KOERDYM™ I & C

Injection Molded NdFeB & Compression Molded NdFeB

PLASTIC-BONDED PERMANENT MAGNETS KOERDYM

range of (BH)max values from approx. 32 to 86 kJ/m³. The manufacturing methods used eliminate the need for machining and permit the production of close-toleranced ready-to-install parts. In addition, injection molding makes it possible to connect the magnets directly to shafts or other components. Diverse shaping possibilities combined with insert and composite techniques and the typical toughness of plastics allow the production of complex magnets offering new and cost-effective solutions in design and manufacture.

NdFeB-based plastic-bonded isotropic permanent magnets from KOLEKTOR MAGNET TECHNOLOGY GmbH are supplied under the names Koerdym I (injection molded) and Koerdym C (compression molded), see Koerdym I & C Data table. Their special features are high magnetic flux density, good magnetic and thermal stability, wide shaping possibilities with close tolerances even on thin-walled parts, good mechanical properties and high edge strength.

PLASTIC-BONDED NdFeB MATERIALS, COMPRESSION MOLDED AND INJECTION MOLDED

Plastic-bonded neodymium-iron-boron (NdFeB) is a magnetic material that still fascinates today, many years after its introduction to the market. Depending on binder, (BH)max values of between 32 and 86 kJ/m³ can be achieved, combined with wide possibilities of shaping through plastic bonding.

Due to the technology of rapid solidification this material is not oriented, but its isotropy offers advantages over oriented, sintered, hard-ferrite, particularly in multi-pole magnetic configurations.

Compression-molded, epoxy resin-bonded NdFeB is generally used in drive and generator applications where the active mechanism is linearly dependent on the remanence of the material; in miniaturized sensors; and in applications where NdFeB systems offer advantages over hard ferrite.

Through the use of different powders, magnets can be tailored to application in terms of very high remanence, thermal stability (e.g. Koerdym C 63 EP) or improved reversible temperature coefficients.

Koerdym C 86 EP offers very high (BH)max values and can be used at temperatures up to approx. 120°C depending on operating conditions. The high-coercivity grade Koerdym C 61 EP can be used at temperatures as high as 160°C and is a good choice for use in servomotors.

Regarding the range of shapes that can be produced, the same limitations apply as in powder metallurgy. Factors to be observed in design are maximum press force, overall height, wall thickness ratios and contours in mould size. Wall thicknesses as low as 0.8 mm can be achieved, while magnet heights up to 40 mm are possible. Attainable tolerances in mould size are 0.05-0.2 mm and in molding direction around ±0.2 mm.

Due to the high fill of magnet powder (approx. 80% by volume) and the nature of the binder, joining and assembly methods are limited to adhesive bonding or additional molding in general. Interference fits are not possible without supporting fillers.

Injection molded Koerdym I magnets offer greater freedom as regards both shape variety and joining methods. Although allowance has to be made for the fact that they cannot match the mechanical strength properties of corresponding ferrite magnets due to the grain size distribution of the NdFeB powders, they allow a wide range of further-processing techniques, which can be decisive in terms of competitiveness. Koerdym I 42 PA has been established in miniaturized dives (e.g. indicating instruments in cars and industrial stepper motors) and in various sensor applications for many years. When specific demands are made on temperature stability and minimum reversible or irreversible temperature dependence, optimized solutions can be achieved through appropriate selection of binders or magnet powders (PPS, Koerdym I 43 PA).

As Koerdym does not require orientation/magnetization in the shaping process, the customer should generally carry out this operation during further processing. Saturation and precision of magnetization (pole widths, pole steepnesses, etc.) will then be dependent on the quality of the magnetizing unit. In such cases, users are

FIGURE 1: COMPRESSION MOLDED PARTS

FIGURE 2: SPECIAL SHAPES PRODUCED BY COMPRESSION MOLDING

FIGURE 3: INJECTION MOLDED PARTS

FIGURE 4: COMPRESSION MOLDED PARTS

advised to liaise closely with the manufacturers in the sample-testing phase.

The need for coating to combat corrosion is governed by end-used criteria, especially relative humidity. Polyurethane and parylene coatings provide excellent chemical and thermal stability, but the extra cost involved has to be examined critically in the case of the miniature magnets. Figures 1-4 show various types of Koerdym I and Koerdym C magnets.

TEMPERATURE BEHAVIOR, AGING AND CHEMICAL STABILITY

In the design of magnetic systems critical operating and environmental conditions have to be taken into account which may have an effect on the magnetic, physical and chemical properties of the magnet.

The magnetic values presented and discussed so far are void at room temperature. Different temperatures result in different magnetic values, and both reversible and irreversible property changes can occur. In addition, the type and magnitude of these changes – and the maximum operating temperatures allowed for stability reasons – are material-dependent. Demagnetization curves for Koerdym C and Koerdym I at different temperatures follow.

The first step, therefore, is to consider the maximum temperature range to which the magnet will be exposed in the application. This will provide criteria for material selection and system design. If the shear condition of the magnet in the system is known, the allowable operating limit can be estimated from the demagnetization curves at higher/lower temperatures.

The reversible changes in intrinsic coercivity HcJ and in saturation polarization Js are approximately linear and are described by the temperature coefficients Tc(Br) and Tc(HcJ) (See Koerdym I and Koerdym C Data tables).

As with sintered NdFeB magnets, the upper operating temperature limit for plastic-bonded NdFeB magnets must always be considered very carefully, both temperature coefficients are negative.

As well as the reversible changes in magnetic values and the shear losses which occur with demagnetization curves with a μr value much greater than 1, irreversible long-term losses under high temperature loading have to be taken into account to achieve a stable system design. Chart 1 shows long-term aging up to 10,000 hours under various temperature and shear loads for different magnet grades. The flux of the magnet was measured at different times but always at room temperature after aging for a period indicated in the chart at the corresponding temperature (the L/D ratio of the specimen indicates the shear load).

If the magnet material comes into contact with certain media in the application, chemical stability under critical conditions must be examined by means of aging tests. For applications involving high humidity or condensation, coatings of polyurethane or parylene offer good corrosion protection, but such coatings usually prove a considerable cost factor, particularly in the case of miniature magnets.

KOLEKTOR

KOLEKTOR MAGNET TECHNOLOGY

KOERDYM™ I

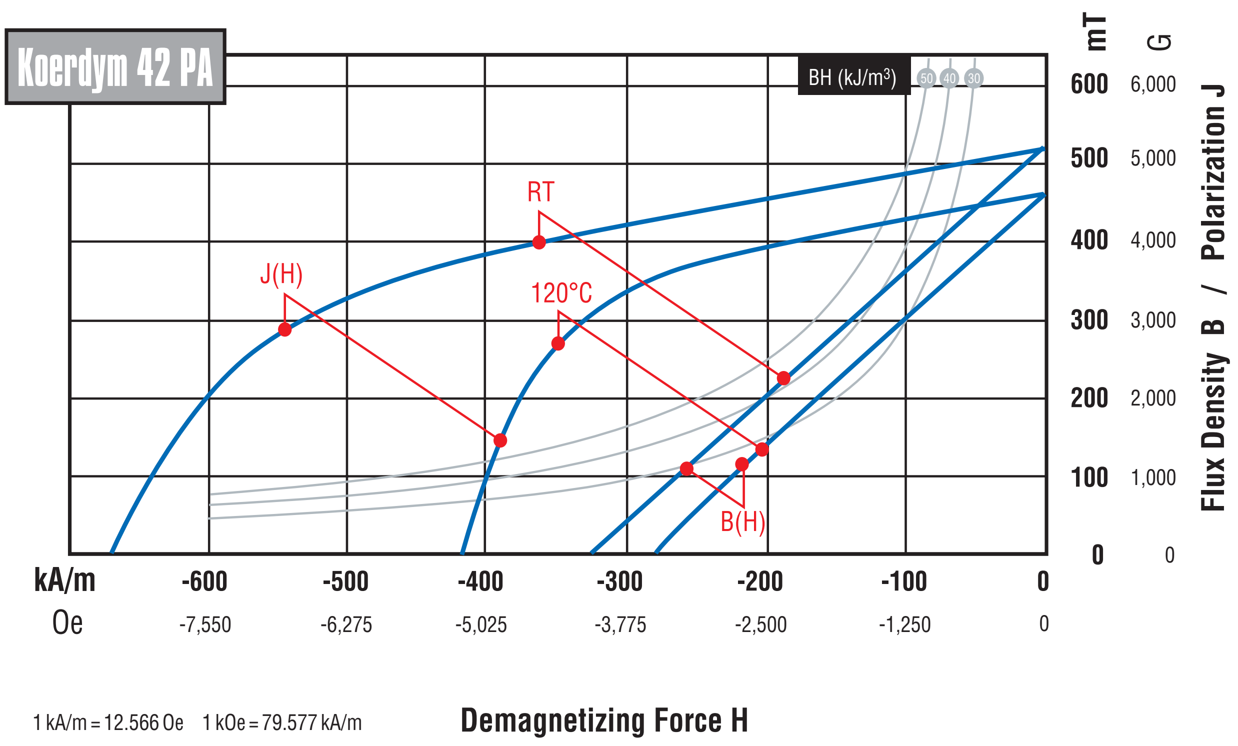
Injection Molded NdFeB

Product 1)	(BH)max kJ/m³ typ.	(BH)max kJ/m³ min	(BH)max MGOe typ.	(BH)max MGOe min.	Br mT typ.	Br mT min.	Br G typ.	Br G min.	H_{cB} kA/m typ.	H_{cB} kA/m min.	H_{cB} Oe typ.	H_{cB} Oe min.	Intrinsic Coercivity H_{cJ} kA/m typ.	Intrinsic Coercivity H_{cJ} kA/m min.	Intrinsic Coercivity H_{cJ} Oe typ.	Intrinsic Coercivity H_{cJ} Oe min.	Relative Permeability typ.	Density g/cm³ typ.	Required Magnetic Field kA/m min.	Temperature Coefficient α (20-100 °C) %/K typ.	Temperature Coefficient β (20-100 °C) %/K typ.
Koerdym I 47PA (44/49)	47.0	44.0	5.91	5.53	550	520	5500	5200	330	290	4021	3644	550	490	6912	6158	1.25	4.9	1600	–0.11	–0.40
Koerdym I 43PA (40/66)	43.0	40.0	5.40	5.03	520	480	5200	4800	330	300	4147	3770	760	700	9550	8796	1.17	4.9	2000	–0.08	–0.40
Koerdym I 42PA (40/62)	42.0	40.0	5.28	5.03	520	490	5200	4900	320	300	4021	3770	650	610	8168	7666	1.19	4.9	1600	–0.11	–0.40
Koerdym I 39PA (37/55)	39.0	37.0	4.90	4.65	480	460	4800	4600	310	280	3896	3519	590	550	7414	6912	1.20	4.9	1600	–0.12	–0.40
Koerdym I 38PA (34/90)	38.0	34.0	4.78	4.27	490	460	4600	4600	320	300	4021	3770	1000	920	12566	11561	1.18	4.9	2000	–0.12	–0.38
Koerdym I 35PA (39/62)	35.0	30.0	4.40	3.77	480	450	4800	4500	300	280	3770	3519	650	610	8168	7666	1.20	4.6	1600	–0.11	–0.41
Koerdym I 32PA (28/90)	32.0	28.0	4.02	3.52	450	420	4500	4200	300	280	3770	3519	1000	920	12566	11561	1.19	4.6	2000	–0.12	–0.38

