Metal Control Technology

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Presentation Overview

- Principles of Magnetic Separators
  - Magnetic Material and Energy
    - Ceramic
    - Rare Earth
    - MGOe
  - Magnetic Circuit Design
  - Magnetic Separator Placement
  - Permanent magnetic separators and energy loss
  - Cleaning Your Magnetic Separators
- Principles of Metal Detection
  - Coil Size versus Sensitivity
  - Product Signatures
- Food Safety and FSMA
  - The 7 Principles of HACCP
  - Control Point or Critical Control Point
  - Monitoring and Validation
  - Reporting and Record-keeping Requirements
- X-ray – Applications in Milling

MPI: Company Overview

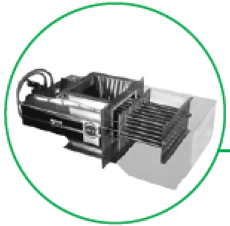
Protecting and Moving the World through Innovation

- Founded in 1981
- Located in Metro Detroit Michigan
- Design and build magnetic separation systems, assemble, distribute and service electronic inspection systems
- Experts in complete metal control systems
- In house fabrication facilities, AutoCAD Inventor design
- Approximately 60 employees
- Primarily operates in: foods, plastics, pharmaceuticals, recycling, textile, and material handling
- Strong emphasis on customer education
- Local Regional Managers & Manufacturing Representatives covering majority of the Americas

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

Principles of Magnetic Separators

- Magnetic Materials:
- Ceramic Magnetic Material
  - Developed in 1952
  - Manufactured of Iron Oxide and Strontium or Barium
  - Maximum MGOe of 3.5
  - Advantages of Ceramic Magnets
    - Low in cost
    - High Coercive Force
    - Highly resistant to corrosion
    - High Tmax (maximum normal operating temperature) of 572F, 300C
    - High Curie Temperature (temperature at which the magnet will become permanently demagnetized) 860F, 460C
  - Disadvantages of ceramic magnets
    - They can only be manufactured up to 3.5 MGOe which limits the amount of suitable applications where we may be looking for smaller mass ferrous tramp metal in high volume production lines

Principles of Magnetic Separators

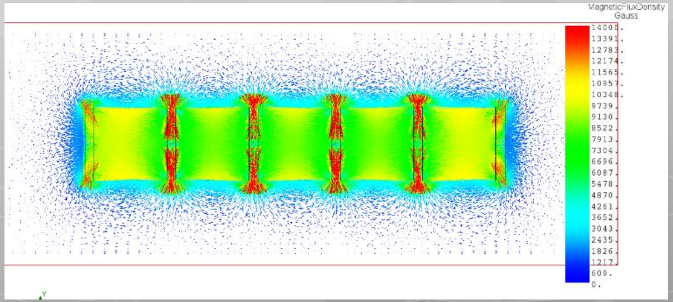
- Magnetic Materials cont.
- Rare Earth Magnetic Material
  - “Rare Earth” magnetic material is not rare. They are called “Rare Earth” because Samarium and Neodymium, both key ingredients in the magnets, fall under the Rare Earth portion of the Periodic Table of Elements
  - Samarium Cobalt
    - Developed in 1966
    - Made with a blend of Samarium, Cobalt and Iron
    - Maximum MGOe of 30
    - Advantages of Samarium Cobalt Magnets
      - Their ability to be used in high temperature applications. Tmax of 572F (300C)
      - Tcurrie of 1382F (750C) make them far superior than Neodymium in applications above 300F
      - High energy product of up to 32MGOe
      - Highly resistant to oxidation
    - Disadvantages of Samarium Cobalt Magnets
      - Higher in cost than other rare earth magnets
      - Are extremely brittle making them highly susceptible to physical damage

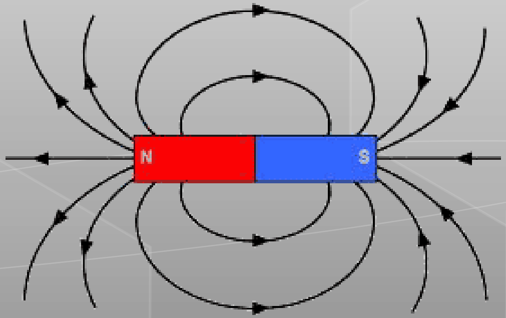
Principles of Magnetic Separators

- Magnetic Materials cont.
- Rare Earth Magnetic Material
  - Neodymium
    - In 1983 joint research between General Motors, Sumitomo Special Metals and the Chinese Academy of Sciences developed the first Neodymium magnet
    - Made with a blend of Neodymium, Iron and Boron
    - Currently 52 MGOe is the maximum energy readily available on the market
    - Advantages of Neodymium magnets
      - They have a very high energy product at 52MGOe+ enabling them to remove fine metal particulate in high volume applications
    - Disadvantages of Neodymium Magnets
      - They are easily oxidized
      - They have low corrosion resistance
      - They have only moderate temperature stability with a Tmax of 302F (150C) and Tcurie of 590F (310C)
      - They are brittle so are subject to damage from shock or vibration

