Why Metal Control

- Protect purity of your product which reduces potential risk of recall, damage to brand reputation and financial liability
- Protecting equipment reduces downtime, maintenance costs and risks of fire hazards or explosion

Ferrous metal on magnet after one week of operation at on receiving leg of mill
Presentation Overview

- Principles of Magnetic Separators
  - Materials and Terms
  - Separator Design
  - Care and Maintenance
- Principles of Metal Detection
  - Operating Principles
  - Variables of Sensitivity
- Food Safety and FSMA
  - Control Point or Critical Control Point
  - Monitoring and Validation
  - Reporting and Record-keeping Requirements
- X-ray – Applications in Milling
Protecting and Moving the World through Innovation

Company Timeline

1981
MPI begins operations in Walled Lake, Michigan

1982
MPI introduces its first magnet audit services

1983
- A Magnet is Not Just A Magnet educational training is first given
- MPI introduces the first generation of self-cleaning magnets

1991
MPI patents the Reciprocating Drawer Magnet

1993
MPI relocates to Highland, Michigan to a state-of-the-art manufacturing facility, doubling capacity

2010
MPI becomes the exclusive US distributor for Cassel

2011
MPI celebrates 30 years

2014
MPI adds checkweigh and x-ray to its offerings

2015
MPI receives USDA certification for several of its magnet models

2017
All Regional Sales Managers become Certified Food Safety HACCP Managers (CFSHM) from The National Registry of Food Safety Professionals

Confidential 800.544.5930 | www.mpimagnet.com
My Background

- 8+ years working at MPI
  - Manufacturing > Purchasing > Inside sales > Outside sales

- Bachelors & MBA from Michigan State University

- Certified Food Safety HACCP Manager

- Certified Magnet Auditor

- Guest Speaker at International Association of Operative Millers meetings
Principles of Magnetic Separators
Magnet Life Expectancy

- Modern magnets boast an estimated loss of life equal to less than one half of one percent every 100 years
MGOe – Megagauss-oersteds

- Unit of measure for maximum stored energy in magnet
- Maximum energy product (often abbreviated BHmax)
Flux and Gauss

Lines of flux connecting north and south pole

Flux density (gauss): Lines of flux in 1 cm square
Ceramic Magnetic Material

- Developed in 1952
- Manufactured of Iron Oxide and Strontium or Barium
- Advantages of Ceramic Magnets
  - Low cost
  - Highly resistant to corrosion
  - High Tmax (maximum normal operating temperature) of 572F
  - High Curie Temperature (temperature at which the magnet will become permanently demagnetized) 860F
- Disadvantages of ceramic magnets
  - Maximum MGOe of 3.5 limits suitable applications for target tramp metal
Rare Earth Magnet Material

- Developed in 1966 and ongoing development
- 2 types: Samarium Cobalt (Samarium, Cobalt and Iron) and Neodymium (Neodymium, Iron and Boron)
- Not “rare” – just a rare earth element
- Most common: neodymium
  - Advantages
    - High MGOe 52+ resulting in more efficient and effective magnetic separators
  - Disadvantages
    - They are easily oxidized
    - They have low corrosion resistance
    - They have only moderate temperature stability starting at 176 F at higher grades and up to 356 F at lower grades
    - They are brittle so are subject to damage from shock or vibration
Magnet Material Development

Figure I
Development of Permanent Magnets in the 1900's

OTHER IMPORTANT CHARACTERISTICS
- Field to magnetize
- Thermal stability
- Mechanical properties
- Corrosion resistance
- Manufacturability
- Cost

Nd-Fe-B
SmCo 1-5 and 2-17
Ferrite
Columnar Alnico
Ks Steel
Mk Steel
Alnico 5
Magnet Material Properties

- Choosing the proper magnet material:
  - Target tramp metal
  - Operating temperatures
  - Size restrictions

<table>
<thead>
<tr>
<th>Magnet Material</th>
<th>Max. Energy Product (MGO)</th>
<th>Max. Operating Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic 8</td>
<td>3.5</td>
<td>400</td>
</tr>
<tr>
<td>Samarium-Cobalt SC HT13</td>
<td>30</td>
<td>662</td>
</tr>
<tr>
<td>Neodymium-Iron-Boron 38HT2</td>
<td>38</td>
<td>356</td>
</tr>
<tr>
<td>Neodymium-Iron-Boron 48HT1</td>
<td>48</td>
<td>248</td>
</tr>
<tr>
<td>Neodymium-Iron-Boron 52REN</td>
<td>52</td>
<td>176</td>
</tr>
</tbody>
</table>
Application to Separators

