Metal Control Technology

Kyle Rhodes, Sales and Marketing Manager

Magnets | Material Handling | Electronic Inspection | Service

Protecting and Moving the World through Innovation

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

Company Timeline

1981
MPI begins operations in Walled Lake, Michigan

1982
MPI introduces its free 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

USDA CERTIFIED

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

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

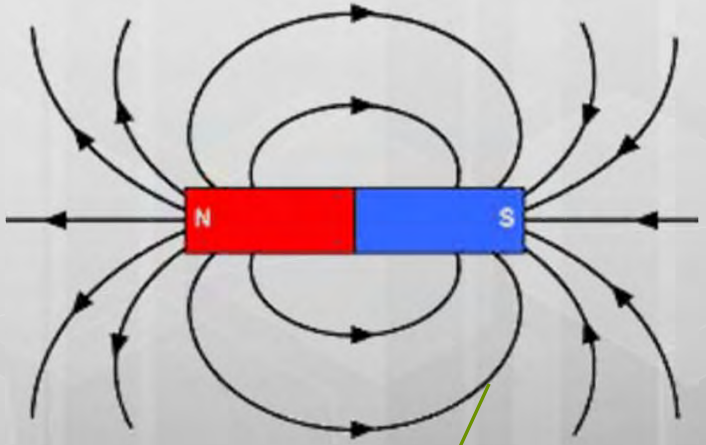
Magnet Life Expectancy

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

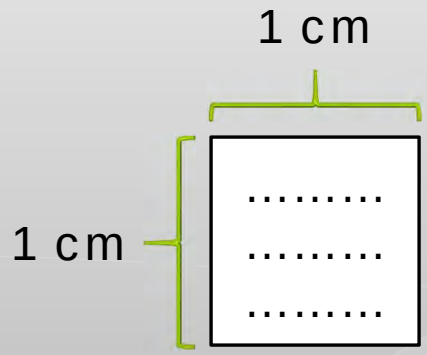
MGOe – Megagauss-oersteds

