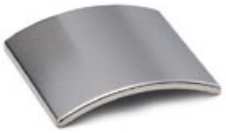
Neodymium Magnets



NEOREC Series

Product Guide

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Contents Update : MARCH 2017

⚠The details can be found by referring to the appended individual delivery specifications.
All specifications are subject to change without notice.

Neodymium Magnets

NEOREC Series

Introduction

The NEOREC series of magnets consists mainly of neodymium, which is a rare-earth element, iron, and boron, and takes full advantage of TDK's state-of-the-art magnetic powder metallurgy technologies. Currently, a maximum energy product of 406KJ/m^3(51MGOe) has been attained. We are striving to further advance the NEOREC series while exchanging results obtained through technological efforts and our unique know-how achieved during such processes among related technical divisions.

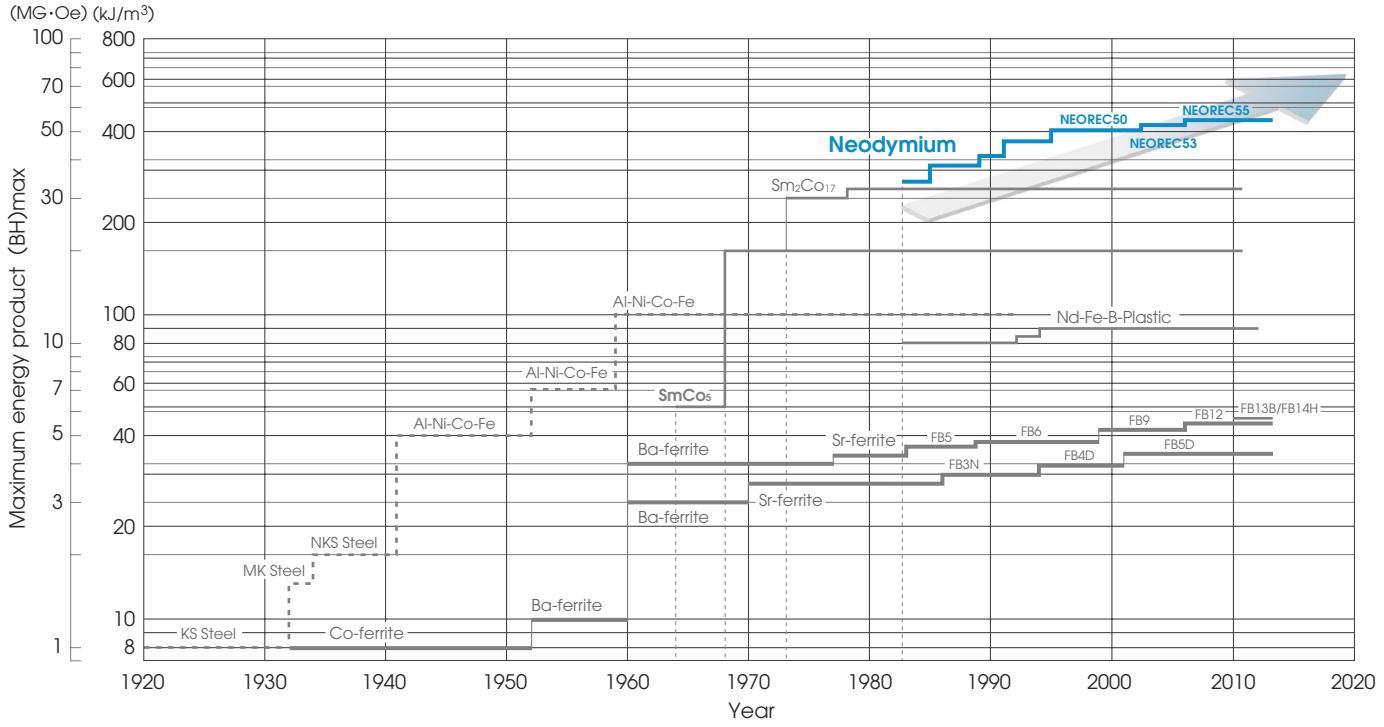
Avoid using materials with a high risk of uneven distribution or market fluctuations, such as Dy (dysprosium), and pioneer a new magnetic property range equivalent to or better than those of the world's highest level high-power materials that have been achieved so far – this is an essential initiative for establishing a permanent and stable supply system for low-cost high-power magnet materials.

We have established a mass-production/supply system for a completely Dy-free material that is comparable to the Dy-added NEOREC 55 series, which has achieved the world's highest level maximum energy product. Meanwhile, we have also developed our unique High Anisotropy field Layer (HAL) production process, which achieves enhanced magnetic coercive force by selectively diffusing Dy in the grain boundary layer of the portions of a magnet that can easily be demagnetized. In order to respond to the latest needs in the technical fields where magnets are applied, including motors, sensors, and actuators, we are committed to lineup expansion and power enhancement of the Dy-free NEOREC series magnets.

We have established an "in-market" service system so as to respond quickly to orders from our customers and address in detail their requests for technical services, with our domestic and overseas manufacturing and service bases as contact points. Responding quickly and accurately to the market needs and promoting development of new markets together with our customers - this is the basic attitude of TDK, who has over 50 years of history of ferrite magnet development.

