Magnifer® 75

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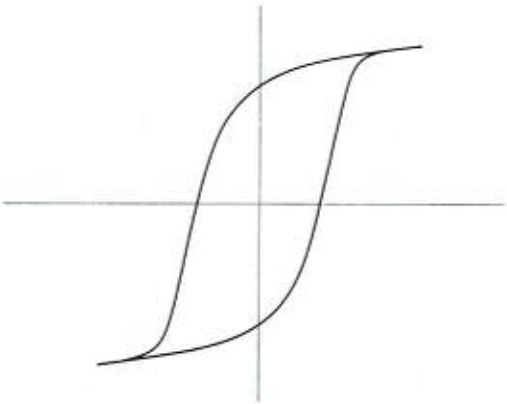

Magnifer 75 is a soft-magnetic nickel-iron alloy with about 75% Ni. It has a saturation induction of 0.8 T, extremely high permeability and low coercivity.

Typical applications of Magnifer 75 are:

- Instrument transformers
- Integrating current transformers for current circuit breakers
- Relay parts
- Screens

Magnetic properties

The magnetic properties of Magnifer 75 depend to a great extent on the final heat treatment. After optimum final annealing (details overleaf) an initial permeability μ_4 between 60,000 and 80,000 can be obtained as well as a coercivity of less than 1 A/m. With strip of 0.1 mm thickness typical values for maximum permeability vary between 200,000 and 240,000. Deviations from optimum annealing conditions may lower substantially the obtainable values for permeability and coercivity.

The shape of the hysteresis loop as well as the temperature dependence of permeability can be adjusted by systematic heat treatment. This results in the following special grades of Magnifer 75:

Magnifer 75 R
Grade with a rectangular hysteresis loop.

Magnifer 75 F
Grade with a flat hysteresis loop.

Magnifer 75 TK
Grade with a low temperature coefficient between about − 25 and + 80 °C.

Table 1 lists the limiting figures for the individual grades.

Figs. 1 to 10 show the magnetic properties of Magnifer 75 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 temperature and cooling rate.

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Magnifer® 75

Magnetic properties

Alloy	Grade	Designation acc. to DIN	Thickness (mm)	Permeability[1] μ_4	Permeability[1] μ_{max}	Coercive force[2] H_c (A/m)	Induction (mT) at H_{eff} = 20 mA/cm	Core loss (W/kg)
Magnifer® 75	ME 3	E 3 DIN 41301	0.05; 0.10	≧ 30.000	≧ 170.000		≧ 400	V_5 = 0.025
			0.20	≧ 30.000	≧ 100.000		≧ 250	
			0.35	≧ 30.000	≧ 50.000		≧ 125	
	ME 4	E 4 DIN 41301	0.05; 0.10	≧ 40.000	≧ 185.000		≧ 450	
			0.20	≧ 40.000	≧ 115.000		≧ 270	
			0.35	≧ 40.000	≧ 60.000		≧ 150	
	ME 6		0.05; 0.10	≧ 60.000	≧ 200.000		≧ 500	V_5 = 0.02
			0.20	≧ 60.000	≧ 140.000		≧ 350	
	ME 8		0.05; 0.10	≧ 80.000	≧ 220.000		≧ 530	
	MH 2	RNi 2, RNi 5 DIN 17405	Bulk material			≦ 2		
Magnifer® 75 R	MER		0.05; 0.10	Rectangular hysteresis loop B_R/B_m ≧ 0.9 with H_{max} = 0.1 A/cm				
Magnifer® 75 F	MEF		0.05; 0.10	Flat hysteresis loop				
Magnifer® 75 TK				Low temperature dependence of permeability				

[1] Measured with toroidal tape-wound cores 22 x 14.5 x 10.

[2] Static measurement after magnetisation to saturation.

Table 1 – Magnetic properties of Magnifer® 75.

Heat treatment

Heavily worked stock should be soft annealed before any further deformation. This annealing operation should be carried out between 800 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 atmosphere.

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 75 is between 1050 and 1200 °C at an annealing time of 2 to 8 h. The cooling process after the final annealing operation is of special importance with high nickel-containing alloys, as the ordering processes which take place in the atomic range affect the magnetic properties to a great extent. The composition of the various charges is selected so that furnace-cooling to about 500 °C over 5 to 6 h, followed by cooling in air, usually results in good magnetic properties. However, to obtain optimum properties, final annealing should preferably be carried out in our factory. This applies in particular to the special grades Magnifer 75 R, F and TK.

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

Magnifer® 75

Chemical composition (nominal data)

Ni 75%	Cu 5%	Cr 2%	Mn 0.5%	Si 0.2%	C 0.02%	balance Fe

Standards and material no.