- 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

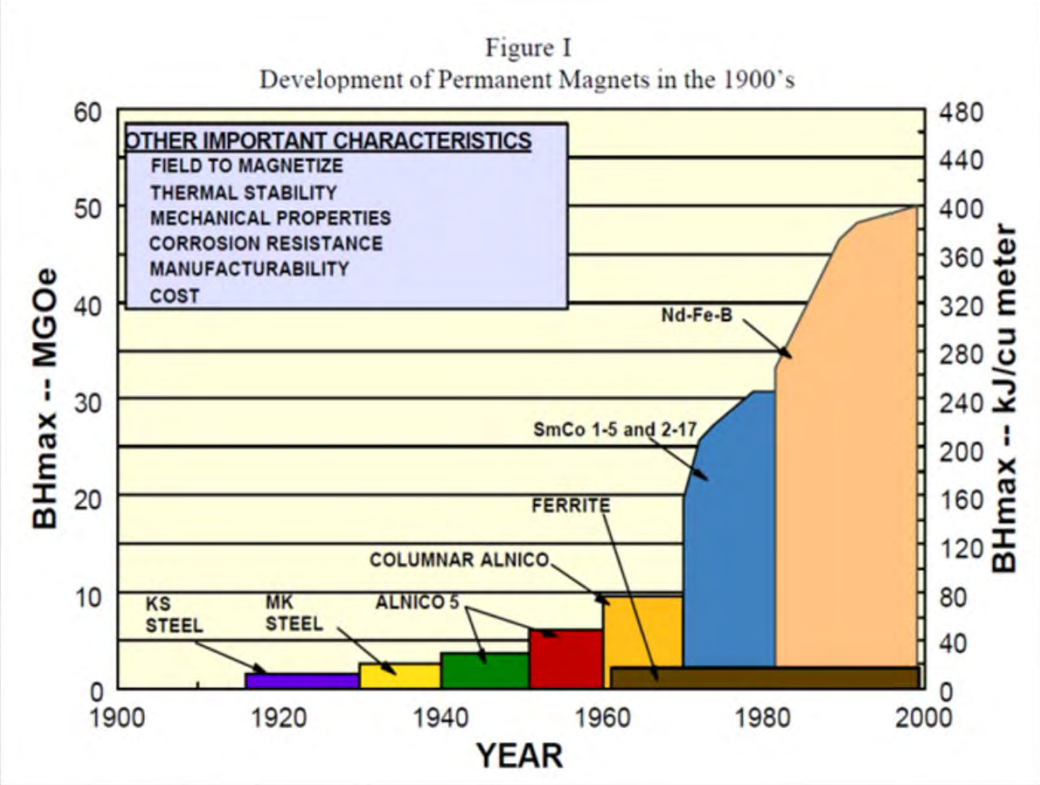
Ceramic Magnetic Material

- 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



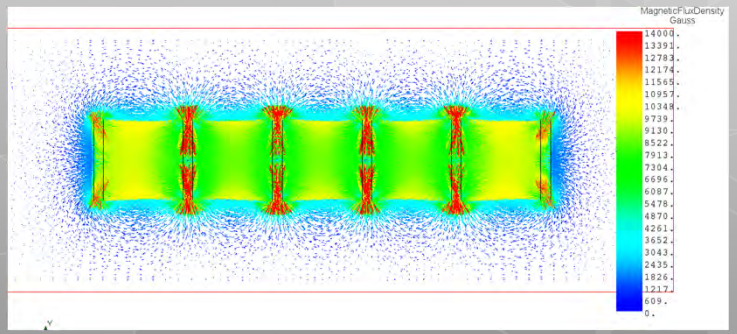
Magnet Material Properties

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

Magnet Material	Max. Energy Product (MGO)	Max. Operating Temperature (°F)
Ceramic 8	3.5	400
Samarium-Cobalt SCHT3	30	662
Neodymium-Iron-Boron 38HT2	38	356
Neodymium-Iron-Boron 48HT1	48	248
Neodymium-Iron-Boron 52REN	52	176

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

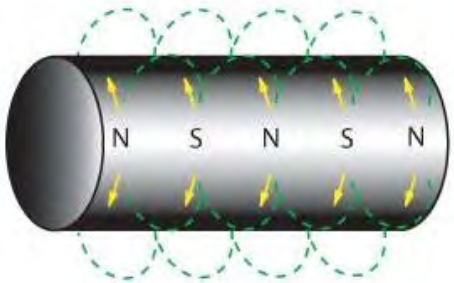


Magnetic Circuit Design

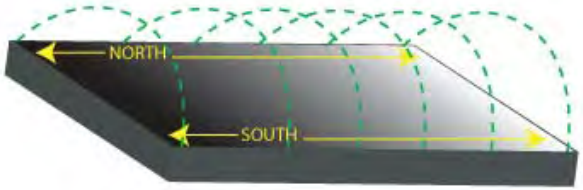
How do separation magnets work?