As a manufacturer providing abundant know-how on magnetic circuit designs as well as high-quality, high performance magnets, we positively support the acceleration and optimization of product designs using magnets.

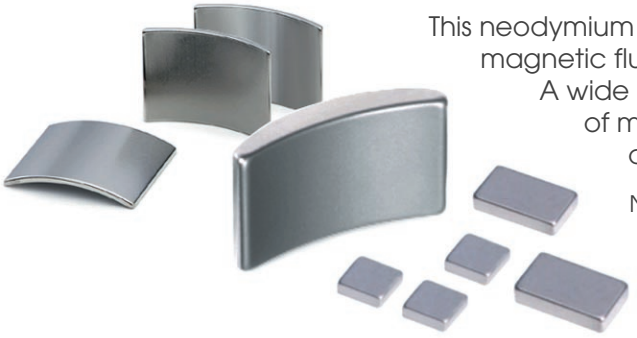
Magnetic characteristics transition of TDK neodymium magnet



Neodymium Magnets

NEOREC Series

Features of TDK Neodymium magnets

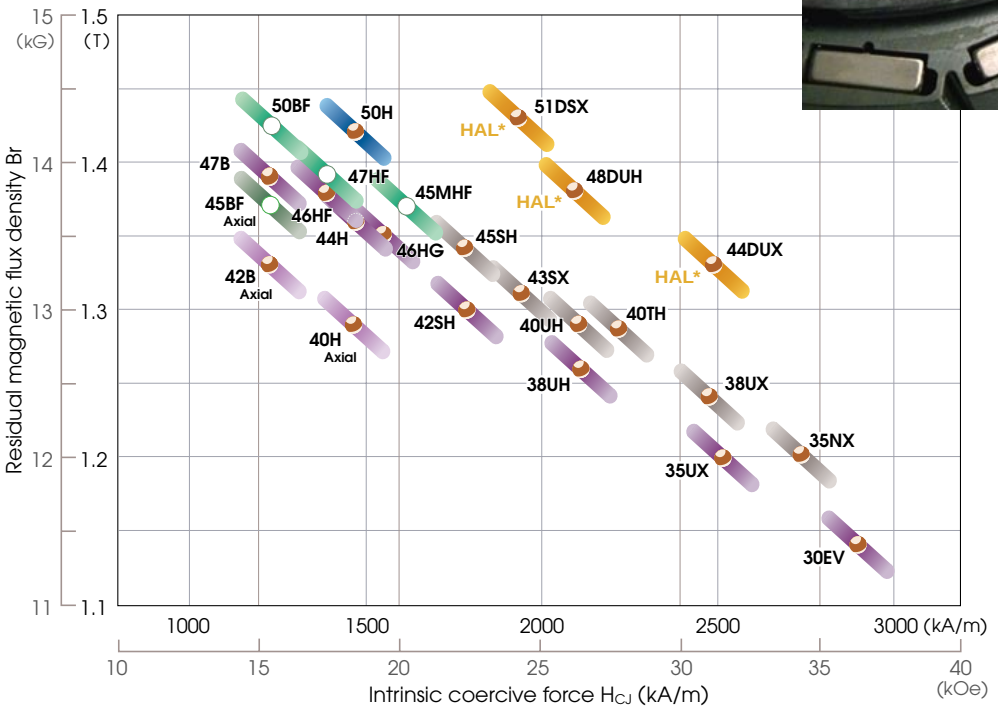


This neodymium magnet achieved the world's highest levels of residual magnetic flux density Br, intrinsic coercive force H_{CJ}, and (BH)max. A wide variety of magnetic characteristics provides a choice of most suitable type, enabling drastic down-sizing, slimming, and increased power of magnet applied devices.

NEOREC50BF/47HF/45MHF/45BF : Dy free material

High performance neodymium magnet for IPM motor

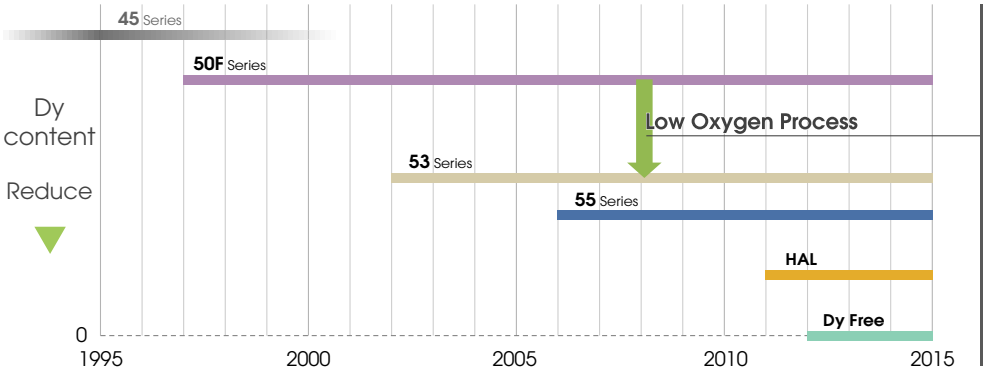
Magnetic characteristics distribution charts of NEOREC Series



