

Ask Orange™

Provides solutions
to process problems



How To

Choose & Use Magnetic Separators

*Complete guide to
Magnetic Materials and
Separation Equipment*



*World authority in advanced
technology for magnetic, vibratory
and inspection applications.*

It's not magic...it's ERIEZ

HOW TO CHOOSE AND USE MAGNETIC SEPARATORS

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Ask Orange™ is a collection of process solution case studies and how-to reference manuals designed to improve understanding and simplify specifying sophisticated magnetic, vibratory and metal detection equipment needed in most process industries. Most of this equipment requires an understanding of its intended use in order to determine proper application.

The "Professor" icon has been developed to help customers identify Ask Orange™ material in printed trade publications, company literature and on its web site. The Ask Orange concept and related images are a tribute to the company's founder, Orange F. Merwin, and his innovative ideas using magnets to remove metal contamination from various process flows.



HOW TO CHOOSE AND USE MAGNETIC SEPARATORS

The use of magnets for removing ferrous contaminants in an industrial environment first began in the 1940s when Orange F. Merwin developed a flat magnetic product to help farmers trap and remove metal contaminants from their grain chutes. At the time, unwanted or “tramp” metal in the grain flow often created a spark that would ignite the explosive dust causing fires... sometimes with catastrophic results. Orange’s early version of today’s plate magnet was a huge success and led to the founding of Eriez Magnetics. After more than 60 years, Eriez remains the world’s authority in magnetic separation solutions for industry.

Ferrous metal contamination damages process equipment and creates impure product that must be scrapped or sold at less than full value. This metallic contamination may come from a variety of sources. Incoming products may contain contaminants from the transportation vessel used to deliver the product, such as a truck bed, rail car, barge or ship hold. The contamination may originate within the plant due to material processing, grinding, crushing or general abrasion. The problems associated with ferrous metal contamination can be reduced or eliminated by using magnetic separation equipment. Magnetic Separators, available in a wide variety of designs, will remove ferrous material such as nails, rust, scale, bolts, welding rod and other contaminants from dry or liquid products. The proper use of this equipment will reduce or eliminate metallic contamination from the process.

Selecting the proper magnetic separator requires an understanding of magnetic properties, the process application and environmental elements that exist in each specific installation. This guide provides a basic understanding of how to choose the proper magnetic separator for different process requirements. Beginning with a magnet material overview, *How to Choose and Use Magnetic Separators* covers various types of materials being processed, numerous magnetic separation techniques, application considerations and a wide variety of magnetic separation equipment currently available.



Did you know?

In order to help customers select the proper equipment, Eriez operates the industry’s largest laboratory of magnetic separation equipment. Here, materials are sampled to ensure product and/or process purity that meets each customer’s specific requirements. Contact your Eriez representative to arrange a sampling. Tour the lab at eriez.com, click: Tour Eriez - USA

1. MAGNET MATERIALS & STYLES

PERMANENT

Magnet material generally refers to the magnetic pressings or castings used to develop the magnetic field within the separator. This material may be cut and arranged in a linear fashion using other materials to create a magnetic circuit. Depending on the desired outcome, circuits may be designed to cast a shallow-wide magnetic field; a deep-narrow field or anywhere in between. This is why it is often difficult to compare competing products made of only similar material. Once the circuit is assembled, it is usually encased within stainless steel to protect the magnet material from wear associated with product flow, damage or from contaminating the feed material.

Since the 1940s, there has been substantial change in the materials used to manufacture permanent magnetic separators for industry. The following is a brief description of the most common magnetic materials used over the past 60-plus years.

ALNICO

Alnico is one of the earliest magnet materials used for ferrous separation. These magnets are commonly recognized by their horseshoe shape. This material is a casting of Aluminum, Nickel, Cobalt and Iron. Although seldom used today, as there are more economical magnet sources, Alnico may still be used in applications involving temperatures in excess of 400 degrees Fahrenheit (204 degrees Celsius). This material is comparable in strength to ceramics and used to remove relatively large pieces of ferrous metals, such as nuts or bolts.

CERAMIC

During the 1960s, problems in South Africa drove up the price of Cobalt forcing manufacturers to search for an Alnico substitute. It was then that manufacturers began using Ferrite ceramic pressings in their magnetic assemblies. Ceramic pressings are easy to work with because they can be cut in all directions, assembled into a circuit and then charged as a complete unit. Ferrite pressings became the standard in permanent magnetic separators until the early 1980s. Ceramic magnet circuits work best when the goal is to remove relatively large pieces of ferrous metal contamination.