The 3 Magnetic Circuits

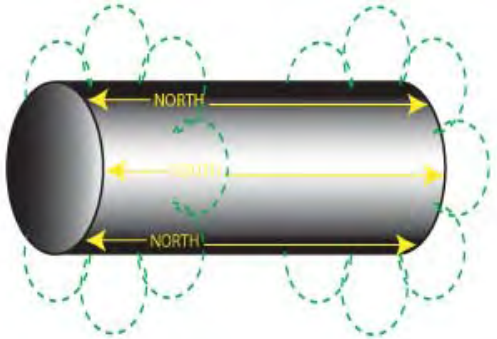
Type A



Type B

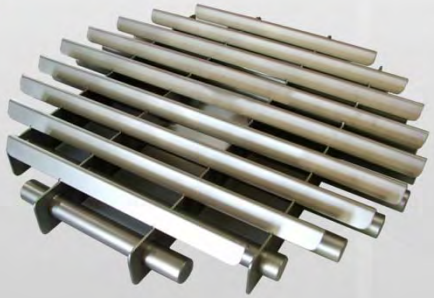


Type C



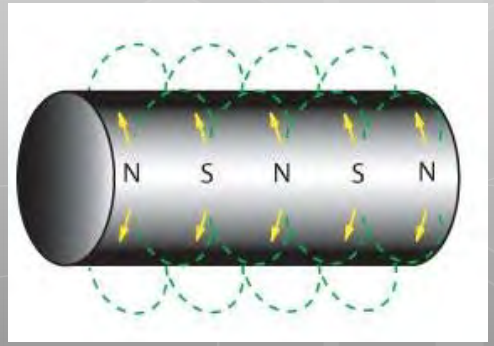
Circuit “Type A” Magnet Examples

Pneumatic Line Magnets

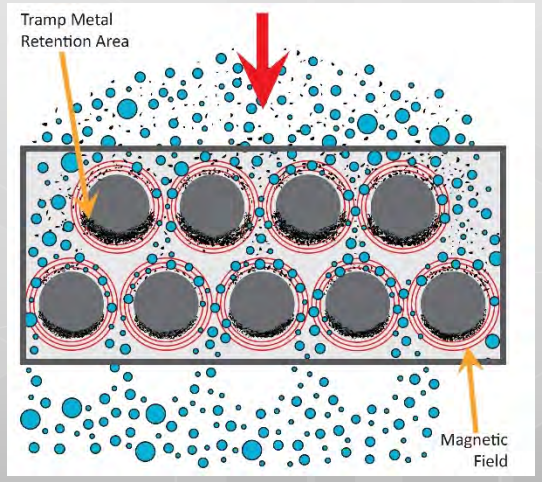


Grate Magnets

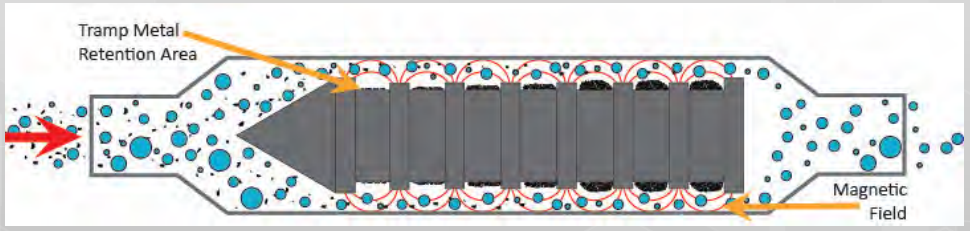
Drawer Magnets



"Type A" Separator Application

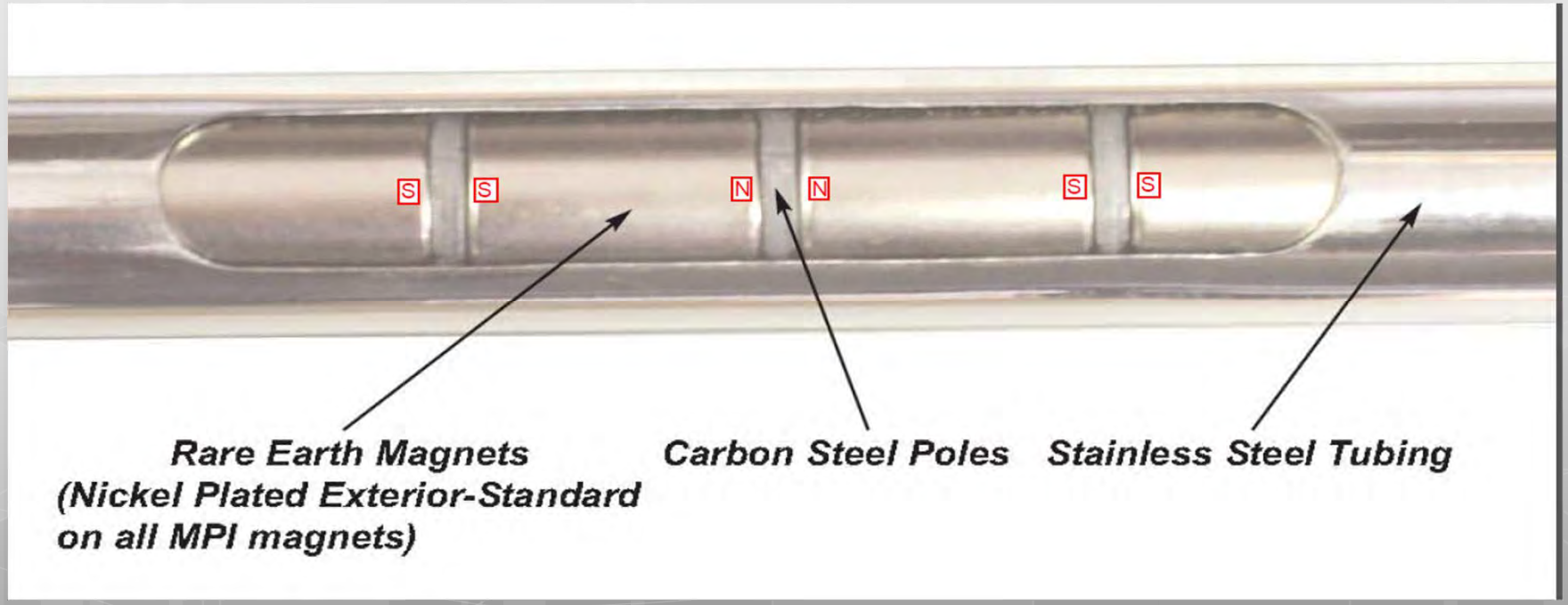


Cutaway view of a Magnetic Tube with product flow in a gravity conveying system.

