Permanent magnetic materials

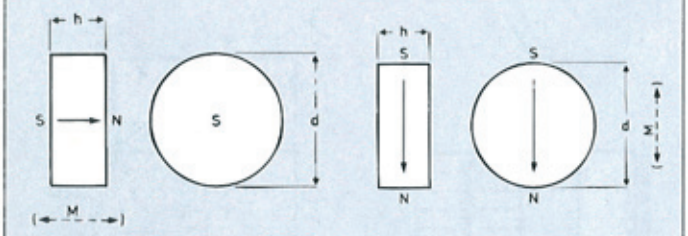
Product types and tolerances

During the manufacturing process especially when moulding and sintering, small variations in the measurements of permanent magnets can occur. If strict tolerances have been specified for the size of the final products. the surfaces of the magnets can be ground or sawn to the exact size. Because the hardness of the magnetic material is very high, these sawing and/or grinding operations have to be performed with special diamond-equipped tools.

Magnetising methods

The most modern magnet materials can be magnetised in various ways. Adjacent illustrations give an idea of the most common possibilities. The in A to D shown can be used with both isotropic and anisotropic magnets. The rest only with isotropic material.

A



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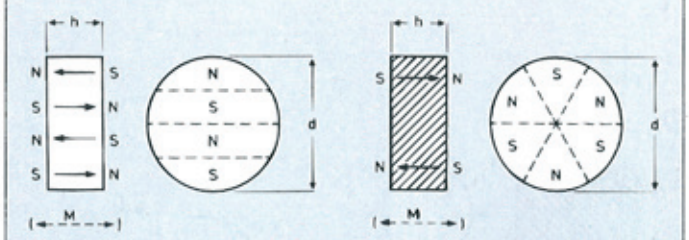

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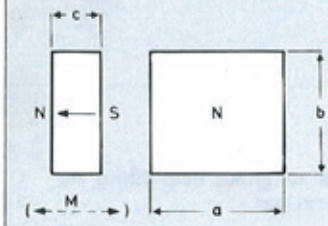

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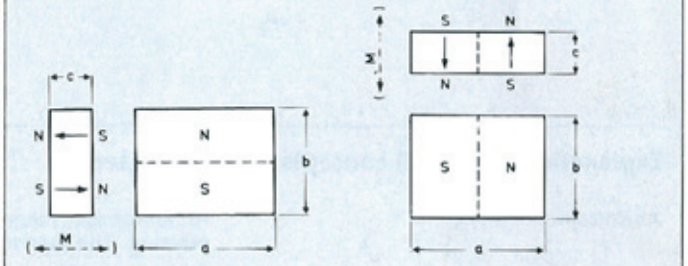

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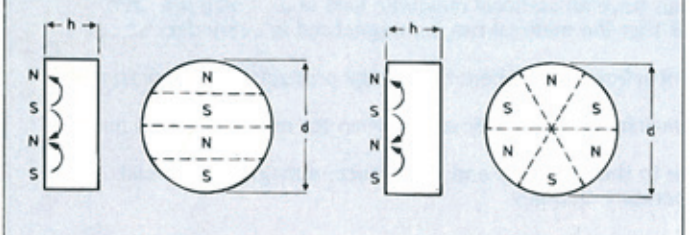

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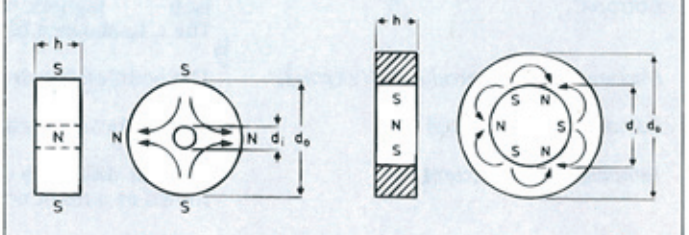
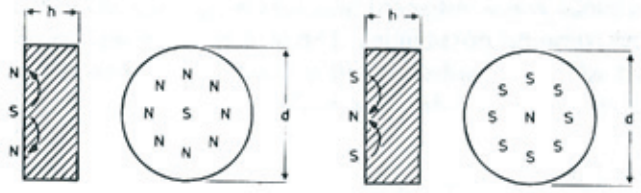


Permanent magnetic materials

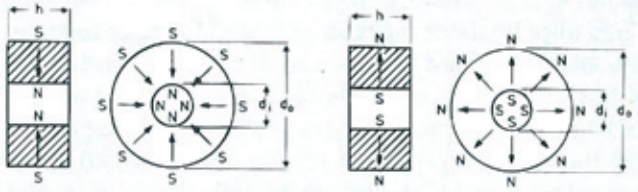
G



Lateral, 2 poles at one side. Central South pole with concentric North poles.

Lateral, 2 poles at one side. Central north pole with concentric South poles.