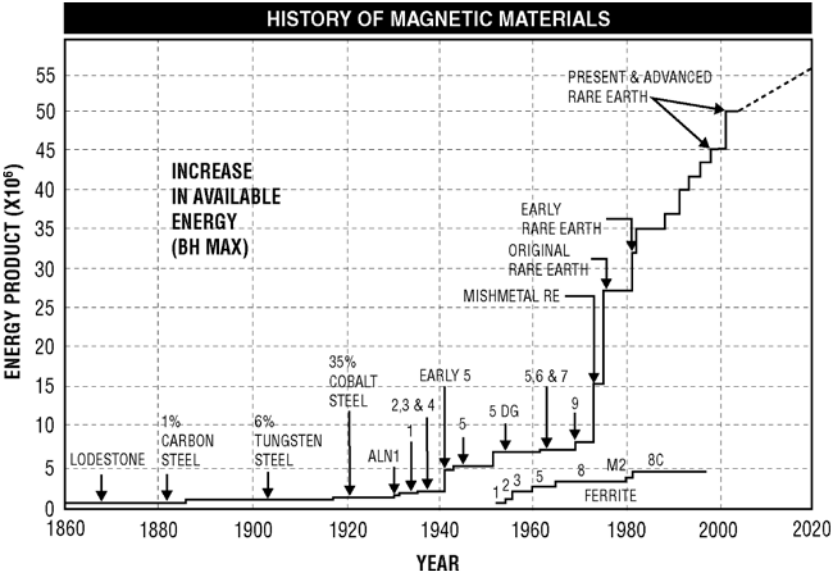
Did you know?

The strength of the field produced by a magnet is usually measured in units called Gauss. Very strong magnetic fields may be measured in units of Tesla, where 1 Tesla equals 10,000 Gauss. For reference, the magnetic field of the Earth is about 0.5 Gauss.



RARE EARTH

The term, Rare Earth, is a misnomer. A rare earth magnet derives its name not because it is rare, nor because it is earth. It is named “Rare Earth” because part of its make-up is one of the Lanthanide elements of the Periodic Table between 57 and 71. There are 14 elements referred to as “The Rare Earth Elements.” Samarium Cobalt was the first such material used in the early 1980s. The next material on the market was Neodymium Iron Boron, called “Rare Earth” because Neodymium, like Samarium, is one of the Lanthanides. Today, Rare Earth magnetic circuits produce a magnet force more than 10 times that of ceramic magnetic circuits. The graph below provides a history of magnetic material improvements.



Eriez’ Rare Earth Material develops an extremely high surface force to enable the magnetic circuit to remove very fine or weakly magnetic contamination such as rust, scale or even work-hardened stainless steel from a product flow. High strength Rare Earth Separators are extensively used by food, chemical and pharmaceutical processors requiring the highest levels of product purity.

ELECTROMAGNETS

For larger industrial separation applications, Eriez developed electromagnetic separators. The popular round-core electromagnet uses round aluminum or copper wire in an oil-filled assembly to generate a powerful electromagnetic field. These electromagnets efficiently remove ferrous metals in heavy industrial applications like coal, limestone, sand and other aggregates.

These large scale magnets are available in a variety of configurations including oil and air-cooled; round, hollow and rectangular core; explosion proof; even cryogenic superconducting magnets capable of producing the world’s strongest magnetic force for separation applications.



Did you know?

Eriez was the maker of the World's Strongest Suspended Electromagnet operating at China National Coal in Qingdao. This Superconducting Electromagnet produces 4000 gauss at 550mm (21.65 inches). That's nearly twice the strength of any similar magnet! **See it at eriez.com, click: Press Room - 3/15/02**

2. APPLICATION CONSIDERATIONS

TEMPERATURE

Permanent magnetic materials lose strength when exposed to elevated temperatures. Some losses are reversible in that when the temperature is returned to normal, the magnetic strength returns. Permanent magnets heated beyond certain temperatures (which depend on the specific material) may also suffer irreversible loss: a reduction in strength that cannot be recovered by cooling. When specifying a magnet application, it is important to note the ambient as well as any Clean in Place (CIP) temperatures to ensure a proper magnet design suitable for long term separation performance.