DIN 17745	2.4500...2.4519	NiFe 16 CuCr	DIN 17405	2.4596	RNi5
DIN 41301	2.4591	E3	DIN 17405	2.4595	RNi2
DIN 41301	2.4592	E4			

Physical properties (nominal data)

Saturation induction	0.8 T	8000 G
Curie temperature	400 °C	820 °F
Saturation magnetostriction	$+1 \cdot 10^{-6}$	$+1 \cdot 10^{-6}$
Electrical resistivity	0.55 Ω mm²/m	349 ohm circ mil/ft
Specific gravity	8,6 g/cm³	0.31 lb/in³
Thermal conductivity	0.34 W/cmK	135 (BTU inch)/(ft h °F)
Mean coefficient of thermal expansion (20–100 °C)	$12.5 \cdot 10^{-6}$/K	$7.3 \cdot 10^{-6}$/°F

Mechanical properties (nominal data)

		cold rolled (about 50%)	*deep drawable soft annealed	after final anneal
Tensile strength	N/mm²	860	600	580
	ksi	122	87	84
Yield stress	N/mm²	800	290	220
	ksi	114	41	32
Elongation	%	5	> 40	> 40
Hardness	HV 5	270	140–180	110–130
	HRB		78– 90	63– 73
	HRC	26		

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

Magnifer® 75

Fabrication

Working
All conventional processes can be used. Fabrication data may be taken 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, cutting 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

The corrosion resistance in humid atmospheres is good, but not so in aggressive media.

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 up to 750 mm O.D., core sheets, relay parts and screens.

