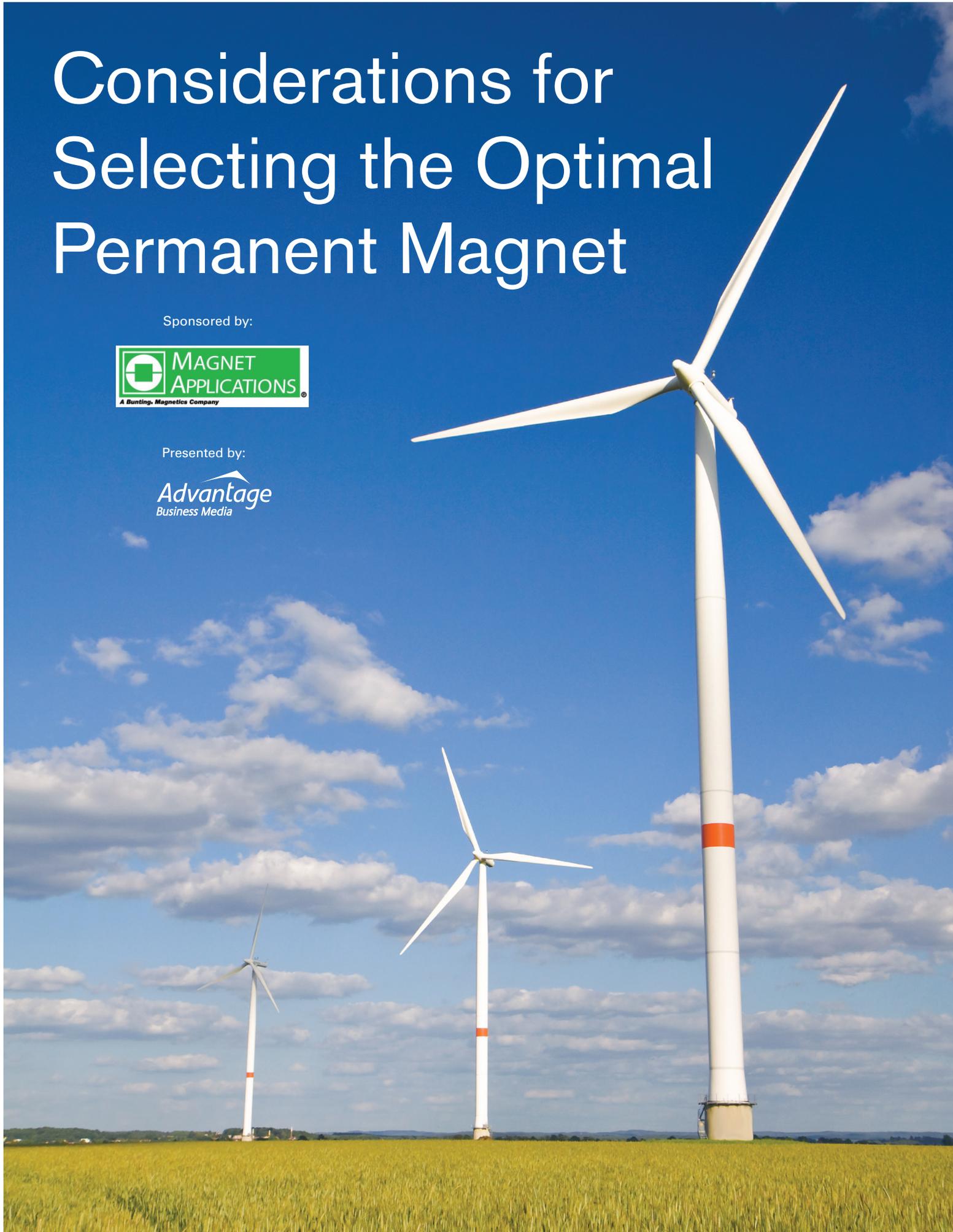


Considerations for Selecting the Optimal Permanent Magnet

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With four major types of permanent magnet materials available, device designers are faced with a bewildering range of options. Neodymium Iron Boron (NdFeB), Ferrite, Samarium Cobalt (SmCo) and Alnico are offered in numerous grades and many are available in both fully dense and bonded forms.