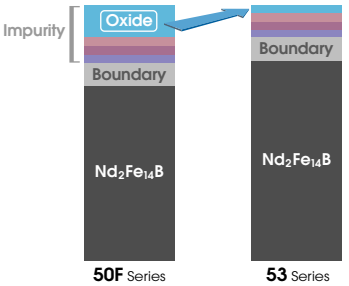
62 Series (HAL*)		Transverse magnetic field molding process
55 Series		Transverse magnetic field molding process
53 Series		Transverse magnetic field molding process
50F Series		Transverse magnetic field molding process
		Axial magnetic field molding process
Dy Free		Transverse magnetic field molding process
		Axial magnetic field molding process

*HAL : Method for increasing coercive force, by diffusing the heavy rare-earth element from the surface of the magnets to inside.

Transition of Dy (dysprosium) reduction/new material development



Substantially reduce the oxidation of alloy powder (impurities generated) by precision atmosphere control



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Neodymium Magnets

NEOREC Series

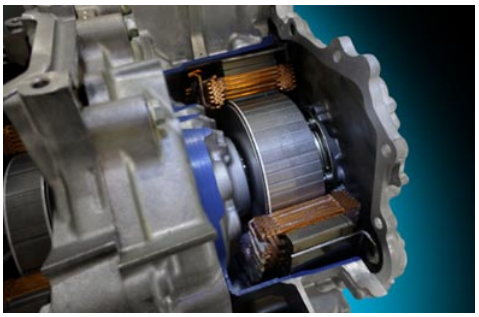
Typical material characteristics

Example of Magnetic characteristics

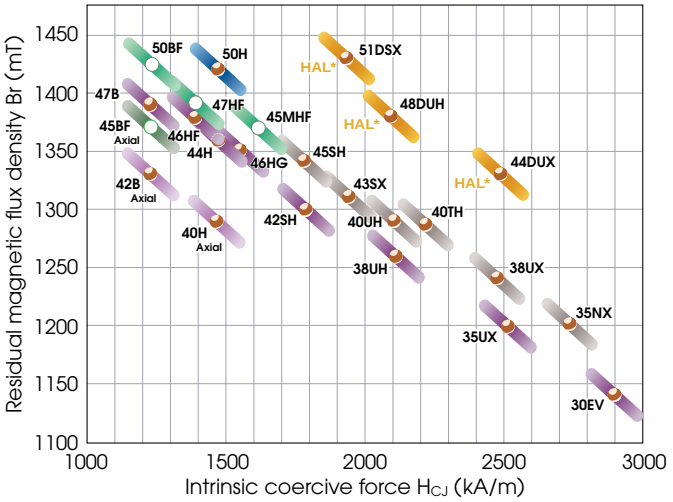
Material group	Molding process	Material name	Residual magnetic flux density Br (mT)	Coercive force H_{CB} (kA/m)	Intrinsic coercive force H_{CJ} (kA/m)	Maximum energy product (BH)max (kJ/m³)
62 Series (HAL)	Transverse magnetic field	**NEOREC51DSX***	1430±30	1095±56	≧1830	390±16
		NEOREC48DUH*	1380±30	1058±56	≧1990	366±16
		NEOREC44DUX*	1330±30	1023±56	≧2387	340±16
55 Series	Transverse magnetic field	**NEOREC50H**	1420±20	1097±48	≧1353	390±16
Dy Free	Transverse magnetic field	**NEOREC50BF**	1420±20	1090±48	≧1114	390±16
		NEOREC47HF	1390±20	1058±48	≧1273	366±16
		NEOREC45MHF	1370±30	1051±56	≧1512	360±20
Dy Free	Axial magnetic field	**NEOREC45BF**	1360±30	1021±56	≧1114	347±16
53 Series	Transverse magnetic field	**NEOREC45SH**	1360±30	1051±56	≧1671	357±16
		NEOREC43SX	1310±30	1012±56	≧1830	331±16
		NEOREC40UH	1290±30	995±56	≧1990	310±16
		NEOREC40TH	1285±30	993±56	≧2109	319±16
		NEOREC38UX	1250±30	966±56	≧2387	294±16
		NEOREC35NX	1200±30	920±56	≧2626	278±16
50F Series	Transverse magnetic field	**NEOREC47B**	1390±30	1035±56	≧1114	366±16
		NEOREC46HF	1380±30	1066±56	≧1273	368±16
		NEOREC44H	1360±30	1003±56	≧1353	350±16
		NEOREC46HG	1350±20	1043±48	≧1432	352±16
		NEOREC42SH	1300±30	979±56	≧1671	326±16
		NEOREC38UH	1260±30	963±56	≧1990	294±16
		NEOREC35UX	1200±30	923±56	≧2387	271±16
		NEOREC30EV	1140±30	867±56	≧2785	231±16
50F Series	Axial magnetic field	**NEOREC42B**	1330±30	987±56	≧1114	334±16
		NEOREC40H	1300±30	971±56	≧1353	318±16

*Magnetic characteristics of materials using HAL method depend on shape and size. For details of the above material, please contact us.