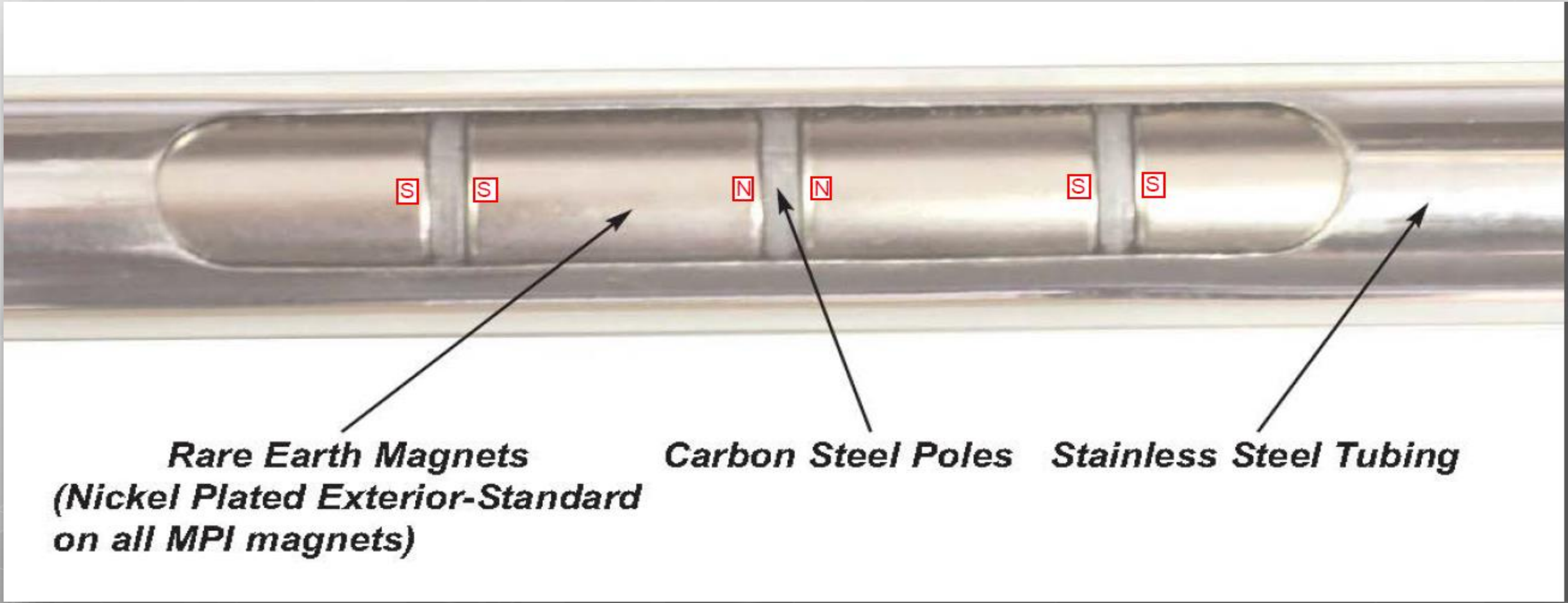
Principles of Magnetic Separators

- Magnetic Material Energy
  - MGOe
    - MGOe is the unit of measurement used when stating the maximum energy product, or maximum amount of energy for a given material used in making a magnet
    - Since MGOe is finite, every manufacturer using the same MGOe material will have the same amount of magnetic energy (flux density) available to use when designing the magnetic circuit
    - Where you focus the energy with the magnetic circuit design determines the effectiveness of the magnetic separator for any given application
      - Focusing more energy at the surface of the magnet results in higher pull test holding values and gauss readings at the surface of the magnet, but less flux density away from the surface of the magnet
      - Focusing more energy away from the surface of the magnet results in greater "reach out," or higher flux density away from the surface of the magnet, but lower pull value holding force or gauss level readings at the surface of the magnet





Magnet Design



Principles of Magnetic Separators

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So if all the manufacturers are using the same MGOe material, how can there be claims that "We have the strongest magnet on the market

Composite Material Construction – Competitive Compromise

- Reducing Air Gap
  - Thinner Tubes – less steel between the magnet and product

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

Competitive Compromise

- Reducing Air Gap
  - Uncoated magnet block
  - Inadequate protective coating

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	

Composite Material Construction

Brand/ Construction	MPI (Hi-G)	Brand "X"		Brand "Y"		Brand "Z"	
Wall Thickness		Less 47%		Less 21%		=	
Gauss @ Surface	10,650	10,848	+1.8%	10,500	-1.5%	9,136	-16.6%
½" Pull Value @ Surface (lbs)	15.5	15.8	+1.9%	15.08	-2.8%	16.24	+4.8%
¼" Pull Value @ Surface (lbs)	5.8	6.1	+5%	5.72	-1.5%	5.55	-4.5%

Magnetic Circuit Design: How do Magnetic Separators Work?

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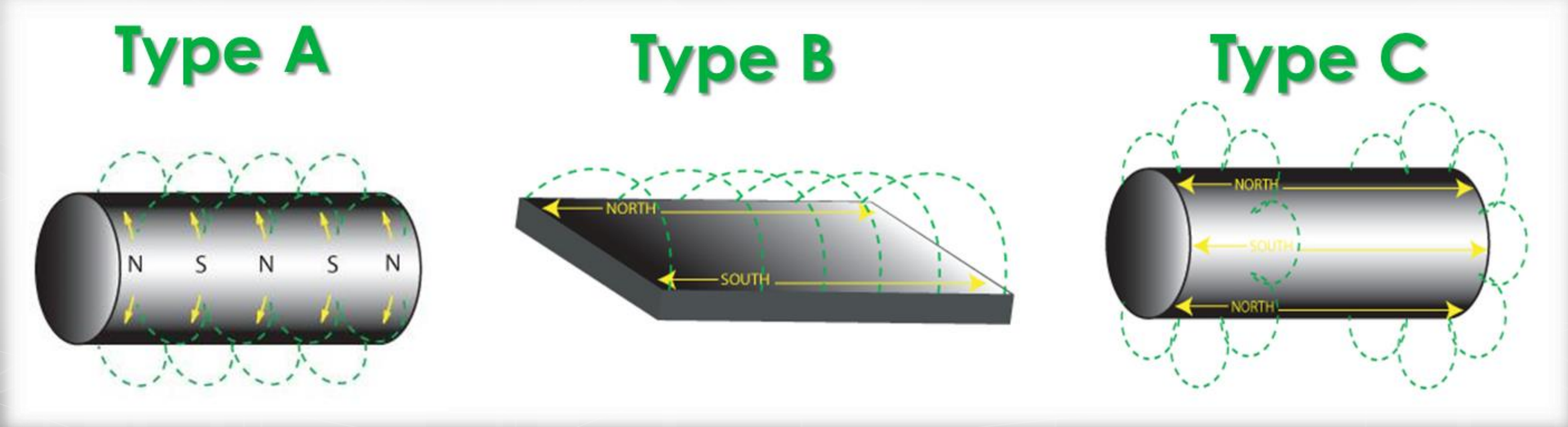
The 3 Magnetic Circuits

