Brochure NiFe Laminations

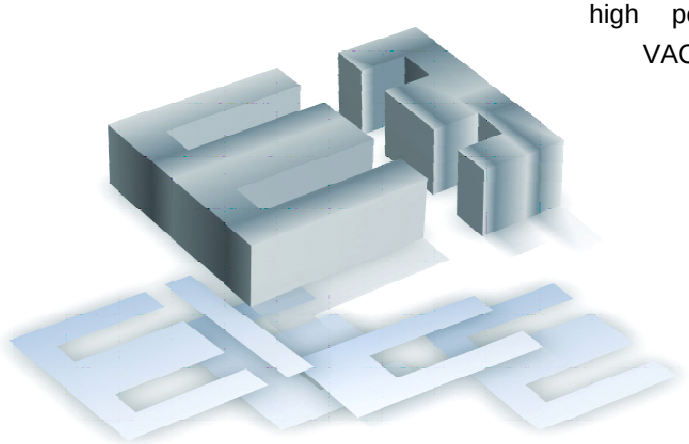
from MUMETALL®, VACOPERM® and PERMENORM®

Introduction

SEKELS GmbH is the exclusive distributor for laminations made of NiFe alloys (MUMETALL®, VACOPERM®, PERMENORM®) from VACUUMSCHMELZE GmbH & Co. KG (Germany).

Standard laminations are described in DIN EN 61021 in a variety of sizes and grades. They are stamped from a pre-material strip of the respective thickness and finished by a consequent annealing process to optimize the magnetic properties. A thin oxide layer which has build up during the annealing process is typically sufficient as interlayer isolation. Especially with thin laminations careful handling is required in order to not reduce or destroy the magnetic properties by elastic or plastic deformation.

Usually laminations are stacked in alternating directions in order to reduce the effective air gap. The possible effective permeability depends, besides from the alloy of course, from the size and shape of the laminations, which both influence the ratio between the mean magnetic path length and the effective air gap (shearing). ED and U laminations exhibit the lowest shearing effect and allow the highest permeability values. In combination with the high permeability alloys MUMETALL® or VACOPERM® they are especially suitable for chokes or transformers which need a high inductivity.



Additionally SEKELS is offering customer-specific sizes and shapes, also from CoFe (VACOFLUX®) or SiFe (TRAFOPERM®). We design and produce according to your individual needs, from prototypes to series quantities.

Alloys and sizes

NiFe alloys are the first choice for applications with high demands on permeability/inductivity, core losses or e.g. harmonic distortion.

The basic properties of NiFe alloys for laminations are listed in table 1. Please note, that permeability and coercivity values have been measured with magnetically annealed ring samples (closed magnetic circuit). Practical values are lower due to size, shape and handling effects. They are defined in the respective Magnetic Qualities (see chapter Magnetic Qualities).

Table 1: Basic material properties of soft magnetic alloys for laminations

Alloy	***Composition***	μ_r ***(0,4 A/m, 50 Hz)***	$H_{c,stat}$ ***[A/m]***	B_s ***[T]***	T_c ***[°C]***	***Density [g/cm³]***
MUMETALL®	80 % NiFe	ca. 30000	3	0,8	400	8,7
VACOPERM® 100	80 % NiFe	ca. 60000	2	0,78	400	8,7
PERMENORM® 5000 H2	50 % NiFe	ca. 10000	10	1,55	440	8,25

