Neofer® p and Sprox® – setting new standards for polymer-bonded magnet materials
Neofer® p and Sprox® – polymer-bonded magnet materials for the most demanding requirements

Magnetfabrik Bonn: Expertise, experience, quality and service

The speed of developments in sensor technology has sparked off an unexpected boom in the polymer-bonded magnet materials industry, particularly in fields where maximum levels of precision, process reliability and dependability are needed in conjunction with acceptable costs. Magnetfabrik Bonn has played a decisive role in this development. Our extensive skills in all aspects of materials, production techniques and applications coupled with 75 years of experience have made us one of the leading experts in this field. Day in, day out, magnets from Bonn are being used with considerable success whether in the automotive industry, in machine tools or in automation technology. They are doing their job in synchronous motors, in small-power motors and generators, as switching magnets, in clutches, timers, speed sensors, speedometers, in fuel gauges, toys and much more. In many fields it is already impossible to imagine a world without contactless and hence wear-free position detection, angular measurement or travel measurement.

Responsibility from A to Z

The demands on polymer-bonded magnets are becoming ever more complex. Which is why we rely on research and development, the expertise of our staff, an intensive dialog with our customers’ specialists and our own production facilities. The result is innovative, competitive products and system solutions which help our customers to keep abreast of the market successfully. Our commitment to a quality management system compliant with DIN ISO 9001: 2000 and ISO/TS 16949: 2002 and an environment management system compliant with ISO 14001: 2004 helps us to take on the responsibility of keeping our products at the cutting edge.

Production of polymer-bonded magnets

Injection molding

Sprox® magnets are manufactured from isotropic or anisotropic magnet materials. Barium ferrite or strontium ferrite powder is compounded with thermoplastic binders to form a granulate suitable for injection molding. The granulate is then processed in customized injection molding machines using specially developed tools. This inexpensive material can be magnetized in a variety of patterns by applying magnetic fields in the injection molding machine. Subsequent magnetization is often not required. This technique is particularly cost-effective for long production runs.

The Neofer® p magnets use an isotropic NdFeB-based rare-earth material which is compounded with thermoplastic binders. The isotropic materials Neofer® 37/60p through 41/100p are magnetized after they have been shaped. This means that any form of magnetization can be implemented.
Compression molding
In this process, NdFeB powder is compounded with thermosetting resins. The actual pressing operation is carried out in tools and machines commonly used in powder metallurgy. After they have been shaped, the moldings are thermally cured to give them mechanical stability. The materials Neofer® 62/60p and Neofer® 55/100p can be compression molded to form common shapes such as blocks, disks, rings, flat sections and segments with and without holes. The higher filling level and resulting increase in density considerably enhance the magnetic properties in comparison with injection-molded products.

Shaping polymer-bonded magnets
The advantage of the injection molding process for producing magnets lies in the wide range of shapes that can be produced. It is also possible for inserts such as axles, bushes or rings to be molded around, with the inserts being loaded by hand or fully automatically, depending on the quantity produced. The costs of assembly operations can be reduced as such materials allow press-fit, snap-fit and positive-fit connections with motor shafts etc. By contrast, the compression molding technique only allows simpler geometries. Both production processes allow products to be manufactured within such tight tolerances that no reworking is generally necessary. Depending on the size of the molding, the tolerances that can be achieved are in the range 0.03 through 0.25 mm. Mechanical reworking of the completed molding is generally not required. As required, however, polymer-bonded materials can be turned, drilled, milled and ground as they are not as brittle as sintered materials. Constant testing and monitoring throughout the production process ensures consistent quality.

Magnetic and physical properties
The proportion of synthetic plastic materials of typically ten percent by weight (injection molding) and four percent by weight (compression molding) mean that the magnetic properties lie below those of unmixed material. On the other hand, with anisotropic grades, it is possible to achieve a directional magnetization during the injection molding process. This in turn improves the magnetic properties.
### Injection molded materials

<table>
<thead>
<tr>
<th>Designation</th>
<th>Code as per DIN IEC 60404-8-1</th>
<th>i/a</th>
<th>Minimum values</th>
<th>Typical values</th>
<th>Binder</th>
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<tr>
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<td></td>
<td></td>
<td>$B_1$ [mT]</td>
<td>$H_a$ [kA/m]</td>
<td>$H_d$ [kA/m]</td>
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<tr>
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<td>REFeB 27/60p</td>
<td>i</td>
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<td>630</td>
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<td>600</td>
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<td>485</td>
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<td>600</td>
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<td>520</td>
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<td>600</td>
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<td>400</td>
<td>600</td>
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</tbody>
</table>

$^1$ The maximum operating temperature for a magnet materials is dependent on the specific application, the type of magnet and the magnet geometry.

Do not hesitate to contact our Application Engineers for more information.

### Compression molded materials

<table>
<thead>
<tr>
<th>Designation</th>
<th>Code as per DIN IEC 60404-8-1</th>
<th>i/a</th>
<th>Minimum values</th>
<th>Typical values</th>
<th>Binder</th>
</tr>
</thead>
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<td>$B_1$ [mT]</td>
<td>$H_a$ [kA/m]</td>
<td>$H_d$ [kA/m]</td>
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<tr>
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<td>REFeB 55/100p</td>
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<td>REFeB 62/60p</td>
<td>i</td>
<td>650</td>
<td>380</td>
<td>600</td>
</tr>
</tbody>
</table>

$^1$ The maximum operating temperature for a magnet materials is dependent on the specific application, the type of magnet and the magnet geometry.

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Temperature behavior

The temperature coefficient of remanence for Sprox® magnets is approximately -0.19 %/K, the intrinsic coercivity $H_c$ on the other hand has a positive coefficient of approximately +0.4 %/K.

The reversible temperature coefficient for Neofer® p magnets is approximately -0.12 %/K. It should be noted that irreversible losses may also occur at high temperatures. The operating temperatures derived from this also depend on the dimensions of the magnet.

Irreversible losses (short-term temperature behavior²)

² Time-dependent irreversible losses also occur with the Neofer® p group of materials. You will find further information on the influence of temperature on permanent magnets in our Applications Brief 1/2008. You can download this from www.magnetfabrik.de.
Magnetization
The flux density at the surface of the magnet decreases exponentially rather than linearly with increasing distance from the surface.

Example: Ring magnets from Sprox® 11/21p, external diameter 14.8 mm, multipole magnetized around the circumference

Example: Ring magnets from Sprox® 11/21p and Neofer® 44/60p, ext. dia. 14.8 x int. dia. 2.5 x height 8 mm, diametrically magnetized
Example: Sensor magnets from Sprox® 11/21p and Neofer® 44/60p, 4 x 4 x 2 mm, axially magnetized along the 2-mm axis

Flux density for various multipolar magnetized Sprox® and Neofer® p materials. The sintered hard-ferrite material Ox® 100 is also listed for the purposes of comparison.
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