Solutions That Stick: The Basics of Using Magnetic Substrates

A White Paper
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Abstract

Small printed magnets and even magnetic signage have been popular printed items for decades, but new magnetic substrates and the enhanced capabilities of printing systems are making magnetic printing more versatile than ever. In this white paper, we will explore both the benefits and the challenges of printing on magnetic materials, and look at some of the top applications. We will also provide an overview of Magnum Magnetics' specialty substrates, as well as some ancillary equipment, that are enabling these new applications.

Introduction to Magnetic Printing

One glance at your refrigerator will likely be all the proof you need that the ability to apply printed graphics to a magnetic-backed material is nothing new. Small magnetic items have been used for novelty and promotional purposes for decades, even if in the past it was largely a small bar magnet glued to the back of a bank or funeral home calendar or similar item. Today, though, even Staples and Office Depot sell magnetic sheets that can be run through a standard desktop inkjet or laser printer. At the higher end, magnetic signs are ideal for buildings, vehicles, and other indoor and outdoor applications. At the even-higher end, magnetic materials can be used for elaborate wall décor and point-of-purchase (POP) displays, where specific graphics can be easily and quickly exchanged, perfect for fast-turnover retail spaces. If you have been to SGIA, ISA, or other specialty graphics printing shows, you know well that printable magnets of all scales and sizes are a hot commodity these days, and both magnetic media and printing systems have become versatile enough to make magnets a high-value print application that goes far beyond the simple fridge magnet advertising the local auto insurance agent or pizza joint.

As you can probably surmise, though, printing on magnets is not a trouble-free process, and a magnetic substrate offers new twists on the traditional challenges of image quality and color management, in addition to the basic problems involved in getting a big magnet through a largely metallic printing press, especially at any kind of productive speed. New developments, however, are opening up magnetic media to entirely new applications for small, wide, and now super-wide-format printers and installers.

From Ancient Greece to Your Refrigerator: A Brief Introduction to Magnets

If you remember high school science classes, you know there is a whole lot of physics involved in magnets and magnetism. However, more than 90% of it is beyond the scope of this white paper. Succinctly, a magnet is a substance that generates a force that attracts certain types of metallic materials, most notably iron. The original magnets were lodestones, bits of iron ore that are magnetized naturally,[1] first discovered in a part of ancient Greece called Magnesia (now Manisa, Turkey). As a result, for you etymology buffs, the Greek word for magnet, *μαγνήτις λίθος*, or magnetis lithos, means "stone from Magnesia." The discovery of the magnetic property of lodestones has been attributed to the 6th-century B.C. Greek philosopher Thales of Miletus, who first documented their attraction to iron.

The first application for natural magnets was in compasses used for navigation, since it turns out that the Earth itself is a gigantic magnet, although no one really knew this until the beginning of the 17th century;[2] for centuries, navigators simply assumed there was a "magnetic mountain" or island somewhere far to the north (hey, it worked, so why ask too many questions about it?).

Given their attraction to iron, these substances are described as ferromagnetic (ferro- being the prefix for iron) and the force is called, not surprisingly, a magnetic force.[3] Whilst the magnetic force attracts ferromagnetic materials, it can attract or repel other magnets, depending on the orientation of its po-

larity (see below). A permanent magnet, as the name suggests, is a substance that, once magnetized, generates its own magnetic field and retains it permanently. Magnets are also described as hard (once magnetized they remain magnetized) or soft (they can be magnetized but the field fades with time).

All magnets have two poles, north and south. By convention, the north pole of a magnet is the one from which, if you mapped the magnetic field lines of the magnet (remember those iron-filing experiments in high school physics?) would be the one from which the field lines emerge from the magnet, while the south pole is the one into which the field lines reenter the magnet. Convention also has it that a magnet's north pole is the one that will point toward the Earth's north magnetic pole. As we all know, opposite poles attract, and like poles repel, and this is because of the direction of the magnetic field lines.

Printing on Magnetic Substrates

Printing on magnetic substrates is not without its challenges, which is why there have emerged several different approaches to printing on magnets, or to be more precise, getting printed images on magnets.