Magnifer® 75

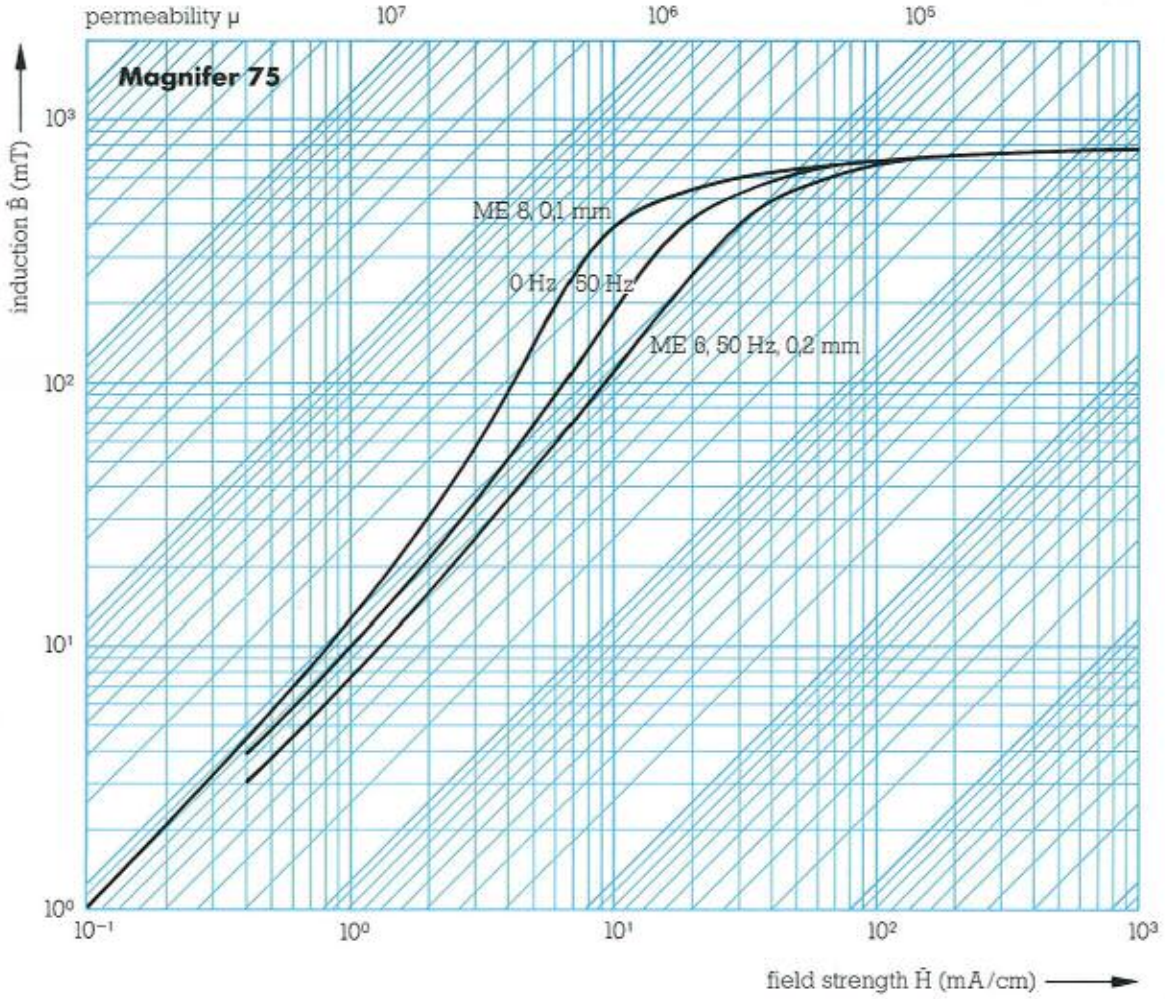


Fig. 1 – Typical induction/field-strength curves of Magnifer® 75, measured on toroidal tape-wound cores of 0.1 and 0.2 mm strip thickness.

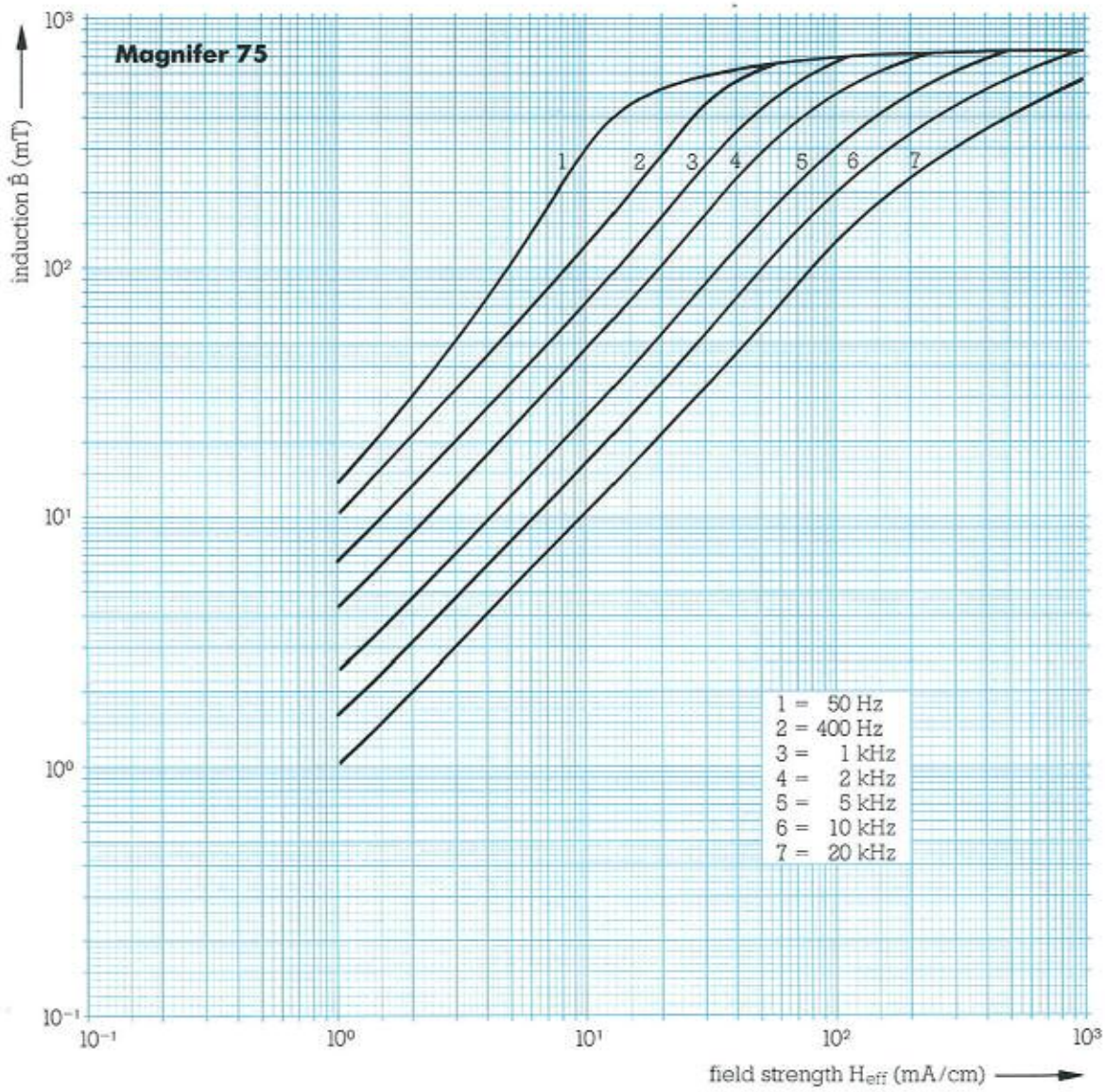


Fig. 2 – Typical induction/field-strength curves of Magnifer® 75 ME 8, measured on toroidal tape-wound cores of 0.1 mm strip thickness at various frequencies.

