Polymagnet Whitepaper January 5, 2016

Polymagnet®
CORRELATED MAGNETICS

Smart Magnets for Product Design that Surprises the Senses

Make Anything Snap, Slide, Turn, Hold, Click, Pop Out, Align Itself, and Feel Great

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Introduction

This document is for product designers who seek to enrich their products with behaviors and attributes that stand out in the marketplace. Since this document coaches designers on what we consider "advanced topics" on smart magnets, it is likely you have already heard a webinar or seen a presentation on Polymagnets.

This document parallels and complements the webinar Smart Magnets for Smart Product Designs – Advanced Topics.

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What is a Polymagnet?

Polymagnets® are **precision-tailored magnets** that enhance products with sophisticated sensory behaviors that go far beyond the attract-and-repel magnets born 180 years ago. Invented and exclusively manufactured for Correlated Magnetics Research, Polymagnets are essentially an everyday magnetic material that has been imprinted with a layer of patterns that translate into a variety uncommon magnetic behaviors including a softer open/close "feel" or an audible snappy grip. Another behavior is to provide the sensation of a spring or latch.

Why do we say that Polymagnets add a new dimension?

Product design, of course, focuses on function and appearance. There are other key dimensions that contribute to the consumer experience, such as behavior and feel, and magnets can figure into both. You can use magnets to add behaviors that transform a consumer's impression of a product, and boost the user's estimation of its value and willingness to pay more for it. There can be a certain sense of magic and sophistication that smart magnets bring to product – particularly when the designer has had the opportunity to learn "the basics" and understands the options and tradeoffs of smart magnets. That puts you, the designer, in a position to unleash your imagination and use smart magnets in completely new ways.

Polymagnets – Where we are on the product adoption curve

Smart magnets are just getting started. While some of the more visionary and creative global consumer brands have introduced products incorporating Polymagnets and seen enthusiastic reception – consumers appreciate the unique, sophisticated "feel" that Polymagnets give to a product – you can still be one of the early adopters. Relatively few product designers have experimented with Polymagnets and understand how they work, but already the value they can bring is demonstrated in products from iconic brands. Your creativity sets the limits of how smart magnets can be used.

It's a relatively new field. Let us help.

Credit for your product design incorporating smart magnets goes 100% to you. At CMR, we built a team of skilled design engineers for the sole purpose of helping you design differentiated, value-added products that will intrigue and delight your end customer – and be amazingly successful in the marketplace. You can take advantage of a Polymagnet expert with design background to help you leapfrog up the learning curve and get you quickly to a viable, finished product design. We want you to have a smooth, hassle-free design experience with no miscalculation of the type or strength of magnet needed. Tell us what you are trying to accomplish, and capitalize on our expertise to make your job much easier.

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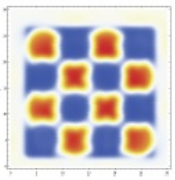
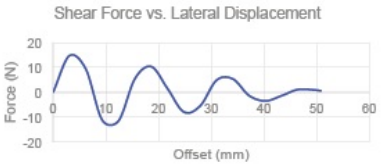
Advanced Uses of Smart Magnets

This paper focuses on these design issues:



• How do I get more magnetic force while limiting magnetic field?



• How do I improve shear strength in the magnetic system in my product?

• How can I incorporate magnet-driven release behaviors in products, such as unlocking, ejecting, popping open, and ease of disassembly?

We discuss some of the considerations and tradeoffs you'll encounter when using Polymagnets, and step you through the process of deciding which features and actions to incorporate in your design.

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How-To #1. May the Right Force and Field Be with You

You probably want more magnetic force, while limiting the magnetic field

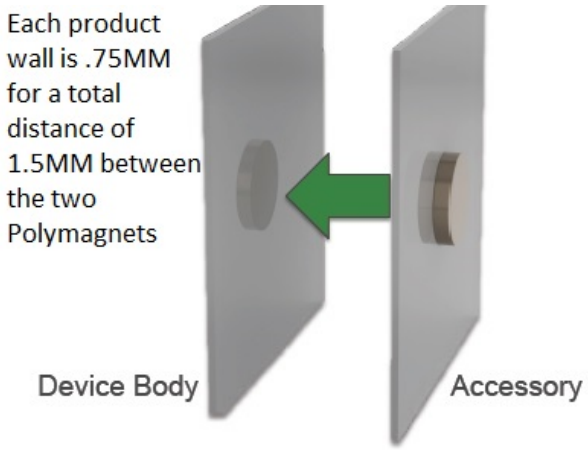
Product designs, to make the most of magnetic behaviors, often need a strong force but with a contained field to protect other components. How do you tame magnetic fields to make magnets safe near sensitive items like a compass or credit card? There are numerous everyday items that can be damaged by magnets, including those that a typical product consumer might put near the magnet you built in.