Direct Printing on Magnetic Substrates

Ideally, the simplest way of printing on a magnetic substrate is...well, printing on a magnetic substrate. That is, you take a sheet or roll of magnetic material and feed it through a press or printer.However, you can see where the trouble lies, especially if you are using a sheetfed or rollfed printer. Basically, any device other than a flatbed printer. For one thing, magnetic sheets are thicker than many other types of media, although it's thinner than a lot of non-magnetic materials, such as various types of board, that many printers run all the time. Still, a magnetic substrate is at the very least considered "semi-rigid"[5] and consequently feeding problems can occur.

There is also the problem that printing equipment has lots of metallic parts which, logically, can be affected in various ways by running magnets over them. Especially if you are running magnetic materials at high speed, this is how you can induce a magnetic field in a material and one thing you don't want to do is magnetize bits of your printer. There is also the potential for printer and print head damage, which may invalidate its warranty and/or service plan ("you tried running what through it?!"). That's why it's critical to choose magnetic material that's suitable for or even certified for your particular type of press.

In addition to damage to the printer, there is also the potential for damage to the magnet. Laser imaging systems, those that use some variety of electrophotography, require high temperatures as part of the fixing process. Not all magnetic materials can withstand exposure to this heat, and can soften, deform, and even melt. And you really don't want melted magnet material slathered all over your equipment.[6] Again, choosing an appropriate magnetic substrate for your press is the key to avoiding a "meltdown."

Printing Via Transfer Sheets

The old, traditional way of getting images onto magnetic substrates has been the tried-and-true method of using an intermediary material. You print via offset, digital, or some other printing technology onto a label, transfer sheet, or other material and then apply it to the magnet, often using a pressure-sensitive adhesive or even dye-sublimation. This avoids all of the mechanical issues involved with printing on magnetic substrates. However, in this day and age, where wide-format printers can print on just about any surface under (and perhaps even over) the sun, transfer sheets and decals are more than a bit passé. Quaint, even. As a result, solutions have emerged that allow you to print directly on magnetic materials while avoiding many of the problems associated with printing on magnets.

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Print-and-Magnetize Solutions

One solution to at least some of the challenges of running magnetic material through a printer has been to use a material that is magnetized after printing. This is referred to as post-magnetized material. You print on it just like any thick plastic or vinyl substrate, then as part of a finishing process you run it through a magnetizing machine. Using post-magnetized material also helps solve one other related magnet problem: stacking. If you stack magnetic graphics, well, the sheets stick together. This stickiness also affects feeding on the input side if you're printing on pre-magnetized material. Post-magnetized substrates are a good way of solving this problem. However, this means that you have an extra piece of equipment to buy: a magnetizer. A magnetizer can be a large, industrial machine; a small, handheld device; or anything in between. Which choice is appropriate will depend on your volume of magnetic print work. If you just run the occasional sign or refrigerator magnet, you don't need an industrial-scale magnetizer, but if you do a substantial volume of magnetic work, it will be faster and more efficient to invest in a large-scale device, or even an inline solution.

Magnum Magnetics manufactures several different types of magnetizers that are suited to its magnetic substrates. It offers a variety of sizes and scales depending on the end user's needs. These include:

- Motorized Magnetizer: This magnetizes cut sheets of Magnum's magnetic material and is suitable for high-volume jobs printed on a regular basis. It can magnetize sheets up to 26 inches wide and at speeds up to 70 feet per minute (fpm).

- Portable Desktop Magnetizer: As its name suggests, this fits on a desktop and is suitable for smaller-scale magnetic print jobs. It's available in high-energy and standard-energy models, depending on the type of magnetic media and applications required (see below). The high-energy and standard-energy portable magnetizers magnetize at speeds of up to 60 and 50 fpm, respectively. It's also portable, and can be stored in a carrying case out of the way when it's not required.

- Handheld Magnetizer: This is a lightweight magnetizer for low-volume and other occasional jobs. It's battery operated and can magnetize a six-inch-wide swath per pass.

- In-Line Magnetization: If you are really serious about magnetic printing, Magnum Magnetics can custom design and build an inline magnetizer for your specific print production workflow.

Danger, Will Robinson! It bears mentioning that magnetizers contain strong permanent magnets. Therefore, people with electric or electronic life-support equipment such as pacemakers should not operate them and, in fact, keep a discreet distance (at least 12 inches) away from a magnetizing unit.

