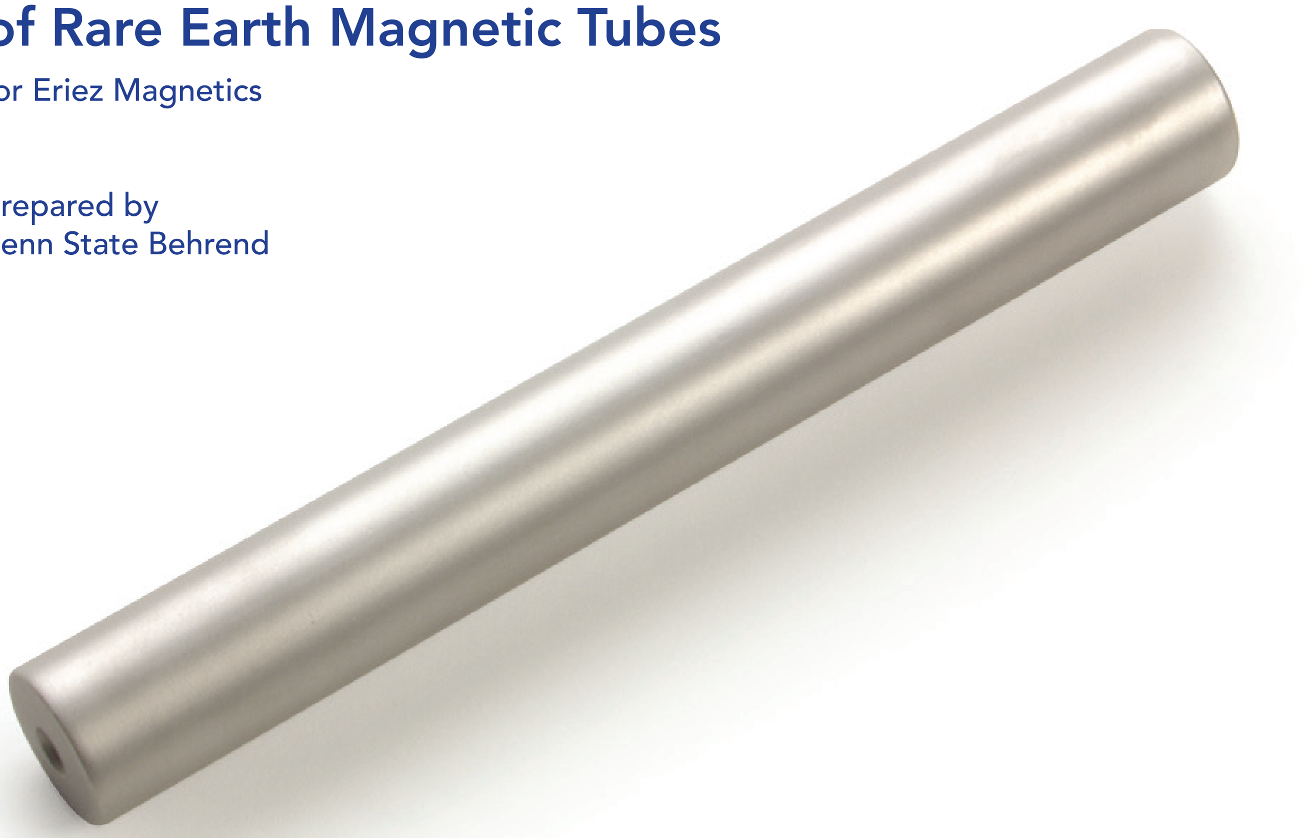
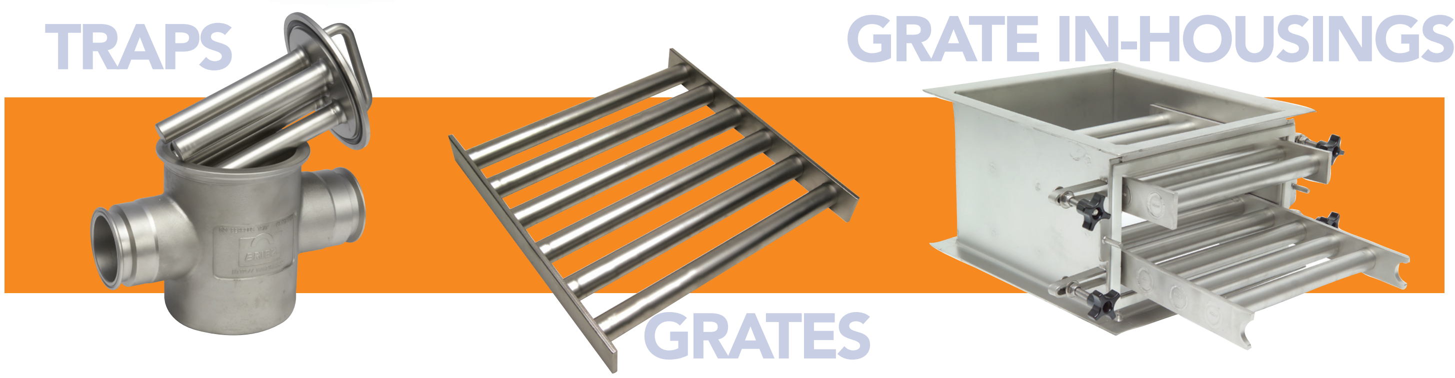
PennState Behrend