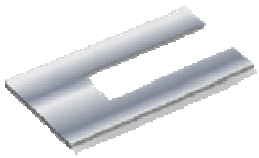
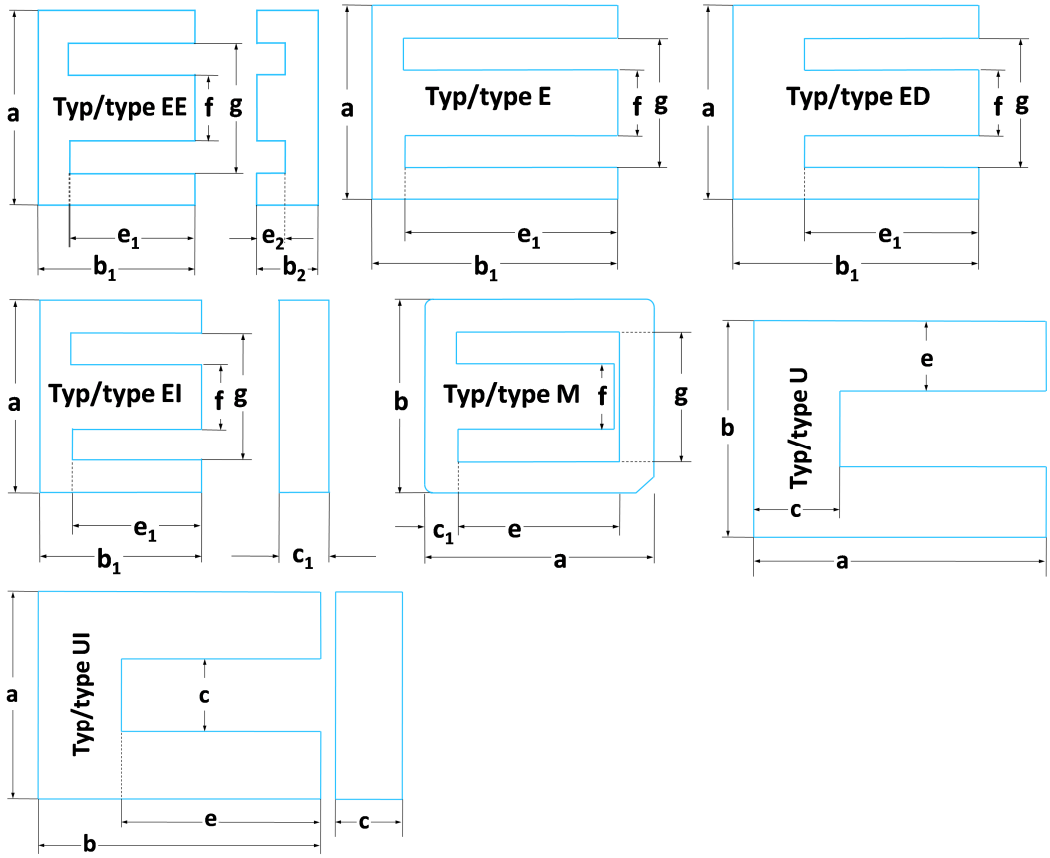


Table 2: Nominal sizes of DIN laminations (selection)

DIN type	a	b(1)	b2	C(1)	e(1)	e2	f	g
	mm	mm	mm	mm	mm	mm	mm	mm
EE 12,6	12,6	8,6	4	-	6,7	2,1	3,8	8,8
EE 16	16	11	5	-	8,6	2,6	4,8	11,2
EE 20	20	14	6	-	11	3	6	14
EE 25	25	17	8	-	13,2	4,2	7,6	17,4
EE 32	32	22	10	-	17,2	5,2	9,6	22,4
EE 40	40	28	12	-	22	6	12	28
ED 12,6	12,6	17	-	-	12,9	-	3,8	8,8
ED 16	16	21	-	-	16,1	-	4,8	11,2
ED 20	20	26	-	-	20	-	6	14
ED 25	25	33	-	-	25,2	-	7,6	17,4
ED 32	32	42	-	-	32,2	-	9,6	22,4
E 12,6	12,6	12,6	-	-	10,7	-	3,8	8,8
E 16	16	16	-	-	13,6	-	4,8	11,2
E 20	20	20	-	-	17	-	6	14
E 25	25	25	-	-	21,2	-	7,6	17,4
E 32	32	32	-	-	27,2	-	9,6	22,4
EI 30	30	20	-	5	15	-	10	20
EI 38	38,4	25,6	-	6,4	19,2	-	12,8	25,6
EI 42	42	28	-	7	21	-	14	28
EI 48	48	32	-	8	24	-	16	32
M 20	20	20	-	3,5	13	-	5	13
M 22	22	20	-	3,5	15	-	5	13
M 30	30	30	-	5	20	-	7	20
M 30z	30	28	-	5	20	-	7	18
M 42	42	42	-	6	30	-	12	30
M 55	55	55	-	8,5	38	-	17	38
M 65	65	65	-	10	45	-	20	45
M 74	74	74	-	11,5	51	-	23	51
M 85	85	85	-	14,5	56	-	29	56
M 102	102	102	-	17	68	-	34	68
U 25/10	25	10	-	5	2,5	-	-	-
U 35/14	35	14	-	7	3,5	-	-	-
U 51/20	51	20	-	10	5	-	-	-
U 71/28	71	28	-	14	7	-	-	-
U 102/40	102	40	-	20	10	-	-	-
U 41/20	41	20	-	10	5	-	-	-
U 57/28	57	28	-	14	7	-	-	-
U 82/40	82	40	-	20	10	-	-	-
UI 30	30	40	-	10	30	-	-	-
UI 39	39	52	-	13	39	-	-	-
UI 48	48	64	-	16	48	-	-	-
UI 60	60	80	-	20	60	-	-	-
Tolerances	± 1/2 IT12	± 1/2 IT12	± 1/2 IT12	-	+/0 IT12	+/0 IT12	0/- IT11	+/0 IT11