Curie temperature Tc (K)	Recoil permeability μ_{rec}	Magnetizing magnetic field (kA/m)
603	1.05	>2000



Motor-generator for HEV



Physical and mechanical characteristics

Density (Mg/m³)	Specific heat (J/kg·K)	Thermal expansion coefficient (ppm/K)		Flexural strength (MPa)	Compressive strength (MPa)	Tensile strength (MPa)	Young's modulus (GPa)	Vickers hardness Hv
		C//*1	C⊥*2					
7.5 to 7.6	419	5.2	−0.8	270	1100	74	170	600

*1. C// : Measurement value in the direction of easy magnetization
*2. C⊥ : Measurement value in the direction perpendicular to the direction of easy magnetization

Neodymium Magnets

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Surface Treatment

The NEOREC series realizes high environmental performance and functionality with respect to their surface treatment, including washability, moisture resistance, salt water resistance, scratch resistance, thermal resistance, electric insulation, adhesiveness, dimensional precision, and cost advantage.

In order to respond to various reliability requirements concerning magnet-applied equipment, including motors, sensors, actuators, and speakers, with optimal environmental performance balance and functionality, TDK has adopted three film structures (plating/inorganic/resin). Five types of film formation processes covering a wide range of development concepts and applications of magnet-applied equipment are available as the standard lineup.

In addition, all products in the NEOREC series are compliant with the RoHS directive, including these five types of surface treatment. For details of RoHS Directive compatible products ▶ http://www.tdk.co.jp/rohs

Surface treatment for the NEOREC series / Comparation of Features and specifications

Type		Ni plating with uniform electrodeposition property	Multipurpose Cu-Ni plating	MD Coat	US Coat	UG Coat
Features/advantages		Cleanliness	Corrosion/scratch resistance	Easy corrosion prevention	Corrosion resistance adhesiveness	Corrosion resistance thermal resistance
Standard film thickness		10 to 20μm	10 to 25μm	0.5 to 2.5μm	10 to 30μm	10 to 30μm
Material		Ni	Cu-Ni	Inorganic	Resin	Resin
Moisture resistance	PCT*	○	○	○	○	○
	85%RH at 85°C	◎	◎	○	◎	◎
Salt water resistance		○	○	—	◎	◎
Thermal resistance		—	○	◎	○	◎
Adhesiveness		○	○	◎	◎	○
Electric insulation		—	—	—	◎	◎
Washability		◎	—	—	—	—
Dimensional precision		○	○	◎	○	○
Cost advantage		○	○	◎	○	○
Major application field		HDD (VCM) Small magnetic circuits	OA/AV equipment Home appliances, Housing equipment Industrial equipment	OA/AV equipment Home appliances, Housing equipment Industrial equipment Automobiles		

* Pressure cooker test : 120°C, 100%RH, 2atm

Ni plating / Cu-Ni plating

Ni plating features an excellent uniform electrodeposition (film thickness) property, and has a high washability that substantially reduces residual dust and foreign objects, along with high dimensional precision.

Cu-Ni plating features high environmental performance, covering a wide range of applications, from office automation and audio-visual equipment to household and factory automation equipment. It particularly exhibits an excellent anti-corrosive property and scratch-resistance.

Major application examples

Ni plating: VCMs (voice-coil motors) for HDDs for which high washability is required, small magnets for magnetic circuits for which high dimensional precision is required at the time of assembly.

Cu-Ni plating: Supports reliability requirements in a wide range of fields, from office automation and audio-visual equipment to household and factory automation equipment, due to its well-balanced environment resistance including good thermal resistance.

Surface Treatment

MD Coat

A low-cost corrosion prevention coating with a film thickness of 0.5 to 2.5 μm.
Exhibits excellent oil resistance and thermal resistance while being a simple inorganic process,
as well as good adhesiveness.

Major application examples

Provides an efficient and proper degree of environmental performance and a low cost merit
to various enclosed motors including those for automotive applications.

US Coat / UG Coat

Two types of resin coat that simultaneously achieve low cost and high functionality.
Both types are provided with significantly high moisture resistance, salt water resistance,
and electric insulation, which are characteristic of resin.
In addition, US Coat features excellent adhesiveness, and UG Coat exhibits outstanding thermal resistance.

Major application examples

US Coat: Motors for various applications, speakers, linear motors for industrial equipment,
and servomotors for which adhesiveness is required along with corrosion resistance