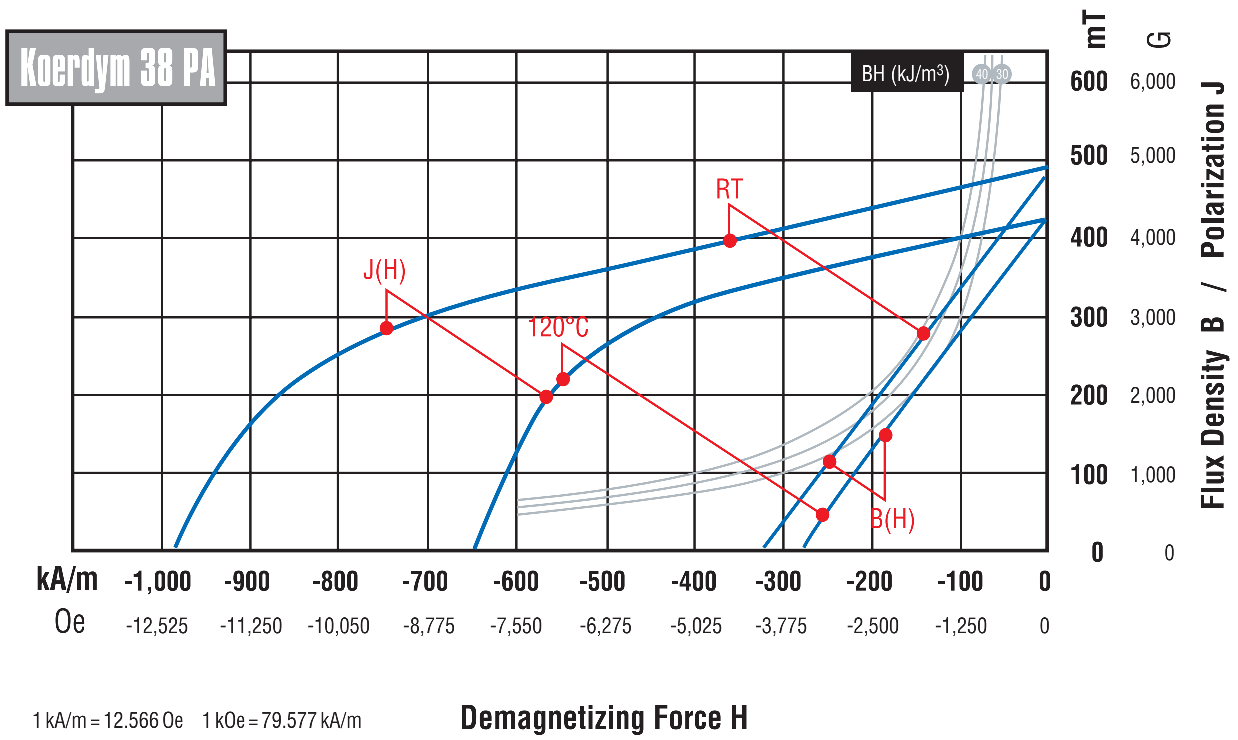
1) Required Magnetic field — Values are dependent on size, shape and characteristics of the magnetizing pulse

Temperature Behavior & Aging

Demagnetization curves J(H) and B(H) at room temperature (RT) and 120°C

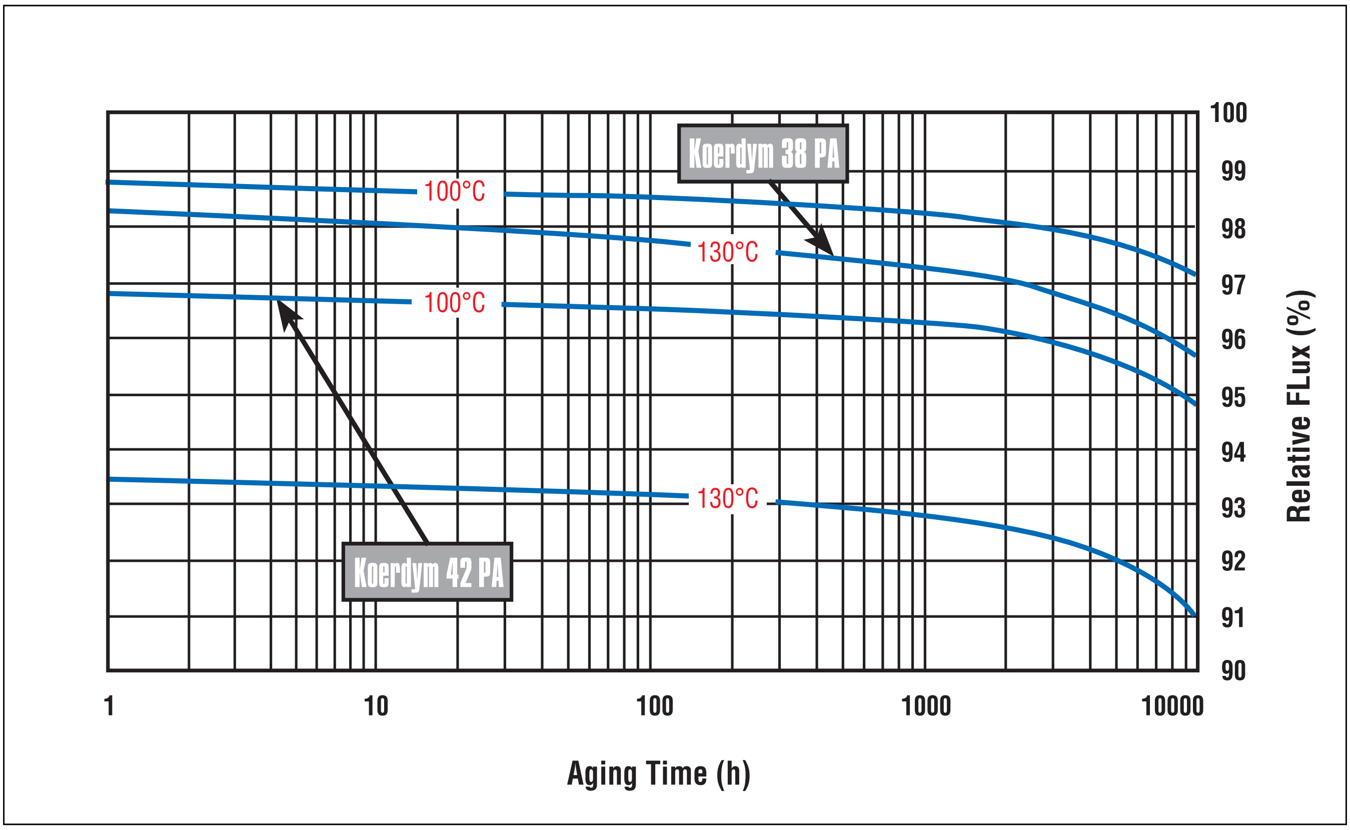


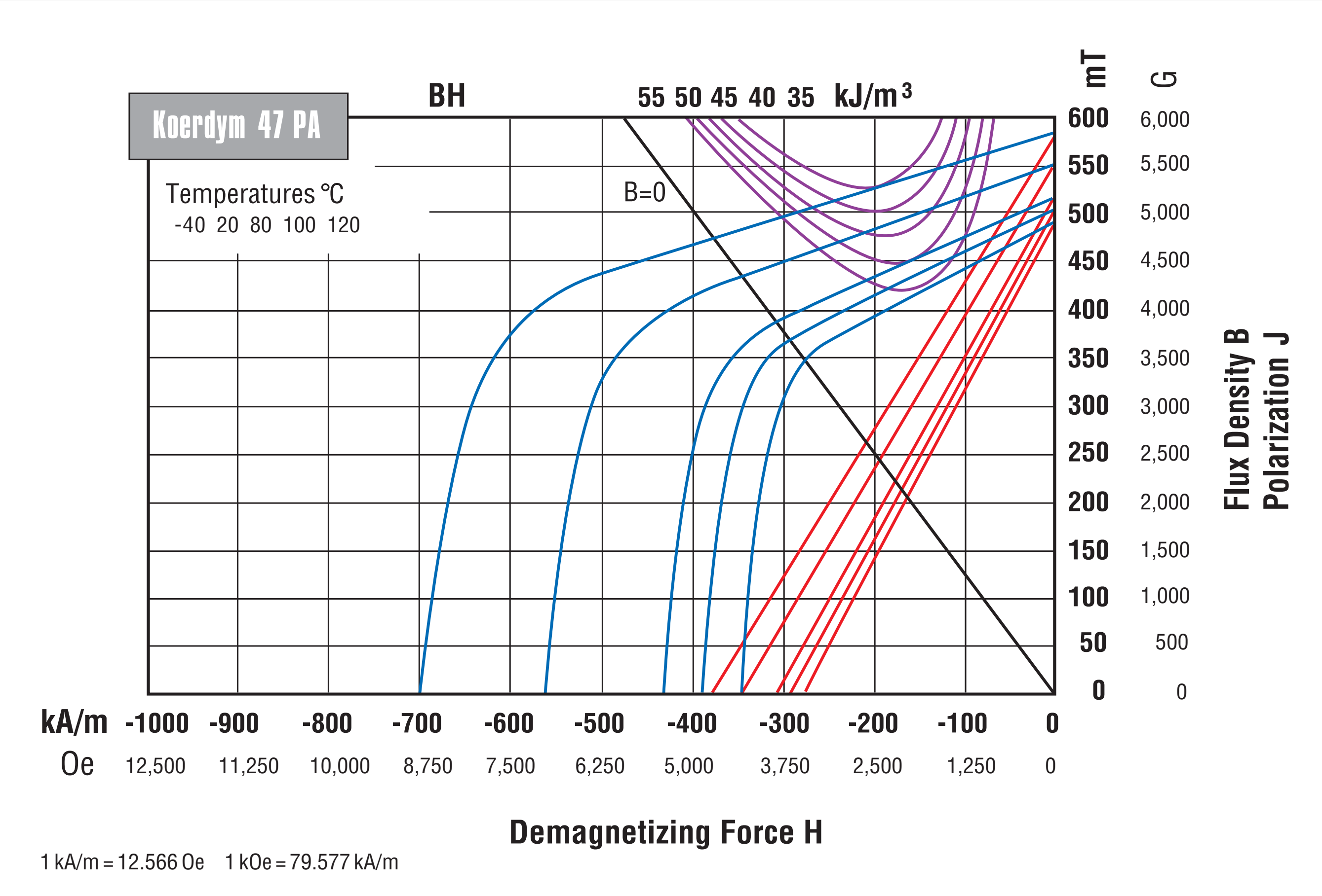
Demagnetization curves J(H) and B(H) at room temperature (RT) and 120°C