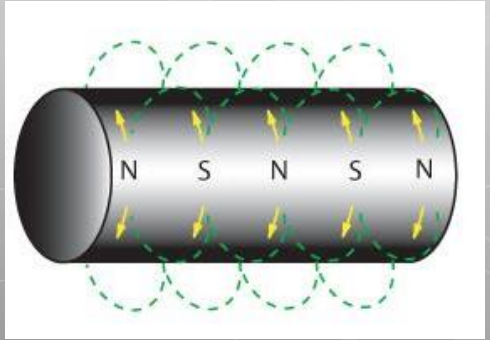


Circuit "Type A" Magnet Examples

Grate Magnets

Pneumatic Line Magnets

Drawer Magnets



"Type B" Principles of Application

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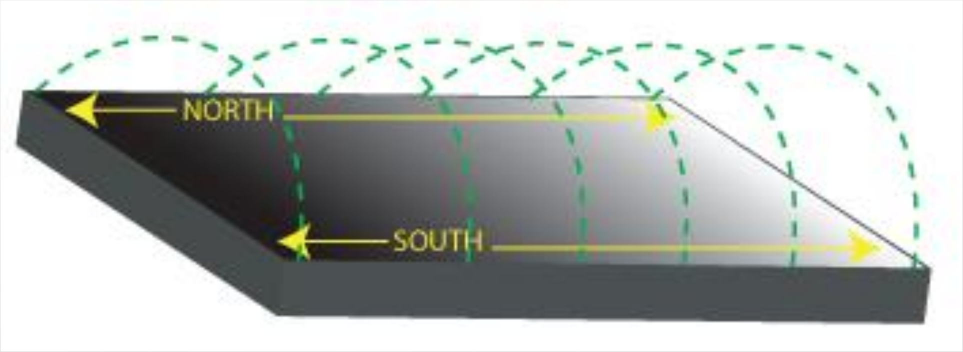
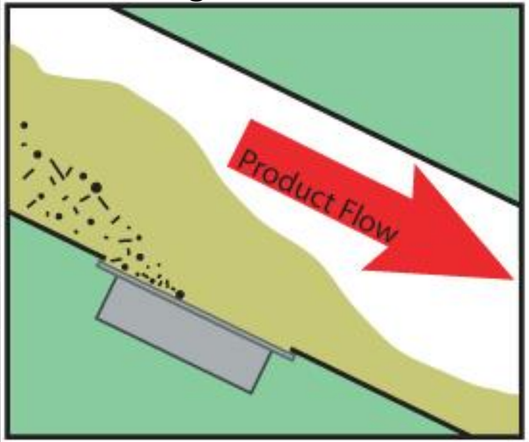
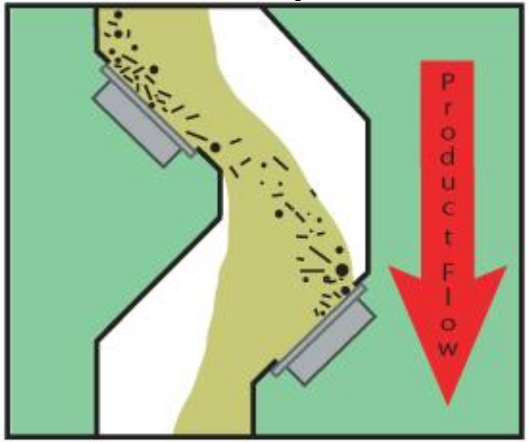


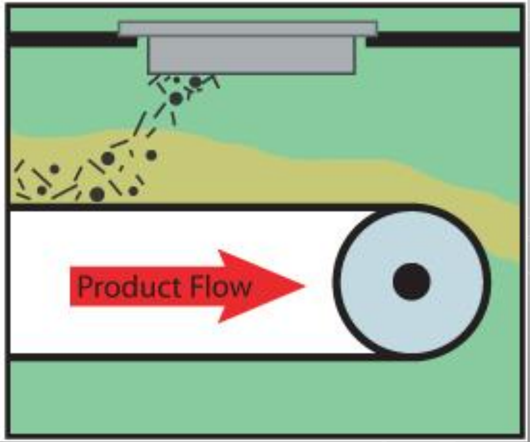
Mounted to Bottom of an Angled Chute



Cross-Mounted in a Vertical-Flow Gravity Chute



Suspended Over a Conveyor Belt or an Angled Chute



Circuit "Type B" Magnet Examples

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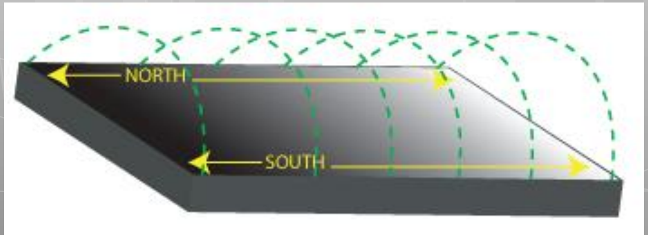
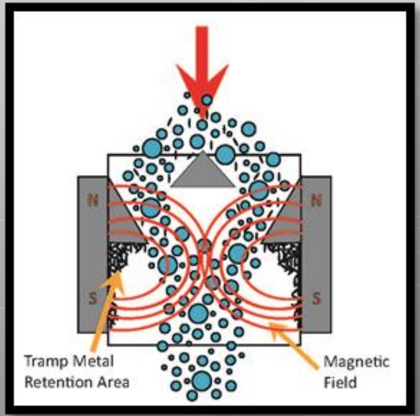
Plate Magnets