Terms see drawings. $b_3 = b_1 + b_2$. $e_3 = e_1 + e_2$.



Magnetic Quality

The Magnetic Quality defines the magnetic limiting values and the testing conditions. For laminations, these are the permeability μ_4, measured with a field strength of 4 mA/cm (equal to 0,4 A/m in SI units) and a frequency of 50 Hz. The measurement is done as random examination with stacked laminations.

Due to the shearing effect, permeabilities with stacked laminations are lower compared to shapes with a closed magnetic circuit, like e.g. tape-wound cores or stamped rings. The relatively highest effective permeabilities are achieved with alternately stacked ED and U laminations, which behave similar to closed shapes up to magnetic saturation. With M, EI and E laminations, the air gap influence significantly increases when half of the saturation flux density is reached due to material saturation in the basis area.

The standard grades are listed in table 3. Often special grades with higher permeability values are possible. Please contact us if you require further information.

Table 3: Standard Magnetic Qualities of laminations

	MUMETALL® ***A - 052***			***VACOPERM® 100*** ***B - 050***			***PERMENORM® 5000 H2*** ***H2 - 050***		
Strip thickness	***0,1 mm***	***0,2 mm***	***0,35 mm***	***0,1 mm***	***0,2 mm***	***0,35 mm***	***0,1 mm***	***0,2 mm***	***0,35 mm***
DIN type	***Minimum permeability values***								
EE 12,6	7500	5500	4000	11000	7000	5000	2700	2200	1800
EE 16	9000	7000	5500	13500	10000	7000	2700	2400	2200
EE 20	10000	9000	7000	16500	13500	10000	3000	2700	2400
EE 25	11000	10000	8000	18000	15000	1200	3000	3000	2700
EE 32	12000	12000	10000	20000	18000	15000	3000	3000	3000
EE 40	13500	13500	12000	22000	20000	17000	3300	3000	3000
ED 12,6	13500	12000	10000	22000	20000	13500	3300	3000	3000
ED 16	15000	13500	12000	24000	22000	18000	3600	3300	3300
ED 20	15000	15000	13500	27000	24000	20000	3600	3300	3300
ED 25	16000	16000	15000	30000	30000	22000	3600	3600	3600
ED 32	16500	16500	16500	30000	33000	24000	3600	3600	3600
E 12,6	10000	9000	8000	18000	15000	10000	3000	2700	2400
E 16	11000	11000	10000	20000	18000	13500	3000	2700	2700
E 20	-	12000	11000	-	20000	15000	-	3000	2700
E 25	-	13500	12000	-	24000	18000	-	3000	3000
E 32	-	15000	13500	-	27000	20000	-	3000	3000
EI 30	-	11000	10000	-	18000	15000	-	3000	2700
EI 38	-	12000	11000	-	22000	16500	-	3000	3000
EI 42	-	12000	12000	-	22000	18000	-	3000	3000
EI 48	-	13500	12000	-	24000	20000	-	3300	3000
M 20	13500	-	-	22000	-	-	3300	-	-
M 22	13500	-	-	22000	-	-	3300	-	-
M 30	13500	-	-	24000	-	-	3600	-	-
M 30z	13500	-	-	24000	-	-	3600	-	-
M 42	15000	15000	15000	27000	30000	24000	3600	3600	3600
M 55	15000	15000	15000	30000	30000	27000	3600	3600	3600
M 65	15000	15000	15000	30000	30000	27000	3600	3600	3600
M 74	15000	15000	15000	30000	30000	27000	3600	3600	3600
M 85	15000	15000	15000	30000	30000	27000	3600	3600	3600
M 102	15000	15000	15000	30000	30000	27000	3600	3600	3600
UI 30	13500	13500	13500	24000	24000	20000	3600	3300	3300
UI 39	-	15000	13500	-	27000	22000	-	3300	3300
UI 48	-	16500	15000	-	30000	24000	-	3600	3300
UI 60	-	18000	15000	-	33000	24000	-	3600	3600

