

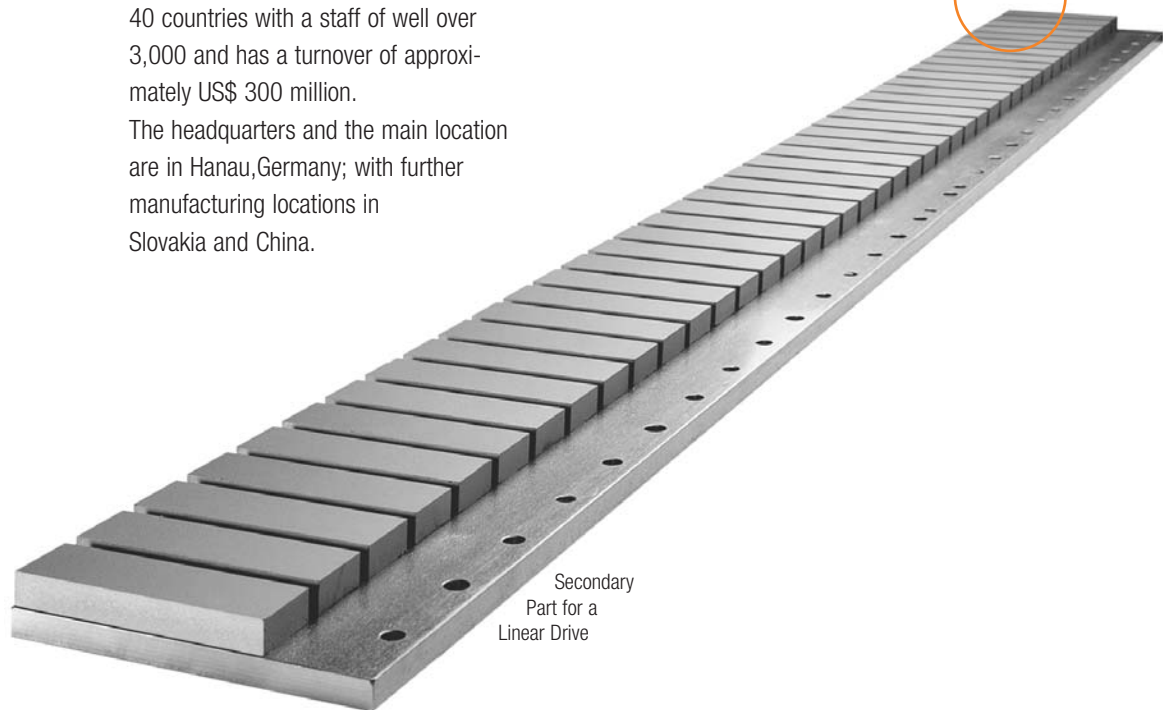
# MAGNET ASSEMBLIES

ADVANCED MATERIALS – THE KEY TO PROGRESS

**VAC**  
VACUUMSCHMELZE

# MAGNET ASSEMBLIES

VACUUMSCHMELZE GmbH & Co. KG (VAC) is one of the leading global manufacturers of special metallic materials with exceptional magnetic and physical properties. Our company is globally represented in 40 countries with a staff of well over 3,000 and has a turnover of approximately US\$ 300 million. The headquarters and the main location are in Hanau, Germany; with further manufacturing locations in Slovakia and China.



## PRODUCT RANGE

Besides the magnets and magnet assemblies described in this publication, our overall product range spans magnetically soft semi-finished products and parts, toroidal cores, inductive components, magnetic shielding and other materials with special physical properties. In addition to the rare-earth permanent magnets described in detail in our PD-002 company publication, we also manufacture ductile permanent magnets and magnetic semi-hard materials as described in our PD-003 company publication.

Our work with the magnetic properties and applications of these special materials dates back more than 80 years. In 1973 VAC started producing VACOMAX<sup>®</sup> permanent magnets based on rare-earth-cobalt using powder metallurgical methods.

We have produced VACODYM<sup>®</sup> magnets on an industrial scale since 1986. They are manufactured from neodymium-iron-boron alloys and exhibit the highest energy density currently possible. From the melting of the alloy under vacuum, to the coating of the finished components, all the steps can be performed in-house, so that we are able to ensure optimum material properties throughout the whole manufacturing process. We are currently the European market leader and one of the leading global manufacturers of rare-earth permanent magnets.

