Magnifer® 36

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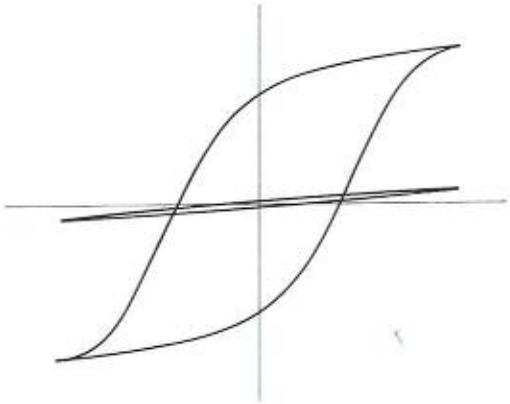

Magnifer 36 is a soft-magnetic nickel-iron alloy with 36 % nickel. It has a saturation induction of 1.3 T and a rather high electrical resistance of 0.75 Ω mm²/m.

Typical applications of Magnifer 36 are:

- LF transducers
- Chokes (coils)
- Screens

Magnetic properties

Magnifer 36 is produced in two grades:

Magnifer 36 K

The permeability curve of Magnifer 36 K exhibits a flat slope over a wide range of field strength. For permeability, DIN 41301 stipulates two groups:
D 1 with permeability of about 2000 and D 1a with permeability of about 2300.

Magnifer 36 W

Magnifer 36 W shows substantially higher permeability values with a steeper rise in permeability. An initial permeability of $\mu_4 \approx 5000$ is typical for this grade, with a maximum permeability of about 30,000. Coercive force is usually less than 10 A/m.

Table 1 lists the limiting values for the individual grades.

Figs. 1 to 9 show the magnetic properties of Magnifer 36 in relation to various parameters, so that the user may deduce the most important data required for dimensioning.

The properties shown in these diagrams are characteristic of the alloy in the heat-treated condition. The various heat treatments are described in the following sections. Variations in these heat treatments will result in changes in the properties of the alloy. The main factors in this respect are annealing temperatures and furnace atmosphere.

Alloy	Grade	Designation acc. to DIN	Thickness (mm)	Permeability [1] μ_{16}	Permeability [1] $\mu_{max.}$	Coercive force [2] H_c (A/m)	Induction (mT) at H_{eff} = 160 mA/cm	Core loss (W/kg)
Magnifer® 36 K	MD 1 MD 1a	D 1 D 1a DIN 41301	0.10...0.35 0.10...0.35	2000 ± 200 [3] 2300 ± 200 [3]				V_{10} = 1.1
Magnifer® 36 W	MD 3	D 3 DIN 41301	0.05...0.35	≧ 2900	≧ 20.000		≧ 350	V_{10} = 0.5
	MD 5		0.05....0.35	μ_4 ≧ 5000	≧ 25.000		≧ 500	
	MH 24	RNi 24 DIN 17405	Bulk material			≦ 15		

[1] Measured at laminations M 42 x 0.35 without air gap.
[2] Static measurement after magnetisation to saturation.
[3] Increase according to DIN 41301: δ_4 ≦ 3.75; δ_{80} ≦ 2.5.

Table 1 – Magnetic properties of Magnifer® 36 K and Magnifer® 36 W.

Magnifer® 36

Heat treatment

Heavily worked stock should be soft annealed before any further deformation. This annealing operation should be carried out between 750 and 1000 °C. Annealing time should not exceed 1 h and can be shorter at higher temperatures. Temperature and annealing time are guided by the desired final condition. Annealing should be carried out in hydrogen, cracked ammonia or a clean inert gas temperature.

Final annealing for optimum magnetic properties

The magnetic properties quoted in this Data Sheet are obtainable only after a special final annealing treatment. Annealing must take place in dry hydrogen or cracked ammonia (dew-point below < – 40 °C). The appropriate annealing temperature for Magnifer 36 W is between 1050 and 1150 °C at an annealing time of 2 to 8 h.

After this final annealing the stock must be furnace-cooled to about 450 °C over a period of 5 to 7 h. Further cooling is then not critical.

The final annealing of Magnifer 36 K is usually carried out at temperatures around 700 °C. The required data for annealing temperature, holding time and cooling are quoted for each individual batch. However, the final annealing of parts produced from Magnifer 36 K should preferably be carried out in our factory.