You start with your required holding force, and then approach the problem of containing the magnetic field as necessary.

A magnet that will be near credit cards should have a field strength of less than 2000 Gauss – anything more, and repeated exposure over time can nullify the credit card. Strong enough, and close enough, and a magnet could even make the card useless on first exposure.

Clamp it: Keeping it together

Most likely, you'll have limited space for magnets inside the product's body. The wall thickness of many plastic products is 0.75mm or more, sufficient to hide magnets in the product body and in whatever you clip to the main body. If there are two magnets, with one in each product surface needing to clamp together, this means you'll have a distance of 1.5 millimeters between the two magnets (through the plastic product sheathing).



Let's say you want 20 newtons of clamping force. That is no problem for Polymagnets, which in addition to being programmable can be up to four times the strength of conventional magnets. Straight from the Polymagnet catalog, you can select a magnet pair to get 27 newtons of clamping force at a distance of 1.5 millimeters.

Takeaway: To work with magnets, it works well to start with the clamping force you need, and then solve the compatibility issues – in other words, pick a magnet that is strong enough, and from there do what's necessary to limit the magnetic field.

Let's say that you choose two magnets, but then find that at the product surface, they exert 2,300 Gauss, which is well over the allowable limit. Polymagnets are designed to operate within a specific range. To get the force products need at a precise location in that zone, but with lower magnetic field, we lower the flux density. To do that, while maintaining the force required, the typical

solution is to increase the size – actually, the surface area of the magnet -- a bit. By lowering the flux density, we can lower the magnetic field to protect circuits in the product. Again, the Polymagnet catalog contains a product which is slightly wider and delivers the force needed, but with the required lower flux and field.

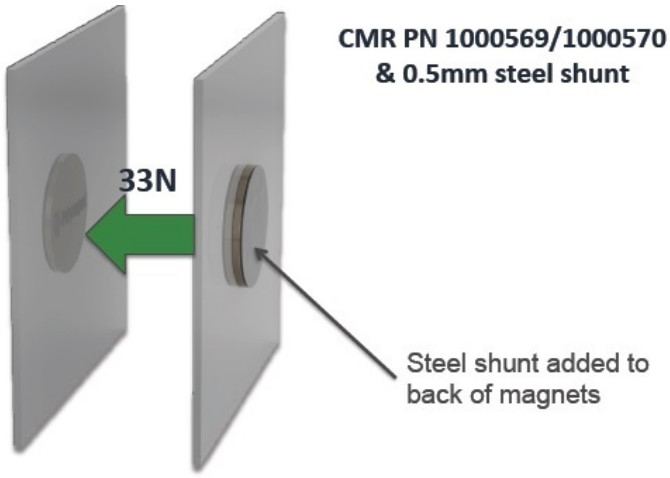
Takeaway: Stretching the dimensions of the Polymagnet increases total clamping force, but reduces the Gauss level at any specific point.

Tradeoff: You might need to go a bit wider than you originally expected, but the payoff is terrific. It's a typical tradeoff with Polymagnets. Our design engineers can either find the ideal Polymagnet or create a new design for your application. In any case, they'll reduce the time you need to resolve issues.

Need more force of attraction?

Shunts optimize performance and compatibility

Once product designers begin using Polymagnets, they quickly start thinking of new applications and inevitably, they come up with uses that require more force. There is an answer for that: shunts. Using shunts, basically a strip of metal behind each magnet (not between them), can increase the force exerted by the magnet. Shunts can also reduce leakage (see below), meaning that a credit card or other item vulnerable to magnetism won't be damaged at the product surface.



So you want more power? Who doesn't?