Permanent magnets have special requirements for assembly and use, and often magnetic parameters may not be a designer's main area of expertise. There are many decisions regarding magnets that impact performance and the overall size and weight of a device. It is critical to optimize the magnetic circuit to get the most out of a magnetic material.

Partnering with a magnet manufacturer or total magnet systems solution provider early in the design process can help select the optimum magnet. For anyone considering using permanent magnets in an application, here are important factors to consider that help designers prepare before contacting a solution provider.

1. Energy Product and Flux Density

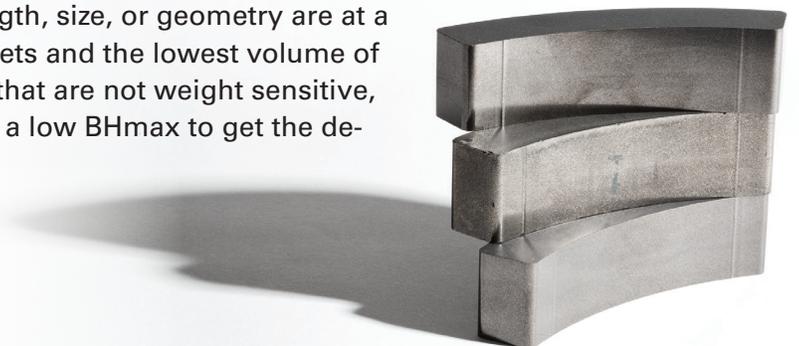
Permanent magnets don't require any energy to generate flux in air, a circuit, or another material; they produce flux with no operating cost. The most important performance characteristic of a permanent magnet is its Maximum Energy Product (BHmax) which determines the volume of magnetic material needed to reach a desired flux density (B).

BHmax can be determined from the second quadrant of a magnet's demagnetization (B-H) curve, and is measured in units of Kilojoule per cubic meter (kJ/m³) or MegaGaussOersted (MGOe). The attainable energy in the air gap of a magnetic circuit is proportional to the energy product (BH).

The range in BHmax is very large for different types of magnets, with flexible Ferrite magnets at the low end of less than 1 MegaGaussOersted (MGOe) and NdFeB magnets in excess of 55 MGOe.

The impact of BHmax on volume is often misunderstood or overlooked during design. The higher the BHmax, the smaller volume of magnetic material is needed to generate a given flux. For example, it would take 55 times more by volume to generate the same 1 MGOe flux from Ferrite compared to NdFeB.

In applications where weight, length, size, or geometry are at a premium, use high BHmax magnets and the lowest volume of magnet material. In applications that are not weight sensitive, use more magnetic material with a low BHmax to get the desired flux density needed.



2. Effects of Temperature

Material properties of permanent magnets such as coercivity and remanence are very sensitive to and change with temperature. So, designers should know the application's operating temperature range and then take into account the demagnetization characteristics of any magnet material being considered over the anticipated operating temperature range.

It is also especially important to know the maximum temperature the magnet will have to withstand because it is possible to demagnetize a magnet with high reverse fields.

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Designers should know what temperature that occurs and either avoid operating at that range or design circuits so the magnets aren't subject to critical demagnetizing fields at that temperature.

3. Resistance to Demagnetization

Another key characteristic of a permanent magnet that designers need to consider is how the flux changes when a reverse field is applied to the magnet. A magnet's response to a reverse field is documented in the second quadrant of its B-H curve, available for every magnet from its manufacturer's website.

It is important to know and compare the shape of the B-H curve and understand its parameters, because if a magnet is to do any useful work, it is always exposed to a field that is trying to demagnetize it. In every real-world application, a magnet will be in the presence of a reverse field, and this response needs to be incorporated into the circuit design from the start.