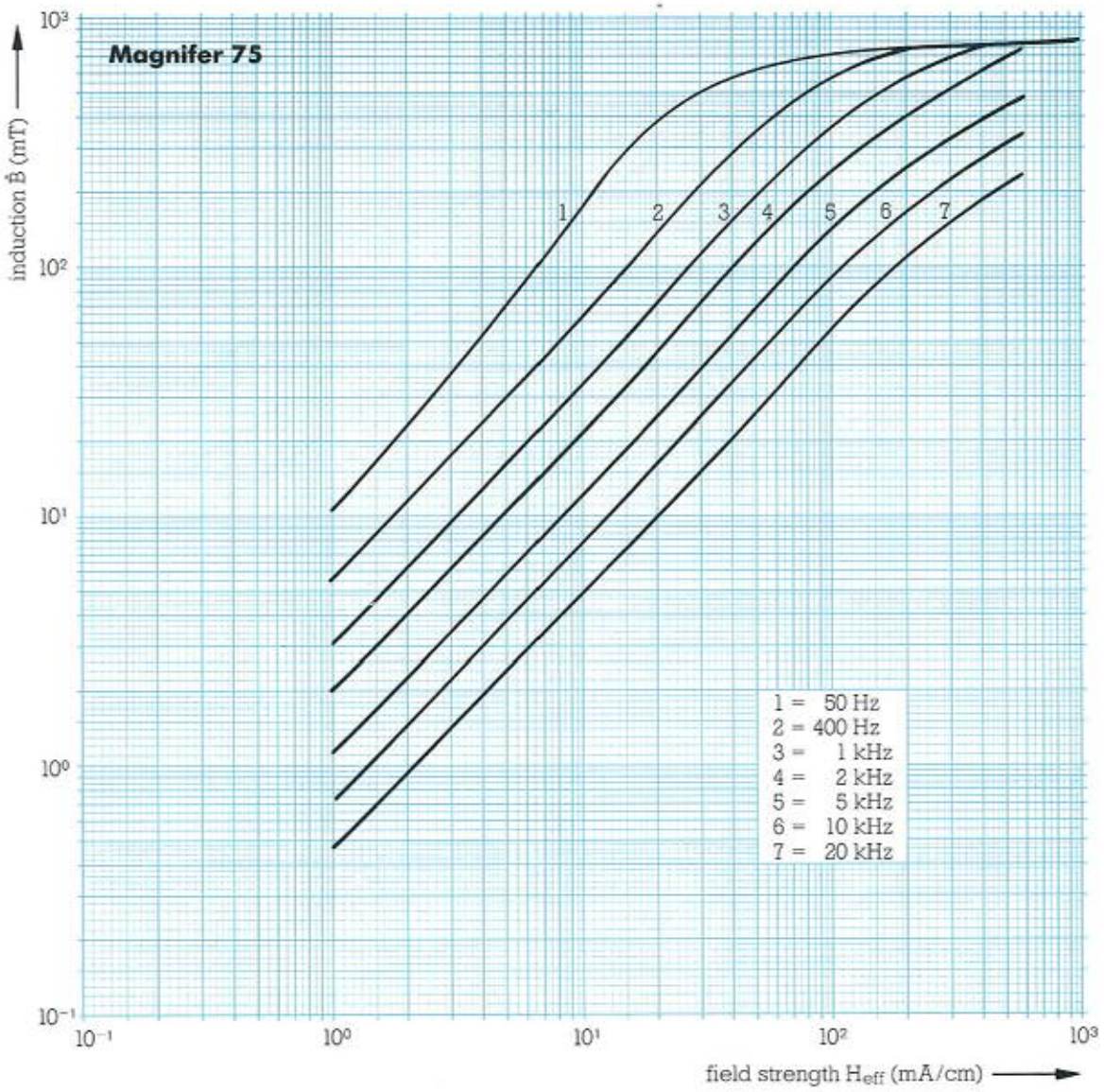
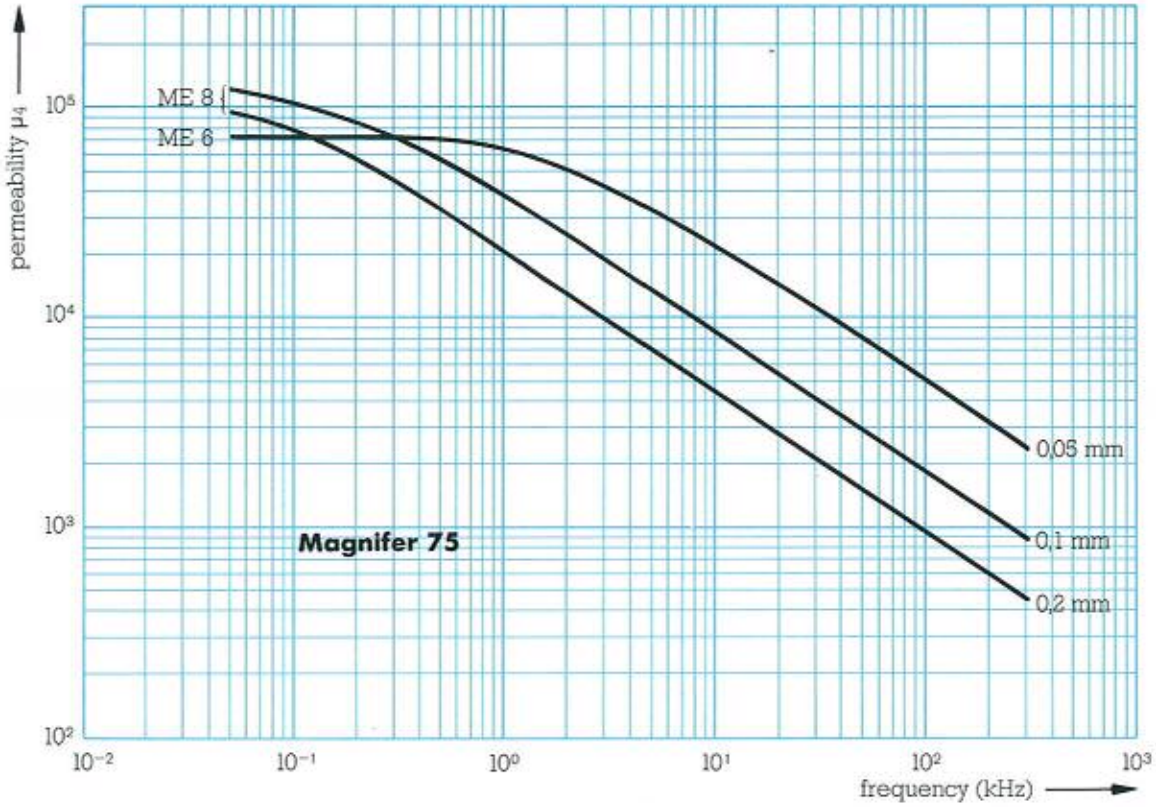