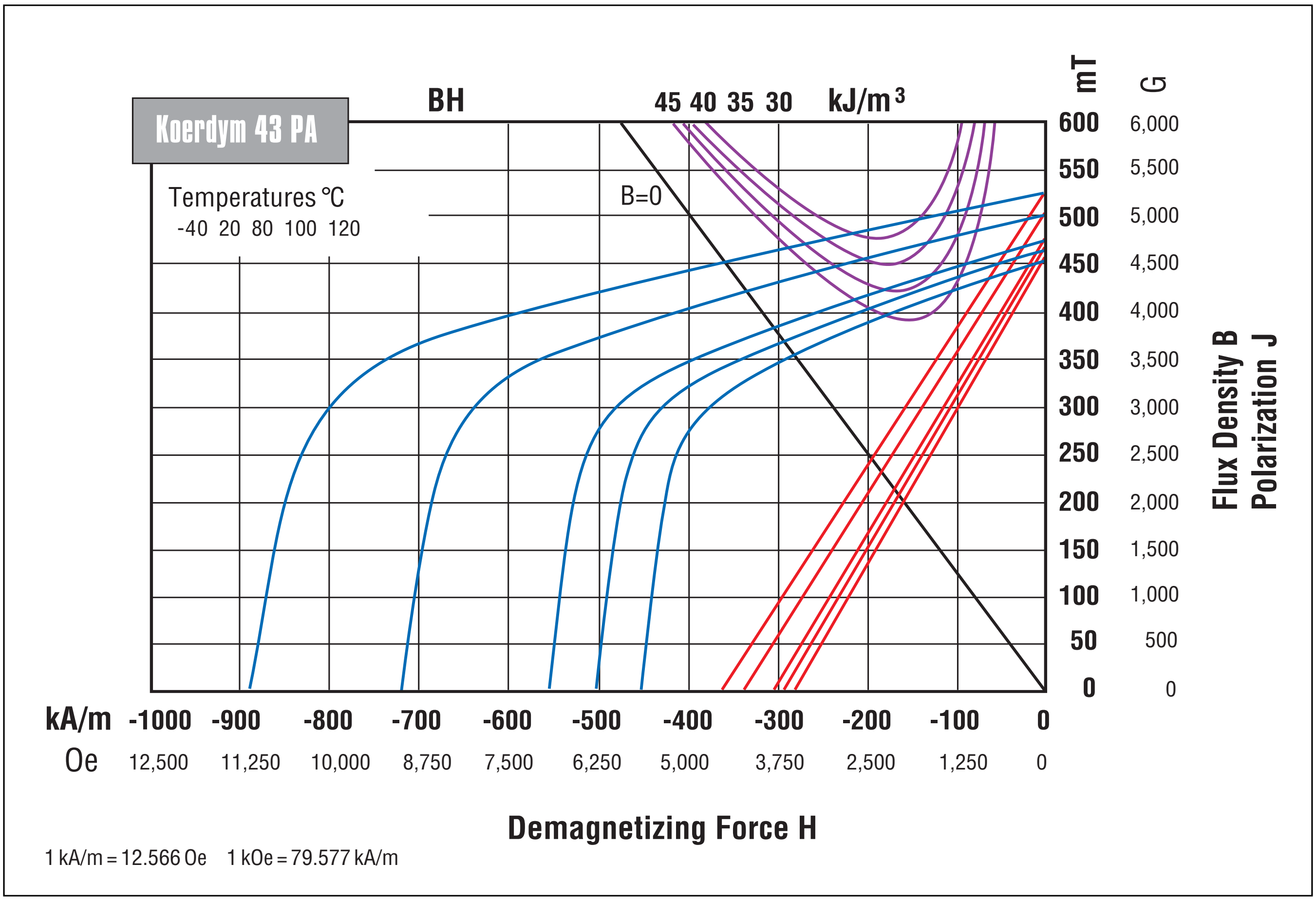


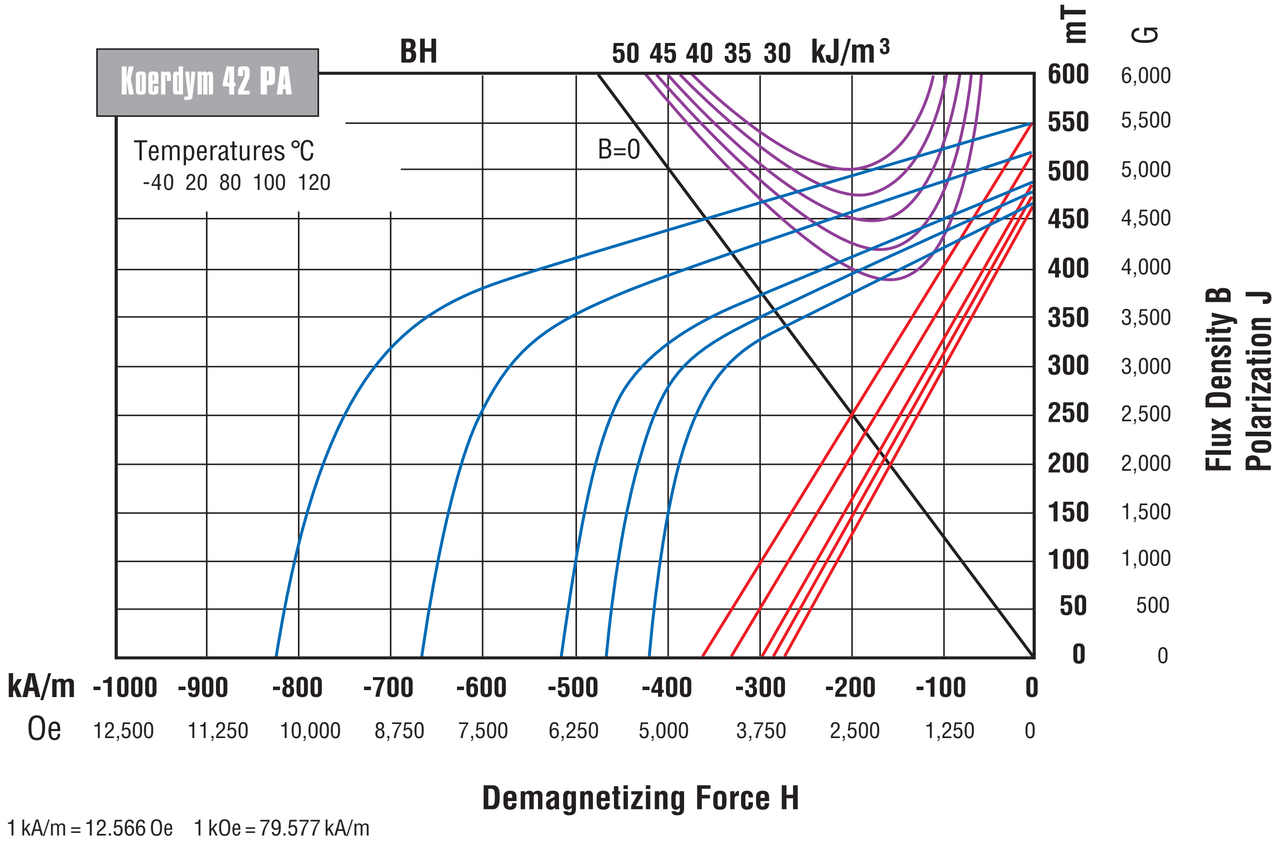
Temperature Behavior & Aging

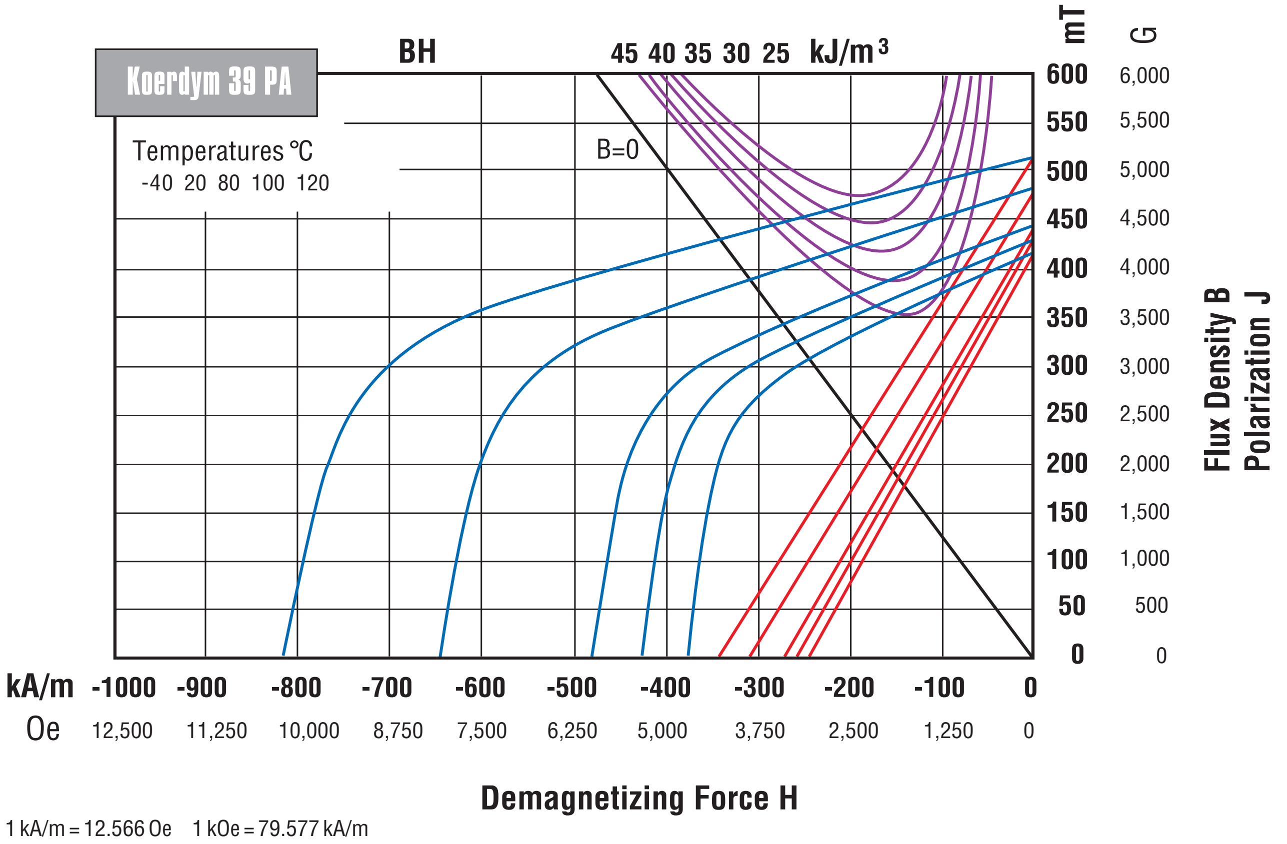
Chart 1: Thermal Aging (Aging Temperature = 100°C / 130°C; L/D = 0.6)