4. Raw Material Cost and Availability

The economics of cost play a big role in which material is the best choice. A magnet's cost is mainly driven by the cost of its raw materials and their availability. By weight, 88% of all permanent magnets produced and used in the world are low energy Ferrite materials. Most applications can use these low cost materials. Only 12% by weight of the magnets produced are NdFeB, but on the basis of value they have around 60% of the market.





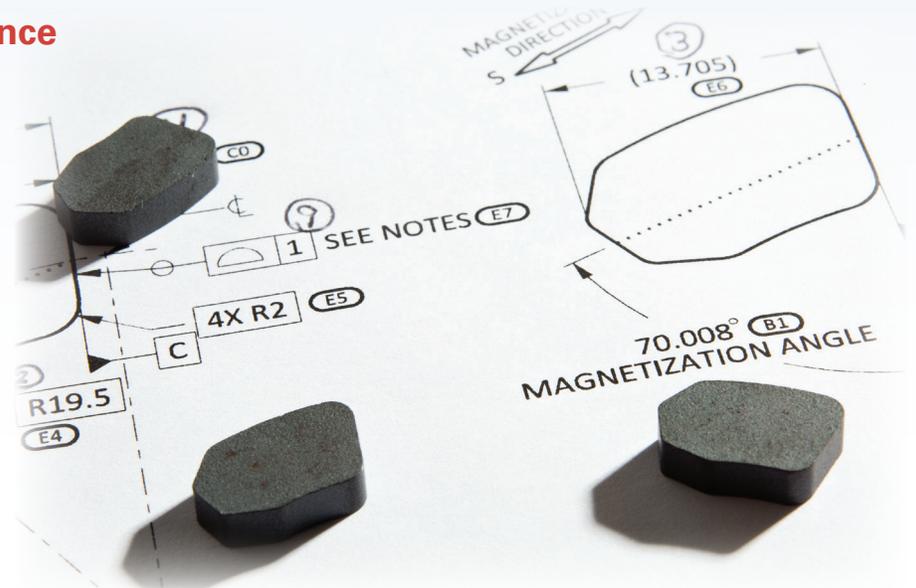
5. Available Sizes, Shapes, and Manufacturability Affects Tooling Investment

Designers should be aware of how different magnet types are manufactured and the sizes and shapes typical available to avoid the high costs of machining when non-standard shapes are desired. Alnico magnets are alloys that are melted and cast at a foundry. NdFeB, SmCo, and dense ferrite magnets are all made by powder sintering processes which normally produce magnets with fairly simple shapes.

Some magnets can be made by injection molding, making it easy to produce complex shapes that don't require post-production machining. When low volumes of around a few thousand magnets per year are needed, the high tooling costs of injection molds may not make economic sense. Other manufacturing processes with less expensive tooling or new designs may be needed. But, for high volumes, injection molding may be more advantageous than the labor-intensive machining costs each piece would incur. Another tradeoff for injection molding is that it produces magnets with lower magnetic output.

6. Corrosion Resistance

If the magnet will be used in a potentially corrosive environment, magnets, particularly NdFeB may need coatings to protect against rust. Electroless nickel plating is the most common coating, and all coatings add to a magnet's cost. They also add an air gap between the magnet and the circuit which reduces the flux available to the circuit.



While NdFeB magnets offer the highest energy product by far and generate the most flux in the smallest package, designers should be aware that all NdFeB magnets need coatings to avoid rust in most environments. Other magnet materials may require them as well.