The shunts are not thick; 0.25 millimeters is sufficient in many cases, for boosting holding force by 20%. A half-millimeter steel shunt behind the same magnet may increase holding force from 25 newtons to 33 newtons, an increase of over 30%.

Takeaway: Shunts can increase the holding force by about 25% or even more.

Tradeoff: The thicker the shunt, the bigger the gain in holding force will be.

This applies to various Polymagnet designs, so working with shunts for added force is not limited to any specific item in our catalog.

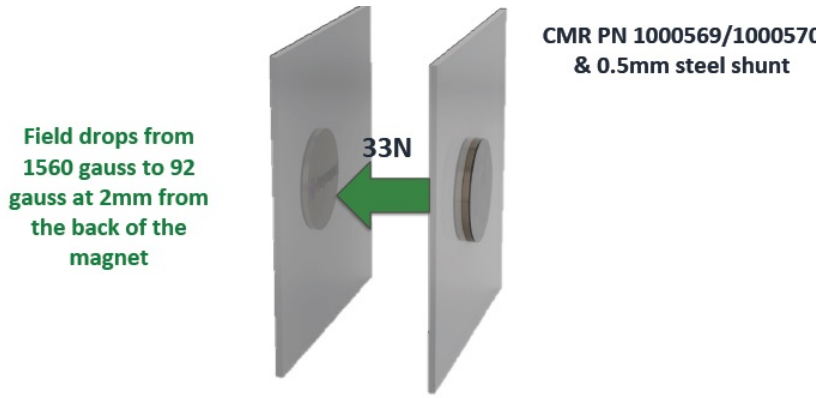
Stay close, so we don't let go

Another technique, which increases the effective force, is to simply lower the distance between the magnet and the target slightly. In one example, as we cut the distance from 2 millimeters down to 1.5 millimeters, the holding force jumps from 50 to 65 newtons, a 30 percent increase.

Takeaway: You can gain significant holding force by reducing the gap between magnet and target.

Compatibility: Cut the leakage, protect other internal components

Another good thing about shunts: they can significantly cut magnetic leakage inside your product. Thus, the shunt has a secondary benefit: protecting the circuits in your product. It can easily cut the Gauss level behind the shunt (inside the product) by 90% or more, particularly close to the magnet. The magnetic field will drop rapidly as the distance increases from the magnet.



In a custom design, we can collaborate to help you cut leakage even further. We understand you require compatibility, not just performance, so our engineering collaboration team is trained to find customized approaches that will maximize both performance and compatibility.

How-To #3. Improve Shear Strength in the Magnetic System in a Product

Conventional magnets can provide good holding force, but they lack shear force – in fact, they offer very little shear resistance. Polymagnets are completely different in this regard. Polymagnets have shear force about 3x or more that of conventional magnets of the same geometry. This makes them excellent at keeping components in correct relative positions.

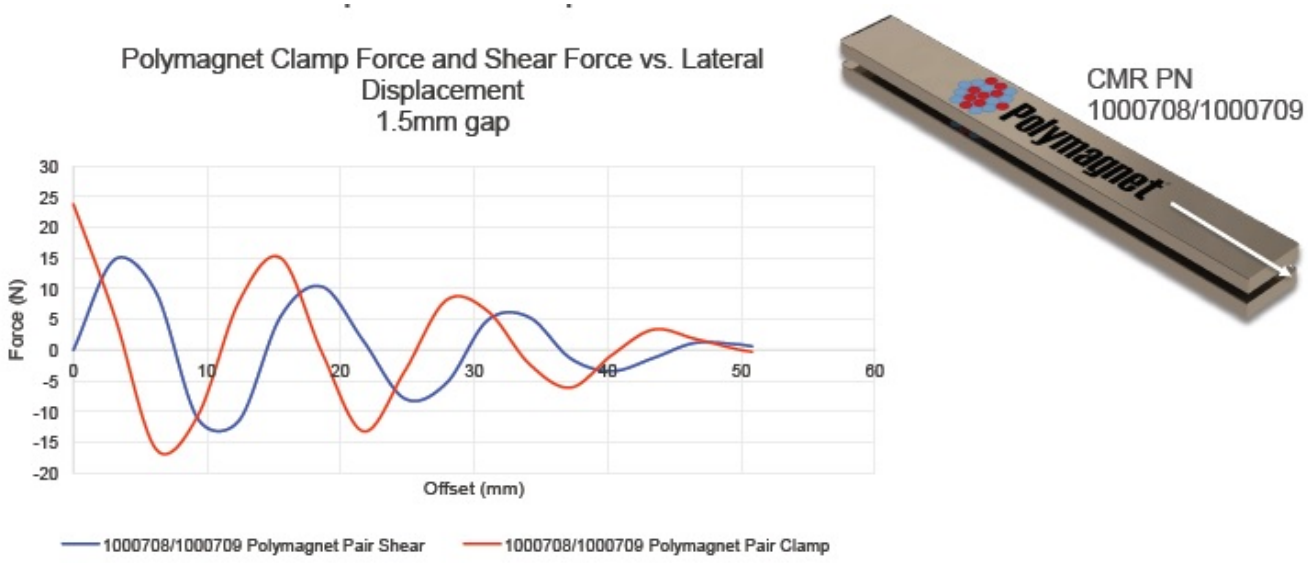
Shear force can be in one or two dimensions, or circular