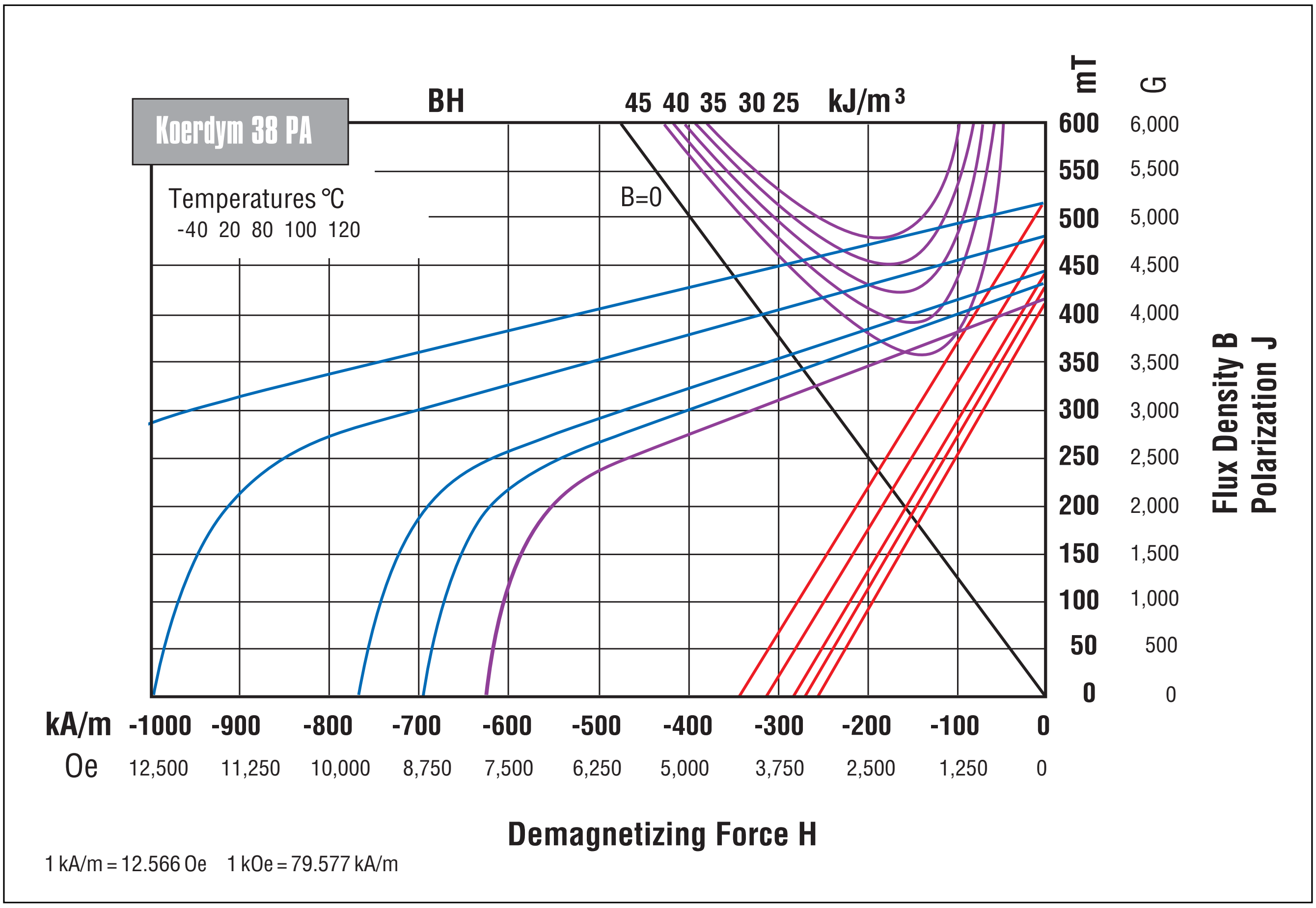


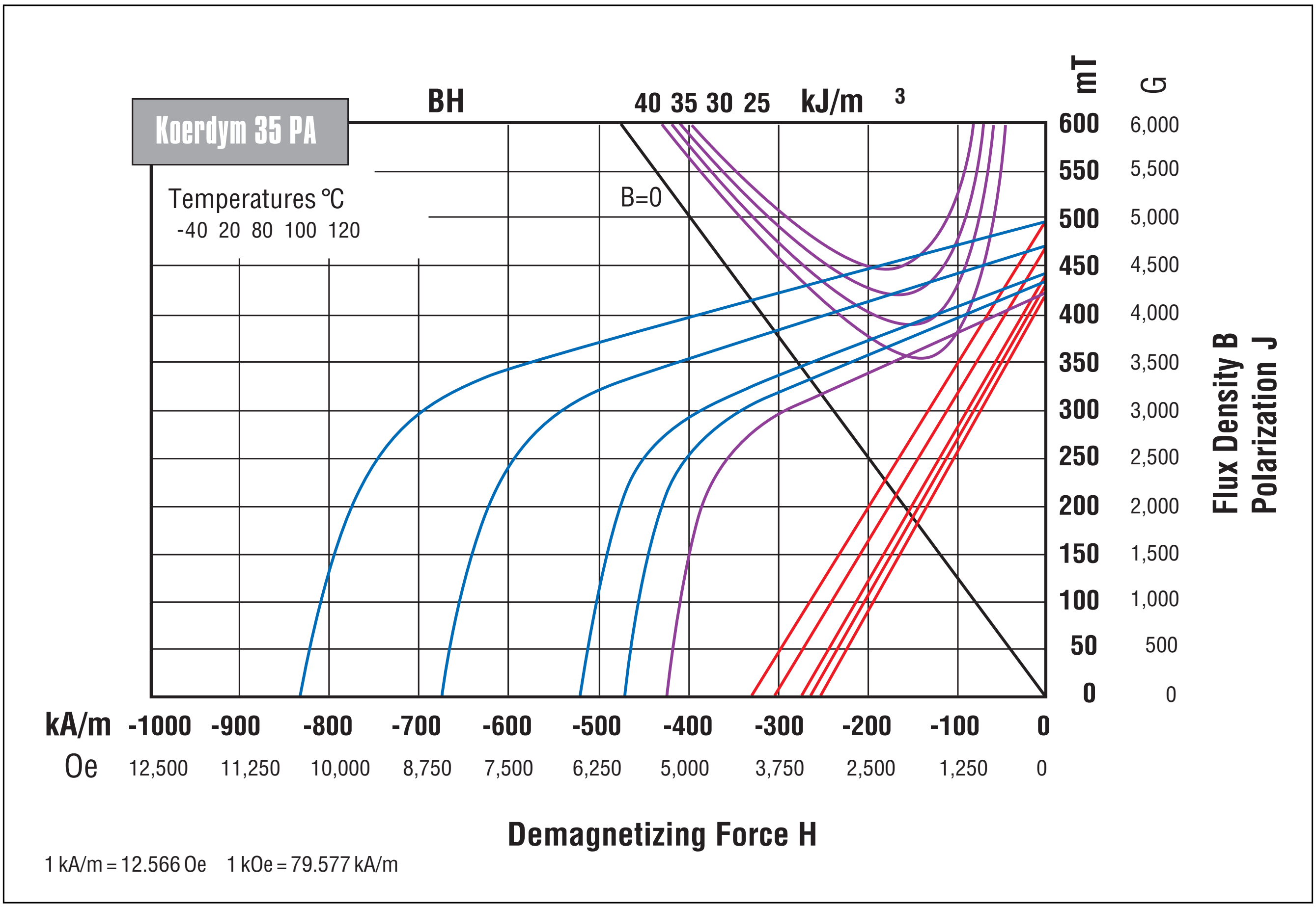

Koerdym 47 PA
BH
55 50 45 40 35 kJ/m³
Temperatures °C
-40 20 80 100 120
B=0
mT
G
600 6,000
550 5,500
500 5,000
450 4,500
400 4,000
350 3,500
300 3,000
250 2,500
200 2,000
150 1,500
100 1,000
50 500
0 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m

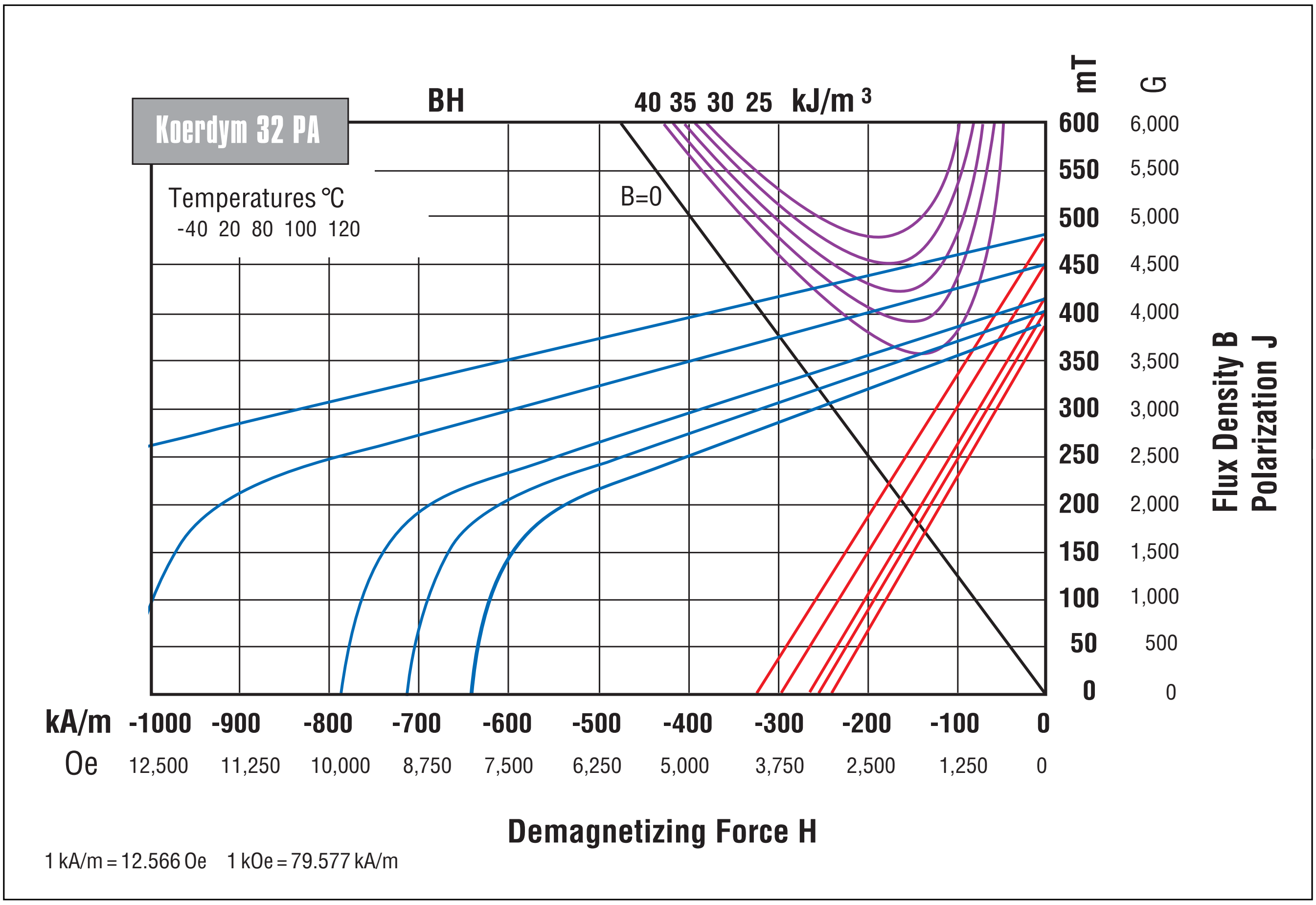

Koerdym 43 PA
BH
45 40 35 30 kJ/m³
Temperatures °C
-40 20 80 100 120
B=0
mT
G
600 6,000
550 5,500
500 5,000
450 4,500
400 4,000
350 3,500
300 3,000
250 2,500
200 2,000
150 1,500
100 1,000
50 500
0 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m


Koerdym 42 PA
BH
50 45 40 35 30 kJ/m³
mT
G
Temperatures °C
-40 20 80 100 120
B=0
600 550 500 450 400 350 300 250 200 150 100 50 0
6,000 5,500 5,000 4,500 4,000 3,500 3,000 2,500 2,000 1,500 1,000 500 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m


Koerdym 39 PA
BH
45 40 35 30 25 kJ/m³
mT
G
Temperatures °C
-40 20 80 100 120
B=0
600 550 500 450 400 350 300 250 200 150 100 50 0
6,000 5,500 5,000 4,500 4,000 3,500 3,000 2,500 2,000 1,500 1,000 500 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m


