Maintaining your magnetic separator's performance by testing magnet strength

Bill Dudenhoefer Eriez

A magnetic separator is critical in eliminating ferrous metal contaminants from dry bulk materials before they can damage your manufacturing equipment or enter the final packaged product. To maintain the magnetic separator's performance, you need to regularly test the strength of the separator's magnet. This article covers how to test the strength of magnetic separators that use a small permanent rare earth magnet.

Protecting your dry bulk materials from metal fines and larger ferrous contaminants (*tramp metal*) during processing and handling is a challenge. Not only are metal contaminants commonly found in incoming raw materials, they can also be introduced into your material during processing and handling. A tortilla plant, for example, might find nuts or bolts coming in with its raw corn, while in a pigment plant, the milling process can introduce tiny metal pieces into the final ground pigment powder. Unless the metal contaminants are quickly removed, they can lead to costly breakdowns of downstream equipment, lost profits from equipment downtime, violation of Hazard Analysis and Critical Control Point (HACCP) and other industry standards, and off-spec product. Using magnetic separators to capture metal contaminants at key points in handling and processing lines is a common way to reduce, if not virtually eliminate, these problems.

But just installing magnetic separators isn't enough. Ensuring that each is performing at optimal levels and effectively removing metal contaminants will require regular separator inspection and maintenance. For magnetic separators containing a small permanent magnet, this includes testing the magnet strength with what's called a *pull test*. Before we discuss the pull test and how to conduct it, let's look at some magnetic separator basics.

About magnetic separators

The magnetic separator does just what its name implies — it uses magnetic force to remove ferrous metals such as rust, nails, scale, bolts, welding rod debris, and other contaminants from dry material streams. In the rare earth magnetic separators discussed in this article, the magnetic force is provided by a permanent magnet, so-called because it's always magnetic, unlike an electromagnet, which is magnetic only when an electrical current is running through it. The rare earth magnet is available in various strengths to suit the application and is made from a rare earth alloy, typically neodymium-boron-iron. Rare earth magnets are substantially stronger than alnico and ceramic permanent magnets, making them especially suitable for magnetic separators in bulk solids applications. The separator is available in various configurations to allow mounting within the material stream, which is the most common placement to ensure that metal contamination is removed. For example, grate magnets are installed inside a feeder hopper to accumulate any ferrous metals.

Rare earth magnetic separators are available in several forms, most commonly these: A *magnetic plate* or *plate magnet* (Figure 1a) is a flat plate installed in a chute, spout, or duct, or in suspension over a nonmagnetic conveyor or screen to remove medium and small contaminants. A *tube magnet* consists of magnets inside a stainless steel tube that can be used alone or with other tube magnets in various applications. A *magnetic grate* or *grate magnet* (Figure 1b) consists of individual tube magnets arranged in a grate assembly that can be installed in a steeply sloped hopper (even one with an odd or irregular shape), floor opening, vertical closed chute, or duct to remove small and fine metal particles or tramp iron from free-flowing products. A *magnetic* *grate in housing* (Figure 1c) is a grate assembly with multiple magnet rows that's installed in a custom-manufactured housing to remove ferrous contamination from free-flowing products as they cascade through the grate.

Why regular magnet strength tests are necessary

By being proactive in testing the strength of your magnetic separator's permanent magnet, you'll reduce the risk that any metal contaminant will be found in your final product. This is particularly critical for a pharmaceutical or food item; the FDA has traditionally been a staunch driver of contamination compliance, particularly for the raw ingredients that enter a food processing plant.

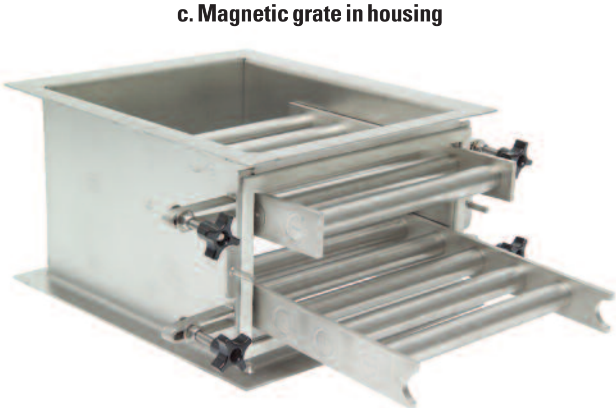
Figure 1

Small permanent rare earth magnets

a. Magnetic plate

b. Magnetic grate

c. Magnetic grate in housing



While a permanent magnet should retain its strength indefinitely under normal operating conditions, several factors can affect its performance:

- Exposing the magnet to high temperatures outside its design range may cause it to weaken or fail completely.
- When welding equipment is used on or in close proximity to a permanent magnet, the equipment's direct current can short the magnetic field and essentially kill the magnet, and the heat from welding will damage the magnetic circuit.
- A breach in the magnet enclosure can expose the magnet to liquids, which will cause the iron in a neodymium-boron-iron magnet to oxidize and, when the magnet gets wet, cause its magnetic circuit to fail.
- Rough handling of the separator will shorten the magnet's lifespan. The magnet material inside the separator is brittle; when it's subjected to repeated abuse or handled a lot, it will break down over time and fail. This can occur even when little physical damage is evident on the separator's exterior.