Polymagnets address longitudinal shear resistance, two-dimensional shear force, and radial shear force.

Here's an example of longitudinal shear force: two long, thin conventional magnets are easy to slide off center lengthwise, where they should be most resistant to displacement. Polymagnets, by contrast, are designed to have shear force. In Polymagnets, shear force has a steep rate of change, becoming much stronger, up to more than 20 newtons, over a short distance of displacement. The result is springy alignment and stability.

Separation? The notion repels.

Polymagnets can also be programmed to repel when pushed too far apart (shifted away from equilibrium position), pushing them back to the equilibrium position. The more you push them apart, the stronger they push back together. These qualities of Polymagnets make them ideal for holding modular products together securely, to improve system stability.



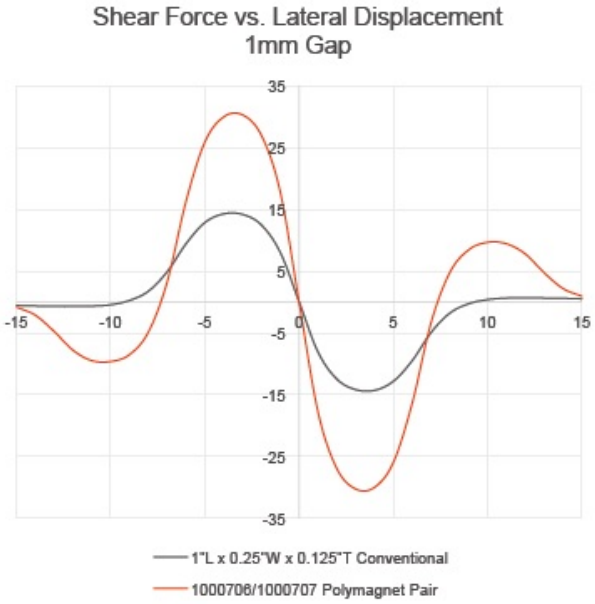
Takeaway: Conventional disk magnets do not give a product the most secure feeling. They are weaklings when it comes to shear force. Polymagnets are the opposite; they have excellent shear force.

Shear force across two dimensions

No doubt you can think of product designs that require significant shear force in two, versus just one, dimensions. The answer is to choose a Polymagnet that has width in two dimensions. By wide, we're talking about 12.7mm width.

Takeaway: A wider Polymagnet gives tremendous improvement in two-dimensional shear strength (along both width and length of the magnets).

Tradeoff: For stronger two-dimensional shear force, the Polymagnet needs to be slightly wider.