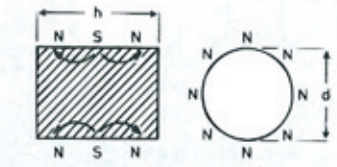
H



Radial, North pole on the inside of the ring.

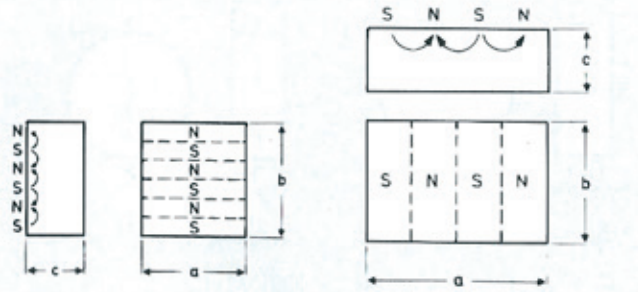
Radial, South pole on the inside of the ring.

I



Lateral, n annular poles (here n=3)

J



Lateral, n poles at one side a x b

Lateral, n poles at one face a x b

Explanation of several concepts and terms used

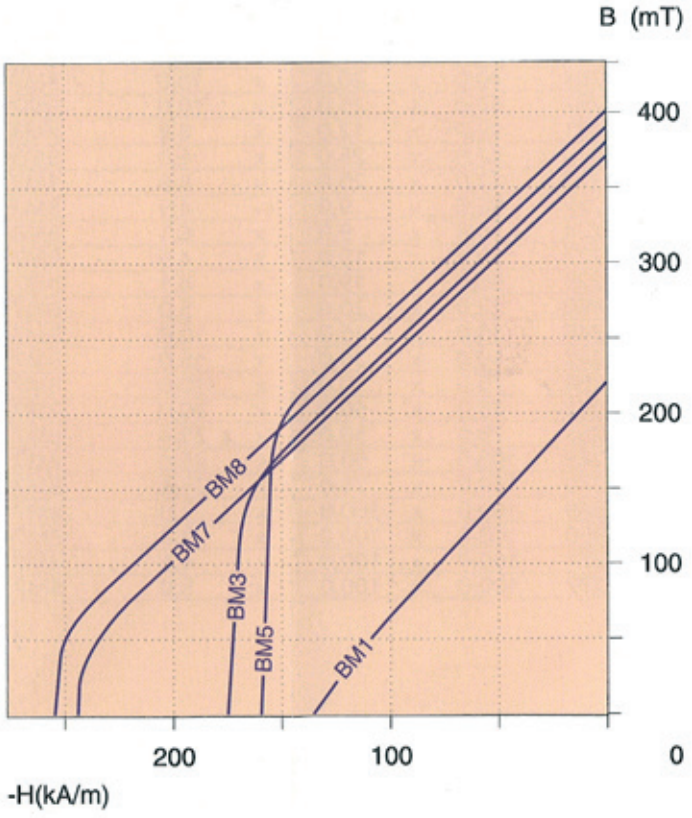
Anisotropic	An anisotropic magnet is subjected to a strong uni-directional magnetic field during its pressing. The magnetic properties are the strongest in this direction.
Coercivity, HcB (kA/m)	The demagnetisation power necessary to return a previously magnetised object to a state of being magnetically neutral.
Curie point (°C)	The temperature at which a magnet loses its magnetic properties.
Demagnetisation curve	The second quadrant of the hysteresis curve that represents the formation of the magnetic field when using the magnet. Also known as the BH curve.
Material density	An indication of the hardness of a material. A measurement of mechanical strength.
Isotropic	Isotropic magnetic materials have an identical magnetic field in all directions. The consequence of this is that the material can be magnetised in every direction.
Maximum energy product BH (kJ/m3)	The point on the demagnetisation curve where the energy product H is at a maximum.
Remanence Br (mTesla)	The magnetic induction remaining in a magnetic circuit when the magnetic field is removed.
Temperature coefficient	Value at which the change to the coercivity and remanence in magnetic materials is shown as a result of temperature changes.

Ceramic magnetic materials

Ceramic magnets can be used in a wide range of situations. In view of their favourable price/performance ratio, they are used in all sorts of industrial and domestic applications. The most common types of ceramic magnetic materials are the anisotropic Strontium, anisotropic Barium and isotropic Barium.
The last material is far and away the favourite for low-cost applications.
The basic material for ceramic magnets is iron oxide to which strontium or barium carbonate and a number of other materials are added to obtain the desired type.
After an automatic process of measuring, grinding and mixing the raw materials, a sort of knitted substance is obtained. This substance is pressed under the influence of an anisotropic magnetic field into the required shape. At the completion of this production phase, the product is demagnetised by reversing the magnetic field.
This is done to prevent contamination by loose magnetic particles. After the products have been dried, the extremely critical sintering process follows after which the products have been given the required mechanical properties. Before delivery, the products are magnetised to the specified level and further finished to match the specifications of the customers.