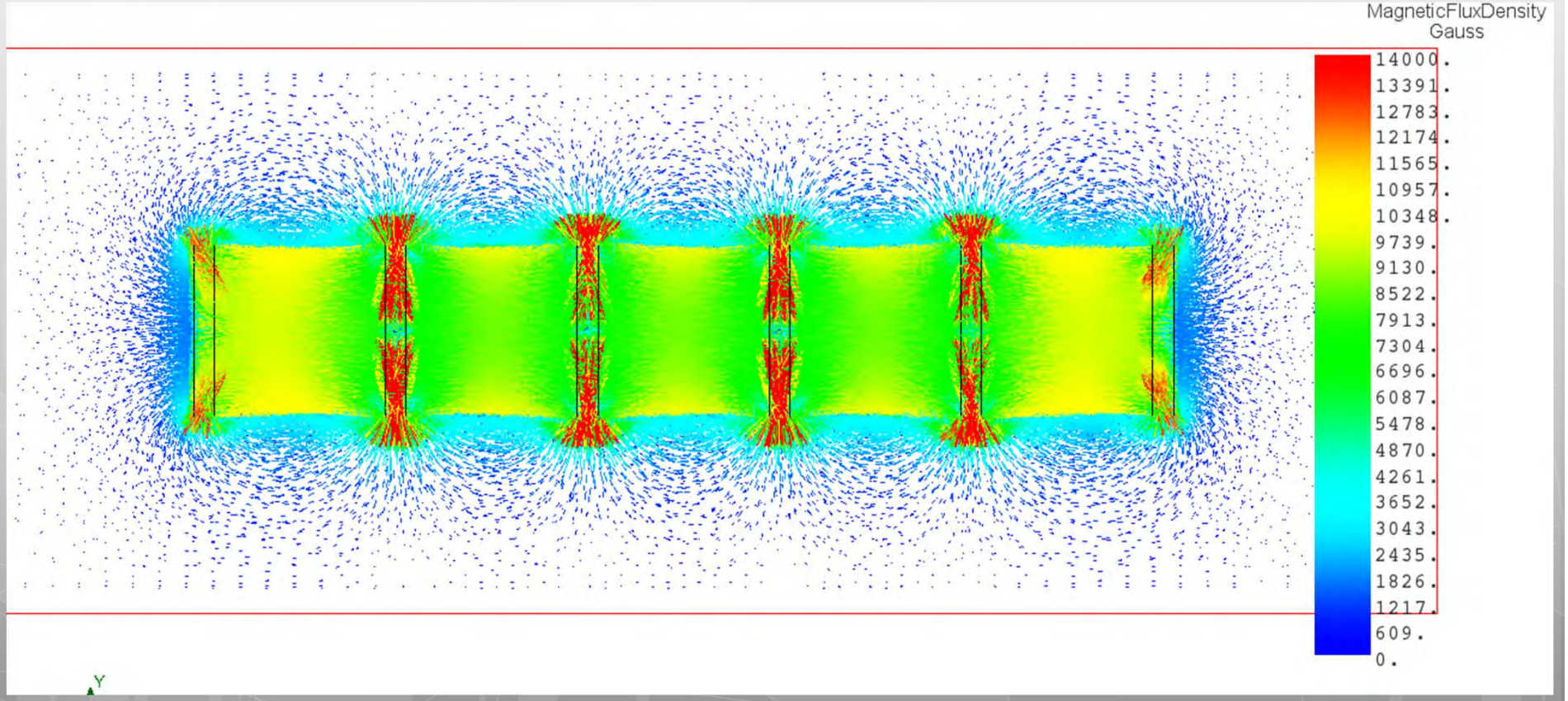


Cutaway view of a Pneumatic Line Magnet with product flow in a dilute phase conveying system.

“Type A” Magnetic Circuit



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

Pros	Cons
Increased holding value	Decrease in durability – tubes are easily dented and product can quickly wear through completely
Increased Gauss	

The "Strongest Magnetic Tube"

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

Pros	Cons
Increased holding value	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
Increased Gauss	

Performance Results

Tube Style				
	Ceramic	Rare Earth	Hi-G	Thin Wall**
1/4" Ball Pull Values*	0.3 lbs	5.0 lbs	5.5 lbs	6.3 lbs
1/2" Ball Pull Values*	1.2 lbs	12.7 lbs	15.5 lbs	16.7 lbs
Gauss Value*	2800	10,000	10,600	11,500
Tube Durability	●●●	●●●	●●●	●
Price	●	●●	●●●	●●●

52 MGO & nickel coated

Circuit "Type B" Magnet Examples

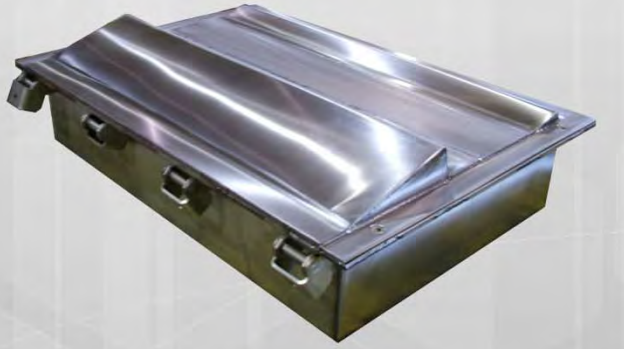
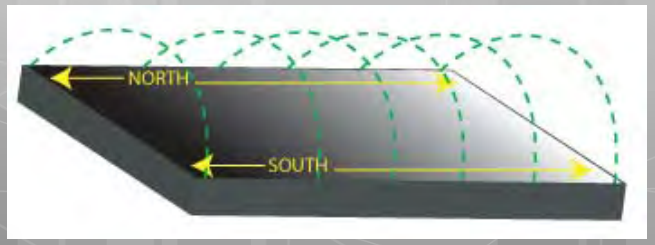
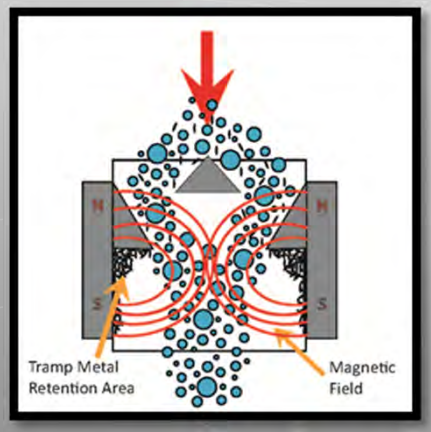