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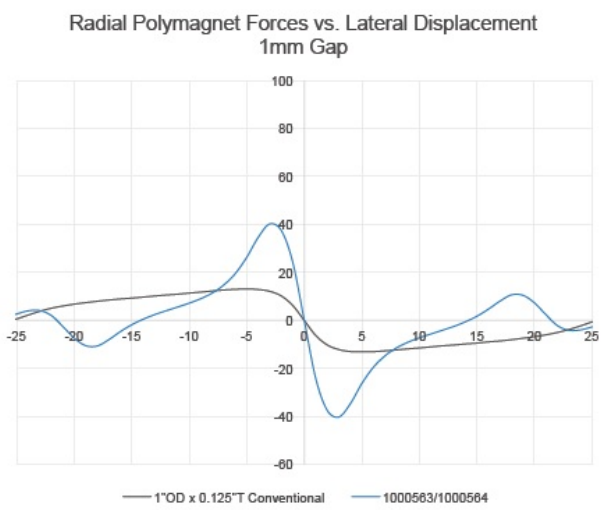
Improved 2D Shear Resistance
This Polymagnet pair gives very good shear resistance along both length and width

Radial tires grip the road; radial disk Polymagnets just grip

We make circular Polymagnets with shear force in every direction, approximately 3x as strong as their conventional lookalikes. These radial grippers exert a strong centering force, helping you create a stable system.

When you need a higher peak force, radial Polymagnets are ideal for aligning components and giving product a secure feeling. The strongest Polymagnets have higher peak force at lower displacement, giving a more precise alignment, and adding stability to systems. Radial Polymagnets are highly effective in this application, with their powerful centering force.



Those are just two examples. There are numerous other options, which the Polymagnet design collaboration team can help you to evaluate.

Takeaway: Radial disk Polymagnets help keep an object in a central position.

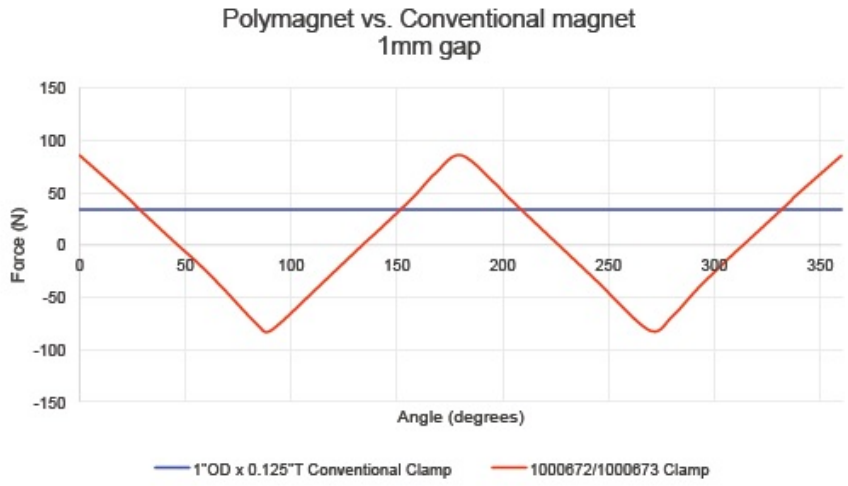
How-To #3. Incorporating Magnet-Driven Release Behaviors in Products

Polymagnets are capable of such release behaviors as unlock, eject, pop open, and easy disassembly. This section looks at the relative ease of instilling any or all of these behaviors in new products.

Magnets let go at a certain distance, of course, but you may want to have something in your product spring out, or apart. Polymagnets can do exactly that. They can make it easy to incorporate behavior that makes disassembly nearly effortless. Among the other benefits that are possible: replacing mechanical parts or screws that can snag, rust, break, or suffer other damage.

Strong hold, easy disconnect – What's the release behavior

Shifting a particular Repel-Release Polymagnet by 4 millimeters cuts its holding force 75 percent. If you shift them by 6 millimeters, you relax the hold force down to zero, which makes disconnection easy and delivers a much better user experience. Polymagnets can also push components back to their original position (see above).



You can also use a Polymagnet that when shifted 4 millimeters or more, exerts a strong repelling force. This is a good way to eject a component, as it replicates a clean spring motion very reliably.

Takeaway: Release and repel-release behavior can do much to distinguish your products, and it goes well beyond greater reliability and fewer exposed parts to break. Magnetic action is a sophisticated, hassle-free way to disconnect accessories – it gives a "cool" feeling.