Technical specifications

		BM1	BM3	BM5	BM7	BM8	
Remanence	B_r	210-220	350-370	390-400	350-370	380-390	mTesla
Coercivity	H_{cB}	130-135	155-175	145-160	210-245	240-255	kA/m
Pol. coercivity	H_{cJ}	210-220	160-180	150-165	220-255	245-260	kA/m
Max. BH product	$(BH)_{max}$	7.2-7.6	24-25.5	28-29.5	24.5-25.5	26-27.8	kJ/m^3
Curie point	-	450	450	450	450	450	°C
Max. operating temp.	-	250	250	250	250	250	°C
Temp. coeff. of B_r (-40° - +20°C)	-	-0.2	-0.2	-0.2	-0.2	-0.2	%/°C
Temp. coeff of H_{cJ} (-40° - +200°C)	-	0.4	0.4	0.4	0.4	0.4	%/°C
Density	-	4.9	4.8	4.9	4.65	4.8	g/cm^3
Barium/Strontium		B	B	B	S	S	
Isotropic/Anisotropic		I	A	A	A	A	



Ceramic magnetic materials

CERAMIC ISOTROPIC DISC MAGNETS
dimensions - diagram 2

Art.no.	A		B	Type
BM 80.018	7,0	x	3,0	BM1
BM 80.020	8,0	x	4,0	BM1
BM 80.022	8,0	x	5,0	BM1
BM 80.025	9,4	x	2,5	BM1
BM 80.027	9,4	x	2,2	BM1
BM 80.034	10,0	x	4,0	BM1
BM 80.037	12,0	x	4,0	BM1
BM 80.038	12,1	x	6,0	BM1
BM 80.040	14,0	x	3,0	BM1
BM 80.041	14,0	x	4,0	BM1
BM 80.043	14,0	x	5,0	BM1
BM 80.045	15,0	x	6,0	BM1
BM 80.048	17,5	x	4,0	BM1
BM 80.049	20,0	x	3,0	BM1
BM 80.052	20,0	x	5,0	BM1
BM 80.053	20,0	x	6,0	BM1
BM 80.060	25,0	x	3,0	BM1
BM 80.061	25,0	x	4,0	BM1
BM 80.063	25,0	x	5,0	BM1
BM 80.064	25,0	x	6,35	BM1
BM 80.065	25,0	x	6,2	BM1
BM 80.070	30,0	x	3,0	BM1
BM 80.073	30,0	x	5,0	BM1

CERAMIC ISOTROPIC BLOCK MAGNETS
dimensions - diagram 1

Art.no.	A		B		C	Type
BM 81.013	8,0	x	8,0	x	5,0	BM1
BM 81.039	24,0	x	9,0	x	5,0	BM1
BM 81.056	30,0	x	9,0	x	5,0	BM1
BM 81.050	25,0	x	11,0	x	6,0	BM1
BM 81.067	39,0	x	9,0	x	5,0	BM1
BM 80.072	41,0	x	17,0	x	5,0	BM1
BM 81.078	50,0	x	15,0	x	6,0	BM1
BM 81.079	50,8	x	15,0	x	6,0	BM1

Calculation using finite elements for permanent lifting magnet

CERAMIC ISOTROPIC RING MAGNETS
dimensions - diagram 3

Art.no.	A		B		C	Type
BM 82.015	8,0	x	4,5	x	3,0	BM1
BM 82.044	13,0	x	5,0	x	5,0	BM1
BM 82.051	14,0	x	5,0	x	4,0	BM1
BM 82.075	18,0	x	5,0	x	5,0	BM1
BM 82.151	27,5	x	20,0	x	5,0	BM1