FLOW RATE

Magnetic separators perform best when the contamination is presented to the surface of the separator. It is best to select a magnetic separator that provides for a thin burden depth over or under the magnet to ensure the magnet will have the best opportunity to capture the ferrous contamination.

FLOW CHARACTERISTICS

Many products exhibit different flow characteristics when damp or moist. Are there large chunks that may plug an opening or gap in the separator? Will the product flow freely through the selected magnetic separator? For example, brown sugar with any significant moisture content will not flow between the tubes in a grate magnet assembly, although they may be positioned nearly one inch (25mm) apart from each other.

PROCESS ISSUES

How will the material be presented to the separator? Is the material metered or do we need to handle a surge flow? Can the system be stopped for cleaning or is a self-cleaning magnet required? Is access available for cleaning? Is there ferrous material in the area that may create a hazard for magnet handling? How much contamination is to be removed? And finally, what level of product purity is required?

3. TYPE OF MATERIAL BEING PROCESSED

Assessing the material being processed is a key step in selecting the proper magnetic separator. Product generally falls into three different categories: dry, moist or liquid. Within each of these groups a wide range of product variation exists. For example, dry product ranges from tiny food grains flowing down a chute to large mined rock moving along a high-speed conveyor. These vastly dissimilar processes require different separation equipment.

DRY FREE-FLOWING, GRANULAR-TYPE PRODUCT

If the material is small and free-flowing, a grate magnet may provide the best opportunity for the ferrous contamination to contact a magnet directly. Grates can be cleaned best for vertical product flows, while plate magnets will work well if the material is cascading down a chute. These cleaning methods require that the product flow be stopped when removing collected iron from the magnet.

Pneumatic flows of free-flowing product work best in a magnetic hump or Radial Field Cartridge. These products also require the suspension of product flow for cleaning.

Drums, pulleys, and suspended magnets can provide for continuous automatic removal of tramp metal (tramp refers to rogue metallic contamination) without needing to stop the flow. These units provide for 24/7 removal of ferrous contamination.

DRY PRODUCT WITH SOME BRIDGING CHARACTERISTICS

While grates provide for very efficient removal of fine metallic contamination they do not work if the material cannot cascade between the magnetic tubes. Plate Magnets do not restrict the flow of material and will not contribute to the bridging (building up of material) problem if installed beneath a sloped chute. Magnetic humps are available for less than free flowing products as long as the material will cascade down a sloped chute. Suspended magnets and pulleys may also work well if the material is conveyed with a belt conveyor or vibratory feeder.

MOIST, STARCHY OR LUMPY PRODUCTS

These products - such as flour or starch - do not flow through grate assemblies due to bridging, nor chutes due to a high angle or repose. The best options include a Deep Reach Separator or a Rota-Grate® assembly. The Deep Reach Separator is completely out of the product flow. The Rota-Grate's continuous rotation through products eliminates bridging problems and allows product to flow freely.

LIQUID OR SLURRY PRODUCTS

Products in a liquid or slurry state require the use of a magnetic trap. Traps are available in either a grate or plate type configuration. Many traps are built similar to grates in that tube magnets are arranged perpendicular to the flow inside in the body of a casting to "trap" any ferrous materials passing through. A U-Trap employs a flat plate magnet in a shallow body so as to minimize damage to the product flowing past. U-Traps are ideal for chunky-flow applications.

4. SEPARATION EQUIPMENT - PLATE MAGNET DESIGNS

Plate Magnets are used in the bottom of an inclined chute or suspended above a thin burden of material on a belt conveyor or stainless steel vibratory feeder to remove occasional pieces of ferrous contamination. Eriez' Ceramic Magnet models like the Super, Maxi, Brute or Super Brute Power plates are effective in



removing relatively large ferrous material such as nuts, bolts, staples, and welding rod from a dry product flow. Rare Earth models will do a much better job on very fine or weakly magnetic contamination such as rust or scale. In a typical chute installation, the magnetic material adheres to the magnet face while the product slides across the face of the magnet. The magnetic field attracts and holds ferrous material until the plate is removed for cleaning. The magnet is usually hinged and swung away from the chute and cleaned manually. Plate Magnets are simple and economical to install as well as very efficient at removing occasional pieces of tramp metal.