As a result, besides single magnets, we are supplying an increasing number of finished magnet assemblies to customers' specifications.

The use of soft magnetic materials as system components, e.g. VACOFUX<sup>®</sup> and VACOFER<sup>®</sup>, enables us to meet customers' specifications at a high quality level. In many cases optimum assembly and magnetization of the systems is only possible when the magnets and the other system components are sourced and put together at the magnet producer.

Partial Pole  
for a  
Large Drive



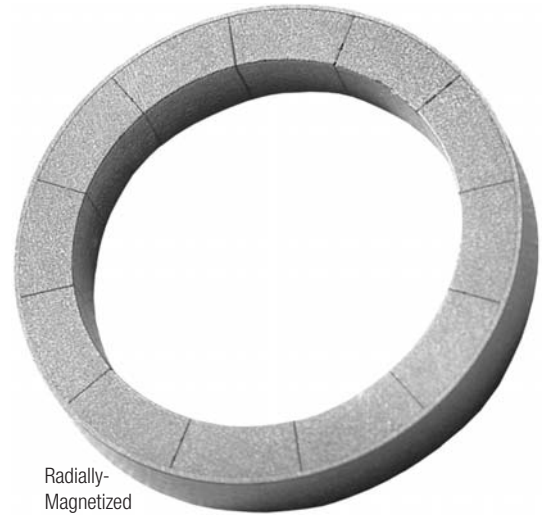
® = Registered trademark of VACUUMSCHMELZE  
\*) = Licenser Sumitomo Special Metals

## MANUFACTURING OF MAGNET ASSEMBLIES

Most of the magnet assemblies manufactured by VAC are constructed using adhesive technology. Selection of the optimum adhesive is a key decision and the following should be considered; the method of assembly, application environment and the properties of all materials used.

Aside from the bonding itself, the next most important aspect is the actual assembly method employed. During assembly it is critical that all surface damage should be avoided. Contamination by any aggressive media is a particular concern, as well as normal mechanical damage.

Corrosion protection is another key point in the manufacture of magnet assemblies. Since the majority of the materials used, such as VACODYM alloys or ferrous alloys, tend to be prone to corrosion, many applications require the magnet assembly to be coated. This ensures that useable life of the assembly goes beyond the service life of the entire system.



Radially-  
Magnetized  
Segmented Ring

## ASSEMBLY TECHNIQUE

The manufacture of samples or small series production of magnet assemblies occurs generally by means of manual bonding. For this process VAC has experienced and highly qualified staff. Every single process step is tested, described in detail in work instructions and is the subject of regular training.

For systems containing small magnets it is usual to carry out the assembly using unmagnetized parts. However, for systems containing large magnets it is often necessary to carry out the assembly using magnetized parts, with correspondingly greater forces involved. Forces measured in tonnes are easily reached in the latter case; as a reference, the mean attraction force of two magnets in direct contact can lie in the order of approx.  $0.1 \text{ N/mm}^2$ . Hence, safety considerations must be paramount. Especially dangerous in such a case are the rapidly increasing magnetic forces at decreasing distances.

Based on the above background it is clear that the design, construction and use of assembly jigs and tools for magnetic systems should be supported by experience. This can be complemented by various calculation aids for designing the tools.

The bonding processes must be automated for cost-effective assembly of large batches. Automation is also advantageous with regard to greater process capability and manufacturing reliability. Our company has special manufacturing-engineering related know-how on the design of automatic bonding assembly systems. Our engineering group always plans and develops such manufacturing equipment in close cooperation with the customer. Tailored and tried-and-tested adhesives allowing fast fixation of each separate bonding component are available for utilization in these assembly lines. Where there are additional requirements for environmental control, these are met by the use of special bonding processes. For example, for some applications the best-possible dust-free environment during assembly and packaging of the systems must be provided to avoid problems occurring later during use in the field.