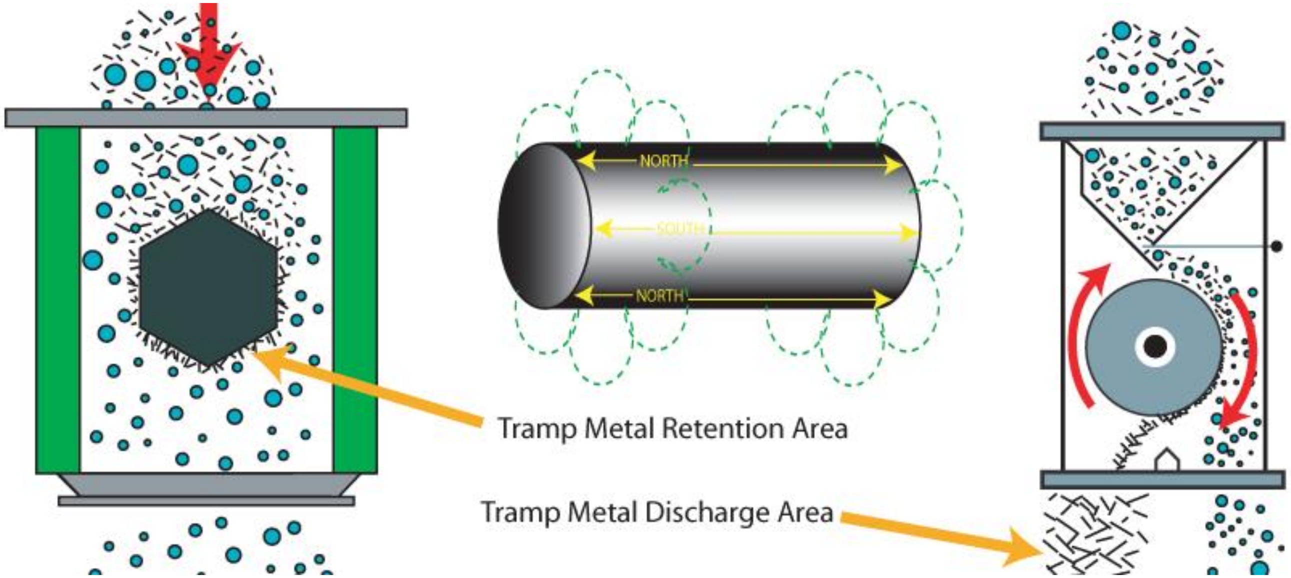


Hump Magnets

Magnetic Chutes



"Type C" Principles of Application

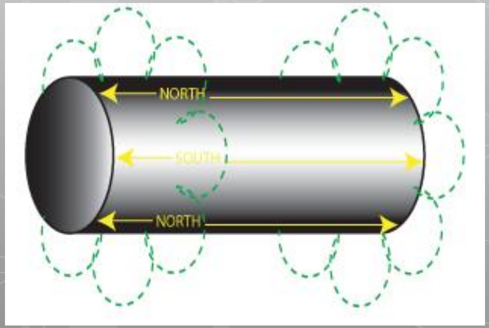


Free Flow Cylinder Magnets

Drum Separator, Housings, and Magnetic Head Pulleys

Circuit “Type C” Magnet Examples

Free-Flow Cylinders



Magnetic Pulleys / Separation Rolls

Magnetic Separator Placement

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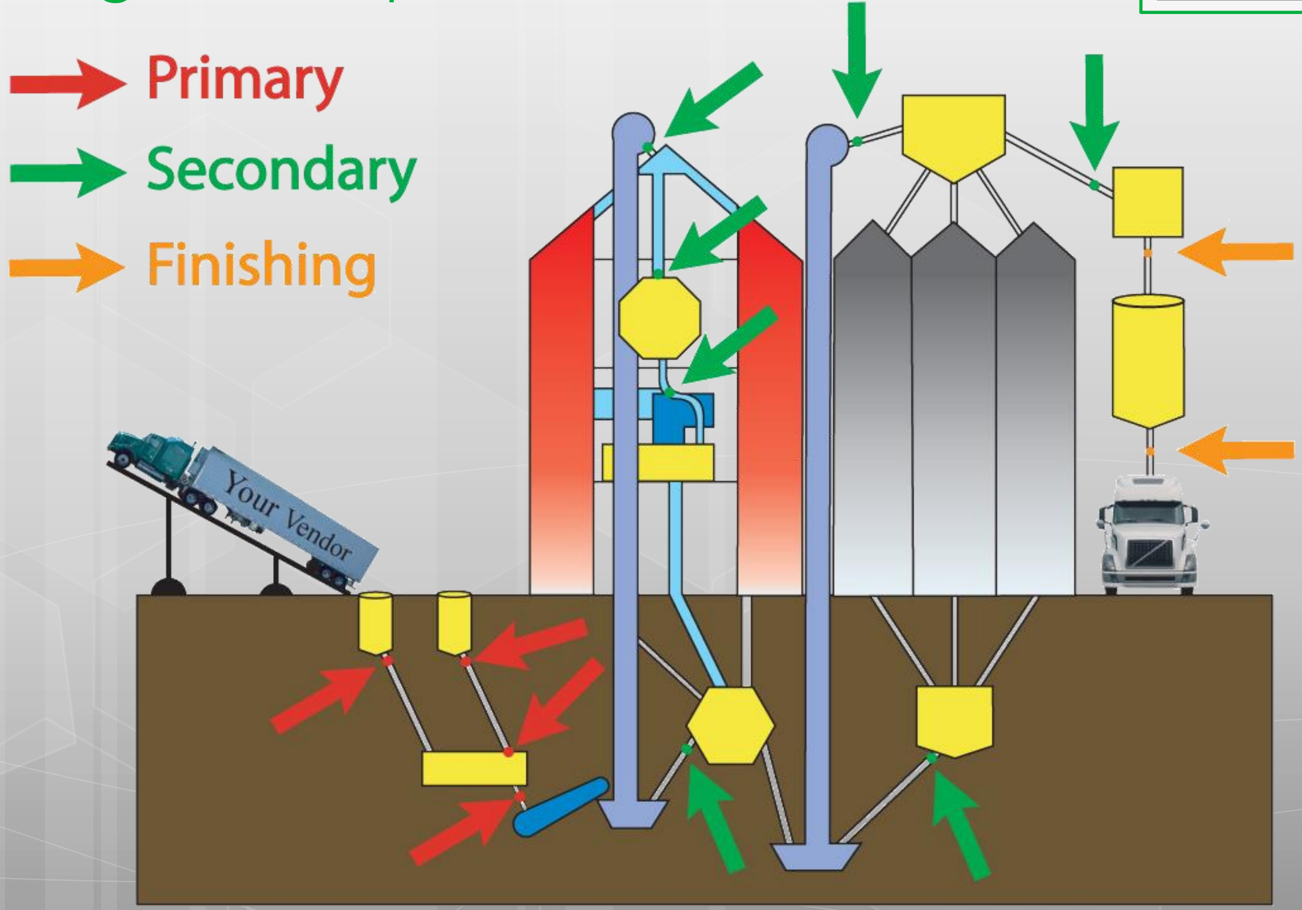