Koerdym 38 PA
Temperatures °C
-40 20 80 100 120
BH
45 40 35 30 25 kJ/m³
B=0
mT
G
600 550 500 450 400 350 300 250 200 150 100 50 0
6,000 5,500 5,000 4,500 4,000 3,500 3,000 2,500 2,000 1,500 1,000 500 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m


Koerdym 35 PA
Temperatures °C
-40 20 80 100 120
BH
40 35 30 25 kJ/m 3
B=0
mT
G
600 550 500 450 400 350 300 250 200 150 100 50 0
6,000 5,500 5,000 4,500 4,000 3,500 3,000 2,500 2,000 1,500 1,000 500 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m


Koerdym 32 PA
BH
40 35 30 25 kJ/m 3
Temperatures °C
-40 20 80 100 120
B=0
mT
G
600 550 500 450 400 350 300 250 200 150 100 50 0
6,000 5,500 5,000 4,500 4,000 3,500 3,000 2,500 2,000 1,500 1,000 500 0
Flux Density B
Polarization J
kA/m -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0
Oe 12,500 11,250 10,000 8,750 7,500 6,250 5,000 3,750 2,500 1,250 0
Demagnetizing Force H
1 kA/m = 12.566 Oe 1 kOe = 79.577 kA/m

KOLEKTOR

KOLEKTOR MAGNET TECHNOLOGY

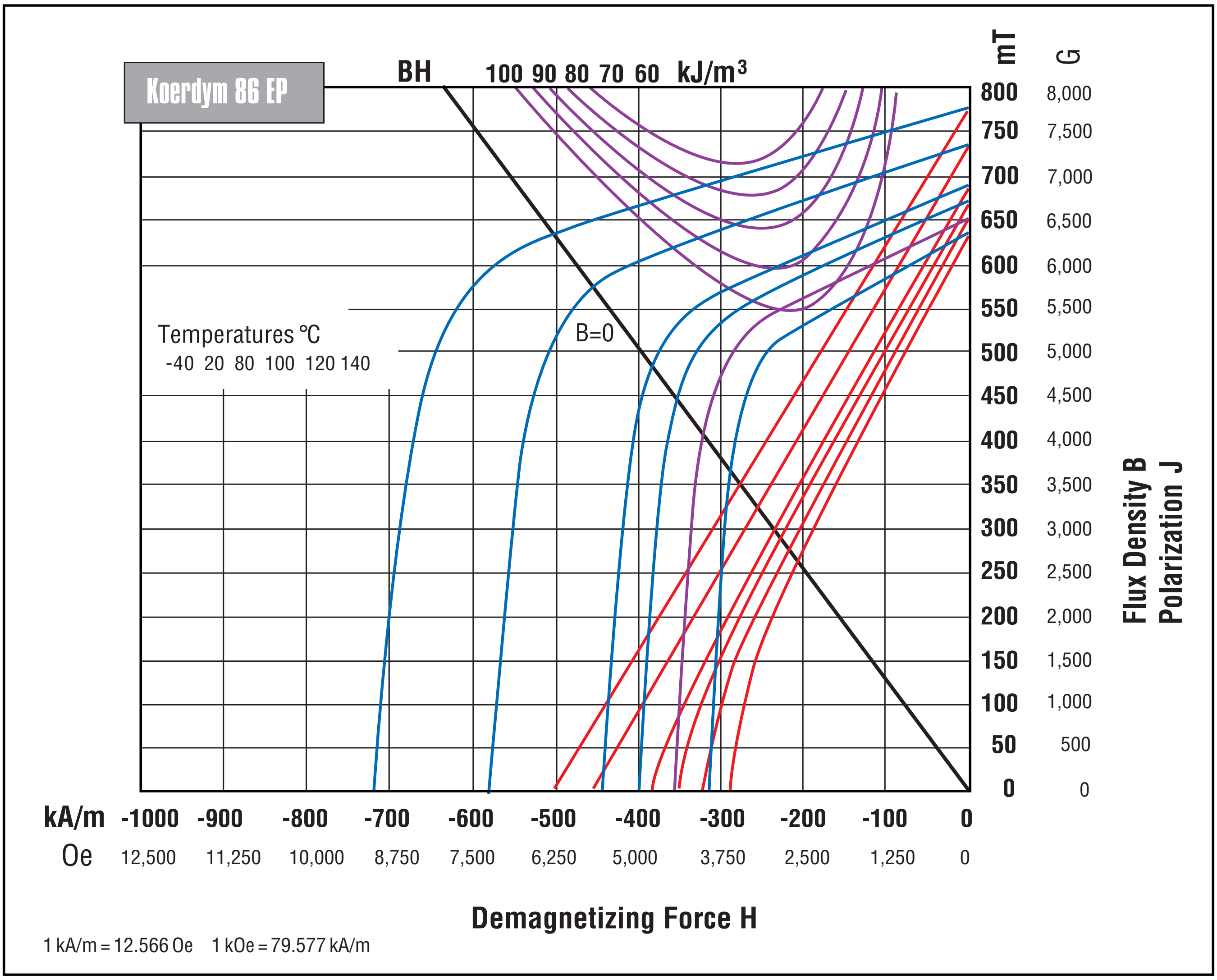
KOERDYM™ C

Compression Molded NdFeB

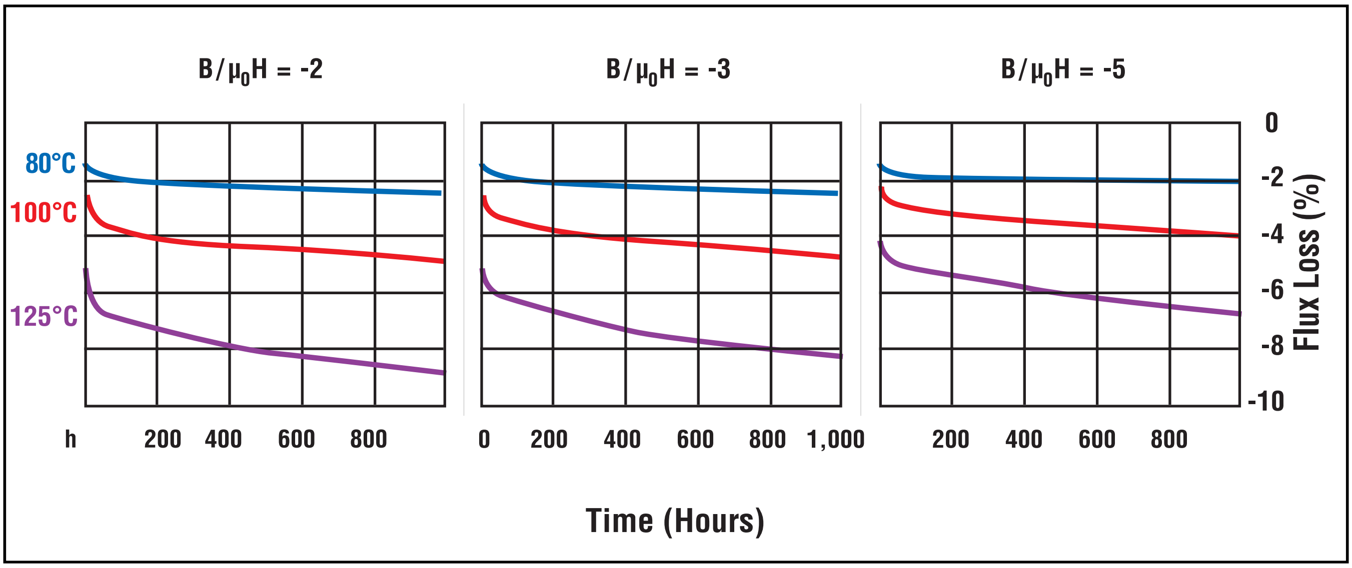
Product 1)	(BH)max kJ/m³ typ.	(BH)max kJ/m³ min	(BH)max MGOe typ.	(BH)max MGOe min.	Br mT typ.	Br mT min.	Br G typ.	Br G min.	HcB kA/m typ.	HcB kA/m min.	HcB Oe typ.	HcB Oe min.	Intrinsic Coercivity HcJ kA/m typ.	Intrinsic Coercivity HcJ kA/m min.	Intrinsic Coercivity HcJ Oe typ.	Intrinsic Coercivity HcJ Oe min.	Relative Permeability typ.	Required Magnetic Field kA/m min.	Temperature Coefficiant Tc/Br) (20-100 °C) %/K typ.	Temperature Coefficiant Tc/HcJ) (20-100 °C) %/K typ.	Maximum Operating Temperature °C
Koerdym C 86EP	86	79	10.8	9.9	730	680	7300	6800	430	380	5404	4775	560	490	7037	6158	1.29	1600	–0.11	-0.40	120
Koerdym C 83EP	83	77	10.4	9.7	695	670	6950	6700	440	390	5529	4901	760	710	9550	8932	1.19	2000	–0.08	-0.40	120
Koerdym C 80EP	80	75	10.0	9.4	700	670	7000	6700	440	390	5529	4901	680	620	8545	7791	1.22	1600	–0.11	-0.40	120
Koerdym C 68EP	68	62	8.5	7.8	640	610	6400	6100	400	360	5027	4524	670	620	8419	7791	1.22	1600	–0.12	-0.43	130
Koerdym C 64EP	64	58	8.0	7.3	630	580	6300	5900	430	390	5404	4901	1030	910	12943	11435	1.19	2000	–0.12	-0.40	130
Koerdym C 63EP	63	56	7.9	7.0	630	580	6300	5800	420	390	5278	4901	950	860	11938	10807	1.17	1600	–0.13	-0.38	150
Koerdym C 61EP	61	55	7.7	6.9	620	570	6200	5700	430	390	5404	4901	1120	960	14074	12315	1.18	2000	–0.07	-0.42	160

Required Magnetic Field – Values are dependent on size, shape and characteristics of the magnetizing pulse
Maximum Operating Temperature – In the presence of strong demagnetizing fields, or if the magnets operate on a low loadline, the maximum temperature may be lower

Demagnetization Curves



Total Flux Loss vs. Time (different Temperatures)



