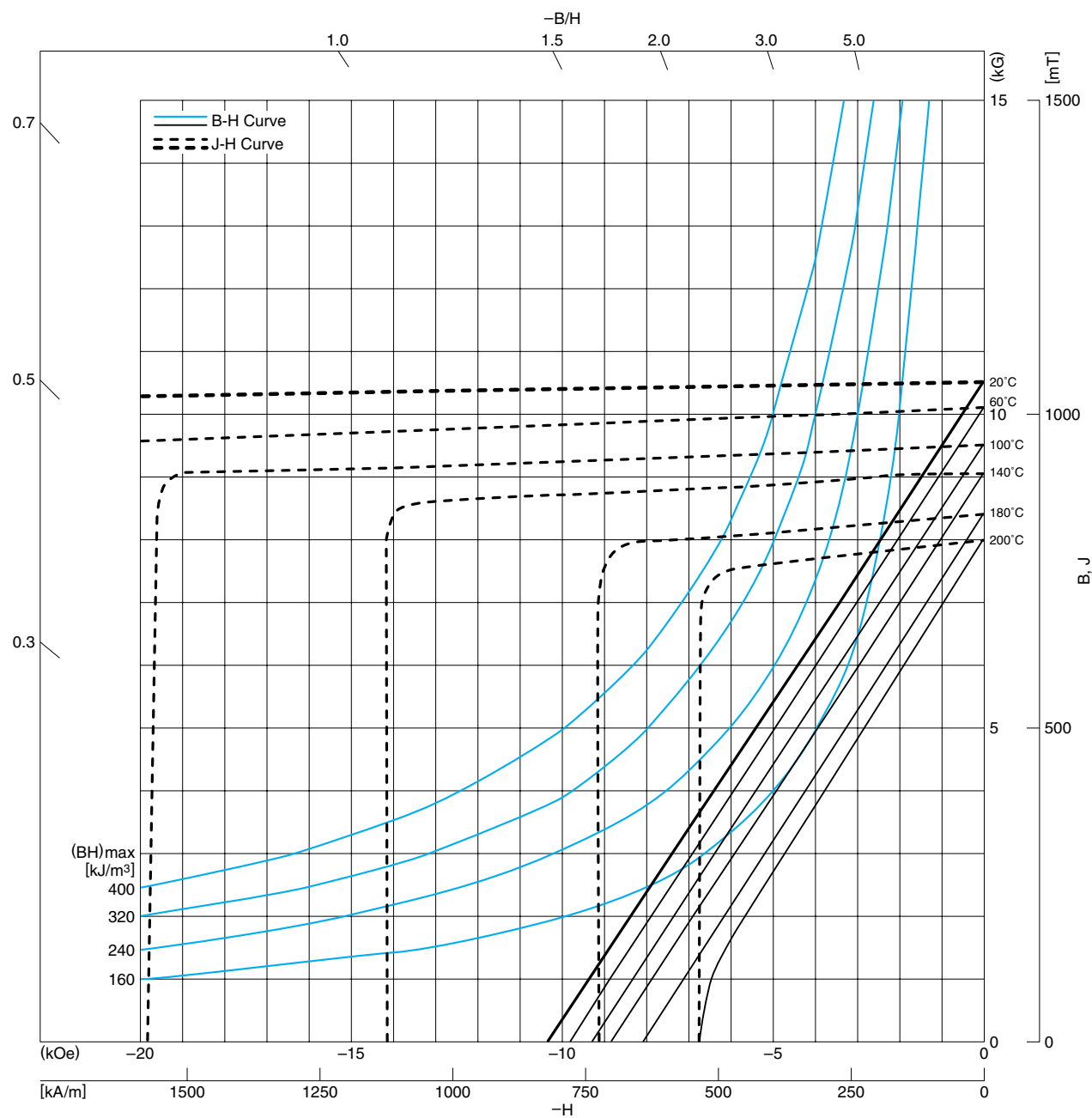


MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1120±30
Br	(kG)	11.2±0.3
Coercive force	[kA/m]	867±48
H _{CB}	(kOe)	10.9±0.6
Intrinsic coercive force	[kA/m]	>1990
H _{CJ}	(kOe)	>25.0
Maximum energy product	[kJ/m³]	239±24
(BH) _{max}	(MGOe)	30±3

• []: in the unit of SI
(): in the unit of CGS

NEOREC27UX
DEMAGNETIZATION CURVE



MAGNETIC CHARACTERISTICS

Residual flux density	[mT]	1080±30
Br	(kG)	10.8±0.3
Coercive force	[kA/m]	819±56
H _{CB}	(kOe)	10.4±0.7
Intrinsic coercive force	[kA/m]	>2388
H _{CJ}	(kOe)	>30.0
Maximum energy product	[kJ/m³]	223±16
(BH) _{max}	(MGOe)	28±2

• []: in the unit of SI
(): in the unit of CGS