After the final heat treatment the parts must not be worked further, as any plastic deformation results in a notable loss in magnetic properties.

Chemical composition (nominal data)

Ni 36%	Mn 0.3%	Si 0.15%	C 0.02%	balance Fe

Physical properties (nominal data)

Saturation induction	1.3 T	13.000 G
Curie temperature	250 °C	480 °F
Saturation magnetostriction	$+22 \cdot 10^{-6}$	$+22 \cdot 10^{-6}$
Electrical resistivity	0.75 Ω mm²/m	451 ohm circ mil/ft
Specific gravity	8.15 g/cm³	0.294 lb/in³
Thermal conductivity	0.125 W/cm K	50 (BTU inch)/(ft h °F)
Mean coefficient of thermal expansion (20–100 °C)	$1.2 \cdot 10^{-6}$/K	$0.7 \cdot 10^{-6}$/°F

Mechanical properties (nominal data)

		cold rolled (about 50%)	*deep drawable soft annealed	after final anneal
Tensile strength	(N/mm²)	750	490	–
	ksi	53	34	
Yield stress	(N/mm²)	700	290	250
	ksi	49	20	17
Elongation	(%)	5	> 40	> 40
Hardness	HV 5	220	130–150	90–110
	HRB	97	73– 82	50– 63

*The required condition, deep drawable or soft annealed, should be stated when ordering.

Magnifer® 36

Fabrication

Working
All conventional processes can be used. Fabrication data may be obtained from the table of mechanical properties. In the "deep drawable" condition, the minimum Erichsen depth is 8 for sheets of 1 mm thickness. The magnetic, final annealed condition is only the final condition in the fabrication of certain parts. It is not suitable as the initial condition for any working operation, as the magnetic properties would be drastically lowered. The hard-rolled state is the most suitable for stamping.

Machining
The cold-worked condition is best suited for machining operations. Alloy properties are similar to those of stainless steels. Low cutting speeds, cooling cuttings oils, hardmetal or high-speed steel tools are necessary. The latter must be kept sharp. After machining is completed, residual oil, grease or dirt films must be entirely removed before annealing the parts.

Welding
The best process is usually resistance spot welding, although in principle other welding processes are also applicable. We are pleased to advise on the best process in special cases.

Corrosion resistance

Corrosion resistance in humid atmospheres is relatively low.

Forms supplied

Semis
Strip, ribbon, sheet, bar and wire are available. Sizes and tolerances are quoted in special data sheets called "Forms supplied, sizes and tolerances".

Fabricated parts
Toroidal tape-wound cores, core sheets and relay parts. We also undertake job-annealing of parts for our customers.