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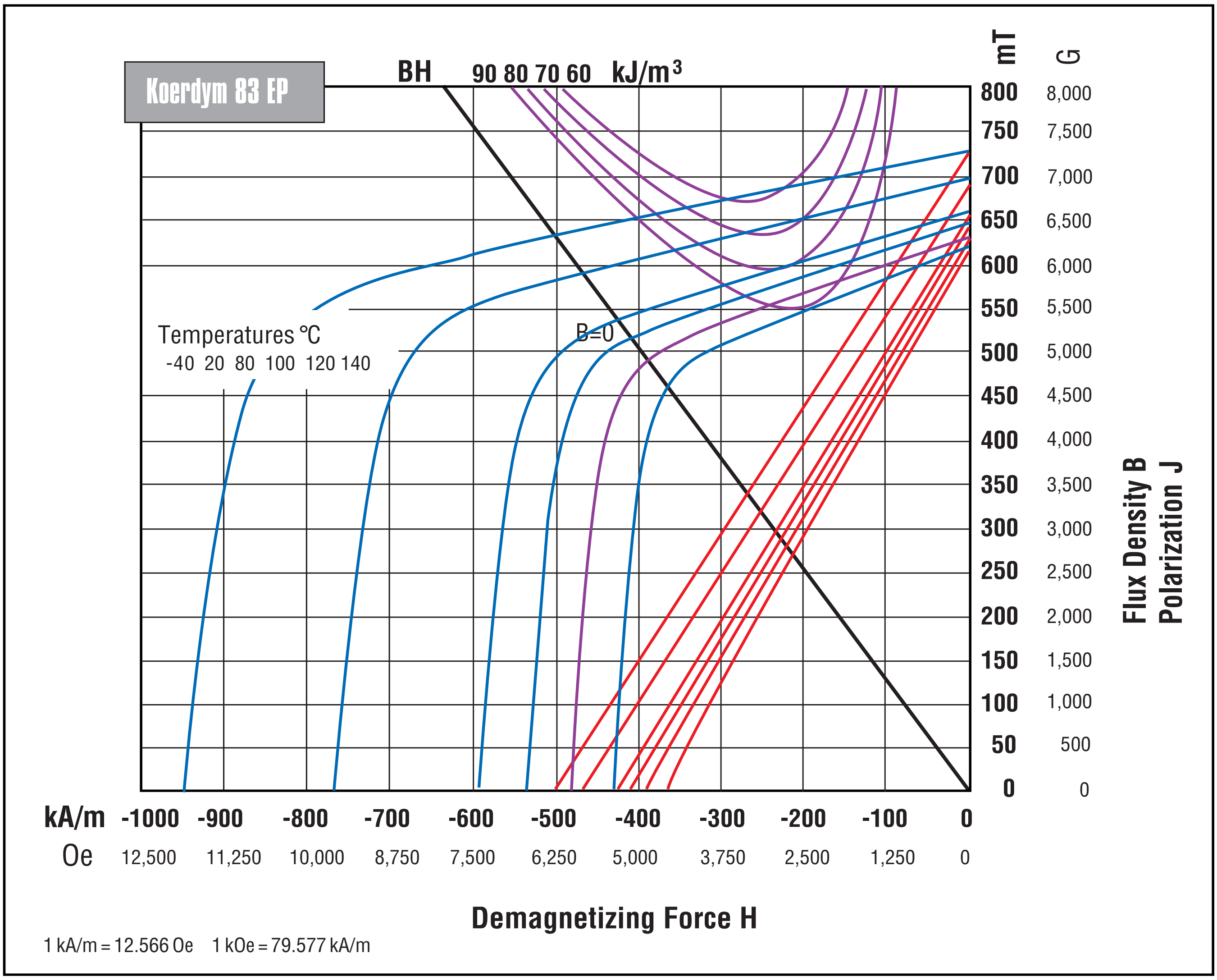

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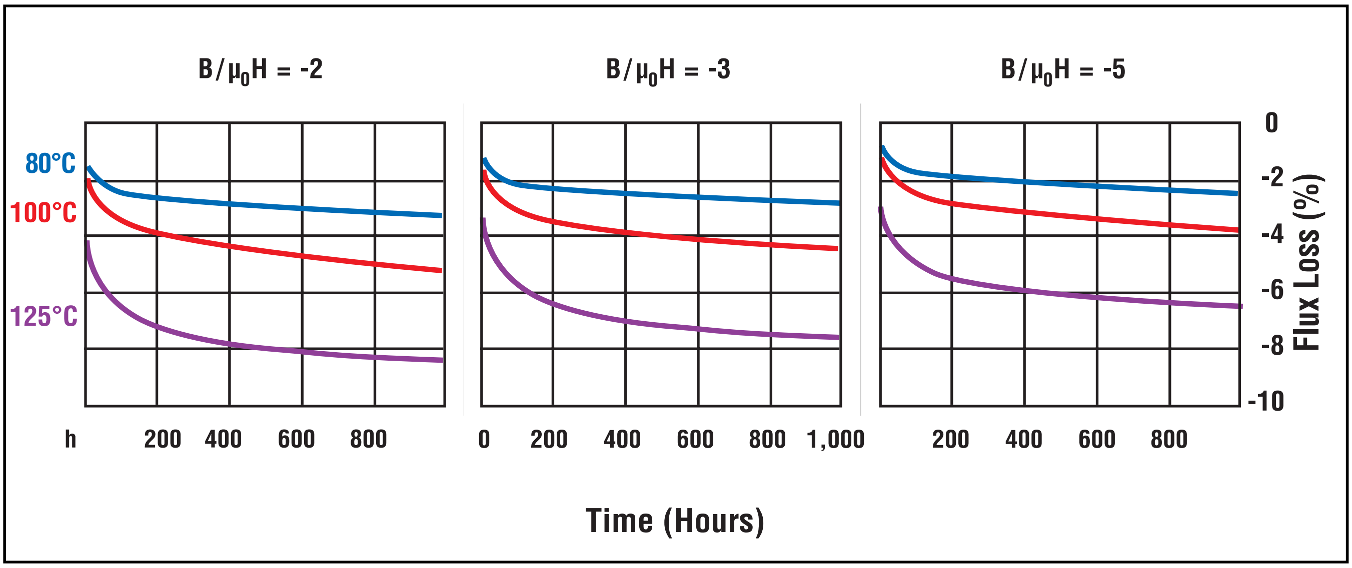

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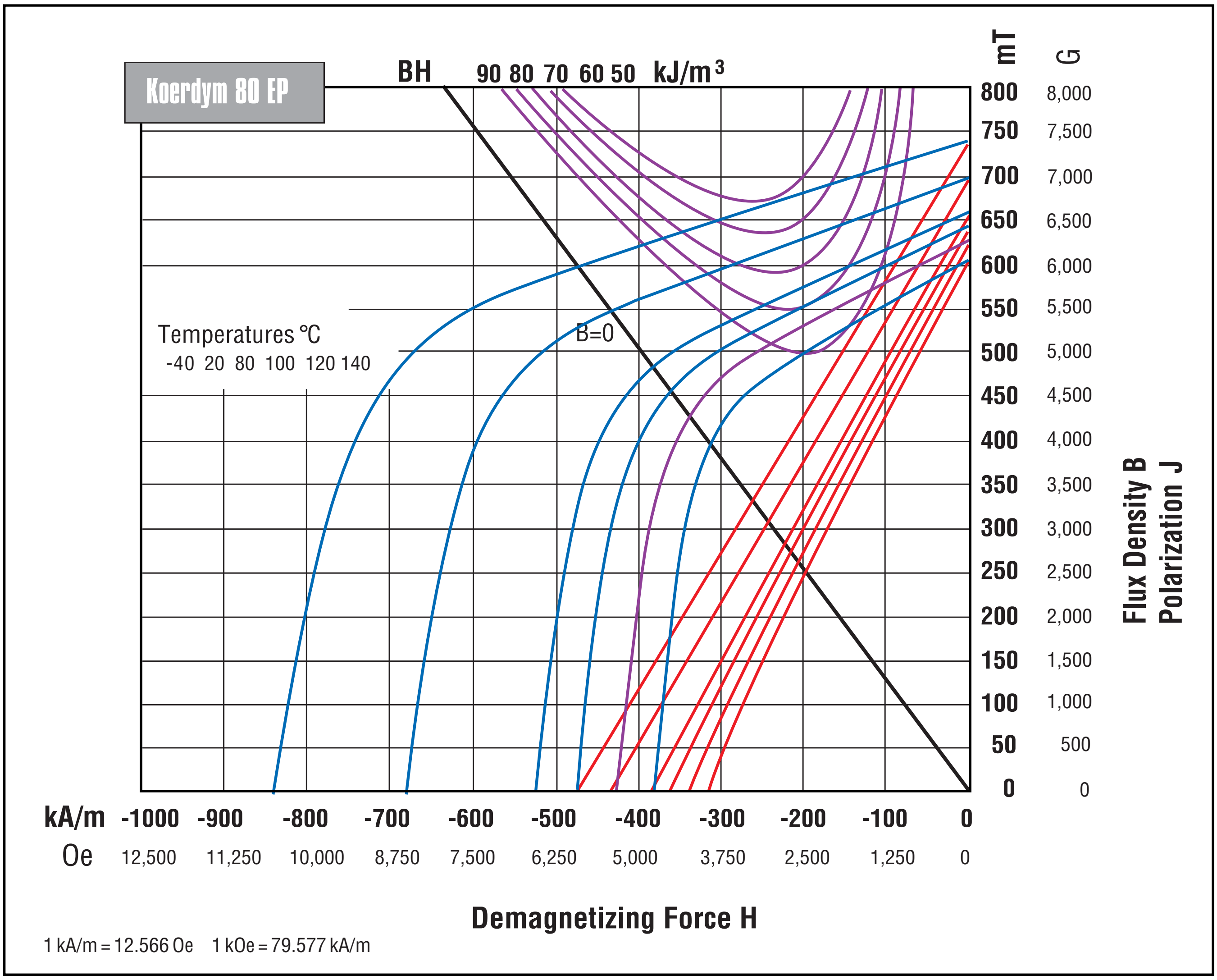
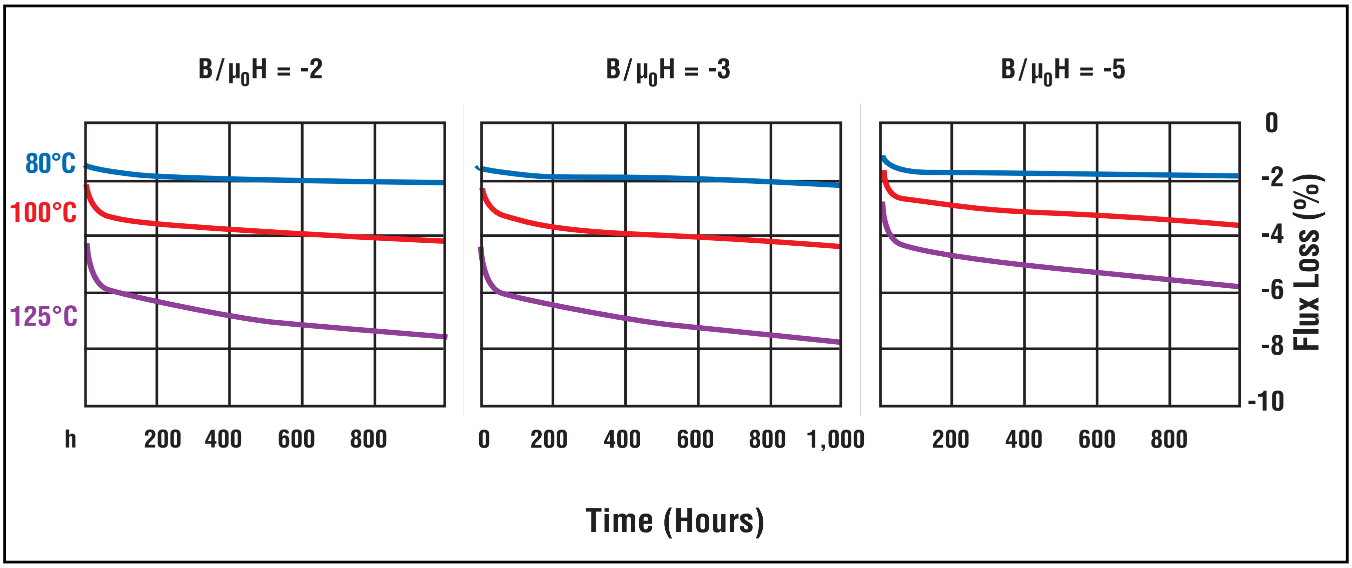


Total Flux Loss vs. Time (different Temperatures)