Form parameters and calculation data

The form parameters and calculation data allow to determine the maximum number of turns, the copper resistance, wire length, inductivity and the dc time constant for different wire diameters. Please note that due to variances of the coil formers and tolerances of the core package, practical values may deviate.

Table 5: Form parameters of laminations (selection). The values are valid for MUMETALL® in strip thickness 0,2 mm.

DIN type	h_p	l_{Fe}	A_{Fe}	A_F	M_{Fe}	m_{Fe}	A_{Cu}	l_{Cu}	m_{Cu}	A_L/μ_r	A_R (20°C)
	mm	cm	cm²	cm²	g	g	cm²	cm	g	nH	µΩ
EE 12,6	3,8	3,0	0,13	1,1	0,2	3,4	0,07	2,8	1,7	0,5	71
EE 16	4,8	3,8	0,21	1,8	0,3	7	0,12	3,5	3,6	0,7	51
EE 20	6	4,8	0,32	2,9	0,5	14	0,19	4,3	7	0,8	39
EE 25	7,6	6,0	0,52	4,5	0,8	27	0,30	5,4	14	1,1	30
EE 32	9,6	7,7	0,83	7,4	1,3	55	0,54	6,8	32	1,4	22
EE 40	12	9,6	1,30	11,5	2,0	108	0,87	8,4	65	1,7	16
ED 12,6	3,8	3,5	0,13	1,5	0,3	3,91	0,07	2,8	2	0,5	71
ED 16	4,8	4,3	0,21	2,3	0,4	8	0,12	3,5	4	0,6	51
ED 20	6	5,4	0,32	3,6	0,6	15	0,19	4,3	7	0,8	39
ED 25	7,6	6,8	0,52	5,8	1,0	31	0,30	5,4	14	1,0	30
ED 32	9,6	8,7	0,83	9,3	1,6	63	0,54	6,8	32	1,2	22
E 12,6	3,8	3,0	0,13	1,1	0,2	3,4	0,07	2,8	2	0,5	71
E 16	4,8	3,8	0,21	1,7	0,3	7	0,12	3,5	4	0,7	51
E 20	6	4,8	0,32	2,6	0,5	14	0,19	4,3	7	0,8	39
E 25	7,6	6,0	0,52	4,2	0,7	27	0,30	5,4	14	1,1	30
E 32	9,6	7,7	0,83	6,8	1,2	55	0,54	6,8	32	1,4	22
EI 30	10	6,0	0,90	6,0	1,0	47	0,26	6,4	15	1,9	41
EI 38	12,8	7,7	1,47	9,8	1,7	99	0,45	8,1	32	2,4	30
EI 42	14	8,4	1,76	11,8	2,0	129	0,55	8,8	43	2,6	27
EI 48	16	9,6	2,30	15,4	2,7	192	0,74	10,0	65	3,0	23
EI 54	18	10,8	2,92	19,4	3,4	274	0,95	11,1	95	3,4	20
M 20	5	4,7	0,23	3,0	0,5	9	0,17	4,3	7	0,6	42
M 22	5	5,1	0,23	3,2	0,6	10	0,20	4,7	9	0,6	39
M 30	7	7,2	0,44	6,4	1,1	27	0,48	6,4	27	0,8	23
M 30z	7	7,0	0,44	6,2	1,1	27	0,40	6,4	23	0,8	27
M 42	12	10,2	1,30	12,2	2,1	115	1,07	8,8	84	1,6	14
M 55	17	13,1	2,60	22,3	3,9	296	1,64	11,3	166	2,5	12
M 65	20	15,5	3,60	31,0	5,4	485	2,38	13,3	282	2,9	9
M 74	23	17,6	4,76	40,5	7,0	729	3,09	15,0	413	3,4	8
M 85	29	19,7	7,57	57,1	9,9	1297	3,28	17,1	502	4,8	9
M 102	34	23,8	10,40	80,9	14,1	2154	5,20	20,4	945	5,5	7
U 25/10	5	5,5	0,11	1,5	0,3	5,4	0,36	3,3	11	0,3	16
U 35/14	7	7,7	0,22	2,9	0,5	15	0,75	4,5	30	0,4	10
U 51/20	10	11,2	0,45	6,1	1,1	44	1,69	6,4	96	0,5	6
U 71/28	14	15,6	0,88	11,9	2,1	120	3,48	8,8	272	0,7	4
U 41/20	10	9,2	0,45	5,1	0,9	36	1,24	6,4	71	0,6	9
U 57/28	14	12,8	0,88	9,9	1,7	98	2,56	8,8	201	0,9	6
U 82/40	20	18,4	1,80	20,4	3,5	288	5,61	12,3	616	1,2	4
UI 30	10	12,0	0,90	12,0	2,1	94	1,20	8,4	90	0,9	12
UI 39	13	15,6	1,52	20,3	3,5	206	2,13	10,7	204	1,2	9
UI 48	16	19,2	2,30	30,7	5,3	385	3,34	13,1	390	1,5	7
UI 60	20	24,0	3,60	48,0	8,4	752	5,41	16,2	781	1,9	5