- Every manufacturer has access to the same materials and the various grades
- Difference in separators is how the circuits are designed
- Manufacturers use the same circuit designs
- The difference in performance from manufacturer to manufacturer depends on:
  - Grade of material used
  - Composite material construction
    - Tube thickness
    - Magnetic material size / amount
    - Size of poles
    - Overall tolerances
Magnetic Circuit Design

How do separation magnets work?
The 3 Magnetic Circuits

**Type A**

**Type B**

**Type C**
Circuit “Type A” Magnet Examples

- Pneumatic Line Magnets
- Drawer Magnets
- Grate Magnets
“Type A” Separator Application

Cutaway view of a Magnetic Tube with product flow in a gravity conveying system.

Cutaway view of a Pneumatic Line Magnet with product flow in a dilute phase conveying system.
“Type A” Magnetic Circuit

Rare Earth Magnets  (Nickel Plated Exterior-Standard on all MPI magnets)

Carbon Steel Poles

Stainless Steel Tubing
Magnetic Tube Flux
The “Strongest Magnetic Tube”

- Tubes – Not bars
- Thickness of stainless tube = durability and performance
- Air gap – distance between pole piece and product contact point

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased holding value</td>
<td>Decrease in durability – tubes are easily dented and product can quickly wear through completely</td>
</tr>
<tr>
<td>Increased Gauss</td>
<td></td>
</tr>
</tbody>
</table>
The “Strongest Magnetic Tube”

- Uncoated vs. coated neodymium
- Nickel coating adds air gap but protects from oxidation

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased holding value</td>
<td>Oxidization (similar to rusting) breaks down the structure of the magnet which then changes permanently, resulting in a progressive loss of magnetic performance, during which the magnet will weaken and break down into a powder</td>
</tr>
<tr>
<td>Increased Gauss</td>
<td></td>
</tr>
</tbody>
</table>
## Performance Results

<table>
<thead>
<tr>
<th>Tube Style</th>
<th>Ceramic</th>
<th>Rare Earth</th>
<th>Hi-G</th>
<th>Thin Wall**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4” Ball Pull Values*</td>
<td>0.3 lbs</td>
<td>5.0 lbs</td>
<td>5.5 lbs</td>
<td>6.3 lbs</td>
</tr>
<tr>
<td>1/2” Ball Pull Values*</td>
<td>1.2 lbs</td>
<td>12.7 lbs</td>
<td>15.5 lbs</td>
<td>16.7 lbs</td>
</tr>
<tr>
<td>Gauss Value*</td>
<td>2800</td>
<td>10,000</td>
<td>10,600</td>
<td>11,500</td>
</tr>
<tr>
<td>Tube Durability</td>
<td>⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐</td>
<td>⭐</td>
</tr>
<tr>
<td>Price</td>
<td>⭐</td>
<td>⭐⭐</td>
<td>⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐</td>
</tr>
</tbody>
</table>

52 MGO & nickel coated
Circuit “Type B” Magnet Examples

- Plate Magnets
- Hump Magnets
- Magnetic Chutes
“Type B” Principles of Application

Mounted to Bottom of an Angled Chute

Cross-Mounted in a Vertical-Flow Gravity Chute

Suspended Over a Conveyor Belt or an Angled Chute
## Plate Magnet Selection for Chute Installation

<table>
<thead>
<tr>
<th>Magnet Type</th>
<th>Tramp Metal</th>
<th>Max Burden</th>
<th>Size / Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic</td>
<td>Large</td>
<td>6-8”</td>
<td>Medium</td>
</tr>
<tr>
<td>Rare Earth</td>
<td>Small to large</td>
<td>3-4”</td>
<td>Low</td>
</tr>
<tr>
<td>Hi-G Hybrid</td>
<td>Small to large</td>
<td>6-8”</td>
<td>High</td>
</tr>
</tbody>
</table>

---

**Protecting and Moving the World through Innovation**
Circuit “Type C” Magnet Examples

Free-Flow Cylinders

Magnetic Pulleys / Separation Rolls
“Type C” Principles of Application

Free Flow Cylinder Magnets

Drum Separator, Housings, and Magnetic Head Pulleys
Care and Maintenance
The Basics

It really doesn’t matter how strong this magnet is...

1. Before selection – consider how it will be cleaned
2. Once installed, establish cleaning schedule & document
3. Test yearly (minimum) for loss of strength or increase and inspect for wear

...Once it gets to this
Why test your magnets?