CERAMIC ANISOTROPIC BLOCK MAGNETS
dimensions - diagram 1

Art.no.	A		B		C	Type
BM 84.021	4,7	x	4,7	x	2,4	BM7
BM 84.023	5,0	x	4,0	x	7,0	BM7
BM 84.028	5,0	x	5,0	x	8,0	BM7
BM 84.031	5,1	x	5,1	x	3,9	BM7
BM 84.033	5,5	x	5,5	x	3,8	BM7
BM 84.042	7,0	x	7,0	x	4,0	BM7
BM 84.046	8,0	x	8,0	x	5,0	BM7
BM 84.083	12,0	x	11,0	x	7,0	BM7
BM 84.088	12,85	x	10,0	x	4,3	BM7
BM 84.092	13,0	x	10,0	x	3,0	BM3
BM 84.096	13,0	x	10,0	x	5,0	BM3
BM 84.100	15,0	x	9,0	x	4,9	BM7
BM 84.105	15,0	x	15,0	x	4,0	BM7
BM 84.116	17,0	x	10,0	x	5,0	BM7
BM 84.122	18,0	x	15,0	x	9,0	BM3
BM 84.132	20,0	x	10,0	x	5,0	BM3
BM 84.140	21,0	x	9,0	x	4,0	BM3
BM 84.159	23,0	x	15,0	x	5,0	BM3
BM 84.150	23,5	x	8,8	x	4,9	BM3
BM 84.155	24,0	x	19,0	x	4,9	BM7
BM 84.156	24,0	x	19,0	x	6,1	BM7
BM 84.157	25,0	x	19,0	x	6,1	BM7
BM 84.181	30,0	x	9,0	x	6,1	BM3
BM 84.187	33,5	x	7,7	x	6,0	BM7
BM 84.192	39,0	x	9,0	x	4,9	BM7
BM 84.362	40,0	x	14,0	x	6,0	BM3
BM 84.204	40,0	x	20,0	x	10,0	BM7
BM 84.207	40,0	x	25,0	x	10,0	BM7
BM 84.371	42,0	x	12,0	x	8,8	BM3
BM 84.454	42,0	x	25,0	x	6,0	BM3
BM 84.370	42,0	x	25,0	x	8,8	BM3
BM 84.222	50,0	x	9,0	x	4,9	BM7
BM 84.224	50,0	x	9,0	x	6,1	BM3
BM 84.227	50,0	x	19,0	x	4,9	BM7
BM 84.229	50,0	x	19,0	x	6,1	BM7
BM 84.460	53,0	x	20,0	x	5,0	BM7
BM 84.246	55,0	x	15,0	x	10,0	BM7
BM 84.247	60,0	x	20,0	x	15,0	BM7
BM 84.258	75,0	x	50,0	x	10,0	BM7
BM 84.262	75,0	x	50,0	x	20,0	BM7
BM 84.263	75,0	x	50,0	x	25,4	BM7
BM 84.269	100,0	x	50,0	x	25,0	BM7
BM 84.270	100,0	x	75,0	x	25,4	BM7
BM 84.949	100,0	x	100,0	x	3,0	BM7
BM 84.950	100,0	x	100,0	x	3,8	BM7
BM 84.271	100,0	x	100,0	x	4,5	BM7
BM 84.272	100,0	x	100,0	x	5,0	BM7

Ceramic magnetic materials

CERAMIC ANISOTROPIC BLOCK MAGNETS
dimensions - diagram 1

Art.no.	A		B		C	Type
BM 84.273	100,0	x	100,0	x	6,0	BM7
BM 84.274	100,0	x	100,0	x	7,0	BM7
BM 84.275	100,0	x	100,0	x	8,0	BM7
BM 84.277	100,0	x	100,0	x	9,0	BM7
BM 84.278	100,0	x	100,0	x	10,0	BM7
BM 84.279	131,0	x	51,0	x	15,0	BM7
BM 84.280	131,0	x	51,0	x	17,5	BM7
BM 84.282	152,4	x	101,6	x	12,7	BM7
BM 84.284	152,4	x	101,6	x	25,4	BM7