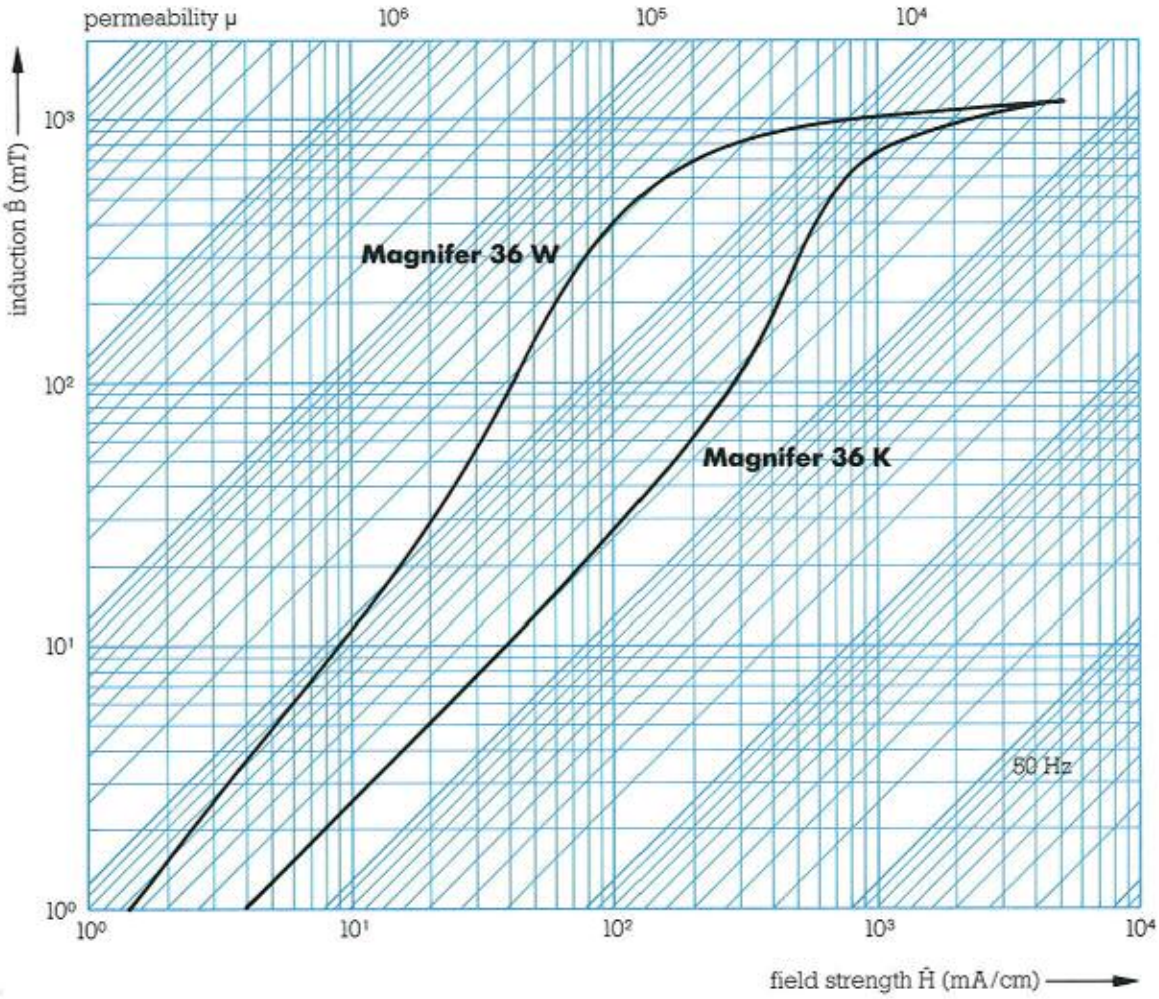

Fig. 1 – Typical induction/field-strength curves of Magnifer® 36 K and Magnifer® 36 W, measured on core sheets M 42 x 0.35.