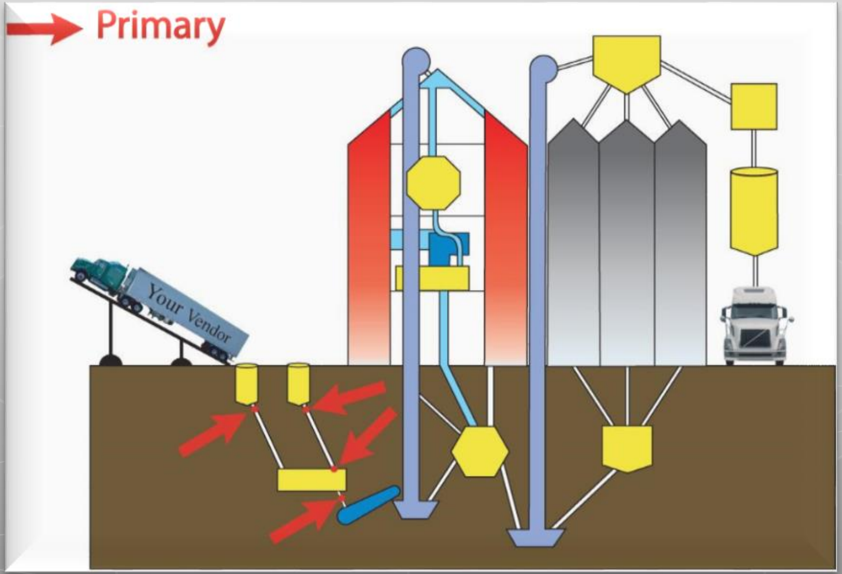
Primary Applications

Function:

- Process high volume product flows
- Remove incoming ferrous tramp
- Retain large volumes of ferrous tramp between magnet cleaning cycles
- Vendor monitoring

Where is It Used?

- Plant receiving areas



Primary Installation

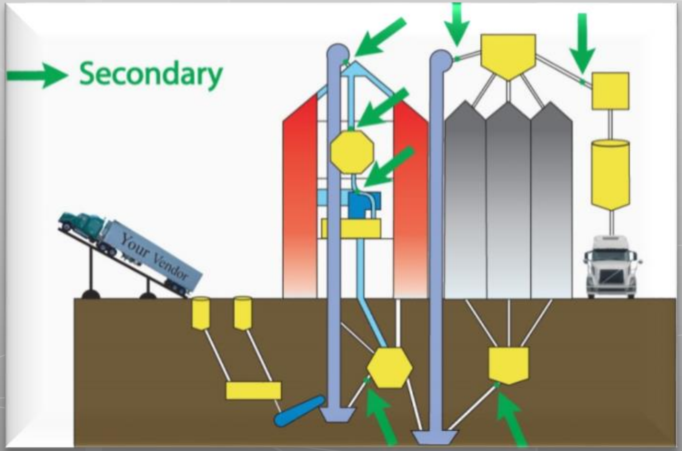
Secondary Applications

Function:

- Protect specific plant equipment
- Detect process equipment malfunctions

Where is It Used?

- Hammer mills
- Airlocks
- Screw & drag conveyors
- Sifters
- Roller mills
- Bucket elevators
- Screeners
- Pumps



Secondary Installation

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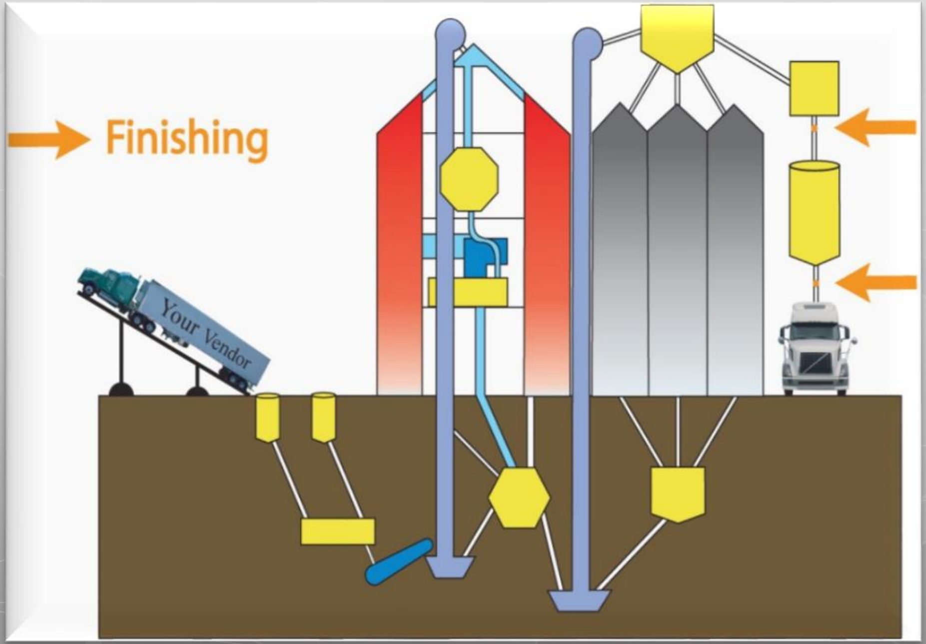
Finishing Applications

Function:

- Maintain end-product quality
- Ensure that the product to be shipped from the plant does not contain any ferrous contaminants
- Consumer protection
- Brand protection

Where is It Used?