Your plant workers should have standard operating procedures and preventive maintenance practices in place to determine when a separator's magnet is failing. This should include regularly testing the magnet's strength with a pull test to ensure that the magnet maintains optimal strength.

How to perform the pull test

The pull test gets its name from how the test is performed — *pulling* a small ferrous metal test piece away from the magnet to measure the magnet's holding force (that is, magnetic strength). Performing the test requires using a pull test kit available from most industrial magnet suppliers.

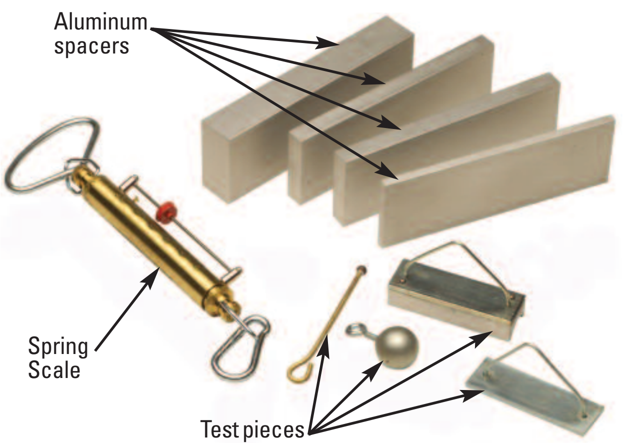
The pull test kit. A pull test kit typically includes several pull test pieces — including steel balls and plates for testing the rare earth magnets discussed in this article — in different sizes to handle your magnet's holding force. In addition to the pull test pieces, the kit usually includes the following components, as shown in Figure 2:

- Digital force gauge or mechanical spring scale with a snap ring or hook positioned at the bottom to suspend the test piece.
- Flat nonmagnetic, aluminum spacers in a range of sizes, such as 1-, ½-, and ¼-inch thick.
- Printed instructions or an instructional video and other miscellaneous items.

Be aware that even though pull test kits from different suppliers look similar, the test pieces can vary by design, weight, dimensions, and composition. To achieve accurate and comparable pull test results, you need to use the exact same test piece for at least three tests performed on the same magnet to produce a reliable average. For example, a rare earth tube magnet is designed to collect small metallic slivers such as threads stripped from a bolt, so achieving optimal pull test results requires using the smallest test piece in the kit. Ideally, this would be a ¼-inch steel ball on a 3-inch-long rod of nonmagnetic Type 316 stainless steel, which is attached to the scale's snap ring. However, the smallest test piece in some pull test kits is a ¼-inch ball with a magnetic hook that attaches by way of a magnetic snap ring to the scale's bottom loop. Since the hook and ring are both magnetic and positioned within the tube's magnetic field, this test piece requires greater pull force than the ball suspended by the nonmagnetic rod from the scale. These equipment variations — sometimes difficult to detect — can inflate pull test values by 10 to 12 percent. *Remember: A side-by-side pull test comparison can only be conducted with identical test pieces from the same kit supplier.*

Figure 2

Kit components



The test steps. Now let's look at the steps in testing a magnet.[1] To simplify this description, we'll describe the test steps for a magnetic grate; the same principles apply to other separators with small rare earth permanent magnets. Note that with a magnetic grate, it's not necessary to pull test each of the grate assembly's tube magnets. Instead, spot-check the grate assembly by performing an average of three pull tests at different points on the assembly, and record the results.

Before you begin, put on protective eyewear. Then clean the magnet surface with a rag or gloved hand to remove particles that can create a gap between the pull test piece and the magnet surface. Even a small gap between the pull test piece and the magnet will adversely influence the test results. Then follow these steps:

1. Select the appropriate pull test piece and spacer for your separator, if needed, based on guidelines found in your pull test kit. (Note that some pull tests, such as for a tube magnet collecting fine metal slivers, don't require any spacers. But for a stronger magnet reaching deeper into the product stream to collect bigger tramp metal, one [or more] spacer is needed to create the necessary limited value for the test. Without use of a spacer, some plate magnets will max out the scale and it could be difficult to pull the test piece from the magnet.) For a grate assembly, it's best to use the ¼-inch steel ball test piece attached to a Type 316 stainless steel bar.
2. With the test piece attached, zero the scale with the appropriate pull test piece attached. If you're using a spring scale, rotate the adjustment knob on top until the scale indicator measures zero, as shown in Figure 3a.