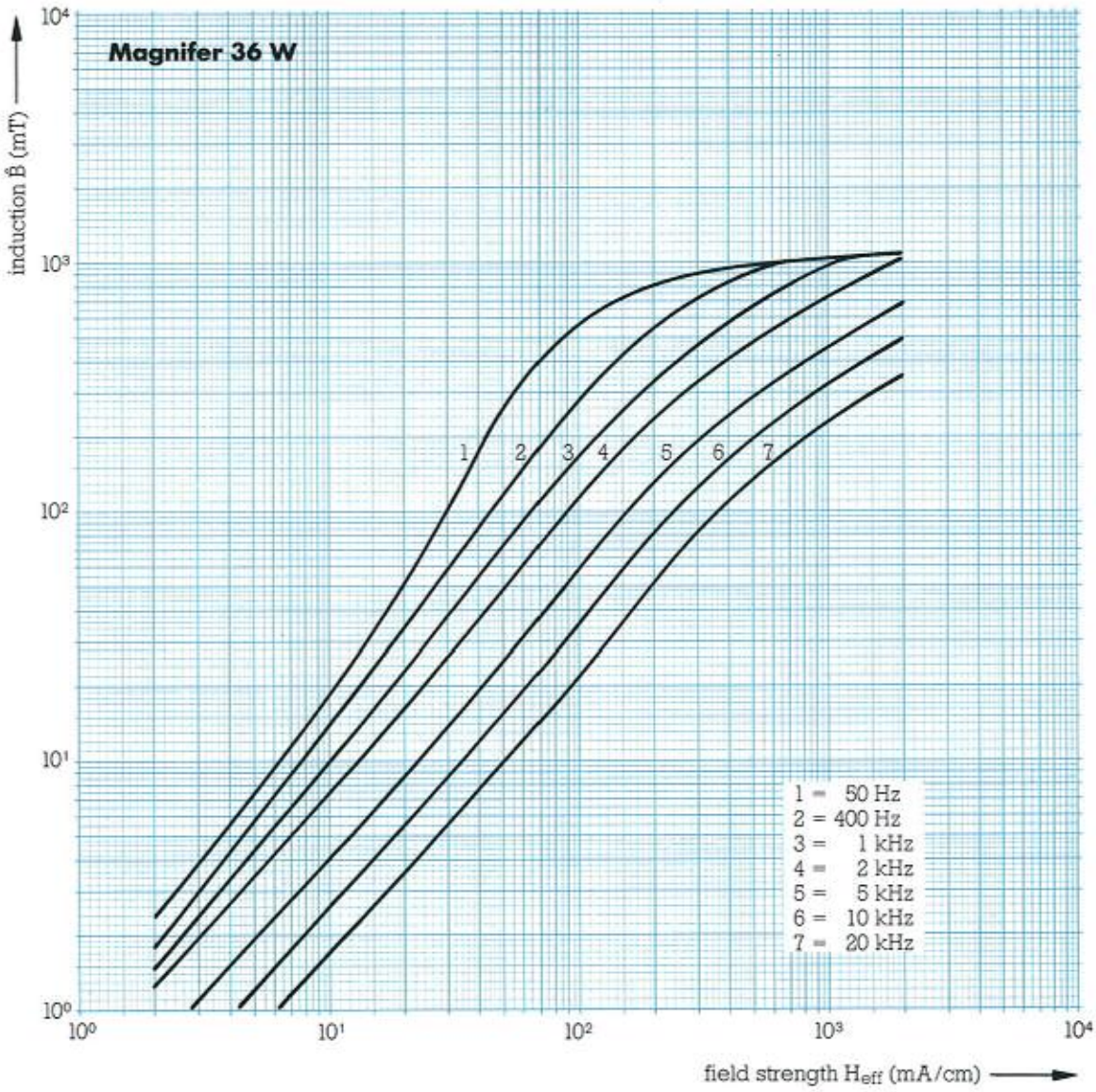

Fig. 2 – Typical induction/field-strength curves of Magnifer® 36 W, measured on core sheets M 42 x 0.35 at various frequencies.