- Packing systems
- Bulk load-out areas



Magnet Life Expectancy

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

Magnet Life Expectancy

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.

Cleaning Your Magnets

- Establishing the cleaning schedule
  1. After installation, inspect your magnet after the first hour of production
  2. If an insignificant amount of metal is observed, return in 2 hours to inspect magnet
  3. If magnet continues to have insignificant amount of tramp metal, you may continue to back off frequency
  4. If significant amount of metal is found on magnet, increase the cleaning interval as required to ensure the magnet does not reach maximum tramp metal capacity
  5. Once your cleaning schedule is established, refer to MPI's Magnetic Separator Cleaning and Testing Recommendation for further guidance

Cleaning Your Magnets

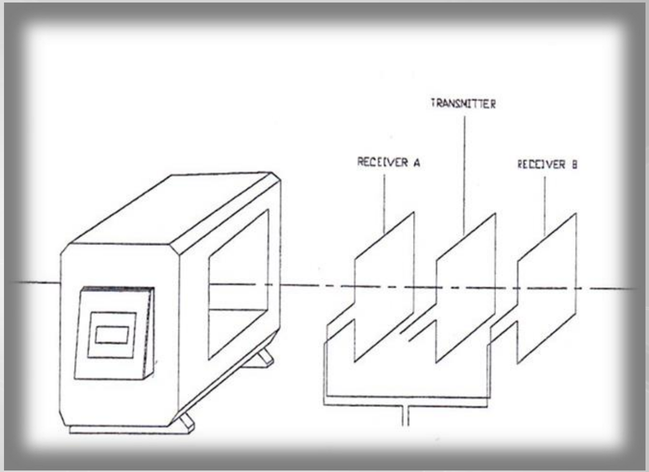
It really doesn't matter how strong this magnet is…

…Once it gets to this

Principles of Metal Detection

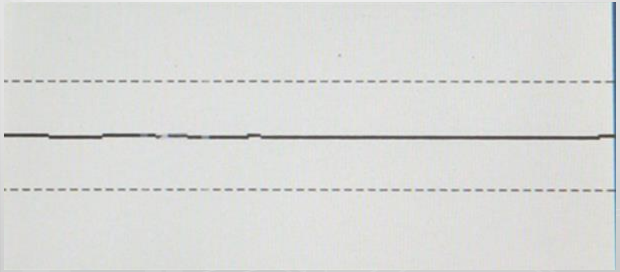
The Theory of Metal Detection
Design of the Search Head

- Modern metal detectors operate on the balanced triple coil system
- Transmitter in the center and two receivers, on the leading and trailing edge
- The transmitter produces an electromagnetic field with a frequency chosen for the application and product
- The transmitters magnetic field produces a voltage in the two receiver coils. The voltages are subtracted from each other and the difference is amplified and filtered. The output voltage of a correctly aligned receiver circuit is zero

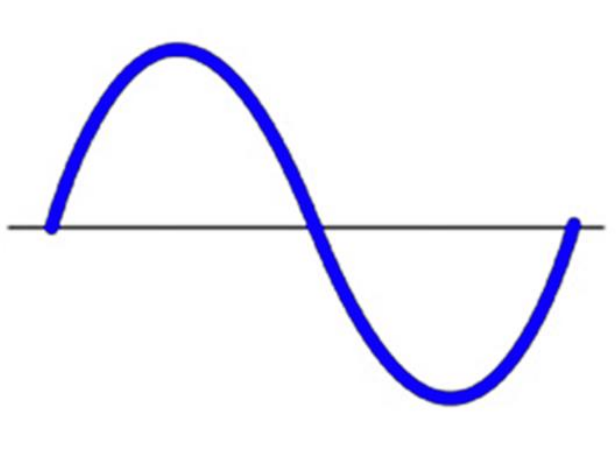


The Theory of Metal Detection
How the Electromagnetic Field Works

- The signals from the receiving coils are connected in opposition to each other so when no disturbance is occurring there will be a net signal across the coils of zero, they are balanced.



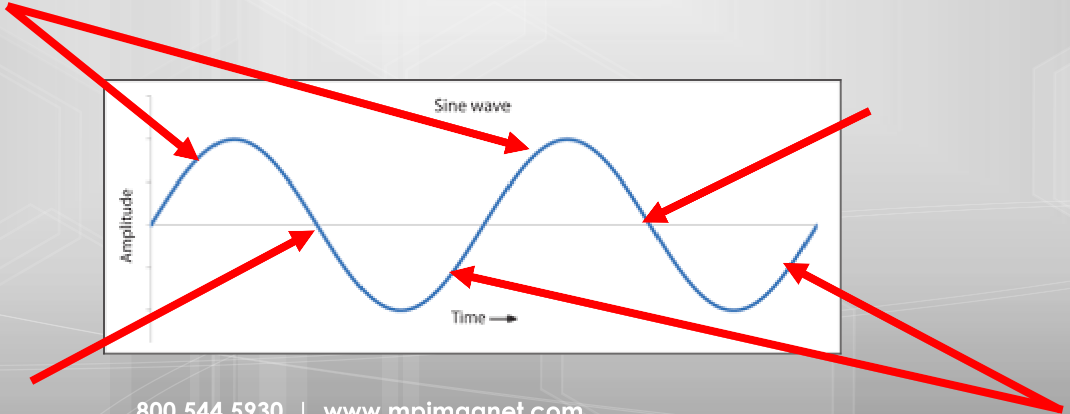
The Theory Of Metal Detection
How the Electromagnetic Field Works



- Every material that is electrically or magnetically conductive causes asymmetry in the magnetic field of the receivers as it passes through the coils, therefore, magnetic and conductive materials can be detected.