CERAMIC ANISOTROPIC DISC MAGNETS
dimensions - diagram 2

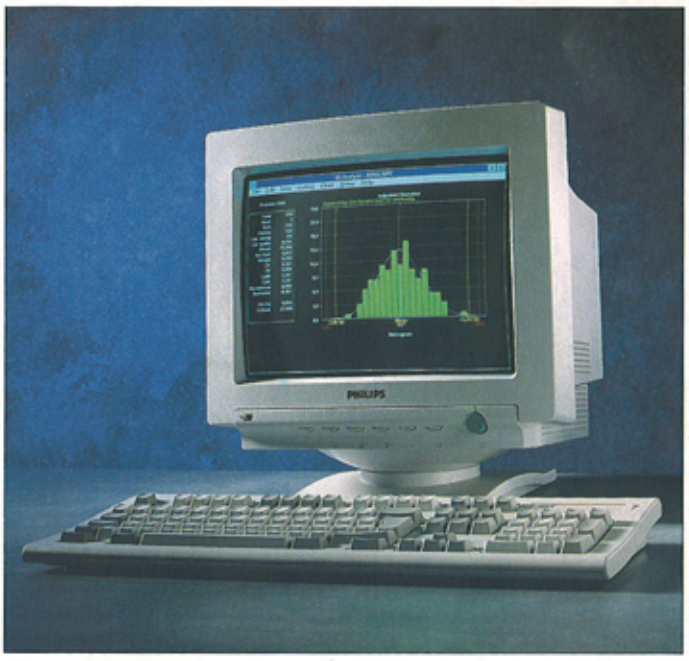
Art.no.	A		B	Type
BM 83.004	4,0	x	3,0	BM3
BM 83.005	4,0	x	4,0	BM3
BM 83.007	4,0	x	5,0	BM3
BM 83.020	5,0	x	5,0	BM3
BM 83.024	5,5	x	1,8	BM3
BM 83.027	6,0	x	2,2	BM3
BM 83.041	8,0	x	2,0	BM3
BM 83.044	8,0	x	4,0	BM3
BM 83.050	9,7	x	5,0	BM3
BM 83.066	9,7	x	7,0	BM3
BM 83.052	10,0	x	2,0	BM3
BM 83.153	10,0	x	3,0	BM3
BM 83.054	10,0	x	4,0	BM3
BM 83.096	10,0	x	4,6	BM3
BM 83.057	10,0	x	5,0	BM3
BM 83.058	10,0	x	7,0	BM3
BM 83.059	10,0	x	10,0	BM3
BM 83.060	10,0	x	12,0	BM3
BM 83.061	10,0	x	14,0	BM3
BM 83.063	10,0	x	16,0	BM3
BM 83.068	10,2	x	7,0	BM3
BM 83.049	10,3	x	4,0	BM3
BM 83.073	12,0	x	3,0	BM3
BM 83.075	12,0	x	4,0	BM3
BM 83.076	12,0	x	6,0	BM3
BM 83.088	15,0	x	6,0	BM3
BM 83.092	15,0	x	8,0	BM3
BM 83.098	20,0	x	5,0	BM3
BM 83.099	20,0	x	6,0	BM3
BM 83.100	20,0	x	10,0	BM3
BM 83.109	25,0	x	6,2	BM3
BM 83.110	27,0	x	7,0	BM3
BM 83.152	27,0	x	7,0	BM7
BM 83.113	28,5	x	6,0	BM7
BM 83.116	30,0	x	4,0	BM3
BM 83.118	30,0	x	6,0	BM3
BM 83.120	30,0	x	8,0	BM3
BM 83.123	30,0	x	10,0	BM3
BM 83.124	30,0	x	10,3	BM3
BM 83.132	39,0	x	7,0	BM3
BM 83.138	45,0	x	9,0	BM3

CERAMIC ANISOTROPIC RING MAGNETS
dimensions - diagram 3

Art.no.	A		B		C	Type
BM 86.005	8,0	x	4,0	x	3,0	BM7
BM 86.040	15,9	x	4,6	x	10,0	BM3
BM 86.050	19,0	x	6,5	x	10,0	BM3
BM 86.083	29,0	x	10,0	x	5,0	BM3
BM 86.095	30,0	x	16,0	x	5,0	BM5
BM 86.110	36,0	x	18,0	x	6,0	BM5
BM 86.112	36,0	x	18,0	x	8,0	BM5
BM 86.127	40,0	x	22,0	x	9,0	BM5
BM 86.134	45,0	x	22,0	x	9,0	BM5
BM 86.150	51,0	x	24,0	x	9,0	BM5
BM 86.165	55,0	x	24,0	x	12,0	BM5
BM 86.181	60,0	x	24,0	x	9,0	BM5
BM 86.182	60,0	x	24,0	x	10,0	BM5
BM 86.186	60,0	x	24,0	x	13,0	BM5
BM 86.212	72,0	x	32,0	x	8,0	BM5
BM 86.213	72,0	x	32,0	x	10,0	BM5
BM 86.216	72,0	x	32,0	x	15,0	BM5
BM 86.252	80,0	x	40,0	x	15,0	BM5
BM 86.262	90,0	x	36,0	x	17,0	BM5
BM 86.303	102,0	x	51,0	x	14,0	BM5
BM 86.326	115,0	x	43,0	x	12,0	BM5
BM 86.345	134,0	x	57,0	x	20,0	BM5
BM 86.372	213,0	x	111,0	x	25,4	BM5

* All measurements in mm.

