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# **White Paper:** Gluing Rare Earth Magnets

## Executive Summary

Rare earth magnets are used in a wide range of industrial and consumer products. The manufacturing of these products often requires gluing of the magnet to another surface or substrate, which can be problematic, either due to the plating of the magnet or the chemical composition of the adhesive.

Several factors should be considered when selecting an adhesive, including static, dynamic and thermal load, thermal expansion, corrosive load and material matching. But even when these issues are addressed, there is no single adhesive solution for every application. Cyanoacrylate adhesive, epoxy resin systems and two-component structural adhesives all have their benefits and their drawbacks.

## Intended Audience

This document is intended for manufacturers that use rare earth magnets.

## Presented by Adams

This white paper is presented by Adams, a leading global manufacturer and supplier of permanent magnets and magnetic assemblies.

## Gluing Rare Earth Magnets

The majority of rare earth magnets are assembled into magnet systems using adhesives.

Such construction may require the adherence of multiple magnets to one another or to support parts. But before doing so, several factors must be considered to assure the effective performance of the rare earth magnet, the adhesive and the resulting bond. Chief among these are the chemical and physical properties of the magnets and the surfaces to which they are affixed.

## What are Rare Earth Magnets?

A rare earth magnet, also known as a neodymium magnet, is the strongest known type of permanent magnet. Because of their lightweight strength, temperature resistance and the consistency of their magnetization, neodymium magnets have become a popular choice for a wide variety of applications, from loudspeakers to magnetic therapy jewelry.

Neodymium magnets (a rare earth magnet made from an alloy of neodymium, iron, and boron) first entered the marketplace in the 1980s. They were always strong – more than 10x stronger than ceramic magnets – but improvements in manufacturing processes and other factors have now also made them affordable for everyday use.

A second type of rare earth magnet, made from samarium and cobalt, is also known for its high magnetic strength, and has a higher temperature resistance than neodymium magnets. Samarium cobalt magnets are less subject to corrosion than neodymium magnets, and usually do not require coating or plating.

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## Factors to Consider in Gluing Rare Earth Magnets

When selecting an adhesive the following should be considered:

*Static, Thermal and Dynamic Load*

The gluing system must take into account the static load (which maintains the same direction and degree of force during operation) and the dynamic load (the load that changes in direction or degree of force during operation). Thermal load, or the thermal resistance of the adhesion under typical operating conditions, is also an important requirement.

*Thermal Expansion*

Once the gluing of the rare earth magnet has occurred, the magnet adhesion must absorb the stresses that act on the adhesive during curing or temperature fluctuations. Differences in the thermal expansion coefficients of adhered materials, as well as the coefficient expansion plus and minus depending on parallel and perpendicular to magnetic axis must be taken into account, or the adhesive film may not hold. Manufacturers must first calculate the coefficient of the thermal expansion.

*Corrosive Load*

Many rare earth magnets are plated in nickel, which is highly resistant to corrosive attack. However, this protection can also make adhesion more difficult, as it prevents the metal from reacting with many chemicals associated with glues and adhesives.

*Gluing Surface*

The nickel used in plating rare earth magnets forms a smooth, hard surface that can also make adhesion more challenging. The practice of sand blasting to prepare rare earth magnets for bonding can also pose difficulties; it may loosen the microstructure on the surface of the sintered magnets.

*Material Matching*

Acceptable material matching of electrochemical potentials will reduce the risk of galvanic corrosion (corrosion stemming from voltaic cell formation).

*Gap Thickness*

The span of the gluing gap will be a determining factor in how much adhesive is necessary.

*Coatings*

Rare earth magnets, particularly those made from neodymium, iron and boron, are vulnerable to corrosion due to humidity or condensation. This can take the form of surface rust or magnet decomposition. If there is acid content in the adhesive, corrosion can be rapidly accelerated.

*Gluing Methods*

Before applying adhesive, surface preparation for the rare earth magnets is recommended. Pre-treatment can be challenging with neodymium-iron-boron,

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as some treatments will be compatible with one material but not another. A polymer coating can be used, as long as magnet demagnetization due to elevated temperature cure is taken into account.

The first consideration when choosing an adhesive is whether the rare earth magnet is coated or uncoated. Glues that work with uncoated magnets might be ineffective with a coated magnet, or one with a surface that is difficult to bond, such as nickel plating. If the magnet has been painted, care must be taken to find a glue that will not damage the paint.

Since nickel-plated rare earth magnets offer one of the more difficult adhesive challenges, it is advisable to contact Adams or your magnet's manufacturer for more information.

### *The Need for Speed*

Rapid-setting adhesive systems are preferred for gluing rare earth magnets, as it eliminates the need for holding devices and expedites mass production assembly while lowering the risk of slippage or magnet separation. For automated assemblies, it should be possible to achieve sufficient curing with a minimum adhesion shear strength of 0.5-1.0 N/mm2 in less than two minutes.

## Four types of glues and adhesives have been used for rare earth magnets with varying degrees of success.

### *Cyanoacrylate Adhesives*

Also known as "instant adhesives," cyanoacrylates meet the fast curing and setting criteria that are advantageous to gluing neodymium magnets. However, they must be processed in a climatized adhesion room having a defined humidity. There may also be longer-term issues with static and dynamic load. If the rare earth magnet may be subjected to moisture, another adhesive would be preferable. However, cyanoacrylates are not just sensitive to moisture, they are also weakened by fluctuations in temperature. They are recommended only when the operating temperature does not exceed 80° C.

### *Epoxy*

A heat-curing epoxy resin system provides the necessary strength and resistance, but these adhesives must be cured using continuous ovens having residence times of up to one hour. More rapid curing is possible but requires additional (and more costly) induction measures. They can be used for rare earth magnets, but the drawbacks, particularly with electronic components, must be taken into account.

### *Two-Component Structural Adhesives*

One of the most common methods for gluing rare earth adhesives is with the use of two-component structural adhesives based on substituted acrylates or methacrylates. They combine the preferred rapid-curing performance with acceptable mechanical and thermal load capacity. Curing can be a challenge when direct adhesion of neodymium magnets is required, however, as these structural adhesives rely on higher concentrations of acrylic, methacrylic, or other organic acids as accelerators for curing. Acid-free adhesive systems are

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required for designing magnet systems composed of rare earth permanent magnets.

*Polyurethane Adhesives*

Polyurethane adhesives provide excellent flexibility, impact resistance, and durability. They bond well to rare earth magnets. However, they also require a catalyst, heat, or air evaporation to initiate and complete curing, and are slow to cure even under optimal conditions. Their shelf life is also shorter due to hydroscopic (water absorption) tendencies.

### Conclusion

A one-size-fits-all solution to gluing rare earth magnets remains elusive. The combination of thermal resistance, rapid curing and high-strength in an acid-free formulation has not yet materialized. Thus, consumers and manufacturers must weigh their options based on product type, production environment and usage.