UG Coat: Motors for EVs or HEVs for which high thermal resistance is required

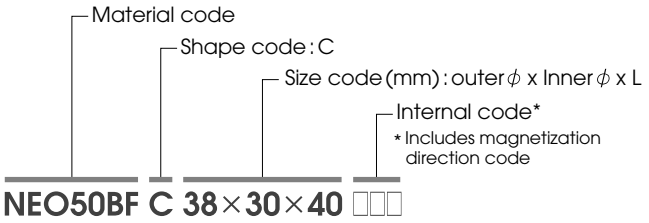
Neodymium Magnets

NEOREC Series

Part number structure

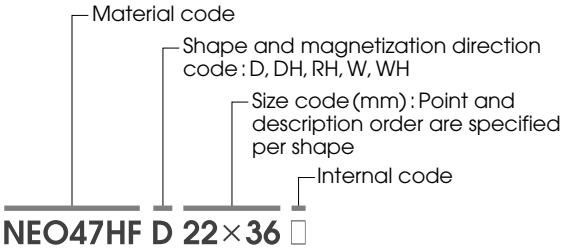
Example of a standard-shaped product -1

Segment type



Example of a standard-shaped product -2

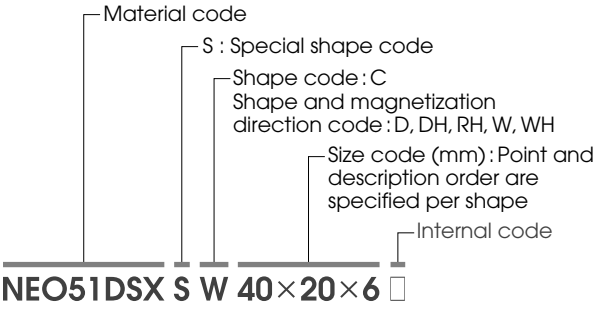
Cylinder type, Circular disc type,
Cylinder type with hole, Ring type,
Cubic/cuboid type, Plate-shaped type,
Cubic/cuboid type with hole, Plate-shaped type with hole



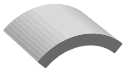
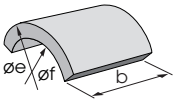
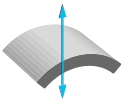
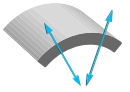
Details on shape and size are specified in the individual delivery specification.

We handle requests for parts in both standard and various special shapes. Please contact for details on shape samples, largest and/or smallest size, etc.

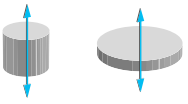
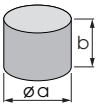
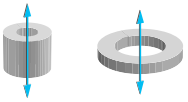
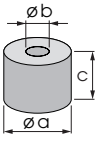
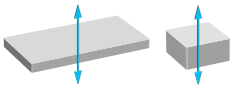
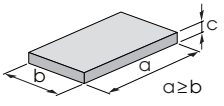
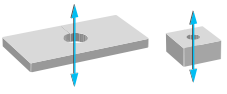
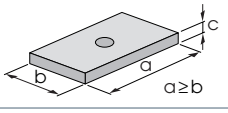
Example of a standard-shaped product



Example -1

Shape	Shape code	Size description point	Size code	Magnetization direction (specified by internal code)
Segment type 	**C**		**e** x **f** x **b**	 Parallel  Radial

Example -2

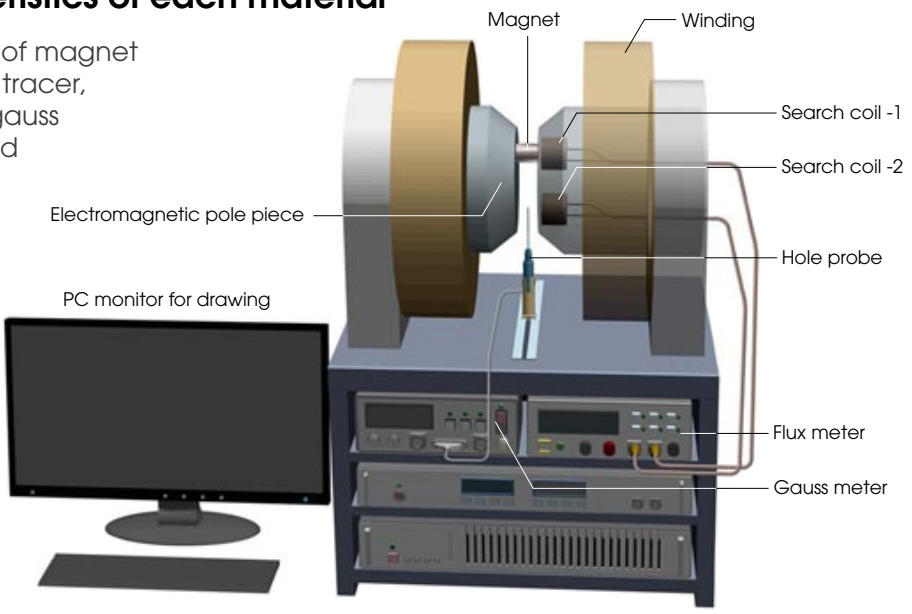
Shape / Magnetization direction		Shape and magnetization direction code	Size description point	Size code
Cylinder type Circular disc type	 Axial direction	**D**		**a** x **b**
Cylinder type with hole Ring type	 Axial direction	**DH**		**a** x **b** x **c**
Cylinder type with hole Ring type	 Orthogonal to axial direction	**RH**		
Cubic/cuboid type Plate-shaped type	 Thickness direction	**W**		**a** x **b** x **c**
Cubic/cuboid type with hole Plate-shaped type with hole	 Thickness direction	**WH**		**a** x **b** x **c**

Measurment method for magnetic characteristics

1. Basic magnetic characteristics of each material

The basic magnetic characteristics of magnet materials are measured via the B-H tracer, which consists of electromagnets, gauss meters, flux meters, hole probes, and so on, using special test pieces manufactured through the same processes as the product.