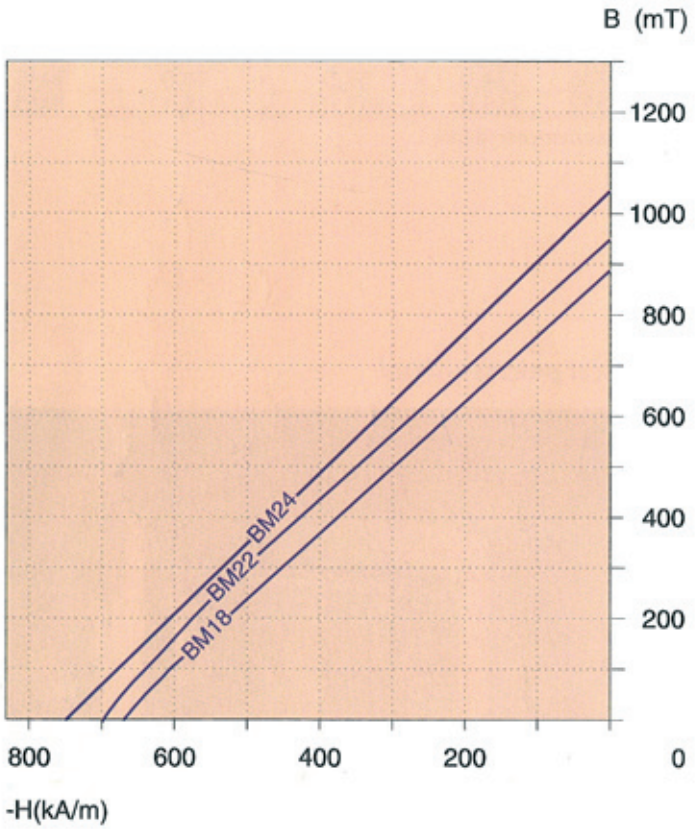
Statistical process control

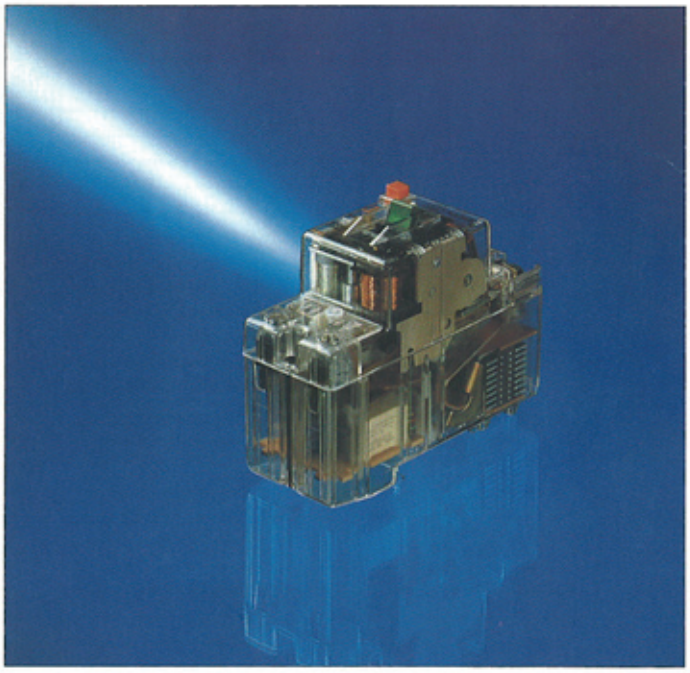


Magnetic materials based on rare earths

Magnetic materials based on rare earths

The manufacturing process for magnetic materials based on rare earths is very advanced. The raw materials are mixed in a protected environment and are ground so that the mixture meets exacting tolerances. Subsequently, the products are pressed and at the same time a powerful magnetic field is used to set the direction of the metallic particles. Finally, the products are sintered in special ovens either in a special mixture of gases. In view of the fact that the final product has a high degree of hardness, the finishing operations are performed with machines equipped with diamond-tipped tools and special cooling techniques are employed. Magnetic materials based on rare earths are Samarium Cobalt (SmCo5) and Neodymium Iron Boron (Nd2FE14B) or Neodymium. To prevent unwanted oxidation, the finished products are supplied with a zinc-, nickel- or epoxy coating. Applications for these high-value magnetic materials can be found where a very high magnetic force is needed (Neodymium is far and away the most powerful magnetic material). These materials are successfully used in places where, in spite of limited space, a powerful magnetic field has to be present (miniaturisation). Neodymium magnets take up to one fifth of the space for the same magnetic force when compared to, for example, ceramic magnets. This, of course, also means that, size-for-size, five times the magnetic power is available.





Application of a magnet in a earth leakage switch

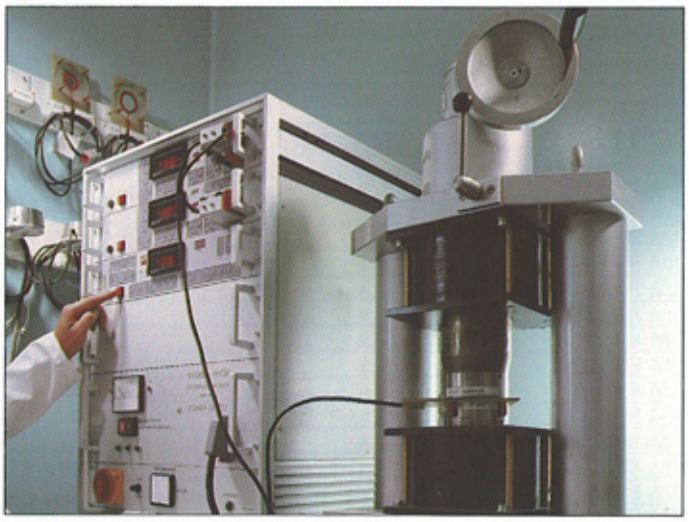
Samarium Cobalt

			BM18	BM22	BM24	
Remanence		B_r	850-890	920-950	1000-1050	mTesla
Coercivity		H_{cB}	620-670	630-700	680-750	kA/m
Pol. coercivity		H_{cJ}	1100-1200	800-1035	1195-1500	kA/m
Max. BH product		$(BH)_{max}$	140-150	150-175	190-205	kJ/m³
Curie point		-	720	800	750	°C
Max. operating temp.		-	250	250	250	°C
Temp. coeff.of B_r	(-40° - +200°C)	-	-0.05	-0.03	-0.03	%/°C
Temp. coeff. of H_{cJ}	(-40° - +200°C)	-	-0.3	-0.3	-0.2	%/°C
Density		-	8.3	8.3	8.3	g/cm³