## PERFORMING BONDING

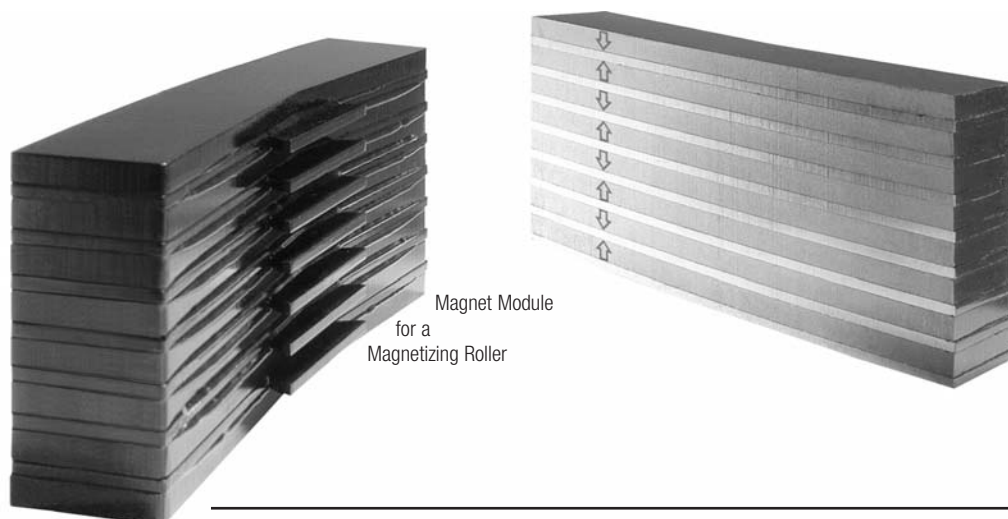
The bonding process starts with preparing the surfaces to be joined. They must be free of contaminants. Therefore, precision cleaning of the surfaces to be bonded is, as a rule, performed immediately prior to bonding. Various methods are available for pre-treating the surface. Their selection is appropriate to the material surface.

Bonding is performed following pre-treatment. The following special conditions must be taken into consideration for the selection of the appropriate adhesive:

- Static and dynamic stress of the bond (strength specifications)
- Thermal load, (duration/short-term/temperature cycles) on the bond
- Properties of the bonded elements
- Corrosive stress of the bond (weathering and chemical resistance of the adhesive)
- Condition of the surfaces (coating, roughness, etc.)
- Width of the bonding gap

Furthermore, for bonding rare-earth permanent magnets we observe the following important fundamental rules: it is not permitted to use acidic adhesives in combination with rare-earth permanent magnets, especially VACODYM. Together with moisture, these products give rise to a rapid disintegration process of the magnet material at the adhesive-magnet interface and can thus cause the bond to fail. Our permanent magnets are passivated following final cleaning. The resulting surface coating is an ideal primer for many adhesives.

The selection of an adhesive for an uncoated magnet or carrier surface is not necessarily applicable to plated surfaces. For the selection of the adhesive we can call on a multitude of adhesives qualified in our company for the most diverse surfaces in combination with important application specifications (temperature stability, resistance to chemical attack, strength, flexibility, curing characteristics, etc.). This puts us in a position to use an appropriate adhesive for virtually every combination of application and surface.

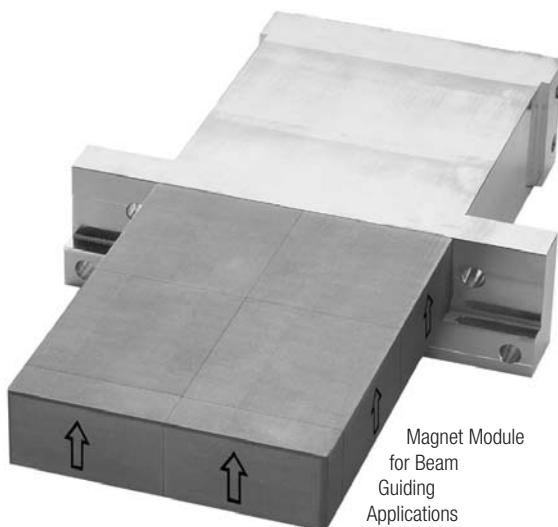


## CORROSION PROTECTION FOR MAGNET ASSEMBLIES

Our rare-earth permanent magnets are offered with various standard coatings. The selection of an appropriate coating is governed by the corrosive stress of the application in question. We can choose from a number of metallic and organic coatings as well as combinations of layers. Please see our PD-002 company publication "VACODYM – VACOMAX Rare-Earth Permanent Magnets". A large number of technically tried and tested surface protective coatings are available for carriers (mostly iron or ferrous alloys)\*.