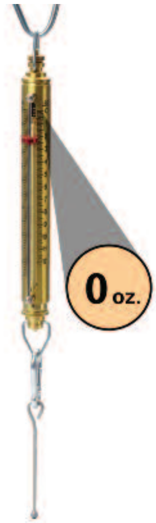
Figure 3

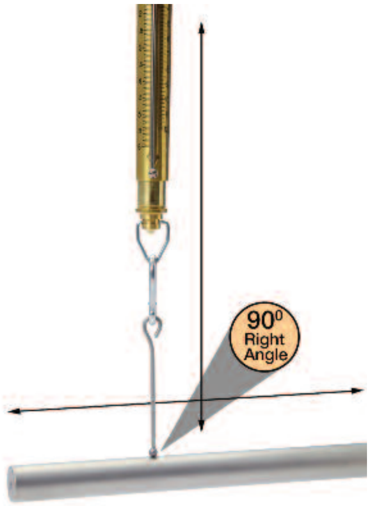
How to conduct the pull test

a. Zero the scale with the appropriate pull test kit piece.

b. Allow the test piece to be attracted to the magnet and position the scale perpendicular to the magnet surface.

c. Pull the scale directly away from the magnet surface slowly, smoothly, and evenly.





3. Allow the test piece to be attracted to the magnet and position the scale perpendicular to the magnet surface, as shown in Figure 3b. *Caution:* Don't pull test near the ends or edges of the grate assembly because the magnet's design constraints will cause the magnet strength to measure less at the edges. Measurements around the center of a tube magnet should represent the magnet's true working strength.
4. Pull the scale directly away from the magnet surface slowly, smoothly, and evenly, as shown in Figure 3c. Be careful because the test piece may unexpectedly snap away from the magnet surface, which is why using protective eyewear is important. Note the measurement by reading the metal band as it slides down the spring scale or by reading the digital gauge's screen. *Then repeat the test to verify the results*.

Using the test results

After three to four pulls, the results should be within a reasonable range — that is, a ¼-inch steel ball might measure 88 to 92 ounces in pull strength during the test sequence on a grate assembly. If the test is repeated in 6 months and pull strength drops to 75 to 80 ounces, the magnet's holding force has eroded and the magnet should be replaced. Regardless of the test results, magnets with visible cracks or wear holes should be removed from operation immediately. In general, magnets showing 15 to 20 percent erosion in holding force over a 6-month to 1-year period should also be replaced, particularly if the magnet is part of a critical control point (such as a step or procedure where controls can be applied to prevent a food safety hazard).

How often to test

Testing frequency depends on your standard operating procedures and maintenance schedule. A magnet that's in an area with frequent wide temperature swings is a candidate for testing every 30 days. For example, a cheese processor might have a plate magnet in a 45ºF room during the day, but then clean the magnet using 140ºF water at night. Under more normal temperature ranges, magnets should be tested every 6 months to 1 year.

Regular pull tests will go a long way in helping you maintain your magnetic separator's performance. You should also request a visit from your separator manufacturer's service team so technicians can assist in validating all of your plant's magnetic separation equipment. This diligence ensures that your product will comply with FDA, USDA, and other industry guidelines. Regularly testing your separators also helps reduce your plant's contamination liability and maintains the product purity your customers expect. **PBE**

Reference

1. An instructional video on using a pull test kit is available at www.eriez.com/Products/PullTestKit.

For further reading

Find more information on this topic in articles listed under "Metal detection/separation" in *Powder and Bulk Engineering*'s article index (later in this issue and at *PBE*'s website, www.powderbulk.com) and in books available on the website at the *PBE* Bookstore. You can also purchase copies of past *PBE* articles at www.powderbulk.com. A white paper, "How to Conduct a Magnet Pull Test," and manual, *How to Choose & Use Magnetic Separators: Complete Guide to Magnetic Materials and Separation Equipment*, are available at Eriez's website at www.eriez.com.

***Bill Dudenhoefer** is a manager–separation products at Eriez, 2200 Asbury Road, Erie, PA 16506; 888-300-3743 or 814-835-6385 (bdudenhoefer@eriez.com, www.eriez.com). He holds a BS in management and business economics from Pennsylvania State University in University Park, Pa.*