A term you will encounter in connection with magnetic material and on magnetizer spec sheets is "poles per inch" (PPI). You saw above that magnets are polarized, they have a north and south pole, and it's the attraction between opposite poles that makes a magnet magnetic. Poles per inch, which in these types of magnetic substrates ranges from a low of four to a high of around 16, refers to the number of north-south poles per linear inch. A higher PPI means a stronger "grip," but the tradeoff is a lower "reach." That is, a magnet with a high PPI will have a higher holding strength than one with a lower PPI, but will attract at a shorter distance. If you have an array of refrigerator magnets, you know that some can hold up a thick postcard or a folded takeout menu without sliding down the front of the fridge, while others can barely hold your daughter's construction paper drawing; likewise, some "grab" the surface from a few inches away, while others need to be right up close before they stick. These differences are essentially due to differences in PPI. PPI is also a function of the thickness of the magnetic sheet.

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Other Magnetic Display Options

So, to get an image on a magnet, you have direct printing on magnets, you have transfer sheets, and you have post-magnetized magnetic material. There are other options out there; one system involves printing graphics on magnetically receptive material rather than on the magnet itself. Flexible magnet sheets can be affixed over a wall or other surface using various adhesives. Then the finished graphics printed not on a magnet but on magnetically receptive material are layered on top.

Ensuring Press Compatibility

As with just about any substrate for digital printing, for best results, you need to ensure that the magnetic substrate you choose is compatible with your particular press.[7] Whether you are using Magnum Magnetics' substrates or those from another supplier, inquire as to whether it has been certified, or at least tested, for use on a given press. Running incompatible media can result in at best poor image quality and color reproduction or at worst an inability to get the material to perform on-press or even damage to the press and/or substrate.

Don't Forget Finishing

As in traditional paper-based printing, especially wide-format or specialty printing, products are finished in some fashion. They are cut, folded, mounted, grommeted, etc. A lot of these probably will not apply to magnetic materials, but those finishing processes that do can also present similar issues with regard to feeding, stacking, and cutting, especially contour cutting. If you are using post-magnetized material, it can be more efficient to magnetize a large sheet rather than smaller cut magnets, depending on the magnetizing system you have. In many cases, you may need to score the output and pull it apart by hand which can be a bottleneck if you are doing high-volume work.

Opportunities, Benefits, and Applications

Despite the challenges of productively working with magnets, there are opportunities in producing these kinds of products. Here is a short list of the types of applications for magnetic media:

- Printed specialty objects
- Labels
- Packaging
- Die-cut magnets
- Indoor/outdoor signage
- Restaurant menu boards
- Retail signage/graphics
- Vehicle graphics
- Interior wall décor
- Changeable POP/POS displays
- Postcards
- Business cards
- Direct mail

And there are more. Magnetic printing is a high-value application and is in many ways only limited by the imagination and creativity of the print provider and the print customer.

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Introduction to Magnum Magnetics

Magnum Magnetics launched its first line of flexible magnetic materials in 1992, and has been expanding steadily ever since. Based in Marietta, Ohio, the company now operates two manufacturing facilities in Ohio. All of Magnum's materials are made in the U.S., which enables logistical efficiencies; often, magnetic substrates coming from overseas add unreasonable delivery times and may suffer from quality issues. We saw above that Magnum manufactures magnetizers, but the company's specialty is substrates and sheeting of all varieties. The short list above of magnetic products that can be produced only gives you a general sense of what is possible with magnetic substrates, but a rundown of the class of substrates Magnum offers can give a more detailed sense of all the options for magnetic media.

Magnum's Substrate Options

Printable Magnetic Sheets for Inkjet Printers: Magnum Magnetics offers both vinyl- and paper-laminated DigiMag® magnetic sheets that are compatible with aqueous, solvent, eco-solvent and latex printers. The paper-based sheets are for suitable for indoor use, while the vinyl is suitable for both indoor and outdoor use. Thicknesses range from .008 to .030 inch, and substrate width is up to 24.375 inches, with roll lengths ranging from 25 to 200 feet. Matte and gloss finishes are also available.

Printable Magnets for Digital Presses: Magnum's DigiMag PLUS and PLUS 2 substrates are unmagnetized materials and require a post-magnetizing process. DigiMag PLUS is designed for digital presses, and has been certified by RIT to run on a variety of HP Indigo and Kodak NexPress systems. It has 14-mil thickness and a cut-sheet size of 12 x 18 inches or rolls 13 inches wide. DigiMag PLUS 2 has a 17-mil thickness and is designed with a clean-cut adhesive that won't gum up cutter blades. It is also rated for one year for use for outdoor signage.