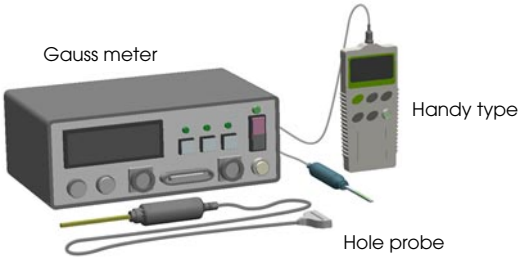
B-H and J-H demagnetization curves are drawn based on the basic data from the B-H tracer, and basic characteristic values such as magnetic flux density Br, intrinsic coercive force H_{CJ} (and H_{CB}), and maximum energy product (BH)max can also be obtained.



2. Magnetic characteristics of each product

The B-H tracer can measure simple block-shaped products. But the consistency (reproducibility) with the measurement results from the individual designs of application products and manufacturing processes of the customers who use the magnets is important for the basic magnetic characteristics of individually-designed products. We therefore follow the conditions and procedures of the simple measurement which our customers and we arranged in advance.

2-1. Tools for simple measurement of magnetic flux density and magnetic flux amount

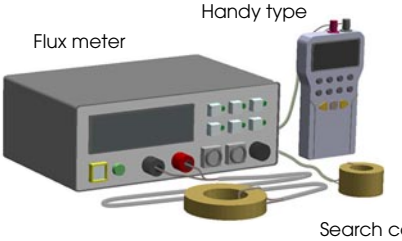


The gauss meter and hole probe are used together to measure magnetic flux density. The measurement accuracy is achieved using probe stands and such, which reduce the unevenness of predetermined measurement conditions (such as the degree of close contact, interval, or parallelization between the hole probe and measured objects).

The flux meter with attached search coils is used to measure the amount of magnetic flux of each product. Measurement values can still differ because of inconsistent speeds of magnet movements and separation distances from the search coils. The assistive tools best suited to each measurement method can ensure accuracy.

In these simple measurement methods, criterial samples are selected from products. Comparative measurement with the samples can avoid errors among measuring instruments.

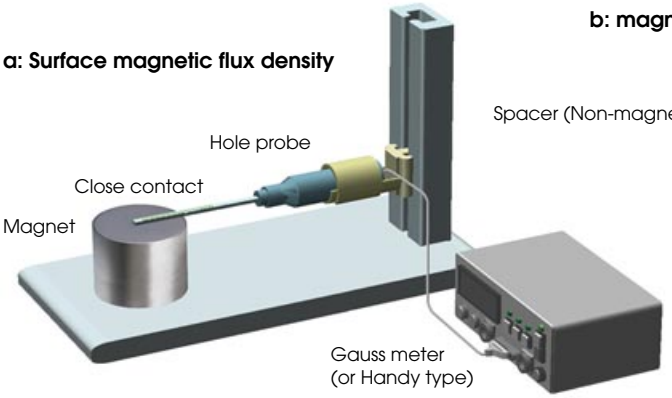
The representative conceptual models are shown in the following page:



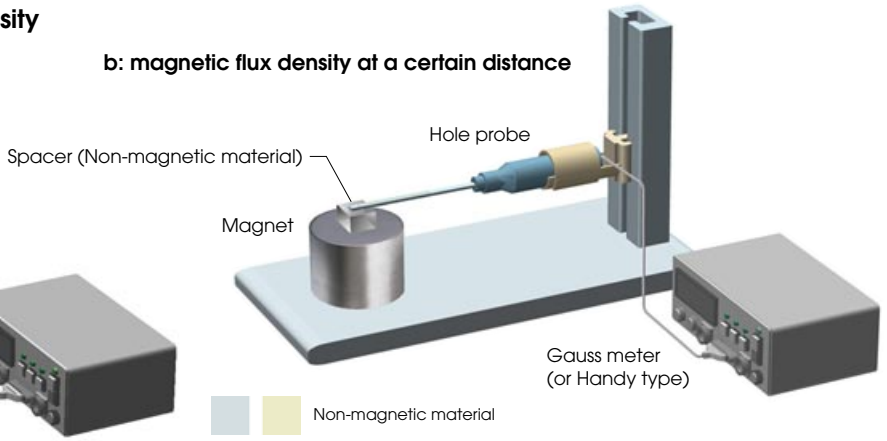
Measurment method for magnetic characteristics