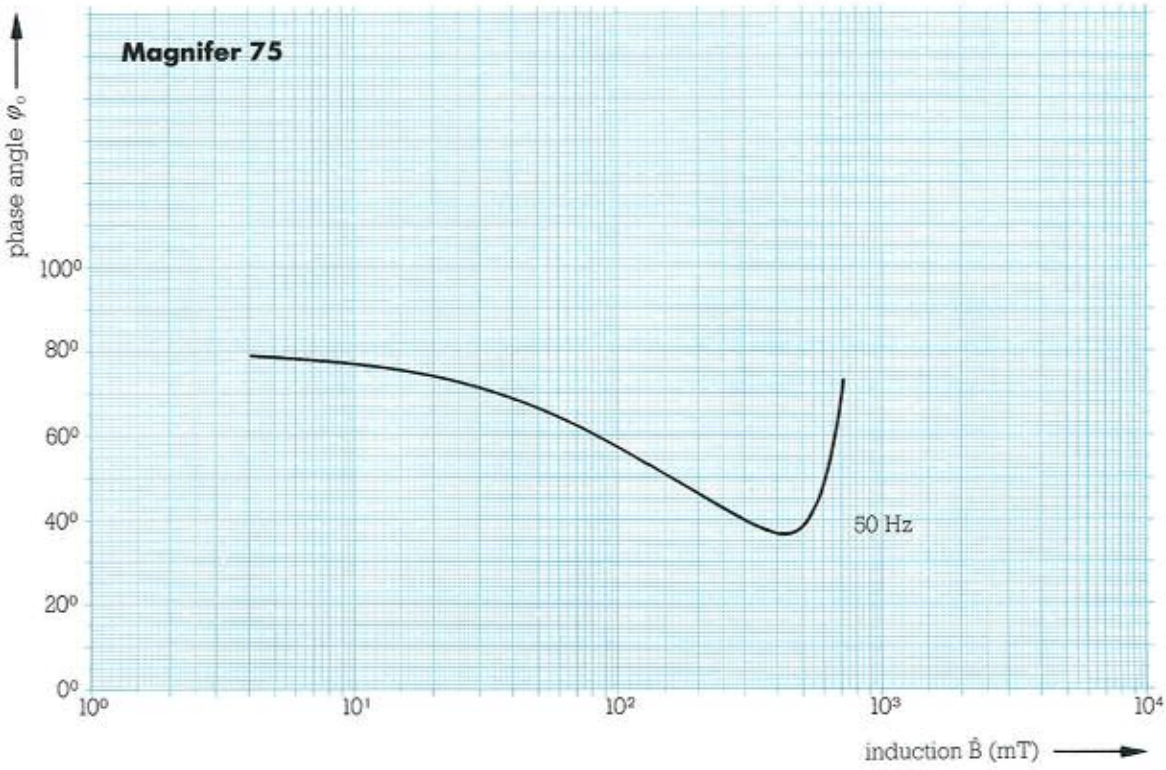