h_p is the stacking height according to DIN EN 61021

l_{Fe} is the mean magnetic path length, calculated from the average of the geometric maximum and minimum path without radii

A_{Fe} is the effective iron cross section, calculated for MUMETALL®, respectively VACOPERM® 100 in strip thickness 0,2 mm and a stacking factor of 90 %

A_F is the surface area of a single lamination

M_{Fe} is the weight of a single lamination in strip thickness 0,2 mm, MUMETALL®, respectively VACOPERM® 100. Due to process-inherent influences, the weight tolerance is about ±10 %

m_{Fe} is the weight of a stacked lamination package of core height hp, calculated for MUMETALL®, respectively VACOPERM® 100 in strip thickness 0,2 mm, a density of 8,7 g/cm³, and a stacking factor of 90 %

A_{Cu} is the effective copper cross section, calculated with copper filling factors between 30 % for smaller sizes, and 45 % for bigger sizes

l_{Cu} is the mean copper length of a single turn, calculated from the core shape. Depending from the coil former practical values may deviate

m_{Cu} is the copper weight, calculated with m_{Cu} (g) = l_{Cu} (cm) x A_{Cu} (cm²) x δ_{Cu} (g/cm³). δ_{Cu} = 8,92 g/cm³

A_L / μ_r gives, multiplied with the permeability values from Table 3 (Magnetic Qualities), the minimum A_L value in nH

A_R is the so-called resistance factor. $A_R = \rho_{Cu} * l_{Cu}/A_{Cu}$. The ratio A_L/A_R is the dc time constant. The dc time constant is the time to reach 63,2 % of the final value after switching on a dc current. ρ_{Cu} is the temperature dependent specific electrical resistance of copper

Table 6: Stacking factors of different alloys and strip thicknesses

	Stacking factors for laminations		
Strip thickness (mm)	*0,35*	*0,2*	*0,1*
MUMETALL®, VACOPERM® 100	92 %	90 %	85 %
PERMENORM® 5000 H2	92 %	90 %	85 %

Data sheets

For each available core packages SEKELS supplies a data sheet with all important information on request. Please the see following example:

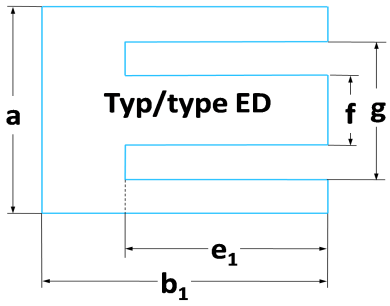
Datenblatt für Kernbleche
Data sheet for laminations

Dieses Datenblatt wurde auf Basis der technischen Unterlagen der Vacuumschmelze GmbH & Co.KG generiert
This data sheet was generated on basis of the technical data from Vacuumschmelze GmbH & Co.KG

Sachnummer (Bestellnummer) / *Part Number* **:**			**S60221-A2220-A002**			
Typ *type*	**Material** *alloy*	**Banddicke** *strip thickness* **(mm)**	**Magnetqualität** magnetic *quality*		$\mu_{4,min}$	**Gewicht** [1] *weight* [1] **(g)**
ED 20	**Vacoperm 100**	**0,1**	**B - 050**	**Standard**	**27000**	**0,31**
					Stück per kg [1] *pieces per kg* [1]	3193

Abmessungen (mm) und Toleranzen/*dimensions (mm) and tolerances* **:**

a	b(1)	b2	C(1)	e1	e2	f	g
20,00	**26,00**	**-**	**-**	**20,00**	**-**	**6,00**	**14,00**
± 1/2 IT12	± 1/2 IT12	± 1/2 IT12	-	+/0 IT 12	+/0 IT 12	0/- IT11	+/0 IT 11



Skizze ohne Maßstab vereinfacht
Draft w/o scale simplified

[1] **gerechnet mit Nenn-Banddicke. Produktionsbedinge Gewichtsschwankungen sind möglich**
[1] *calculated with the nominal strip-thickness. Process depending mass tolerances are possible*

Kern - Kenngrößen für gestappelte Kernbleche (Richtwerte, nur zur Information):
Form parameters and core constants for stacked laminations(guideline values, for information only):

Stappelhöhe package height	h_p (mm):	**6,00**	A_L (gerechnet mit $\mu_{4,min}$) A_L *(calculated with* $\mu_{4,min}$*)*	A_L (nH):	**19226**
Eisenquerschnitt *iron cross section*	A_{Fe} (cm²):	**0,31**	Kupferquerschnitt *copper cross section*	A_{Cu} (cm²):	**0,19**
Mittl. Eisenweg mean iron path	l_{Fe} (cm):	**5,4**	Mittl. Kupferweglänge *mean copper path*	l_{Cu} (cm):	**4,3**
Kerngewicht [1] *core mass* [1]	m_{Fe} (g):	**16,0**	Kupfergewicht *copper mass*	m_{Cu} (g):	**7,3**
Widerstandsfaktor bei 20 °C *resistance factor at 20 °C*	A_R (µΩ):	**39**	DC-Zeitkonstante bei 20 °C *DC time constant at 20 °C*	τ_0 (ms):	**496**
Widerstandsfaktor bei 100 °C *resistance factor at 100 °C*	A_R (µΩ):	**52**	DC-Zeitkonstante bei 100 °C *DC time constant at 100 °C*	τ_0 (ms):	**366**

About us

SEKELS GmbH develops, produces and trades technical products which are mostly related with magnetism. With a team of about 20 employees, more than half of them being physicists or engineers, SEKELS presently serves more than 500 customers worldwide.

As an expert distributor of German VACUUMSCHMELZE GmbH & Co. KG we are offering an in-depth knowledge of their product lines and the applications, are available for technical consultation and provide the fast availability of samples and series deliveries through comprehensive stock keeping and worldwide logistics.

SEKELS develops, designs and produces customer-specific laminations and core packages, magnetic shielding and shielding systems, inductive components and magnet systems - from prototyping to series deliveries.

All parts, components and systems are either produced in Germany, or with quality partners in Eastern Europe based on our technical specifications. We are DIN EN ISO 9001:2008 certified and familiar will the relevant norms and standards.

Your partner for core packages and laminations

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