Round Pipe Separators (RPS) are actually plate magnets with a fabricated transition from a round pipe to the rectangular chute that contains the Plate Magnet. The RPS consists of an inlet transition to match the existing pipe or tubing, a neoprene deflector to deflect the product against the plate magnet then transitions back to the chute. The material flow must be stopped to clean the accumulated tramp metal from the plate magnet



Hump Magnets are similar to the Round Pipe Separators except Eriez provides the fabricated chute and two plate magnets instead of one. This extra plate effectively doubles the chances of collecting ferrous material. The Hump consists of a dogleg chute that allows the product stream to cascade from one magnetic plate to another as material moves through the dogleg. Units are available for pressure, vertical or horizontal pneumatic applications. The material flow must be stopped to clean each plate. Self-cleaning units are also available to cycle the plate magnet away from the flow so that a stripper may automatically remove the accumulated tramp metal contamination from the plates.

Plates are in cleaning position.



Deep Reach Separators use a plate magnet style circuit but incorporate it into a vertical chute. These units work well when sticky products do not readily flow down sloped chutes or when headroom is at a minimum. Two large magnet assemblies are fixed to opposite sides of a stainless steel chute and attract ferrous contamination as material flows by the chute. The magnetic circuit is designed for an exceptionally deep reach into the product flow which makes these separators effective at removing large, chunky tramp metal.

5. SEPARATION EQUIPMENT - GRATE MAGNET DESIGNS

Grate Magnets consist of one-inch diameter (25mm) magnetic tubes in a grid formation designed to allow feed material to cascade through the grate, effectively spreading magnetic protection through the cross sectioned area of a pipe, chute or hopper. Ceramic Magnet models are effective in removing relatively large ferrous contamination such as nuts, bolts or staples. Rare Earth models will do a much better job on fine or weakly magnetic material such as rust or scale.



There are a variety of grate magnet designs available for almost any application. The simplest of these incorporate a single layer for use in a hopper so raw materials must pass through the grates as material feeds from the hopper. Multiple row units improve separation effectiveness. Some applications will utilize a single row of magnets and incorporate them into a *grate housing assembly* of the user's design. Eriez will also fabricate housings that include one or multiple rows of magnetic grates, depending on the level of protection required for the application. These units are common for vertical chutes of free flowing materials.



Eriez' many grate-housing designs may include a standard grate that is removed from the housing for manual cleaning. An **Easy-to-Clean** grate design provides for a push/pull operation to strip accumulated tramp metal from the grates without physically handling the magnet. Rota-Grates or rotating magnet designs are available for materials that bridge or do not flow well. Self-cleaning units are also available so that the cleaning process is completely automated.



6. SEPARATION EQUIPMENT - LIQUID LINE TRAP MAGNETS

Magnetic Traps employ the same powerful tube magnet used in Eriez Grate assemblies but are specifically designed for liquid product flows. The traps are available in a variety of designs but basically include an inlet port to match the existing pipeline, a magnetic element to collect the tramp metal contamination, then a transition





back to the existing pipe. Ceramic Magnet models are effective in removing chunky metallics like baling wire or staples. Eriez' Rare Earth models will do a much better job on fine or weakly magnet contamination such as rust or scale from food, chemical and pharmaceutical products.

7. SEPARATION EQUIPMENT - PNEUMATIC LINE MAGNETS



The Radial Field (RF) Cartridge Magnet is ideal for pneumatic flows of ingredients like starch, flour or any product typically conveyed with air from a rail car. The assembly is designed to match the existing pipe and is then transitioned to a larger pipe that incorporates an enclosed magnet element. The material cascades around the magnet and ferrous material collects on the magnet as it is conveyed through the assembly. *See also Humps.*

8. SEPARATION EQUIPMENT - SUSPENDED MAGNET DESIGNS

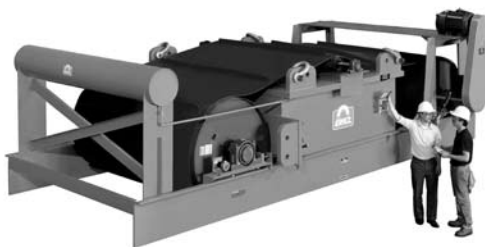
Suspended Magnets are designed to hang above conveyors to remove material from the burden of material on the conveyor as it passes under the magnet. They are effective in removing large ferrous metals from a burden to protect crushers and other processing equipment from damage. Manual cleaning magnets are typically swung away from the conveyor periodically to allow the tramp metal to fall into a collection chute or bin. The collected tramp metal must be removed manually (by dragging or picking) from a permanent manually cleaned suspended magnet, but will be released automatically when the power is removed from an electro 'manually cleaned' suspended magnet. Self-cleaning units may be either permanent or electro, and incorporate a system of pulleys that drive a belt around the magnet to automatically discharge the collected ferrous, either in-line with the conveyor over the head pulley or at a right angle when positioned across the conveyor.