PERFORMANCE TESTING
of Rare Earth Magnetic Tubes

for Eriez Magnetics

Prepared by
Penn State Behrend





Tubes are used in a variety of magnetic separation equipment

Magnet Strength Evolution

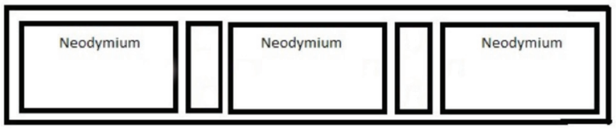
ABOUT MAGNETS

Neodymium magnets are the strongest and most commonly available type of rare earth magnet. Many suppliers have developed a product known as tube or grate magnets to provide enhanced product protection against metal contamination. This report documents the pull strength and magnetic field strength measurements for twelve commercially available tube magnets.

Neodymium magnets are very powerful, but to utilize the magnets to greatest effect, the magnets are arranged as shown in **Figure 1**. This organization of the magnets creates poles between each adjacent pair that are stronger than a single piece of neodymium could provide.

This general strategy for application of neodymium magnets is used by many companies; however particular modifications are developed by each manufacturer. Each producer has its own specifications that will determine how well the magnet will perform.

Figure 1 - Side View of Neodymium Magnet



RESULTS AND ANALYSIS

Each bar magnet was subjected to thirty-six pull force tests with a 0.25-inch steel ball and twelve magnetic flux tests. This yielded a large amount of data. For ease of comprehension and presentation the data was ‘normalized’ by calculating the mean and standard deviations using an Excel spreadsheet. **Figure 2** shows the average pull force of each magnet in ounces with a 0.25-inch steel ball while **Figure 3** displays the average magnetic flux density, measured in kilogauss.

Figure 2 - Average Pull Force Data of Each Magnet

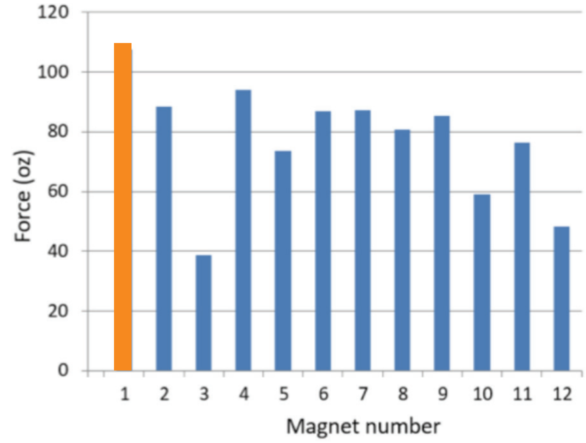
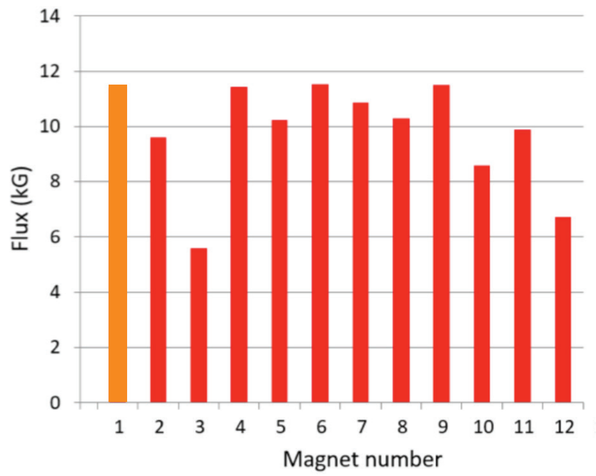