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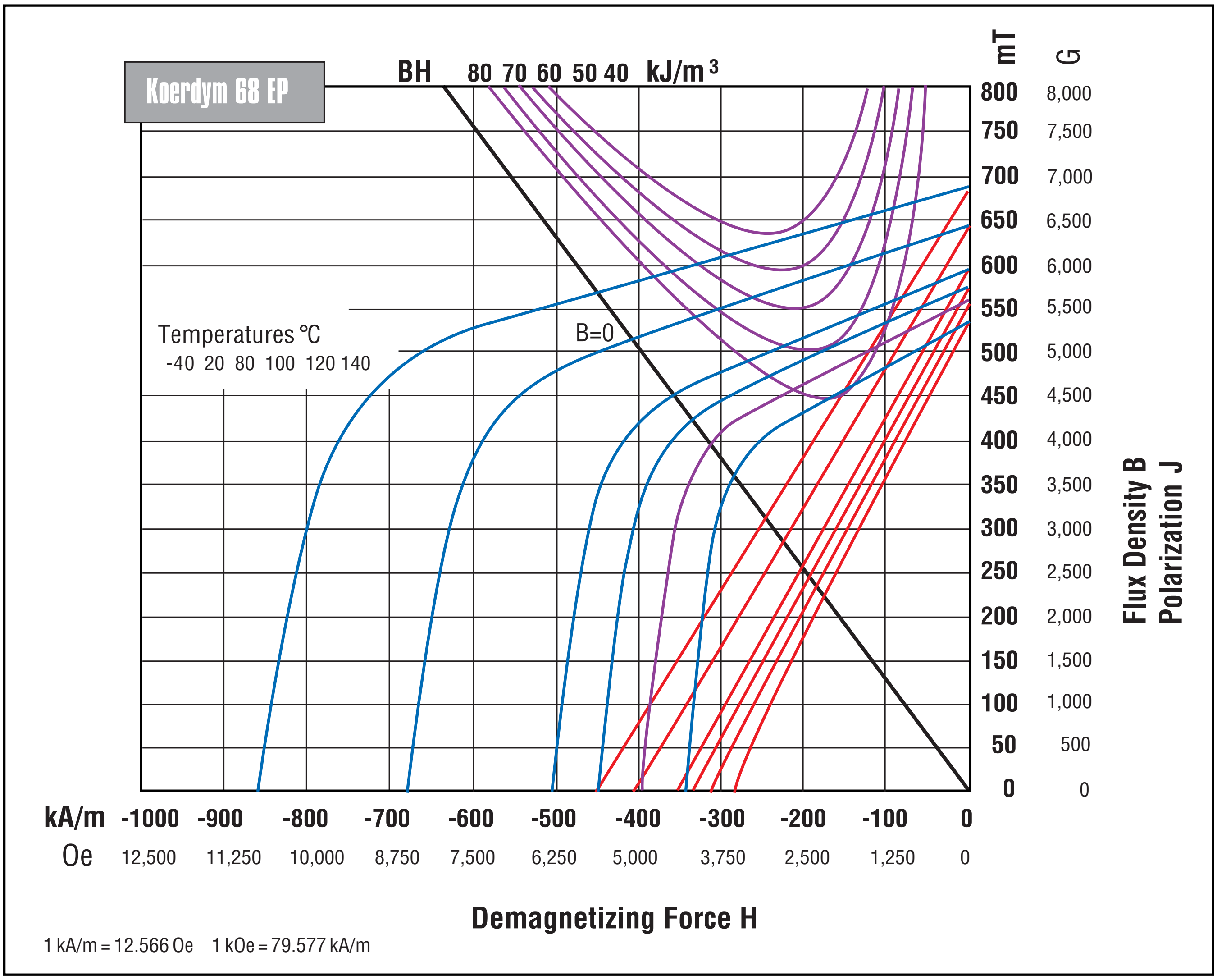
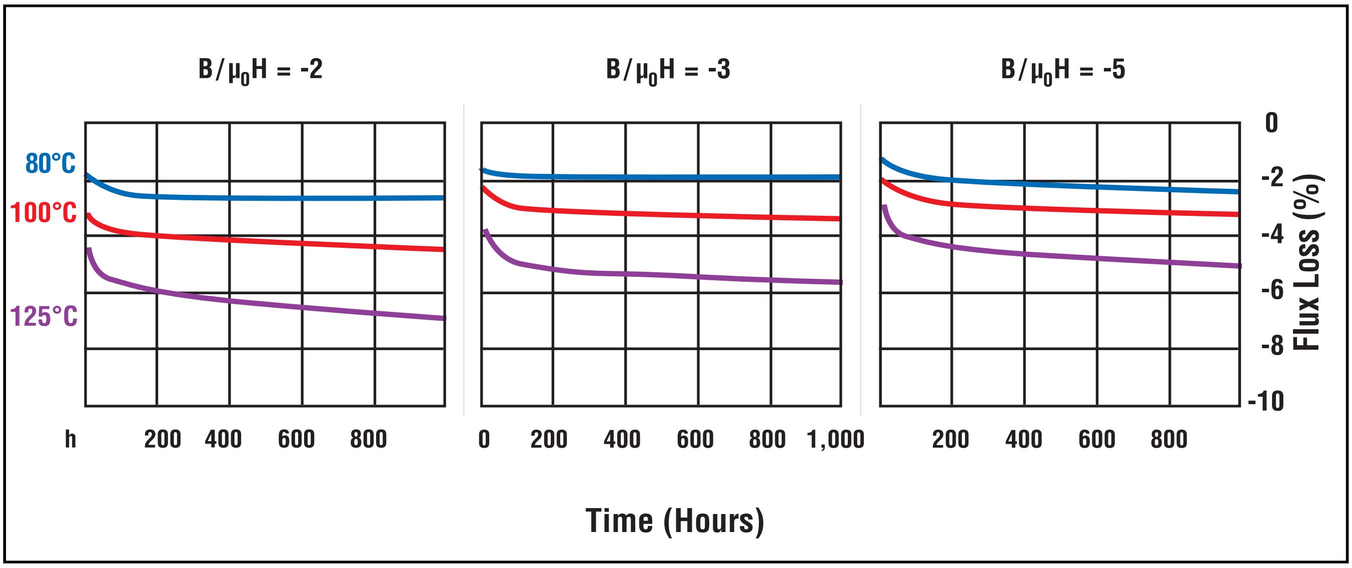


Total Flux Loss vs. Time (different Temperatures)



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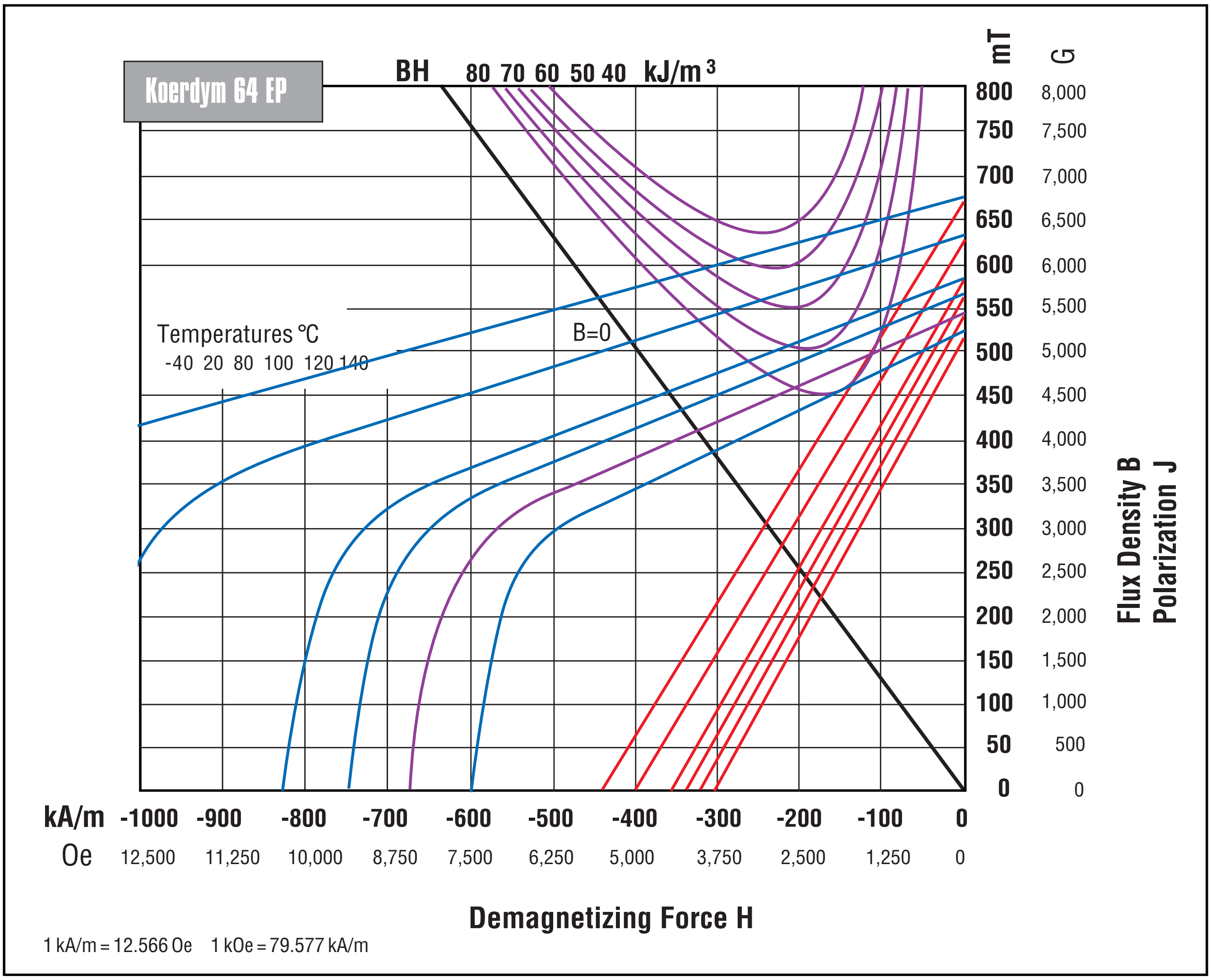
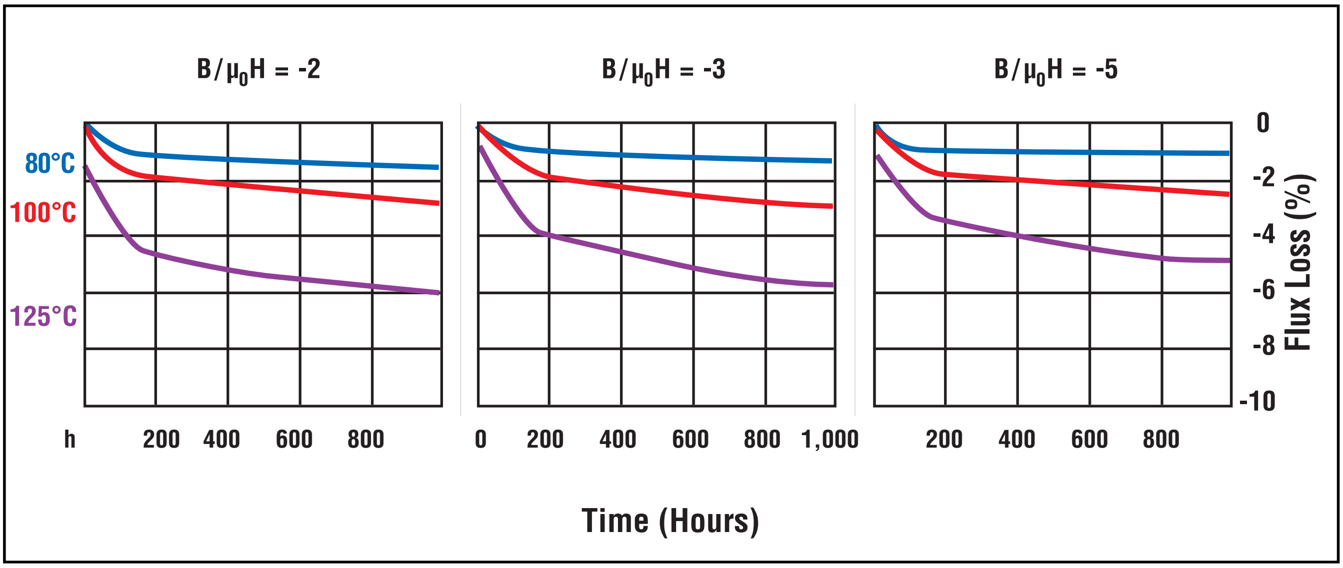