Did you know?

Eriez offers a Burden Depth Calculator to help assess individual applications and recommend the proper suspended magnet separator.

Order yours at eriez.com, click: Free Tools



Suspended magnets are used in a wide range of applications, hence the need for an array of both permanent and electro magnetic designs. Some of Eriez standard models include:

SP6000 SERIES

This line of **Permanent Magnetic Separators** employs ferrite magnets to remove tramp metal contamination from many light industrial applications. The magnets are permanently charged so they require no external power source to function. Typical applications involve wood, tire chips or light aggregate recycling.

SE7000 SERIES

The SE7000 is Eriez' most popular line of round core *electromagnets*. They contain round aluminum or copper wire coils in an oil-filled assembly that generates a powerful electromagnetic field to efficiently remove ferrous material from heavy industrial applications involving material like coal, limestone, sand, and other aggregates.



Did you know?

Eriez' 7000 Series SE's carry the industry's only five-year warranty and can ship in five-weeks.

Details are available at eriez.com, click: Press Room 1/8/03

SED 800 EXPLOSION PROOF SERIES

The 800 series magnet is also referred to as an air-cooled assembly. The magnet utilizes a special copper or aluminum coil assembly potted within the magnet eliminating the need for coolant. A dry magnet is common for enclosed applications where explosive dusts like coal or grain are present. The unit is accepted for grain dust applications and can be supplied in a CSA approved version when required.

SE700U EXPLOSION PROOF SERIES

The SE700U is similar to the 800 in that it is a dry magnet design but meets all requirements set forth by *Underwriters Laboratories (UL)* and the *Mine Safety and Health Administration (MSHA)*. The unique coil assembly is wet wound to improve heat dissipation and reduce the external magnet temperature. These units are often used for underground mining applications involving explosive dust.

SE2400 CHUTE MAGNET AND SER700 SERIES

These powerful magnet assemblies use rectangular aluminum and copper coils to spread the magnetic field across wide belts associated with mining or sugar cane processing. Typical mining applications involve very wide and fast moving belts that require extremely powerful magnets to achieve a high level of separation efficiency. The unique rectangular core and coil assembly generates a powerful magnetic field unmatched by conventional round core magnet assemblies.

FORCE-COOLED MAGNET ASSEMBLIES

Some application environments involve exposure to high ambient temperature or require smaller magnet assemblies due to limited space requirements. Eriez can optimize the performance of a typical oil cooled magnet assembly by re-circulating the oil coolant to improve heat dissipation increasing magnet strength. This creates similar magnet strength in a smaller area.



Did you know?

Eriez offers a Magnet Load Monitor to alert the operator when the suspended electromagnet's face needs to be cleaned. For details visit eriez.com, search: monitor

HOLLOW CONDUCTOR MAGNETS

Hollow conductor can be utilized in the coil design so coolant can be circulated directly through the coil wire, enabling the magnet to generate extremely intense magnetic fields without heating the magnet assembly beyond the conductor's insulation limit. Chilled coolant is circulated through the magnet enabling the coil to use more current without generating damaging temperatures. These highly special designs allow for extremely deep burdens of material and effect a high level of separation efficiency on small tramp metal.

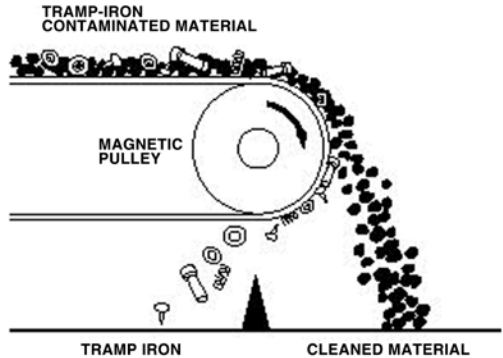
SUPER CONDUCTING MAGNETS

Eriez' magnet design capability culminates in a superconducting hollow magnet design. The SSE, Super Suspended Electromagnet, system incorporates a cryogenic superconducting magnet placed in a sealed vacuum enclosure

incorporating two Cryo-cooler heads and a recycling liquid helium reservoir. This results in the coil temperature being maintained below 4 degrees Kelvin in a superconducting state. Once ramped up, the magnet only requires a trickle of power to maintain its very intense magnetic field.