The Theory of Metal Detection
How We See Metal

- As metal passes into the detector coil the magnetic field of the leading receiver is affected and the first half of the wave is produced.
- When metal is exactly at the transmitter coil the influence to the magnetic field is equal on both sides of the coil so the signal is zero.
- As the metal piece moves toward the trailing receiver the opposite wave is produced.
- If the speed is constant a sine wave signal is produced.



The Theory of Metal Detection
What Influences the Electromagnetic Field?

The magnetic field is effected in two different ways:

Magnetic Conductivity-Reactive Effect

- A paramagnetic material results in the amplification of the signal. Iron, ferrite, nickel and cobalt are good magnetic conductors and have high permeability. (Why they are used in magnetic material)

Electric Conductivity-Resistive Effect

- On the surface of electrically conductive materials eddy currents are produced as soon as they are exposed to the magnetic field. The higher the frequency of the magnetic field, the stronger the eddie currents are. The eddie currents produce their own magnetic field which resists the original field. Because of this, energy is subtracted from the original field. This creates a "resistance" to the receiver coil called "Resistive Effect" which causes a phase signal in the receiver. (The higher the detection frequency, the stronger the eddie currents. This is why we can detect smaller non-ferrous metals with a higher frequency unit. However, more conductive products cause more product effect)

*Sensitivity

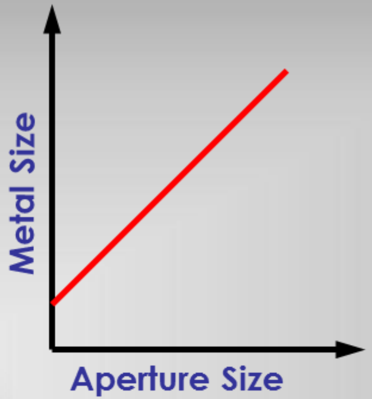
- The fundamental way most people judge a metal detector is by its detection ability or "sensitivity"

- The sensitivity of a metal detector depends on the following factors:
  - Aperture size and type of detector
  - Kind of metal
  - 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

- Tunnel style detectors are more sensitive than flat coil systems.
- The larger the aperture, the less sensitivity therefore we build them only as large as necessary.



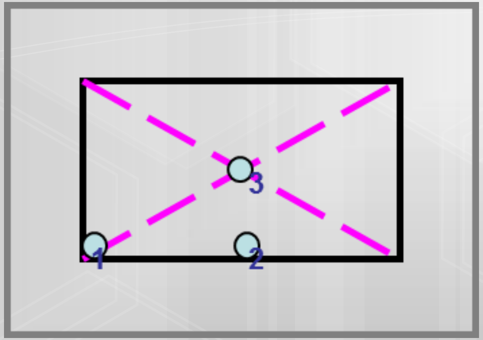
Sensitivity: Kind of Metal

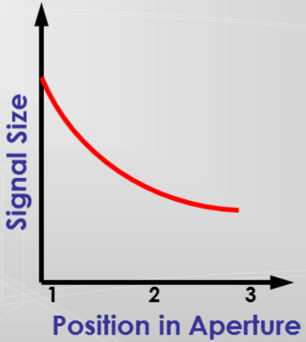
The different types of metal:

- 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. Keep in mind there are varying grades of stainless steel and its characteristics may vary

Sensitivity:
Position of the metal inside the detector

- Inside a tunnel style detector the least sensitive area is in the center of the tunnel. The field is less concentrated here.
- The highest sensitivity is directly on the aperture surface. With rectangular coils the corners are even more sensitive.





Sensitivity: Environmental Conditions

External "noise" and bad working conditions affect the detectors signal stability and lead to false tripping and a reduced sensitivity setting.

The most common sources of "noise" are:

- Vibrations – A metal detector sees vibration near 90 degrees phase angle, almost identical to ferrous metal.
- Frequency interference caused by other electrical equipment (vfd's).
- Moving metals inside the metal free zone.
- Intermittent eddie-current loops in the construction of the conveyor.
- Static electricity on the production floor.
- Direct sunlight, rain, wind.
- Coil not isolated during mounting.
- Conveyor belt, antistatic material or contamination in belt.

Sensitivity: Product Effect

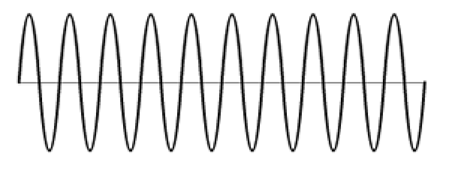
- Almost all product cause an effect to the magnetic field. We call this "Product Effect" and categorize this into two basic groups:

  - Non conductive or "Dry Products" such as powder, grain, plastics, textiles, etc. Dry product causes a weak reactive effect that can be easily learned.

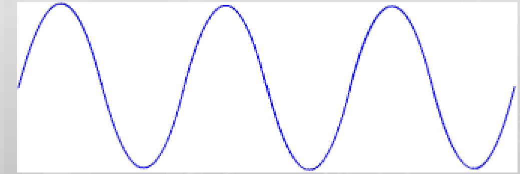
  - Conductive products or "Wet Products" such as meat, cheese, sauces, dressings, or anything else that contains moisture or minerals such as salt. Wet products cause mostly a resistive effect which is usually strong and changes constantly.

If product effect is produced during inspection it must be compensated for or "learned" in order to not have false rejects. When we learn a product signature, we also lose detection ability, especially with the kind of metal closest to the effect.