Plate Magnets

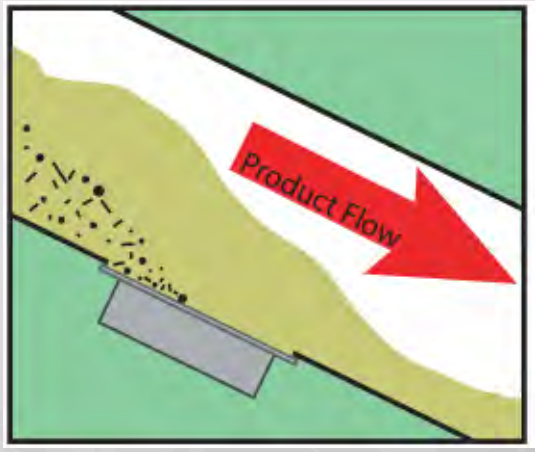


Hump Magnets

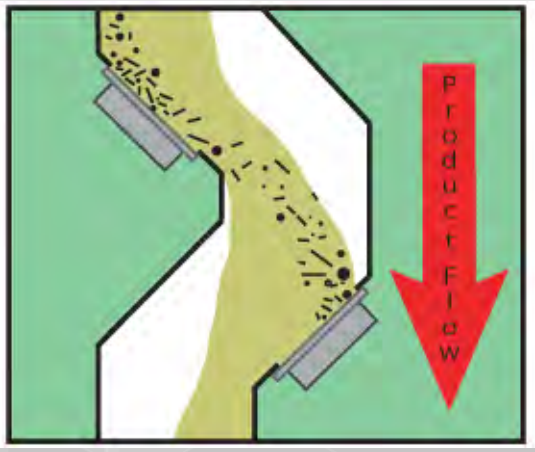
Magnetic Chutes



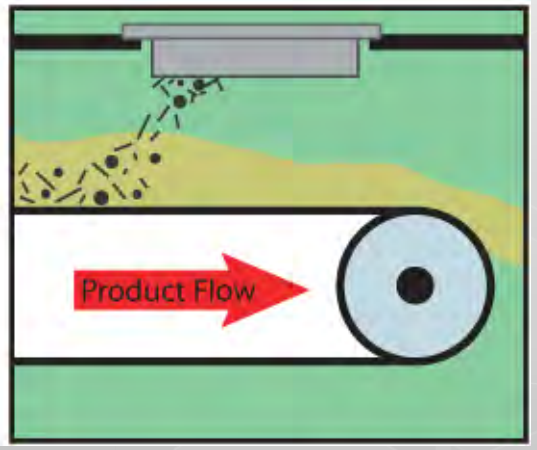
"Type B" Principles of Application



Mounted to Bottom of an Angled Chute



Cross-Mounted in a Vertical-Flow Gravity Chute



Suspended Over a Conveyor Belt or an Angled Chute

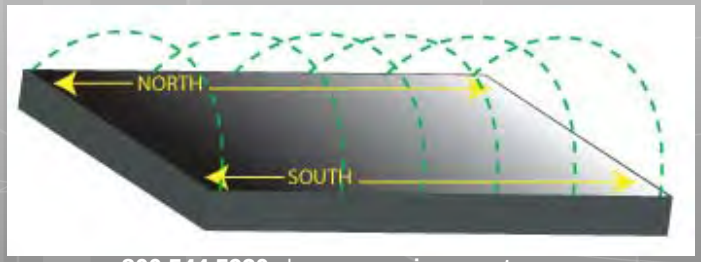
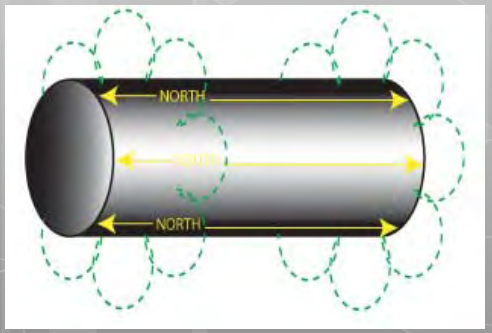


Plate Magnet Selection for Chute Installation

Magnet Type	Tramp Metal	Max Burden	Size / Weight
Ceramic	Large	6-8”	Medium
Rare Earth	Small to large	3-4”	Low
Hi-G Hybrid	Small to large	6-8”	High