Fig. 3 – Typical induction/field-strength curves of Magnifer® 75 ME 6, measured on toroidal tape-wound cores of 0.2 mm strip thickness at various frequencies.

Magnifer® 75


permeability μ_i
10^5
10^4
10^3
10^2
ME 8
ME 6
Magnifer 75
0,05 mm
0,1 mm
0,2 mm
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
frequency (kHz)


Magnifer 75
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)

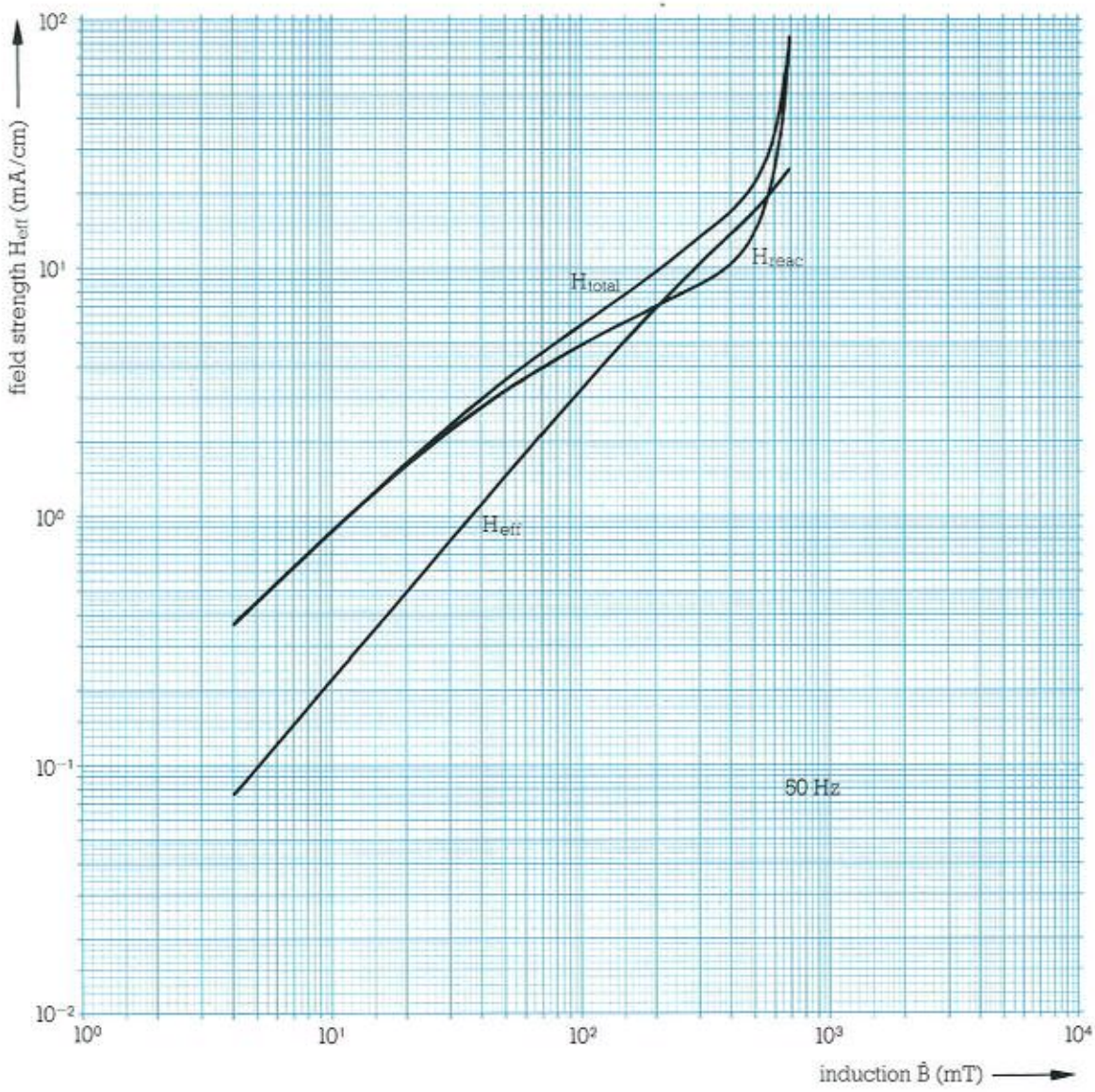


Fig. 6 – Components of the magnetization curve of Magnifer® 75, measured on toroidal tape-wound cores of 0.2 mm strip thickness.