7. Physical Strength

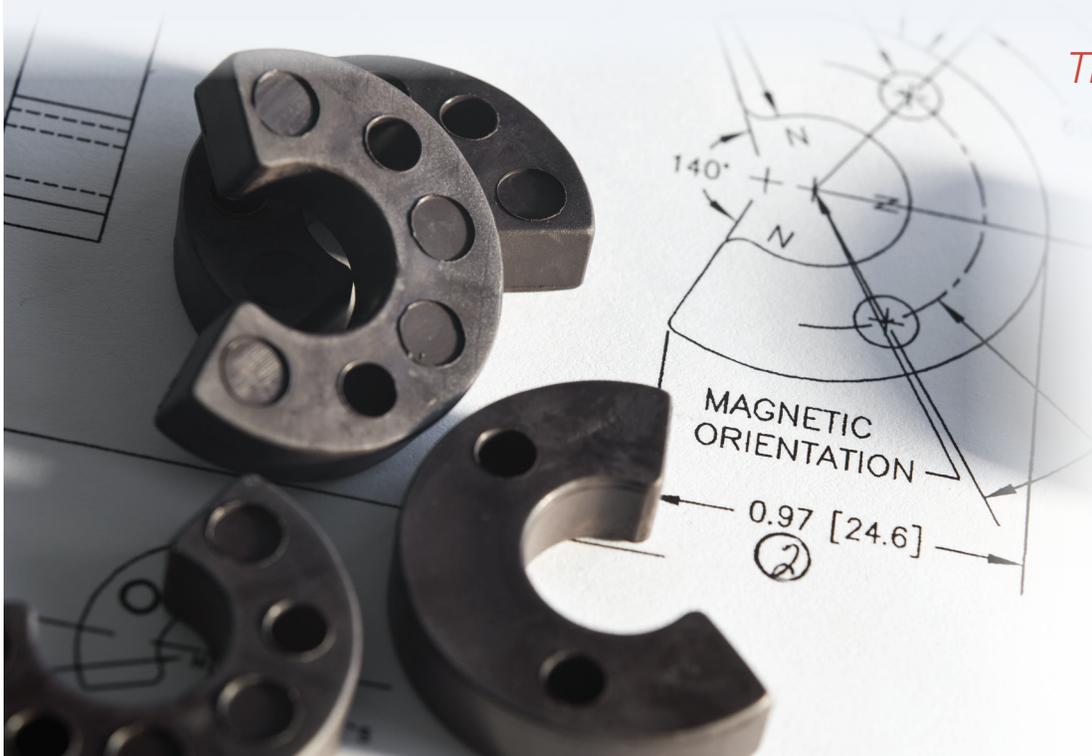
The physical strength of a magnet is important for designers to consider. Most brittle materials are difficult to handle during magnet assembly and disassembly. Knowing whether the magnets will be assembled by hand or in an automated process helps determine the physical properties a magnet needs in terms of toughness to avoid breaking.

SmCo rare earth magnets are the most difficult to handle and require very careful assembly. NdFeB are a little easier to handle. Ferrites are next, and finally, Alnico are very tough.

A new trend is to design for the recovery and recyclability of raw materials, making it easy to disassemble magnets at device's end-of-life rather than throw them away. This is especially important when rare earth magnets are used since there is a push to extract and recover rare earth materials from recycled devices as a way to provide alternate sources of these minerals, the majority of which are currently sourced from China.

8. Magnetizing Field Requirement

Designers should consider the magnetizing field requirement as part of the overall design and magnet selection and ideally opt for the magnet that is easiest to magnetize, whether before or after assembly. Know if there will be enough space in the device to magnetize the magnet in the assembly.



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A magnet that comes finished from a manufacturer has not yet been magnetized. This is typically done by electro-magnetic fields, requiring a coil with enough turns and high pulsing currents held in the proper direction and distance away to generate a sufficient field to saturate the magnet. Assembling an already magnetized magnet can be difficult because of the enormous forces that are generated between the magnet and the circuit.

It is more common to assemble a magnet into a device's circuit and then magnetize it "in-situ," but there is typically very little room to insert a magnetizing fixture. A magnet that requires a low field to magnetize it needs a smaller electromagnet with a fewer number of turns that takes up far less space than a magnet that needs large fields and lots of space. Knowing the magnetization field requirements early in the design process makes it easier to design a magnetizing fixture that will fit in the space available.

Select a Trusted Partner

Not one magnet material is ideal. Each has its tradeoffs. The engineers at Magnet Applications, Inc. can assist in selecting the optimum magnet material. Using 2D and 3D magnetic modeling software it can help optimize the total magnetic circuit to provide the most cost effective solution for a wide range of application needs.

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