Total Flux Loss vs. Time (different Temperatures)



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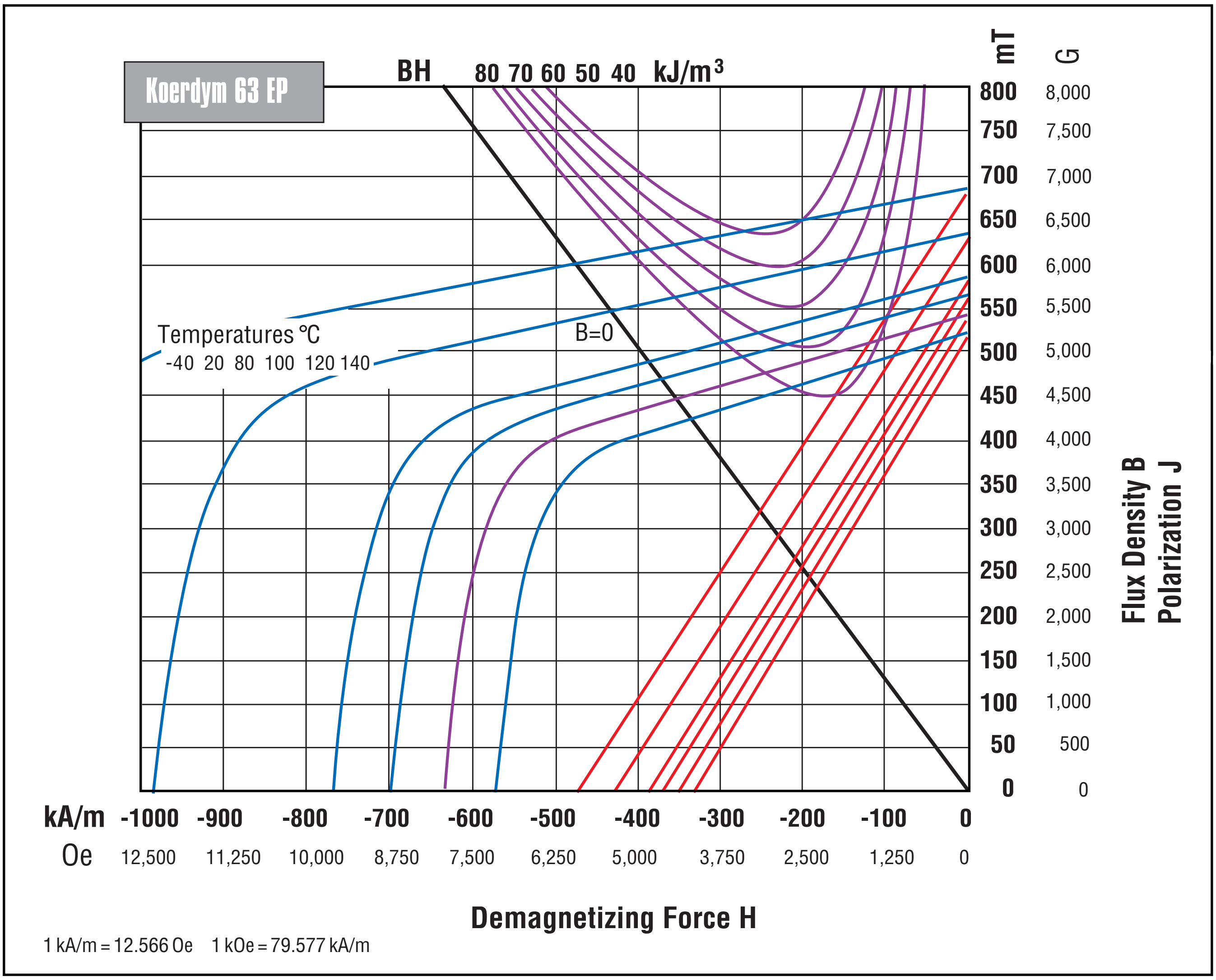
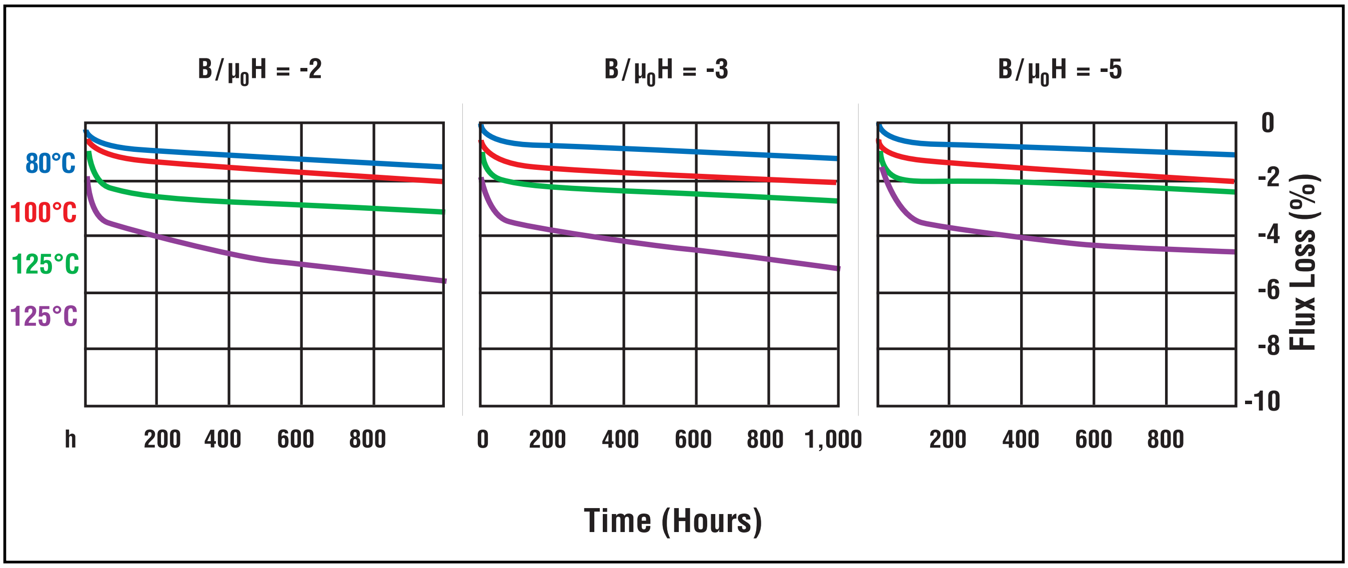


Total Flux Loss vs. Time (different Temperatures)



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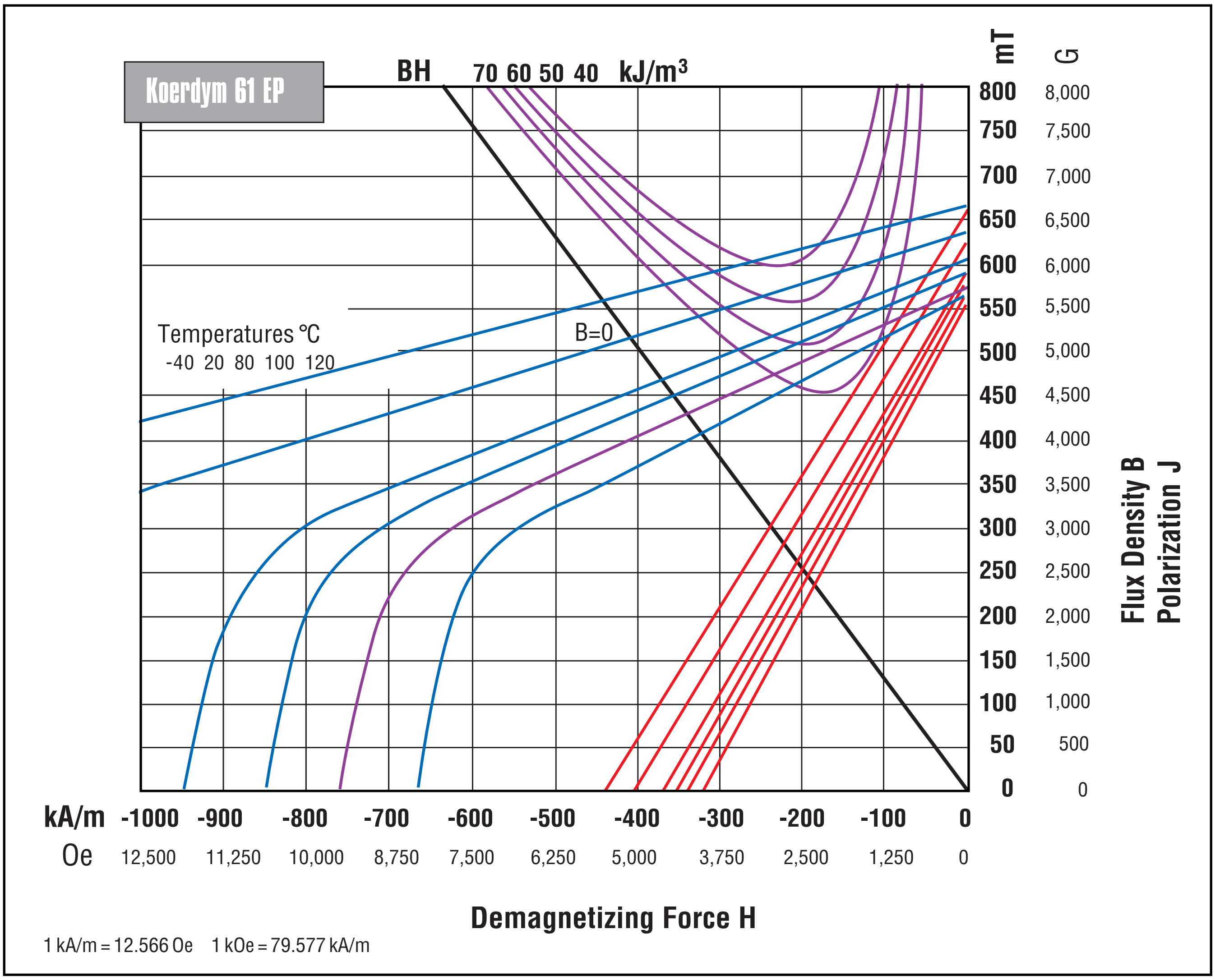

Total Flux Loss vs. Time (different Temperatures)