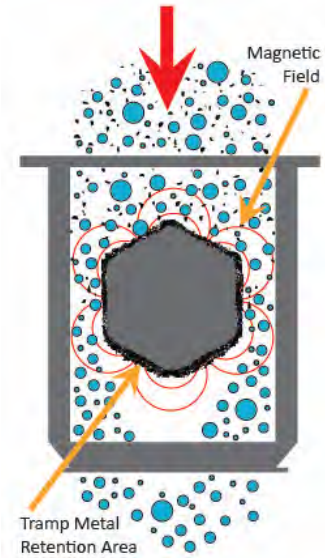
Circuit “Type C” Magnet Examples

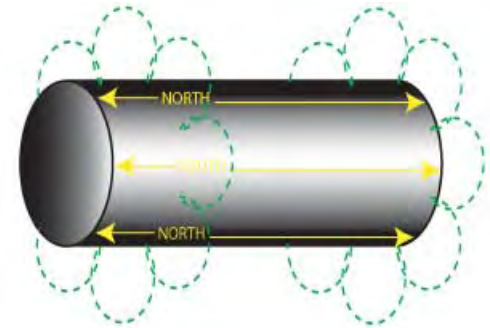
Free-Flow Cylinders

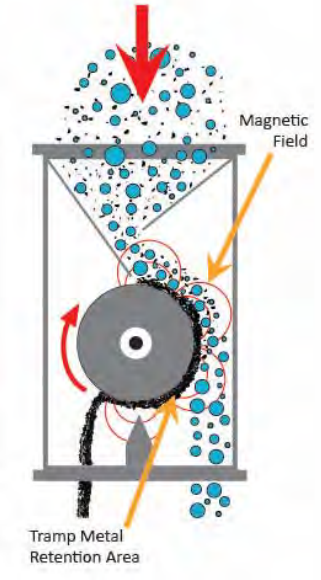


Magnetic Pulleys / Separation Rolls

"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

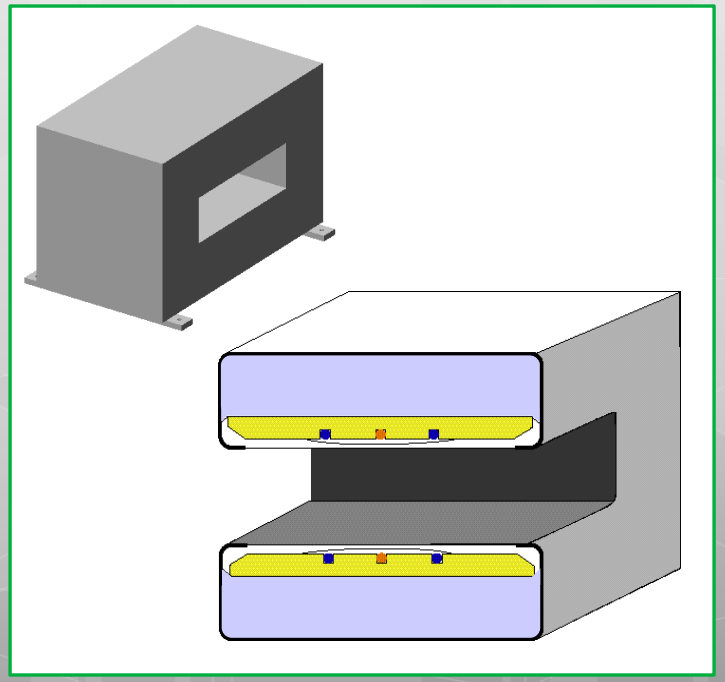
Gauss Meter: Measures flux density

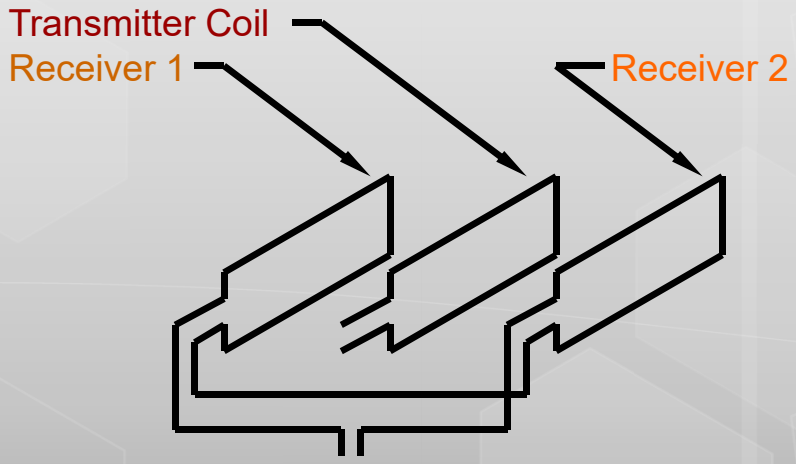
WHITE PAPER

Magnetic Separator Testing:
Pull Test Or Gauss Test?
@ www.mpimagnet.com

Principles of Metal Detection

Balanced Coil Metal Detector





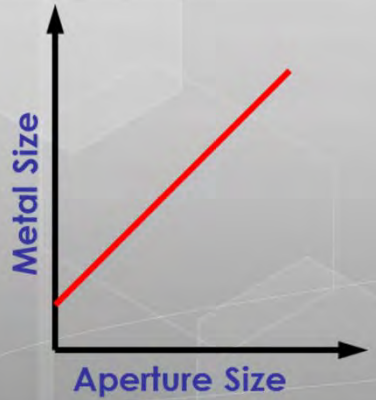
- Balanced triple coil system
- (1) Transmitter coil in center, and (2) receiver coils
- Transmitter produces electromagnetic field at set frequency chosen for the application and product
- Receiver coils wound in series opposition
- Net voltage = zero until metal enters coil