Figure 3 - Average Magnetic Flux Density of Each Magnet



Magnet Vendor:

- 1 - Eriez RE7
- 2 - IMI
- 3 - Bunting NPB
- 4 - Bunting NHI
- 5 - MPI
- 6 - McMaster Carr
- 7 - Puritan
- 8 - Cesco
- 9 - Aussie Magnetics
- 10 - Dings
- 11 - Dimetale
- 12 - Casa Del Iman

Note:
The 2004 Penn State study evaluated Eriez RE5HP (classic design) at 84.3 oz - and still stronger than most competitors best offerings to date.

MATERIAL DISPOSITION

Neodymium, a chemical element (Nd) with an atomic number of 60, is classified as a rare earth, but is generally available and is widely used in the permanent magnet industry. The strength of the magnet is provided by the neodymium, but for the magnet to work as it was intended a second medium is required. Steel is an appropriate medium because of its low magnetic permeability. This allows manipulation of the direction of the magnetic field, without weakening it. Stainless steel is also used as the casing for these magnets, again because of its low magnetic permeability.

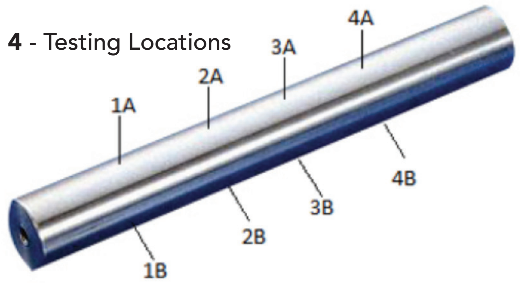
TESTING

To perform the tests, neodymium bar magnets were procured from various suppliers and numbered for ease of reference. In total, there were thirteen tube magnets tested.

Blind Test: Each magnet was stripped of brand identity then provided to Penn State, the Behrend College for testing. Because of this, the researchers at Penn State did not know which company manufactured which magnet.

Each tube magnet was then marked at its poles to indicate three specific radial locations and four specific axial locations. Each axial location was directly on top of the magnetic pole and then three radial locations were marked around that pole at 120° radial spacing. **Figure 4** shows the alignment set up. (NOTE: 1C, 2C, 3C, 4C not pictured)

Figure 4 - Testing Locations



The testing program first considered magnetic pull force. To perform the test, a ¼ inch steel ball was placed on the magnetic pole locations and pulled perpendicular to the surface of the tube magnet.

The force was measured until the ball and magnet completely separated. This measurement was taken using a calibrated and certified handheld digital force gauge. Each location was tested three times to ensure the repeatability of each test. Thus thirty-six pull tests were performed on each magnet.*

Magnetic field strength tests were then performed using a Gauss meter with an axial probe. Each magnet was tested at the twelve pole locations for peak magnetic flux density.* The probe was held perpendicular to each marked location and adjusted slightly to find the peak magnetic field strength at that location. Trials were run before the actual testing to determine the accuracy of the experiment and it was determined that each location would only need to be tested once leading to a total of twelve tests on each magnet.

**Magnets 3, 11, and 12 did not have enough poles to provide thirty-six total tests for pull force and twelve total tests for magnetic flux. These three magnets were tested at three axial locations instead of four for a total of twenty-seven pull force tests and nine magnetic flux tests.*

CONCLUSIONS

Definite conclusions can be drawn from this 'single-blind' study. A substantially higher pull force was provided by the Eriez magnet than any of the other samples. Eriez' magnet was also among the best performers in terms of magnetic flux density.

While it might be suggested that use of a hand held device may introduce human error into the measurement of force, it should be borne in mind that a careful test method was developed and shown to be repeatable, reliable and accurate. Therefore, Penn State Behrend is confident that the results, in terms of the trends represented in summary graphs and supported by comprehensive data provided in this report, faithfully reflect the influence of the factors investigated.

REFERENCES

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[2] "standard-deviation". The American Heritage Science Dictionary. Source location: Houghton Mifflin Company. Dec 12, 2015

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