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Fig. 4 – Frequency dependence of the initial permeability of Magnifer® 75, measured on toroidal tape-wound cores of various strip thicknesses.

Fig. 5 – Phase angle φ_o of Magnifer® 75, measured on toroidal tape-wound cores of 0.2 mm strip thickness.

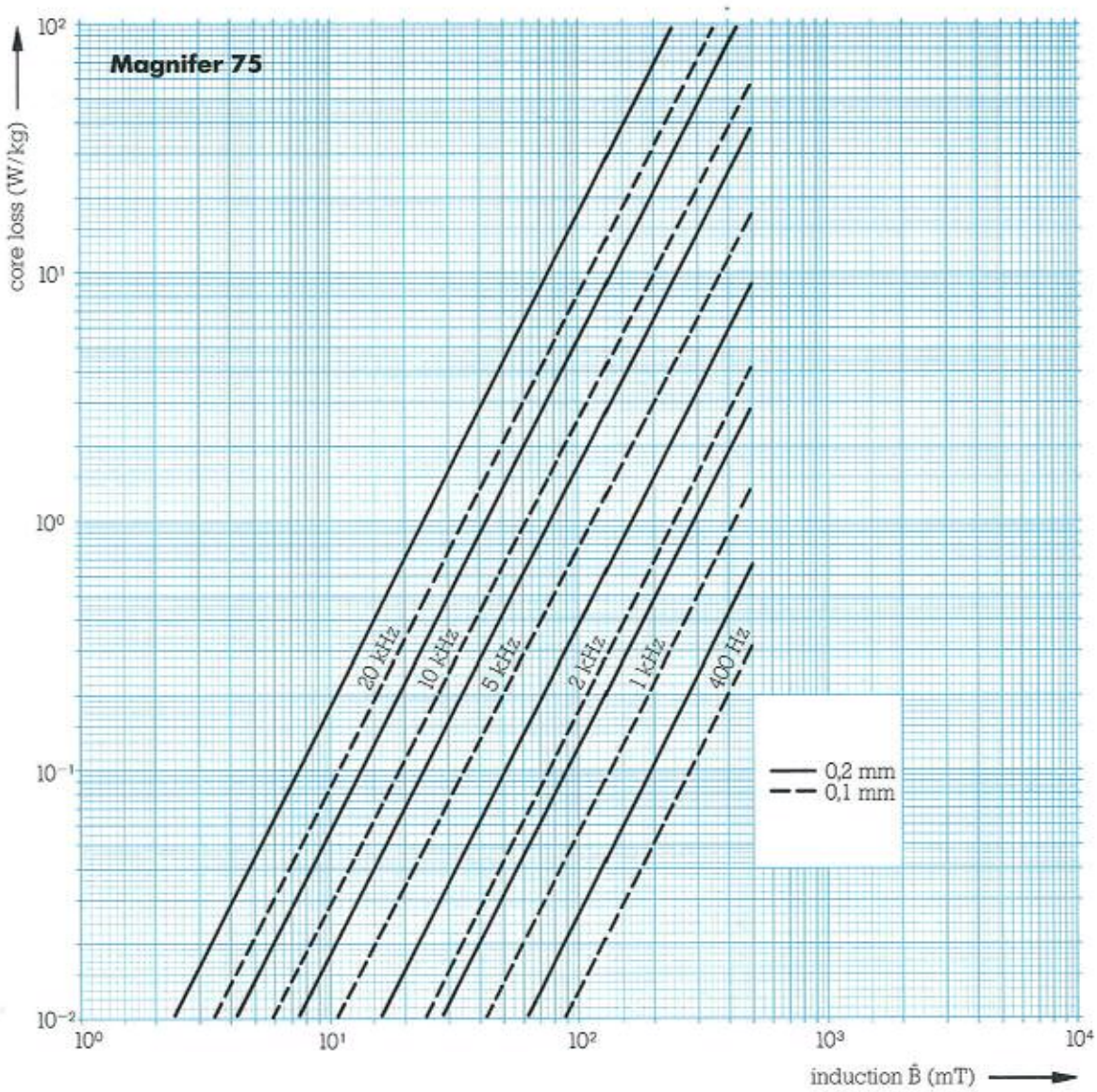

Fig. 7 – Core loss of Magnifer® 75, measured on toroidal tape-wound cores of 0.1 and 0.2 mm strip thickness at various frequencies.