Printable Magnets for Offset Presses: DigiMag OFFSET is specifically engineered for offset presses, has a semi-gloss surface, 17-mil thickness, and comes in 19 x 24 inch sheets on press-ready skids. Like other DigiMag PLUS substrates, it requires a post-magnetization process.

Premium Magnetic Material: Like DigiMag PLUS, DigiMag XTRA falls into the category of post-magnetized material, and features a higher-quality paper or polypropylene surface for more accurate registration, better feeding, and greater ink adhesion than the PLUS lines. The DigiMag XTRA is designed for digital presses.

Printable Magnets For Labels: LabelMag® is magnetic material designed for labeling applications, and has been designed for compatibility with label machines. Thicknesses range from .012 to .020 inch, and widths range from one to five inches. Roll lengths up to 400 feet are available. Simply load the roll onto your Kirk-Rudy and go.

Magnetically Receptive Material: In addition to the magnets, Magnum also offers magnetically receptive rolls and sheets. RubberSteel® is a flexible substrate that is not itself magnetic, but will strongly attract magnetic sheets, magnetic strips, custom magnetic profiles, or hard magnets on either flat or curved surfaces. This is ideal for POP/POS and other retail displays that can be easily and quickly changed.

Die-Cut Flexible Magnets: Magnum Magnetics offers a variety of pre-cut shapes such as business cards, houses, telephones, photo frames, #1s, and delivery vans. They can also custom-cut virtually any shape.

Flexible Magnetic Profiles: Magnetic "profiles" are specially extruded shapes and objects, such as "C" channels for labels and "T" profiles for applications like shower doors, pen clips, and similar specialty objects. They are often used for warehouse rack labeling.

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Thin Sheets: MessageMag® is a thin, lightweight magnetic material available in rolls or sheets for offset or flexographic presses. It does not require post-print magnetization.

High-Energy Magnetic Sheets: Depending on the application, you may need a magnetic material that is a bit stronger than a typical refrigerator magnet. "High energy" magnetic material is formulated to have stronger magnetic properties and thus a higher level of "stickiness" than standard-energy material. High-energy magnetic material is suitable for applications like vehicle graphics, where there is the danger of the magnetic material sliding around or falling off.[8] MuscleMag® is Magnum's high-energy magnetic material compatible with a variety of wide-format printing systems, such as solvent, eco-solvent, UV, and latex inkjet (MuscleMag Inkjet 15) or small-format digital presses (MuscleMag Digital 17), the latter of which requires post-magnetization.

Two-Sided Magnets: Need magnetic postcards? DigiMag DUPLEX features a matte polypropylene surface on both sides, enabling duplex printing. It is 17 mils thick, is compatible with most types of digital presses, and can even be sent through the U.S. Postal Service.

Super-wide Magnetic Substrates: DigiMaxx® is a printable, flexible magnetic material designed for super-wide format (greater than 40 inches wide) printing applications. DigiMaxx runs on wide-format UV flatbed or roll-fed presses. Its standard thicknesses are 20 mil and 30 mil, but custom thicknesses can be produced. Magnum can also customize roll lengths and widths, laminates, and adhesive backings.

Magnum Magnetics also offers **back coating** and **back printing** options, **magnetic strips**, and other related products, but the above list should give you a sense of the breadth of magnetic substrates and solutions that are available.

Selecting the Right Product

How do you know which is the best solution? Asking yourself a few basic questions can help point you in the right direction when navigating product catalogs, be they from Magnum Magnetics or any other substrate supplier:

- What press/printer will the job be printed on? Small-format digital like a Kodak NexPress or HP Indigo? Wide-format flatbed UV? Wide-format Latex? Wide-format aqueous? Wide-format solvent or eco-solvent? Offset? Flexo?
- What specific types of objects or products do you want to print? Small tchotchkes? Signage? Wall displays? Where will be final products be used? Indoor? Outdoor? Sent through the mail?
- What will be the print run? Is it a one-off job or will you be running similar jobs like it in the future? This will help determine the type of magnetizer that would offer the highest productivity.
- What finishing processes do you plan to use? Cutting? Contour Cutting? Lamination.

You may notice that these are (generally) the same fundamental questions you would ask when choosing virtually any specialty substrate, so there is little reason to think that magnetic substrates are some arcane material, or that they are anything to be afraid of. In fact, magnetic substrates can open up new opportunities for print providers by creating unique, high-value products and solutions for clients.