Magnetic materials based on rare earths

SAMARIUM COBALT DISC MAGNETS
dimensions - diagram 2

Art.no.	A		B	Type
BM 88.302	2,0	x	10,0	BM18
BM 88.303	3,0	x	3,0	BM18
BM 88.304	3,5	x	1,0	BM18
BM 88.305	4,0	x	1,0	BM18
BM 88.400	4,0	x	1,5	BM18
BM 88.306	4,0	x	2,5	BM18
BM 88.307	4,0	x	3,0	BM18
BM 88.308	4,0	x	4,0	BM18
BM 88.309	4,0	x	5,0	BM18
BM 88.312	4,5	x	1,0	BM18
BM 88.311	4,5	x	2,0	BM18
BM 88.313	5,0	x	1,0	BM18
BM 88.315	5,0	x	1,5	BM18
BM 88.318	5,0	x	1,6	BM18
BM 88.316	5,0	x	2,0	BM18
BM 88.317	5,0	x	2,5	BM18
BM 88.320	5,0	x	4,0	BM18
BM 88.324	5,9	x	6,0	BM18
BM 88.329	6,0	x	3,0	BM18
BM 88.336	6,0	x	7,5	BM18
BM 88.347	7,0	x	8,0	BM18
BM 88.353	8,0	x	5,0	BM18
BM 88.357	10,0	x	1,5	BM18
BM 88.360	10,0	x	3,0	BM18
BM 88.362	10,0	x	4,0	BM18
BM 88.372	14,0	x	4,0	BM18
BM 88.375	14,0	x	7,5	BM18
BM 88.376	14,0	x	8,0	BM18
BM 88.379	15,0	x	8,0	BM18
BM 88.387	25,0	x	10,0	BM18

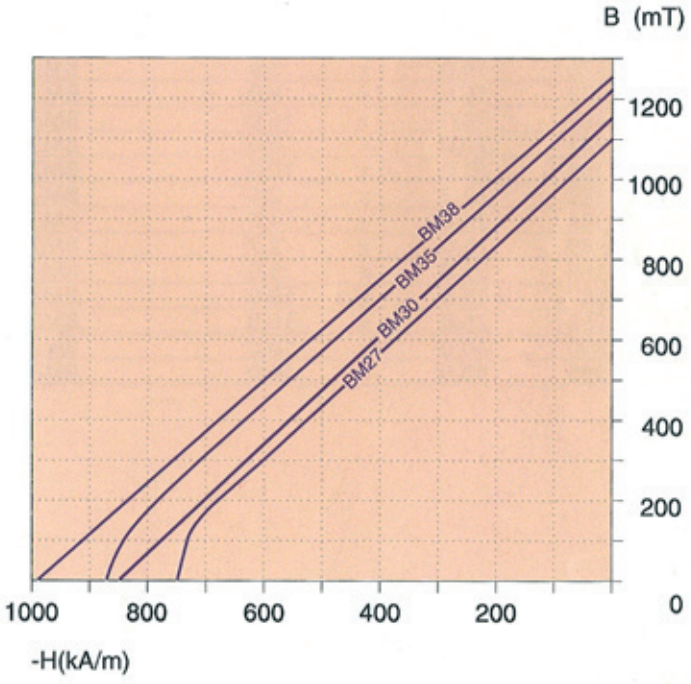


Computerized Permagraph

SAMARIUM COBALT BLOCK MAGNETS
dimensions - diagram 1

Art.no.	A		B		C	Type
BM 88.601	4,0	x	4,0	x	1,3	BM18
BM 88.603	4,0	x	4,0	x	2,0	BM18
BM 88.604	5,0	x	5,0	x	1,5	BM18
BM 88.616	13,0	x	7,0	x	2,5	BM18

* All measurements in mm.