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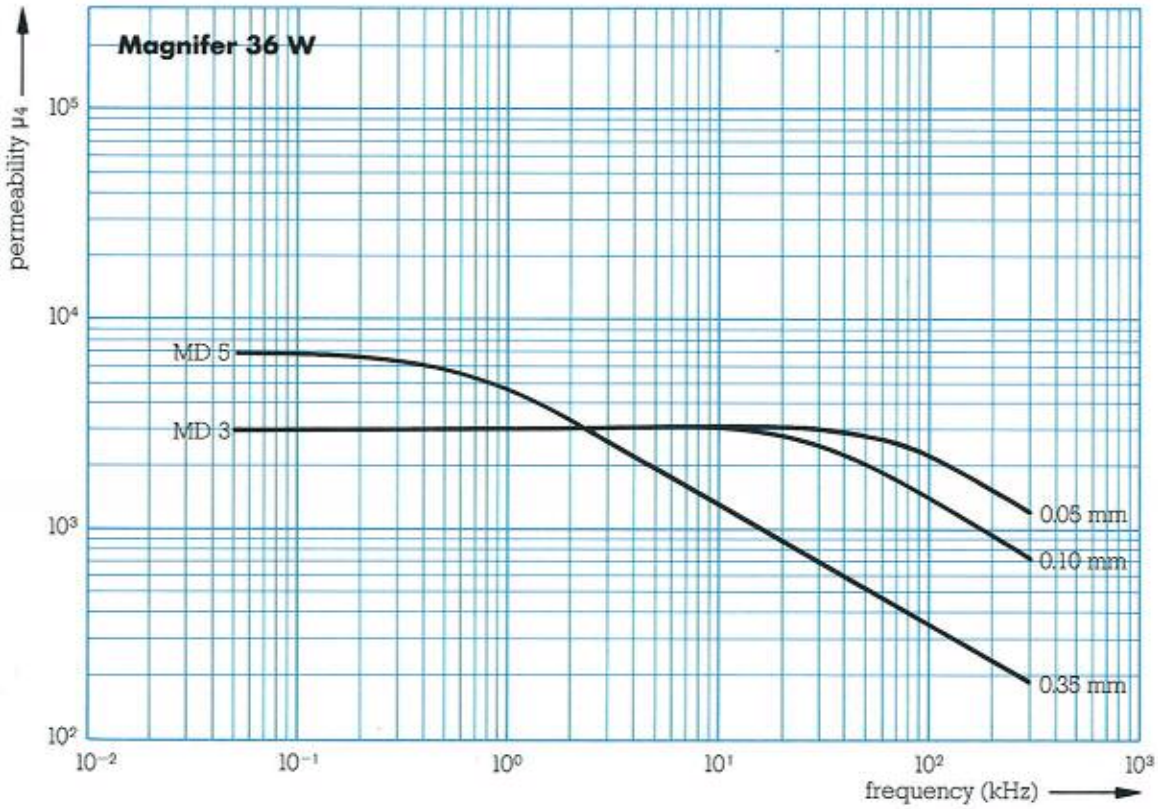
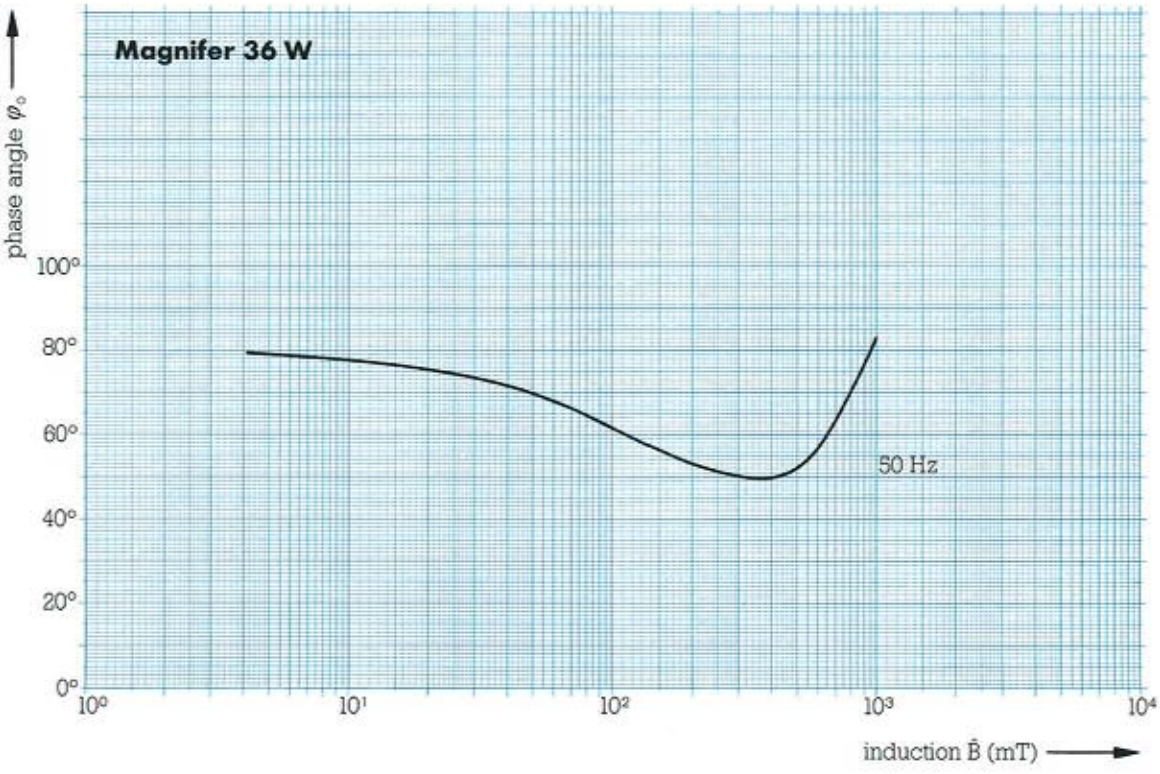

Magnifer 36 W
permeability μ_4
10^5
10^4
10^3
10^2
MD 5
MD 3
0.05 mm
0.10 mm
0.35 mm
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
frequency (kHz)


Magnifer 36 W
phase angle φ_0
100°
80°
60°
40°
20°
0°
50 Hz
10^0
10^1
10^2
10^3
10^4
induction $\hat{B}$ (mT)