2-2. Measurement of magnetic flux density

a: Surface magnetic flux density

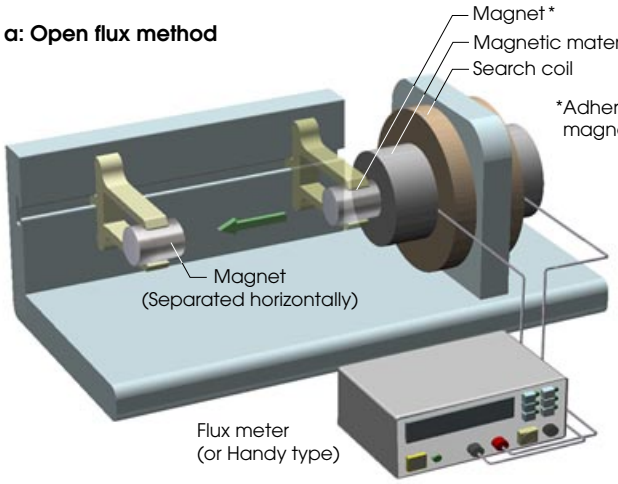


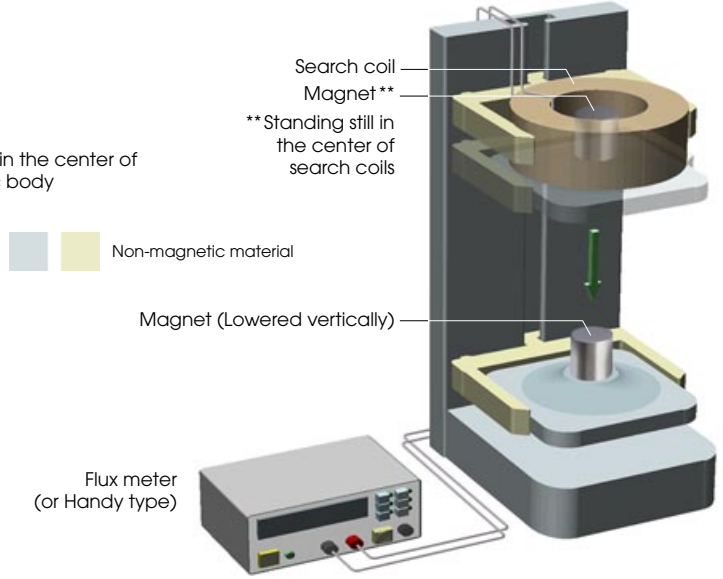
b: magnetic flux density at a certain distance



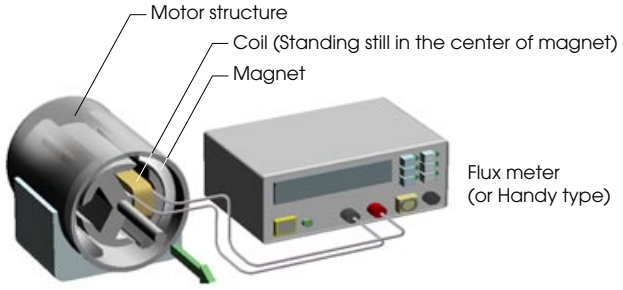
2-3. Measurment of amount of magnetic flux

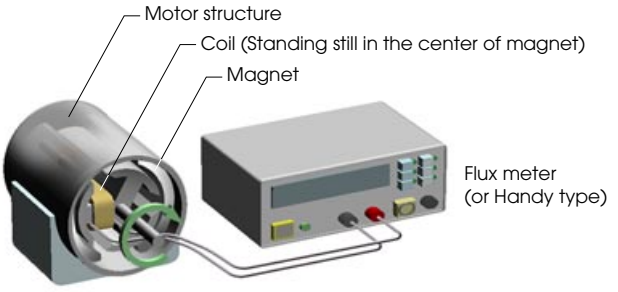
a: Open flux method

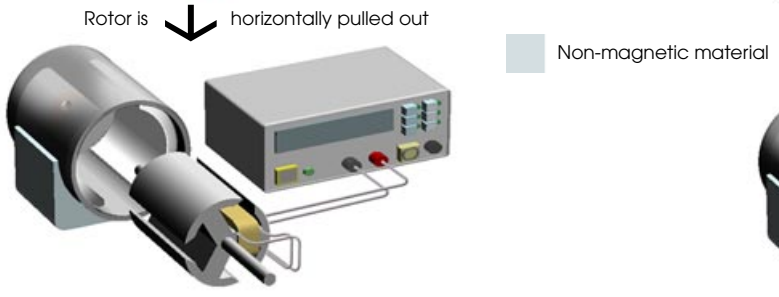




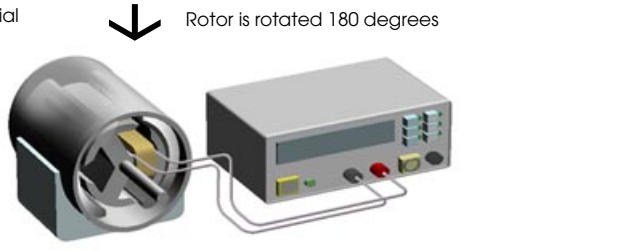
b: Method using magnetic circuits







Non-magnetic material



Neodymium Magnets

NEOREC Series

Precautions regarding safety and use

Please read these instructions before using the product.

Safety Precautions

When using magnets, pay great attention to safety after reading the following precautions. Using the product incorrectly may cause the product functions to be damaged or lead to an accident.

In order to use this product even more correctly and safely, please request a delivery specification form from which more detailed product features and specifications can be confirmed.

⚠WARNING

- It is extremely dangerous to bring a magnet close to a person possessing electronic medical equipment such as a pacemaker or other types of electronic medical equipment. It may impair normal operations of the equipment and lead to a fatal accident.
- Be careful not to swallow magnets.If a magnet is swallowed, consult a doctor immediately. Keep the product out of the reach of children.