Neodymium

			BM27	BM30	BM30H	BM30SH	BM35	BM38	
Remanence		B_r	1020-1100	1080-1150	1080-1150	1080-1150	1180-1220	1210-1265	mTesla
Coercivity		H_{cB}	715-835	755-835	810-850	810-850	795-875	940-990	kA/m
Pol. coercivity		H_{cJ}	750-1000	750-1000	1150-1350	1300-1590	750-1000	1130-1180	kA/m
Max. BH product		$(BH)_{max}$	195-220	220-245	220-245	220-245	260-285	287-303	kJ/m^3
Curie point		-	310	310	310	310	310	310	°C
Max. operating temp.		-	100	100	120	150	100	120	°C
Temp. coeff. of B_r	(-40° - +200°C)	-	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	%/°C
Temp. coeff. of H_{cJ}	(-40° - +200°C)	-	-0.6	-0.55	-0.55	-0.55	-0.6	-0.6	%/°C
Density		-	7.4	7.4	7.4	7.4	7.4	7.4	g/cm^3

Magnetic materials based on rare earths

NEODYMIUM DISC MAGNETS
dimensions - diagram 2

Art.no.	A		B	Type
BM 89.301	2,0	x	8,0	BM35
BM 89.302	2,5	x	4,0	BM35
BM 89.310	2,5	x	5,0	BM35
BM 89.304	3,0	x	2,0	BM35
BM 89.313	3,0	x	10,0	BM35
BM 89.306	4,0	x	2,0	BM35
BM 89.307	4,0	x	2,5	BM35
BM 89.308	4,0	x	3,0	BM35
BM 89.312	4,0	x	5,0	BM35
BM 89.315	5,0	x	1,5	BM35
BM 89.316	5,0	x	2,0	BM35
BM 89.331	6,0	x	4,0	BM35
BM 89.334	6,0	x	6,0	BM35
BM 89.336	6,0	x	7,5	BM35
BM 89.338	7,0	x	1,5	BM35
BM 89.353	8,0	x	5,0	BM35
BM 89.358	9,65	x	2,0	BM35
BM 89.357	10,0	x	1,5	BM35
BM 89.360	10,0	x	3,0	BM35
BM 89.362	10,0	x	4,0	BM35
BM 89.396	10,0	x	6,0	BM35
BM 89.370	13,1	x	1,5	BM35
BM 89.372	14,0	x	4,0	BM35
BM 89.376	14,0	x	7,5	BM35
BM 89.379	15,0	x	8,0	BM35
BM 89.382	18,0	x	16,0	BM35
BM 89.381	20,0	x	5,0	BM35
BM 89.385	22,0	x	10,0	BM35
BM 89.383	22,2	x	2,0	BM35
BM 89.384	24,0	x	4,0	BM35
BM 89.389	25,0	x	2,7	BM35
BM 89.386	25,0	x	5,0	BM35
BM 89.387	25,0	x	10,0	BM35
BM 89.388	25,0	x	16,0	BM35
BM 89.390	40,0	x	10,0	BM35
BM 89.395	50,0	x	10,0	BM35

NEODYMIUM BLOCK MAGNETS
dimensions - diagram 1

Art.no.	A		B		C	Type
BM 89.603	4,0	x	4,0	x	2,0	BM35
BM 89.604	5,0	x	5,0	x	1,5	BM35
BM 89.605	5,0	x	5,0	x	3,0	BM35
BM 89.606	8,0	x	3,5	x	1,0	BM35
BM 89.611	8,0	x	3,6	x	1,0	BM35
BM 89.608	8,0	x	5,0	x	3,0	BM35
BM 89.613	10,0	x	7,0	x	2,0	BM35
BM 89.616	13,0	x	7,0	x	2,5	BM35
BM 89.617	13,0	x	7,0	x	5,0	BM35
BM 89.620	16,0	x	13,0	x	3,0	BM35
BM 89.621	16,0	x	16,0	x	4,0	BM35
BM 89.622	18,5	x	8,3	x	4,3	BM35
BM 89.626	26,0	x	21,0	x	4,5	BM35
BM 89.627	30,0	x	8,5	x	2,0	BM35
BM 89.629	33,0	x	28,0	x	5,0	BM35
BM 89.631	36,0	x	15,0	x	10,0	BM35
BM 89.632	36,0	x	31,0	x	10,0	BM35
BM 89.634	42,0	x	42,0	x	10,0	BM35
BM 89.669	50,0	x	50,0	x	30,0	BM35
BM 89.640	63,0	x	36,0	x	10,0	BM35

NEODYMIUM RING MAGNETS
dimensions - diagram 3

Art.nr.	A		B		C	Type
BM 89.800	14,2	x	10,8	x	2,65	BM35
BM 89.902	14,5	x	10,5	x	5,0	BM35
BM 89.801	19,0	x	6,5	x	10,0	BM35
BM 89.802	19,5	x	5,4	x	2,0	BM35
BM 89.910	25,5	x	21,5	x	5,0	BM35
BM 89.913	28,0	x	10,0	x	12,5	BM35
BM 89.928	40,0	x	23,0	x	6,0	BM35
BM 89.933	41,0	x	27,0	x	7,5	BM35
BM 89.808	72,0	x	38,0	x	8,0	BM35

* All measurements in mm.