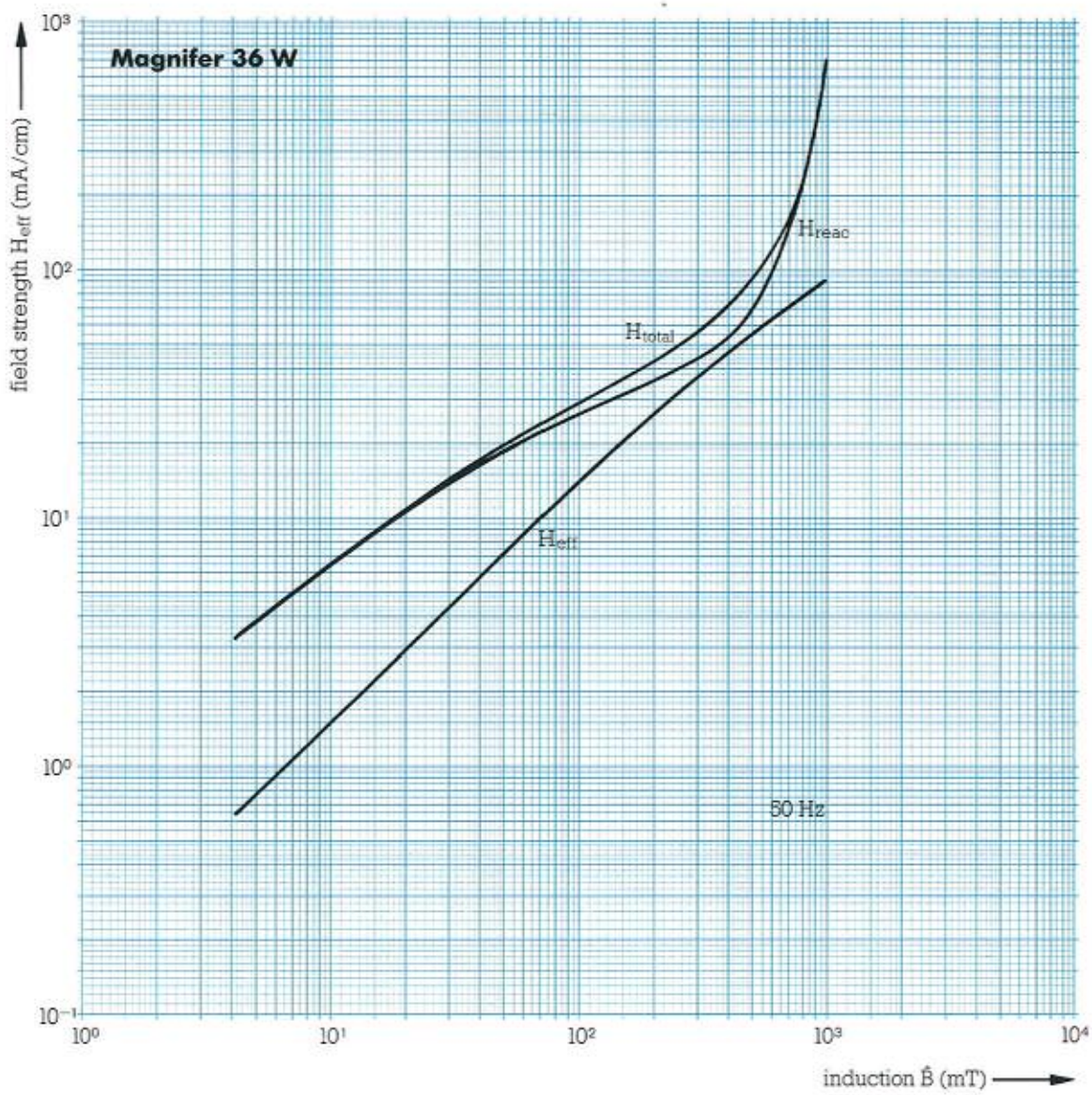


Fig. 5 – Components of the magnetization curve of Magnifer® 36 W, measured on core sheets M 42 x 0.35.

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Fig. 3 – Frequency dependence of the initial permeability of Magnifer® 36 W, measured on core sheets of various strip thicknesses.

Fig. 4 – Phase angle φ_o of Magnifer® 36 W, measured on core sheets M 42 x 0.35.