⚠PRECAUTIONS

The following precautions must be strictly observed to avoid the occurrence of injuries or functional failures.

[**Design**]

- In general, a magnet loses its magnetism when heated. Check the temperature characteristics in the product catalogue and exercise caution to prevent temperatures from become too high during assembly or use.
- The property values in the catalogue are not guaranteed values. The property values may not be obtained depending on the magnet size or other factors. Perform confirmation before starting the design process using a sample, etc.
- Some magnets demagnetize at low temperatures. When using a magnet, be sure to confirm that it has a material property (demagnetization curve) supporting the maximum and minimum temperatures of the environment in which it is used.
- When magnetizing a magnet, the magnetic property may not be achieved as designed if the magnetization method, etc., is inappropriate. Consult with us in advance concerning magnetization.
- Avoid using or storing magnets in a corrosive gas atmosphere, a highly conductive environment (in water containing electrolytes, etc.), a hydrogen atmosphere, in acid or alkali, or in an organic solvent. It will cause corrosion, deterioration of the characteristics or strength of the magnet. Check the delivery specifications concerning the weather resistance and thermal resistance of the product. If a problem is expected, contact us in advance.
- When processing a magnet, magnetization deterioration or magnetization failure may occur. Consult with us concerning processing conditions. When processing a magnet, pay attention so that chipping or cracking would not occur.
- Magnets are hard and brittle; they may crack or fall out when used in places where vibration or shock is applied. When using a magnet in such a location, pay attention to the design so that the magnet will not fall out even if it becomes cracked.
- There is a risk that a magnet will be damaged by a high-speed rotating body such as a motor. When performing design, take preventive measures so that magnet fragments will not scatter even if it is damaged.
- When performing press-fitting processing, magnets or the counterpart material may become damaged depending on the press-fitting conditions. Pay attention to the press-fitting conditions when performing design.
- When using an adhesive agent for bonding a magnet to another magnet, a york, a pole piece, or other objects, check the type, adhesion conditions, environmental resistance, amount, and adhesiveness of the adhesive agent and give adequate consideration to adhesion reliability.

[**Assembly/Handling**]

- Since magnetized magnets have a strong attractive force, there is a risk that your fingers or hands may get caught between two magnets or a magnet and another magnetic substance (metal fragment, knife, scissors, etc.), resulting in injury. There is also a risk that a magnet will break due to a strong shock caused by the attractive force, and scattered fragments of the magnet may enter the eyes. In order to avoid such risks, exercise caution when handling magnetized magnets.
- Pay attention to the sharp edges of magnets; they may cause finger or hand injuries.
- When magnetizing a magnet using an air-core coil, there is a risk that the magnet may jump out of the coil; secure the magnet for safety.
- A magnetized magnet will attract iron powder or magnet fragments. Pay attention to the environment in which the magnets are handled, since there are cases where cleaning becomes necessary after assembly.
- When bonding a magnet, pay attention so that no oil, dirt or other foreign object adheres to the bonding surface. It may decrease the adhesive force, causing the magnet to drop off

[**Storage**]

- Store magnets in places free from impact due to being dropped. Chipping or cracking may be caused by impacts.
- Do not store magnets in places where they are exposed to rain or dust or under conditions in which moisture condensation occurs; surface conditions, physical properties, or magnetic properties may change if stored under such conditions.

[**Other**]

- Keep magnets away from magnetic recording media such as floppy disks, magnetic cards, magnetic tapes, prepaid cards, and train tickets. If a magnet is placed close to a magnetic recording medium, recorded information may be destroyed.
- Keep magnets away from electronic devices; if a magnet is placed close to an electronic device, it may affect its measuring gauge or circuit, resulting in a failure or accident.
- If you are allergic to metals, contact with a magnet may cause your skin to become irritated or turn red. If such symptoms appear, take measures such as wearing protective gloves to avoid direct contact with magnets.
- Do not lick magnets. Never drink fluids that came into contact with magnets.

[**Special Note Concerning Neodymium Magnets**]

- Do not handle neodymium magnets in a way in which neodymium magnet powder is generated, such as by causing friction. Neodymium magnet powder has a risk of being ignited.
- When handling cut pieces or ground powder generated when cutting neodymium magnets, note the following reminders. Neodymium magnet powder contained in cut pieces or ground powder may have a risk of spontaneous combustion.

  (1) Keep fire, flammables, organic solvents, etc., away.
  (2) Do not vacuum magnet powder with a vacuum cleaner.
  (3) Prepare a dry chemical fire extinguisher or sand in case ignition occurs.
  (4) Do not leave cut pieces or ground powder exposed to air, but keep them immersed at all times in a container filled with water.

  Contact us concerning the disposal of stored cut pieces or ground powder.

For Our Customers

- When using magnets, please sufficiently discuss matters in advance with the related departments of our company. In addition, please consult with us when you wish to change the application or assembly method following discussions with the related departments of our company.
- We wish to prevent any safety issues caused by magnet usage methods or magnet application designs through detailed advance discussions with our customers.