We also offer complete coating of magnet assemblies. Our proven coating processes ensure compliance with the most stringent corrosion protective and chemical resistance requirements combined with excellent temperature stability. Available for magnetized systems are various high-quality stoving coatings and also air-drying coatings. Features of the coatings we offer are excellent adhesion to metal substrates and also most adhesives, so that they provide optimum long-term protection for many applications.

\*) "Praktische Oberflächentechnik" by K.-P. Müller, Vieweg Verlag, Braunschweig/Wiesbaden 1995.



## MAGNETIZING TECHNIQUE

Magnetization for rare-earth permanent magnets or magnet assemblies is as a rule performed by pulse discharge of a capacitor battery on a magnetizing coil.

In order to apply the magnetization status so that it is also stable against opposing field stresses developing in the future, it must be ensured that an adequate magnetizing field is attained in each internal part of the permanent magnet. Inductions of more than three Tesla for VACODYM magnets and more than seven Tesla for VACOMAX magnets are usually required in the apparatus. The permanent magnets and the magnet assemblies do not develop their magnetic dynamic effect until after magnetization. It is also important to take this dynamic effect into consideration during magnetization of permanent magnets and magnet assemblies!

For the production of many magnet assemblies it is convenient not to apply magnetization until at the latest possible stage. Since no magnetic forces develop prior to magnetization, it is easier to assemble the components and also handle and store the systems before magnetization. Conversely, however, achieving full magnetization in such a case requires special efforts, be it because of the partial shielding effect of the associated soft-magnetic components, because of the spatial arrangement of the magnetic poles or because of the eddy currents occurring during magnetization, which also have a shielding effect.

For all these instances we have ready solutions allowing magnetization to occur at the optimum moment for each respective system.

At our disposal we have adapted energy units for small, medium and large parts. Customized devices are also available or can be developed for special purposes, e.g. preferred radial directions.

## MEASURING FACILITIES, MEASURING EQUIPMENT

Besides their mechanical dimensions and also magnetic parameters, permanent magnets and permanent magnet assemblies can also be described by functional parameters – this is especially true for magnet assemblies.

For the mechanical characterization of permanent magnet assemblies we have mechanical precision measuring equipment of classical types (magnetizable, used only while the system is not magnetized) and, if necessary, also not-magnetized types (for taking precision measurements of magnetized systems). Unidimensional height-measuring equipment as well as coordinate measuring machines are available for complex mechanical measurements.

For magnetic characterizing we use conventional measuring processes:

- Flux meter with a Helmholtz coil for characterizing the magnetic moment
- Gauss meter with Hall probes for characterizing the magnetic field in the air gap or the outside of magnet assemblies at defined spots
- Flux coils with flux meters for integral characterization of the magnetic flux (e.g. in annular gap systems)
- 4-D scanning equipment (linear and rotary strokes)

If necessary, we are also able to characterize product-related functional parameters such as:

- Cogging torques of motors on a special test assembly
- Adhesion force tests
- Shear strength tests of adhesive joints

## CONSULTATION/DIMENSIONING

For the design of permanent magnets the description “magnet circuits”, i.e. a combination of permanent magnet alloys and soft magnetic and other functional materials, is usual.

The selection of the best possible alloy grade with regard to material, shape and dimension can be a very demanding task, especially if it is not possible to fall back on simple functional interrelationships or when influences such as “magnetic saturation” of keepers lead to non-linear effects.

As a manufacturer of soft and also permanent-magnet materials, VAC has in-depth experience of magnetic properties and the processing of these materials. VAC applies this know-how to application development in its optimum advisory service on the design of permanent magnet assemblies functional parameters.

The scope of our dimensioning service includes:

- Analytical methods of describing the magnetic circuits
- Simplified calculation methods for dimensioning pure permanent magnet circuits
- Numeric approximation methods for complex simulations
- Finite element processes in two and three-dimensional space on current DP platforms, including allowing for time-dependent processes and processes including motion.

To provide you with this consultation service we require a specification profile describing the required function of the magnet assemblies, the acceptable dimensions, the thermal and environmental conditions, and electrical limiting conditions.

Based on this information we develop a basic concept with an approximate price for the dimensioning costs.

Jointly with you we develop precise specifications, on which a detailed quotation is based.

Cost-effective production equipment, the latest testing techniques and a quality management system certified in compliance with ISO/TS 16949:2002 are as natural for our company as active environmental protection (certified according to DIN EN ISO 14001) and continuous further training of our staff. Because of these proven principles of our company policy we remain your reliable and competent partner.



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