How Magnets Lose Strength

**Heat** - Heat above the maximum level rated for the magnet material in your separator will decrease the strength of the magnet. Standard rare earth material from MPI has a maximum temperature of 176°F and standard ceramic material has a maximum temperature of 400°F. Higher temperature materials are available and may have been used in your system. Consult the factory if you have questions on what the maximum temperature is for your system.

**Impact** - Sharp impacts to the magnet from physical abuse or handling can result in the decreased magnet strength. The magnet material inside your separator is brittle and these impacts can lead to fractures in the material, weakening its strength.

**Welding** - Welding on or around the magnet can lead to decreased magnet performance. This can be a result of the heat or current generated from the welding process.

**Liquid ingress** - If your magnet housing is compromised, moisture can enter the housing of the magnets. This can lead to oxidation of the magnet material which will eventually lead to a weakened magnetic system. If the housing is compromised, the magnet should also be replaced for sanitary concerns.
How to Test Magnets

Pull Test: Measures holding force

Gauss Meter: Measures flux density

Magnetic Separator Testing: Pull Test Or Gauss Test?
@ www.mpimagnet.com
Principles of Metal Detection
Balanced Coil Metal Detector

- Balanced triple coil system
- (1) Transmitter coil in center, and (2) receiver coils
- Transmitter produces electromagnetic field at set frequency chosen for the application and product
- Receiver coils wound in series opposition
- Net voltage = zero until metal enters coil
Variable of Sensitivity

- Aperture size and type of detector
- Type of metal detected
- Position of the metal inside the detector
- Environmental conditions
- Product effect of the material being examined
- Orientation of metal
- Detection frequency
Sensitivity: Aperture size and type

- Larger aperture = less sensitivity
- Built only to size required for package or spout
Sensitivity: Kind of Metal

- **Ferrous** – Iron and magnetic steel: have a high permeability **and** are good electric conductors. They are the easiest to detect.

- **Non-ferrous** – Brass, copper and aluminum: have low permeability **but** are good conductors. They are less detectable than ferrous.

- **Stainless Steel**: Has low permeability **and** are not good conductors, which is why it is the most difficult to detect. Varying grades of stainless steel have different characteristics.
Sensitivity: Position of Metal

- Complete all testing and validation at position 3 – worst case scenario
Sensitivity: Environmental Conditions

- External “noise” and poor installation affect the detectors signal stability and can lead to false tripping or reduced performance.
- The most common sources of “noise” are:
  - Vibrations - Metal detector sees vibration at almost the same phase angle as ferrous metal.
  - Frequency interference caused by other electrical equipment (VFD’s).
  - Moving metals inside the metal free zone.
  - Intermittent eddy-current loops in the construction of the conveyor.
  - Static electricity on the production floor or product.
  - Coil not properly isolated during mounting.
  - Contamination in belt / dirty belt.
Sensitivity: Product Effect

- A product’s impact on the magnetic field is referred to as the “Product effect”
- Product effect categorized into two basic groups:
  - Non-conductive or “Dry Products” such as flour = low product effect
  - Conductive products or “Wet Products” such as meat or cheese = high product effect

Product effect must be compensated for or “learned” in order to not have false rejects.
Sensitivity: Orientation of metal

Ferrous Wires:
A - Easiest position, biggest signal.
B, C - Hardest Position, smallest signal.

Non-Ferrous and Stainless Steel Wires:
B, C - Easiest position, biggest signal.
A - Hardest position, smallest signal.
Sensitivity: Detection Frequency

- In general, higher frequency = higher sensitivity
- Dry products (flour) tend to utilize a higher frequency as there usually is little product effect while wet conductive products are built with lower frequencies.
- The frequency is chosen by the factory based upon the application details including the product to be examined.
Metal Control & FSMA
Control Point or Critical Control Point

- **Control Point:** Any step at which biological, chemical or physical factors can be controlled
- **Critical Control Point:** A step at which control can be applied and *is essential to prevent or eliminate* a food safety hazard or reduce it to an acceptable level
- **Critical Limit:** A maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard
Magnets

- Maintain cleaning schedule and document when completed
- Develop performance standard
- Audit / test magnet at least yearly and document results
Metal Detection

- Test internally every on a regular basis (often each shift)
- Calibrate / Validate by independent third party at least yearly
- Looks for systems which have features such as:
  - Automatic printing of HACCP reports
  - Onboard data logs
  - Password protection
  - PVS (Performance Validation Software)
Note on X-ray

- X-ray is another technology for metal control
- X-ray technology inspects product based on density
- For more information on x-ray in the milling industry, contact MPI
Questions and Contact

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