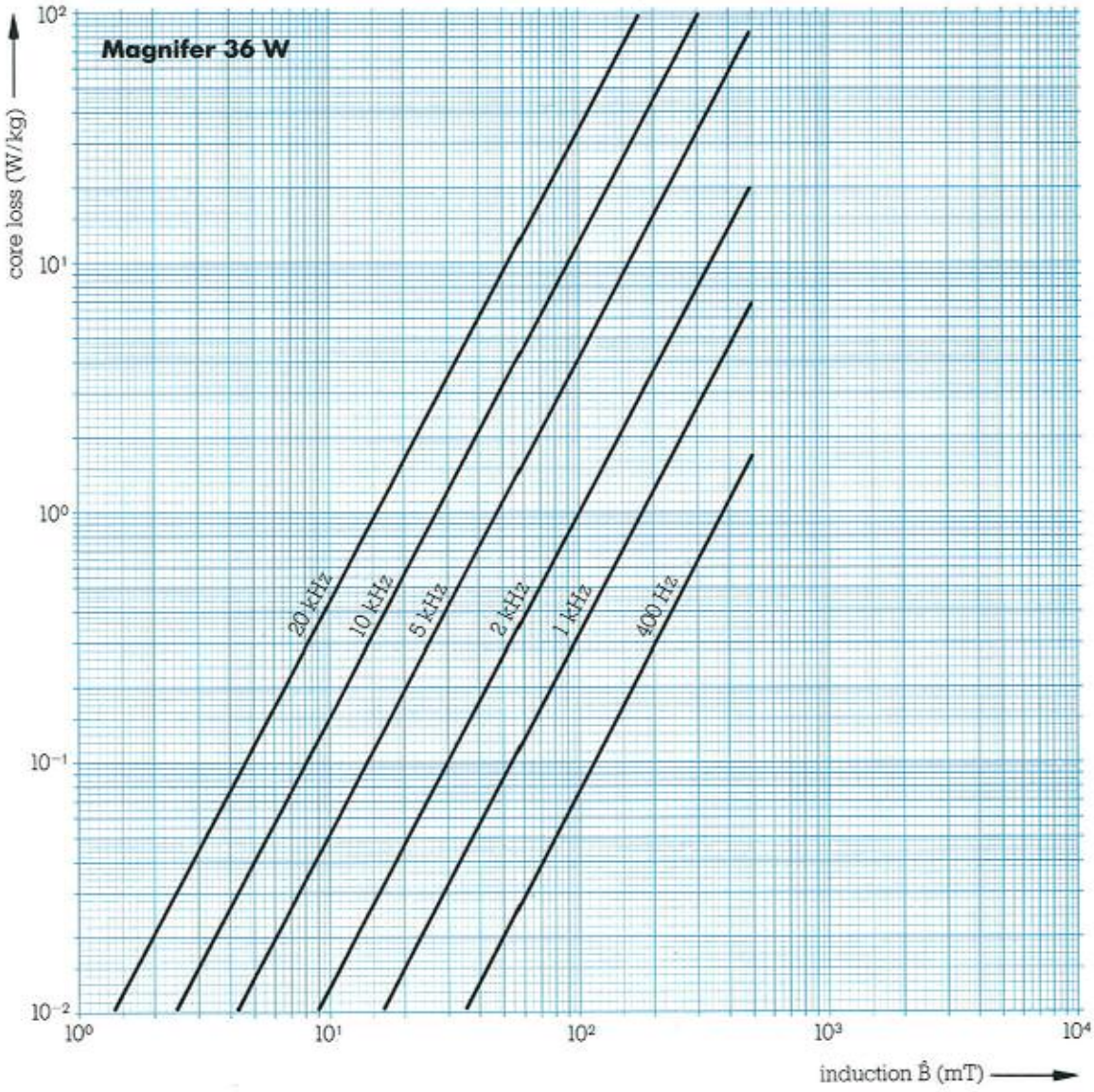

Fig. 6 – Core loss of Magnifer® 36 W, measured on core sheets M 42 x 0.35 at various frequencies.