9. SEPARATION EQUIPMENT - PULLEY AND DRUM MAGNET DESIGNS

Magnetic Pulleys replace standard conveyor head pulleys and effectively convert the conveyor into a self-cleaning magnetic separator. As the conveyed material passes the head pulley and discharges in its natural trajectory, the magnets “scalp” large tramp metal from the burden, then discharge it as the belt pulls away from the backside of the pulley.



Drum Magnets are self-cleaning magnet assemblies that continuously remove tramp metal from a product flow. The magnet assembly is enclosed within a stainless steel drum and fixed in position. The drum rotates around the magnet conveying material through the magnetic field. Clean or nonferrous material cascades off the drum face while the magnetic material is drawn around the drum and discharged at the bottom. Eriez Drum separators use ceramic magnet circuits to remove relatively large ferrous material such as nuts, bolts, staples, and welding rod from a dry product flows. Eriez Rare Earth models will do a much better job on very fine or weakly magnet contamination such as rust or scale.



10. SEPARATION EQUIPMENT – HIGH INTENSITY MAGNETIC DESIGNS

In some applications, such as mineral processing, higher levels of separation or purification are needed. In many instances, the objective is to actually “collect” or concentrate the magnetic mineral from the host material. Much of the equipment featured in this section is designed for specific applications.



Rare Earth Roll Separators are effective at concentrating or removing weakly magnetic minerals from a dry process stream. These minerals include silica, feldspar, hematite and alumina among others. The RE Roll operates as a pulley (as described in section 9) in a self-contained housing. A hopper and vibratory feeder spread the material onto a thin belt, which is then conveyed over the magnetic roll for separation. These separators often contain multiple rolls used in a series to enhance the separation or purity of the product.

Wet High Intensity Magnetic Separators (WHIMS) feature high-intensity electromagnets and a flux-converging matrix to concentrate paramagnetic or weakly magnetic minerals. The magnetic field induces a magnetic field in the matrix (similar to expanded metal or steel wool) that produces an area of high magnetic gradient and creates the mineral “collection” zone. The matrix is designed to collect the paramagnetic minerals from a slurry and allow the non-magnetic material to pass through. Minerals are then collected when the electromagnets are shut-off. Today, WHIMS are used primarily for concentrating hematite and ilmenite.

High Gradient Magnetic Separators (HGMS), or high capacity magnetic filters use the same separation techniques as WHIM. However, it is a batched operation. These filters are designed for the purification of clay and other “fine-grained” earthy minerals.

There are a number of other mineral processing magnetic separators for both wet and dry, and high and low intensity applications. Eriez.com features an entire section devoted to minerals processing.

11. SEPARATION EQUIPMENT FOR NONFERROUS METALS



Eddy Current Separators use a different approach to magnetic separation...they “repel” nonferrous metals. Widely used in recycling aluminum, copper, silver and other nonferrous metals, these powerful magnetic separators “kick-out” the nonferrous metallic products or contamination being conveyed while allowing other materials to continue in the flow. Eriez’ Eddy Current Separator systems contain rare earth magnetic rotors, are available in a range of configurations and often include vibratory pan feeders, conveyors, hoods...even suspended magnets to remove ferrous metals.

***For solutions to
your process problems
contact your nearest
Eriez representative
and just: Ask Orange.***



CONTACT ERIEZ

With manufacturing plants on five continents and a global network of factory-trained representatives, getting professional assistance is just a call away.

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*World authority in advanced technology for magnetic,
vibratory and inspection applications*

Eriez manufactures magnetic lift and separation, metal detection, materials feeding, screening, conveying and controlling equipment for application in the process, metal working, packaging, recycling, mining, aggregate and textile industries among others. Eriez manufactures and markets these products through nine international facilities located on five continents... Australia, Brazil, Canada, China, England, India, Japan, Mexico, South Africa, as well as the United States.

Some safety warning labels or guarding may have been removed before photographing this equipment.

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