Magnifer® 75

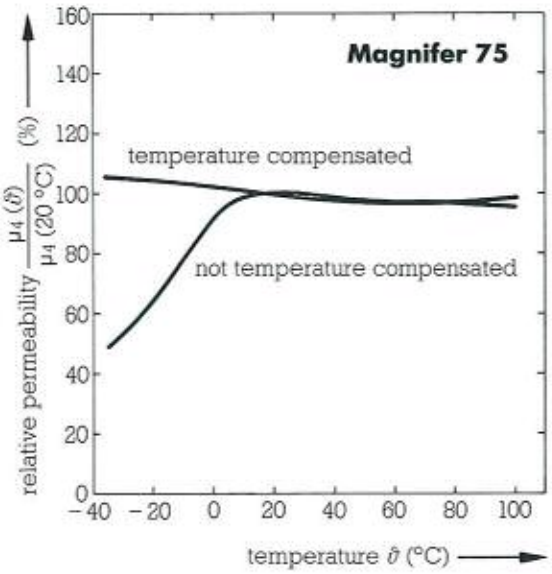

Fig. 8 – Temperature dependence of the initial permeability of Magnifer® 75.

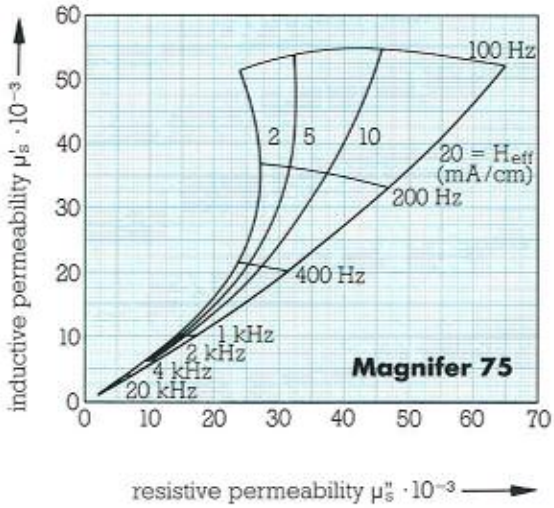

Fig. 9 – Locus curves of complex permeability of Magnifer® 75, measured on toroidal tape-wound cores of 0.2 mm strip thickness.

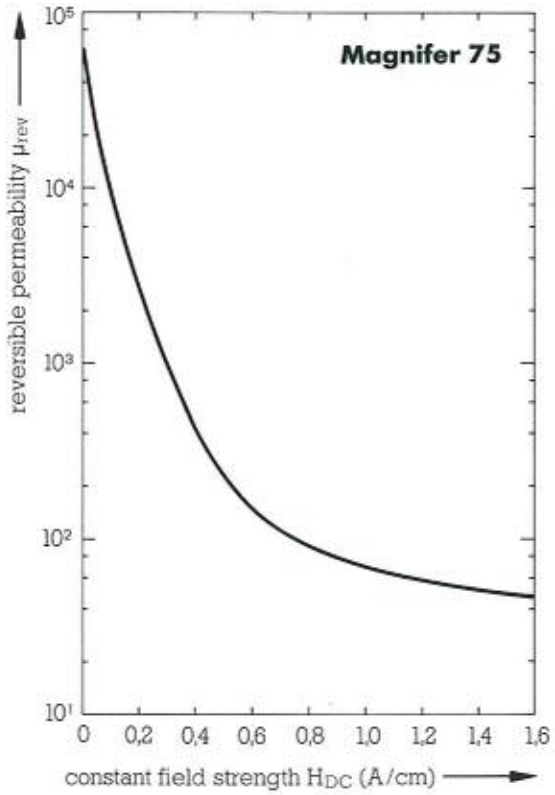

Fig. 10 – Reversible permeability of Magnifer® 75, measured on toroidal tape-wound cores 50 x 40 mm of 0.2 mm strip thickness at 100 Hz.

This issue supersedes Data Sheet no. 9003, edition 5/1983.

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Please ask for the latest edition of this Data Sheet.

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