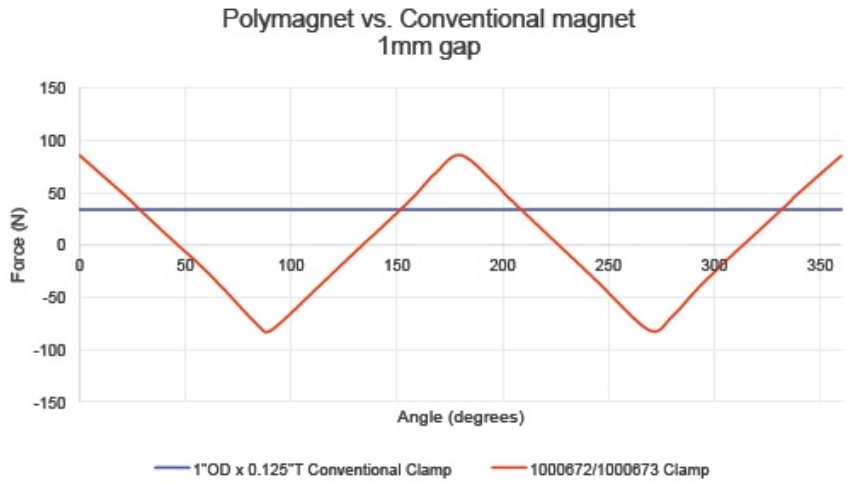
Lateral repel, even over a long distance attachment

Our catalog offers various lateral-repel Polymagnets to provide the release behavior you need. For example, the "hold-then-repel" Polymagnet mentioned above has almost no clamping force at a distance of 4 millimeters. But move it an additional 1 millimeters, and it repels strongly – this provides an efficient "eject" capability, as it closely replicates a spring's action. Very versatile, this type of Polymagnet can also be used to aid in correct assembly of several components.

Takeaway: A number of lateral release behaviors can be provided by Polymagnets. These are ideal when the release is achieved by sliding or pushing in a single direction.

We can also design new variations of lateral release-repel Polymagnets, to suit your application.

Twist-repel release behavior: No accidental lockout



Disk-shaped Polymagnets are an excellent choice for a hatch or door that you want to spring open easily, but without a latch and zero risk of mechanical snags. Latches: with a rotational offset, the hold force drops to zero. There is mild repel force over the rest of the range, makes it easy to create latches that stay open until they are actively twisted to lock the hatch into place, so there is no need or accidental lockout. When Matt Damon leaves the mother ship to repair a solar panel on the return to Earth, you definitely don't want an accidental lockout situation – he went through enough on Mars.

Going up slightly in size – to just 25 millimeters diameter --- gets you a much strong Polymagnet with force up to 85 newtons. It releases when rotated 45 degrees, in effect unlocking a door or hatch. Even better, once you rotate one of the Polymagnets from its twin 90 degrees, it repels strongly. This lets you design a hatch or port that springs open energetically. This unique magnet works well in long-distance applications, as a torque engine, or to create torque transfers without direct contact.

Tradeoff: Going up to 2.5 centimeters in diameter makes for a dramatically stronger Polymagnet, but might exceed the available space.

Takeaway: Relatively detailed behaviors for twist-release are available in disc-shaped Polymagnets.

What if I need a different, new magnetic action?

If you think of a new magnetic behavior for your product, we can help. Just from the existing Polymagnet product line, there are numerous other actions and behaviors available. In addition, we continue to define and implement new and versatile 'magnetic behaviors.' Remember, these are essentially programmable magnets. If you think of a new Polymagnet, tell us and we may be able to create it. You can also combine existing Polymagnets with specific behaviors in new ways that nobody has thought of previously. Here is where your own creativity is truly the limit.

Be sure to view our Polymagnet Webinar 4, and we invite you to speak with our Collaboration Team.

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About CMR and Polymagnets

Correlated Magnetics Research (CMR) invented and is the sole manufacturer of Polymagnets®. Polymagnets are precision-tailored magnets that enhance existing and new products with specific behaviors that go far beyond attract-and-repel. Essentially programmable magnets, Polymagnets are the first fundamental advance in magnets in 180 years, since the introduction of electromagnets. Polymagnets have been granted over 100 patents, all held by CMR. With Polymagnets, new products can have softer “feel” or snappier or crisper closing or opening behavior, and may be given the sensation of a spring or latch. For more, visit www.polymagnet.com.