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

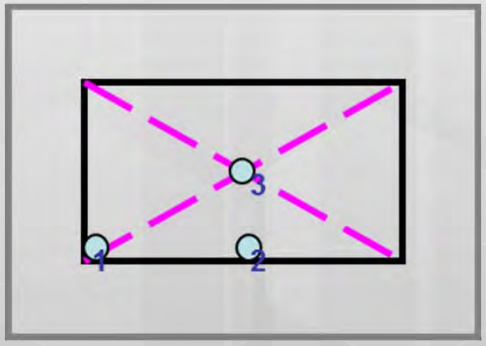
- Larger aperture = less sensitivity
- Built only to size required for package or spout

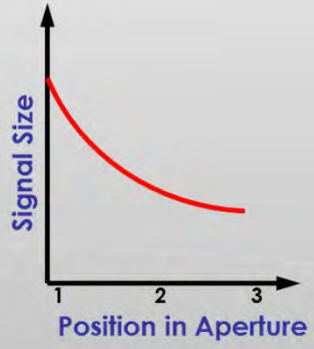


Sensitivity: Kind of Metal

- 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

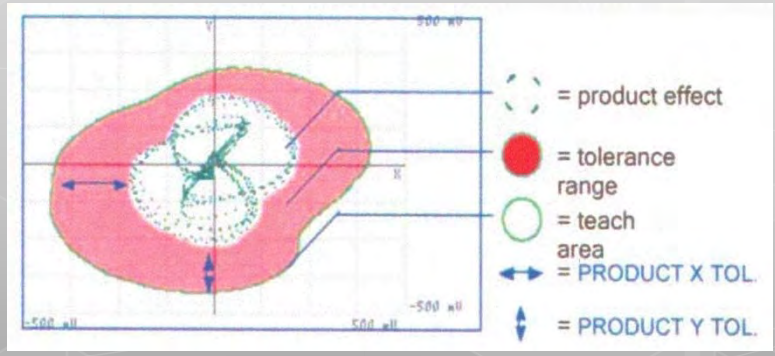
- External “noise” and poor installation affect the detectors signal stability and can lead to false tripping or reduced performance
- The most common sources of “noise” are:
  - Vibrations – Metal detector sees vibration at almost same phase angle as ferrous metal
  - Frequency interference caused by 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 products impact on the magnetic field is referred to as the "Product effect"
- Product effect categorized into two basic groups:

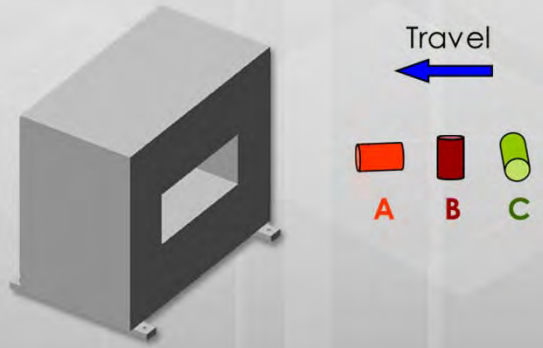
Non conductive or "Dry Products" such as flour = low product effect

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.

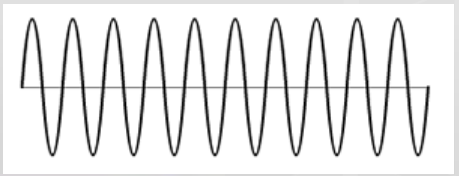
B, **C** - Hardest Position, smallest signal.

Non-Ferrous and Stainless Steel Wires:

B, **C** - Easiest position, biggest signal.

A - Hardest position, smallest signal.

Sensitivity: Detection Frequency



15 kHz ⟷ 600+ kHz

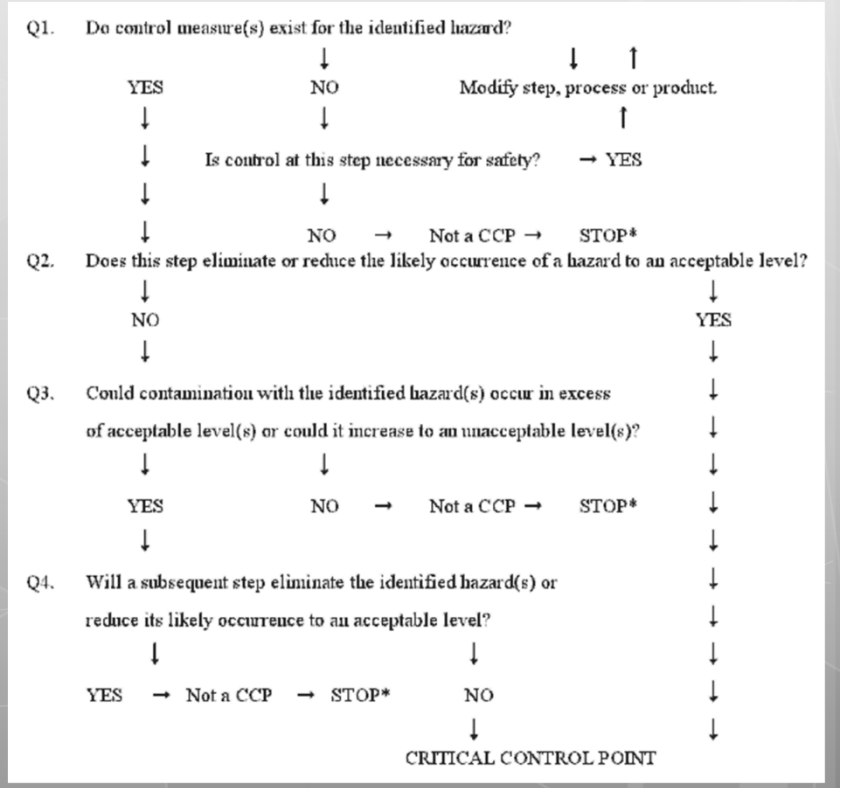
- In general, higher frequency = higher sensitivity
- Dry products (flour) tend to utilize a higher frequency as there usually is little product effect while wet conductive products are built with lower frequencies.
- The frequency is chosen by the factory based upon the application details including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