FAQ

Can I use magnetic substrates on my printer/press?
Almost certainly yes. Magnetic material is compatible with virtually all offset and digital (and even flexo) printing technologies. As indicated above, ensure that you are buying magnetic substrates that have been tested on and even been certified for your particular device.

Will magnetic sheeting feed smoothly through my printer/press?
Magnetic substrates may require a little more hand-holding than more conventional materials, particularly with regard to slackness and tension, but is easily controlled.

My inkjet printer has a metal platen, shell, etc...Will magnetic substrates be attracted to it and cause feeding problems?
There are two solutions. First, you can use a material that is magnetized after printing to avoid any potential feeding problems caused by magnetic attraction between the material and metallic parts of the printer. A second option is to create an air gap to help print on the magnet. Magnum recommends cutting a slice of the magnet itself and covering the offending metal part with it. The rest of the material will feed smoothly over the surface of the magnet slice, and the thickness of the material is enough to create the air gap that will prevent sticking. (Video tutorials are available on YouTube.)

Do I need to worry about head strikes?
As with any thick, semi-rigid substrate, yes. To avoid damage to the print heads, first make sure that your printer is capable of feeding the substrate's thickness. Then, set the printer's head height to the highest setting.

Can magnetic substrates be cut with the knife that's built into my printer?
Some built-in knives are not strong enough to cut magnetic material cleanly, and they may dull quickly. In fact, some printer manufacturers recommend against using built-in knives to cut magnetic sheeting. You may thus have to cut it by hand with knives or scissors, or use more robust cutting equipment.

Are color profiles for magnetic material available?
Yes, depending on which front-end system you are using, magnetic substrates i.e., a given printer, ink, and substrate combination can be profiled and incorporated into a color management system. Hundreds of profiles are available on Magnum's web site (www.magnummagnetics.com), with more being uploaded all the time.

Magnetics In Motion

Who uses Magnum Magnetics' substrates? Large commercial printers.

One in particular looked to add new revenue streams and came across Magnum's product lines. Incorporating magnetic materials into projects for a slate of core customers in a variety of vertical markets, this company was able to eliminate cost components that have in turn enabled it to be more competitive and increase market share. **"Magnum Magnetics is a key supplier that has been instrumental in supporting several core pieces of business for our organization,"** says the VP of Operations. **"They are a responsive organization that has repeatedly exceeded our expectations and have consistently met every challenge we have given them with focus and enthusiasm. We are fortunate to be aligned with them and look forward to a long and mutually beneficial relationship in an ever changing market."**

Conclusion

Magnetic media can be used to create a wide variety of products and solutions, from small promotional items to large and super-wide displays and signs—and anything in between. And while, yes, magnetic media do present some unique difficulties, both technologically and logistically, they offer one more specialty product niche for printers to exploit, offering customers new types of—or new variations on—high-value applications.

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[1] Geologists today are still not entirely certain of the process by which this occurs.

[2] It was English physicist William Gilbert's seminal 1600 treatise De Magnete (On the Magnet) that revolutionized our knowledge of magnetism and especially the Earth's magnetic force.

[3] The physics of the magnetic force is beyond the scope of this white paper, but suffice to say the magnetic force is the result of moving electrical charges in elementary particles of matter. In fact, the same process that uses an electric field to induce a magnetic field in large bits of metal like magnetic substrates happens at the subatomic level naturally in natural magnets.

[4] The Earth's north magnetic pole is actually the south pole of the Earth's magnetic field. Okay, let's quickly start talking about printers...

[5] You would think that rigidity would be a binary state—something is either rigid or it's not, much like someone can't be "slightly pregnant" or meat can't be "semi-boneless" (although I have seen signs in the supermarket advertising such an item). Still, moderately flexible materials are considered "semi-rigid."

[6] Okay, it doesn't really melt that badly, but you get the idea.

[7] This is also true if you are using an offset press, but since just about all offset presses beyond the basic heatset/nonheatset web or sheetfed distinction use the same fundamental imaging technology and inks, you don't need to be as device-specific as with digital equipment.

[8] This tends not to be an issue with refrigerators but then again, "fridge races" are not unheard of, and at least one person has announced he will run the London Marathon with a refrigerator strapped to his back. Think of the sponsorship options that magnetic materials would enable! http://www.runnersworld.com/general-interest/man-will-run-london-marathon-four-times-with-fridge-on-his-back.