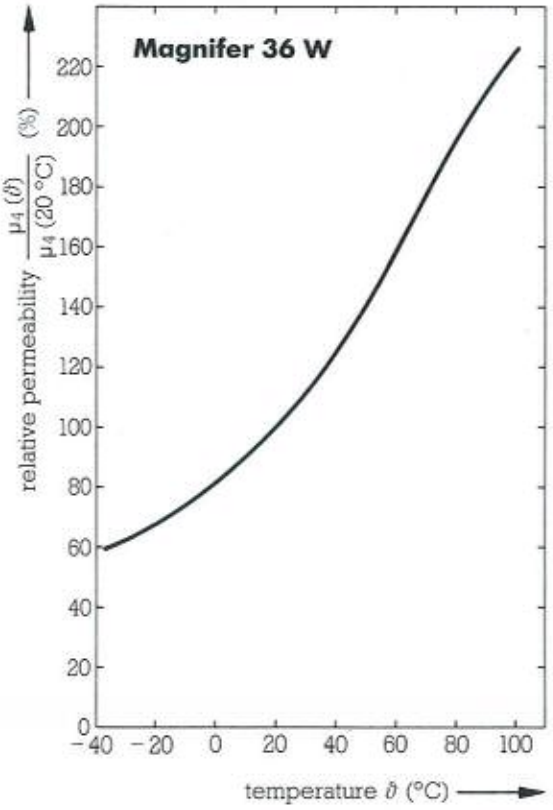

Fig. 7 – Temperature dependence of the initial permeability of Magnifer® 36 W.

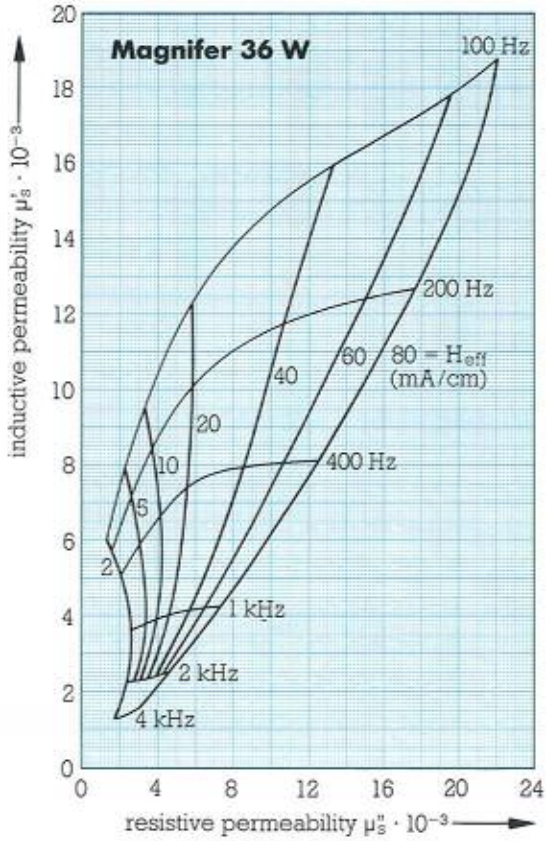

Fig. 9 – Locus curves of complex permeability of Magnifer® 36 W, measured on core sheets M 42 x 0.35.

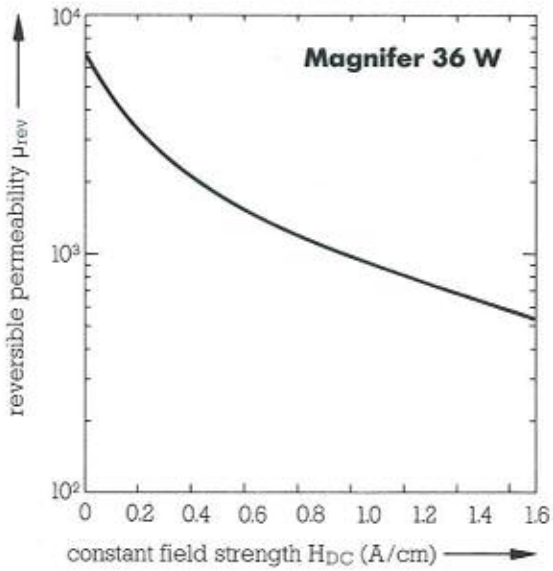

Fig. 8 – Reversible permeability of Magnifer® 36 W, measured on core sheets M 42 x 0.35 at 100 Hz.

This issue supersedes Data Sheet no. 9001, edition 5/1983.

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Please ask for the latest edition of this Data Sheet.

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