Protecting and Moving the World through Innovation

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

Magnet Cleaning Log

Plant Location: _____ Department: _____

Magnet ID. #: _____ Magnet Location: _____

Magnet should be cleaned every _____ hours.

Date	Inspected By	Date	Inspected By	Date	Inspected By

Protecting and Moving the World through Innovation
800.544.5930 | www.mpimagnet.com | 683 Town Center Dr., Highland, MI 48357

MAGNET AUDIT INSPECTION FORM

Audit Date:	[redacted]	Priority:	C
Company:		Department:	[redacted]
Plant Location:		Magnet Location:	
Application:	Primary	Magnet ID:	
		Magnet Material:	Rare Earth

System Description: Prior to screener
Magnet Size/Description: 10" drawer magnet with 2 tiers (4 over 5) of 1" tubes on 2" centers. Self clean design

Manufacturer Name:	Model Number:	Products Handled:
MPI	DMU-210-SC-S	Dirty wheat
Magnet Cleaning Interval:	Ease of Cleaning:	
1/Shift	Easy	

Pull Test Results:

Test	Test Piece	Test Location	Pull 1	Pull 2	Pull 3	Average
1	1/2" Sphere	Contact	13.64	13.18	13.31	13.38

Personal Assessment: New magnet
Recommended Action: None

Inspected by:	James Bushong	Position:	Regional Sales Manager/Certified Magnet Auditor
Inspected by:	[redacted]		

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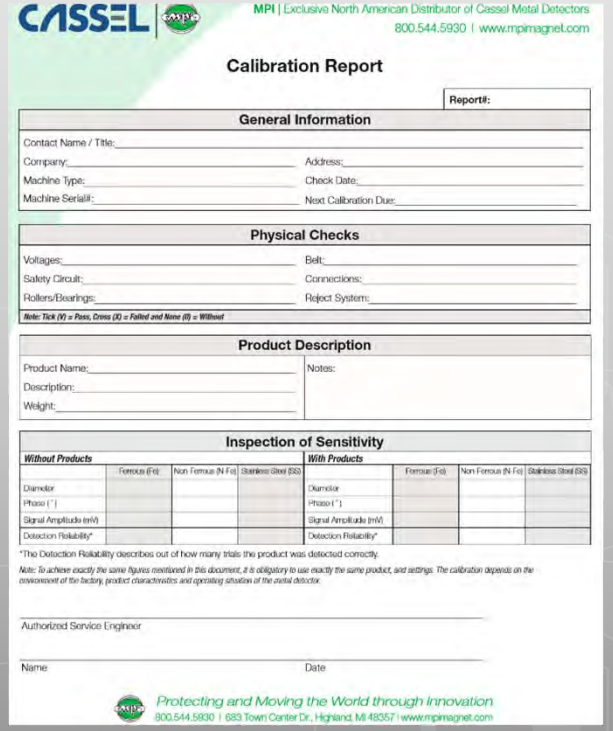
Metal Detection

- 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)



CASSEL | MPI | Exclusive North American Distributor of Cassel Metal Detectors
800.544.5930 | www.mpimagnet.com

Calibration Report

Report#:

General Information

Contact Name / Title:
Company: Address:
Machine Type: Check Date:
Machine Serial#: Next Calibration Due:

Physical Checks

Voltages: Belt:
Safety Circuit: Connections:
Rollers/Bearings: Reject System:

Note: Tick (√) = Pass, Cross (X) = Failed and None (0) = Without

Product Description

Product Name:
Description:
Weight:
Notes:

Inspection of Sensitivity

Without Products	Ferrous (Fe)	Non Ferrous (N-Fe)	Stainless Steel (SS)	*With Products*	Ferrous (Fe)	Non Ferrous (N-Fe)	Stainless Steel (SS)
Diameter				Diameter			
Phase (°)				Phase (°)			
Signal Amplitude (mV)				Signal Amplitude (mV)			
Detection Reliability*				Detection Reliability*			

*The Detection Reliability describes out of how many trials this product was detected correctly.

Note: To achieve exactly the same figures mentioned in this document, it is obligatory to use exactly the same product, and settings. The calibration depends on the environment of the factory, product characteristics and operating situation of the metal detector.

Authorized Service Engineer

Name Date

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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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