

Comparing Strengths of Magnets



Rare earth magnets are the most powerful in the world, but how does their strength compare to other magnets?

How is magnet strength measured?
Magnet strength is measured using the maximum energy product, which shows the maximum amount of magnetic energy stored in a magnet. It is expressed in mega-gauss-oersteds (MGOe).

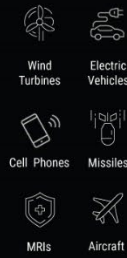
What are rare earth magnets?
Permanent magnets made by alloying rare earth elements with elements like iron and cobalt. Neodymium magnets and samarium magnets are two types of rare earth magnets.

1
Neodymium
Grade: N42

Neodymium Composition



Neodymium Applications

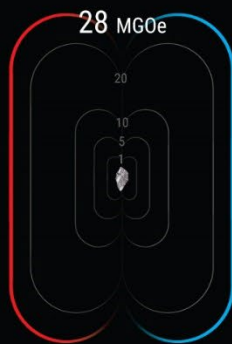


Samarium cobalt magnets can operate at temperatures from as low as -273°C up to 350°C, and are highly resistant to corrosion.

Neodymium magnets produce high amounts of magnetic energy despite being relatively lighter.



2
Samarium Cobalt
Grade: SmCo 2:17



Samarium Cobalt Composition
Samarium, Cobalt
Applications
Generators, Motors, Sensor Systems, Drilling Equipment

3
Alnico
Grade: Alnico 5



Alnico Composition
Iron, Aluminum, Nickel, Cobalt
Applications
Microphones, Motors, Sensor Systems, Electric Guitars

4
Ferrite
Grade: Ferrite 8



Ferrite Composition
Ceramics, Iron Oxide
Applications
Speakers, Fridge Magnets, Motors, Brakes

5
Magnetic Rubber
Grade: Y



Magnetic Rubber Composition
Strontium or Barium, Synthetic Rubber, PVC
Applications
Vehicle Signs, Toys, Door Seals, Stationery

Source: First4Magnets, 2022



Published on July 6, 2022

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How Strong Are Rare Earth Magnets?

Magnets are an integral part of many technologies and appliances in the 21st century.

From tiny fridge magnets that hold to-do lists to powerful ones that create magnetic fields for electricity generation from wind turbines, there are many different types of magnets.

The world's strongest magnets, also known as rare earth magnets, are made by alloying certain rare earth elements with other materials.

But just how strong are rare earth magnets, and what makes them so powerful?

Measuring Magnet Strength

The above infographic uses data from First4Magnets to compare the strength of magnets. But before looking at the strongest magnets, it's essential to understand how to measure magnetic strength.

The maximum energy product, measured in mega-gauss-oersteds (MGOe), is one of the primary indicators of magnetic strength. It is a multiplication of two measurements: a magnet's remanence and its coercivity.

- **Remanence:**

To become magnets, ferromagnetic substances need to enter the magnetic field of an existing magnet. Remanence, measured in Gauss, is the magnetism left in the magnet after removing the external magnetic field.

- **Coercivity:**

Coercivity is the energy required to bring a magnetic material's magnetism down to zero. Measured in oersteds, it essentially captures the magnetic material's resistance to demagnetization.

The Strength of Rare Earth Magnets

Each magnet has a grade, which typically denotes its strength. For example, a neodymium magnet of grade N42 has a strength of 42MGOe.

To put the power of two common rare earth magnet grades into perspective, here's how their strength compares with common grades of other permanent magnets:

| Magnet (Grade) | Composition | Maximum Energy Product (MGOe) |
|-----------------------------|--|-------------------------------|
| Neodymium (N42) | Neodymium, iron, boron | 42 |
| Samarium Cobalt (SmCo 2:17) | Samarium, cobalt | 28 |
| Alnico (Alnico-5) | Iron, aluminum, nickel, cobalt | 5.5 |
| Ferrite (Ferrite-8) | Ceramics, iron oxide | 3.5 |
| Magnetic rubber (Grade Y) | Strontium or barium, synthetic rubber, PVC | 0.8 |

Neodymium and samarium—two of the 17 rare earth elements—are ferromagnetic, meaning that they have inherent magnetic properties and can be magnetized. These metals are first mined, refined, and then combined with materials like iron, boron, and/or cobalt to make the strongest magnetic alloys.

Neodymium magnets are typically composed of one-third neodymium, along with iron and boron. Some of the neodymium in magnets can be replaced with praseodymium, another rare earth material. For this reason, neodymium magnets are also known as NdPr magnets.

Due to their strength, neodymium magnets have found their way into various technologies, from phones and laptops to motors in electric vehicles. In fact, according to Adamas Intelligence, 90% of all EV motors use NdPr magnets. Because these magnets also offer relatively high strength for a smaller size, they are also the predominant choice for wind turbines, reducing turbine weight significantly.

Samarium-cobalt magnets exhibit exceptional resistance to extreme temperatures. These magnets can operate from temperatures as low as -270°C up to 350°C and are also highly resistant to corrosion. Consequently, they have important applications in harsh marine environments and technologies with high operating temperatures.

The Demand for Neodymium Magnets

Global EV sales more than doubled last year, up from around 3 million cars in 2020 to 6.6 million in 2021. Similarly, renewable energy is expanding at a record pace, with capacity installations in 2022 set to break the record set the previous year.

With that in mind, it's no surprise that the demand for rare earth magnets is expected to increase. Neodymium magnet consumption is forecasted to grow from more than 100,000 tonnes in 2020 to 300,000 tonnes by 2035, with EVs and wind turbines driving growth.

However, the supply chain of neodymium magnets remains a concern with China controlling the majority of rare earth extraction, refining, and downstream magnet production.

Source: <https://elements.visualcapitalist.com/how-strong-are-rare-earth-magnets/>