Sensitivity: Frequency



- In general, the higher the frequency, the higher the sensitivity. Dry products 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.



Food Safety, HACCP and FSMA

- 7 Principles of HACCP
- Control Point or Critical Control Point
- Monitoring and Validation Requirements
- Reporting and Record Requirements

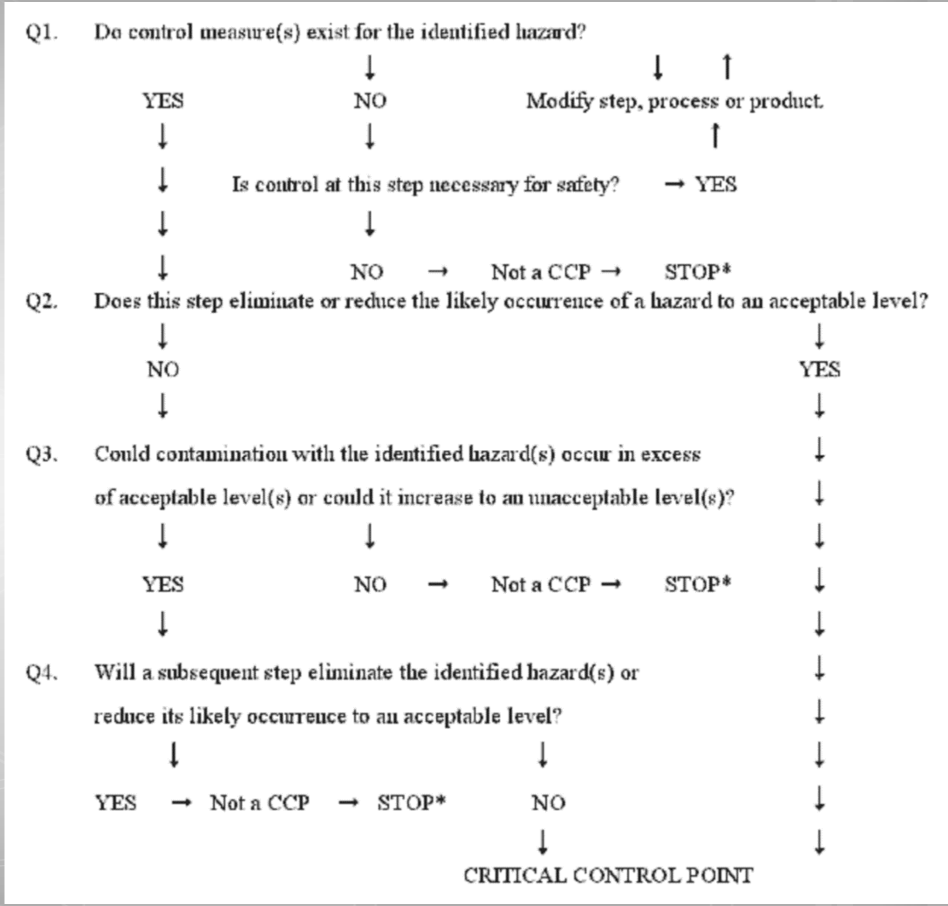
7 Principles of HACCP

- Conduct a Hazard Analysis
- Determine Critical Control Points
- Establish Critical Limits
- Establish Monitoring Procedures
- Establish Corrective Actions
- Establish Verification Procedures
- Establish Record-keeping and Documentation Procedures

Food Safety and 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



Monitoring and Validation

- Monitoring: Ideally monitoring is continuous but if not continuous, it should be done on a batch basis
- When it is not possible to monitor on a continuous basis, it is necessary to establish a monitoring frequency and procedure that will be reliable enough to indicate that the CCP is under control
- Statistically designed data collection or sampling systems lend themselves to this purpose
- Examples of monitoring activities include visual observations
- Monitoring should be completed at a frequency level and conducted by personnel as described in the HACCP plan
- Monitoring equipment must be carefully calibrated for accuracy

Monitoring and Validation

- Validation is defined as those activities, other than monitoring, that determine the validity of the Hazard Analysis and Critical Control Point plan that the system is operating in accordance to the plan
- Validation activities should be scheduled by the HACCP Coordinator and conducted yearly or upon HACCP system change
- Information for validation often include expert advice and scientific studies and in-plant observations, measurements, and evaluations

Reporting Requirements and Records

- All records and documents associated with Critical Control Point Monitoring should be dated and signed or initialed by the person doing the monitoring

Maintenance Inspection Log

Plant Location:________________ Department:____________

Magnet ID. #: ________________ Magnet Location:____________

Date:	Inspected By:
Comments:	

Date:	Inspected By:
Comments:	

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

Reporting Requirements and Records

Magnet Inspection Report

Plant Location: ______ Department: ______

Magnet ID. #: ______ Magnet Location: ______

Magnet Application Type:	System Description:
☐ Primary ☐ Secondary ☐ Finishing	

Magnet Product Type:	Magnet Size/Description:
☐ Ceramic ☐ Rare Earth ☐ Other: ______	

Manufacturers Name: ______ Model Number: ______

Products Handled/Characteristics: ______

Flow Capacity (Min-Max) Typical: ______

Magnet Pull Test Results:

	Pull 1	Pull 2	Pull 3	Average	Using
Contact					
___ Gap					
___ Gap					

Ease of Cleaning:	Personal assessment of magnet performance, cleaning access, and type/size for application:
☐ Very Difficult ☐ Satisfactory ☐ Easy	
Magnet Cleaning Interval:	Recommended Action:

Inspected By: ______ Date of Inspection: ______

Department/Position: ______

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 (V) = Pass, Cross (X) = Failed and None (0) = Without

Product Description

Product Name: ______ Notes:

Description: ______

Weight: ______

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 the 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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X-Ray

- X-ray technology in not in widespread use in the milling industry
- X-ray technology is a density separator and because flour itself is dense, it does not lend itself well for use of the technology
- Metal Detection and Sifter technologies lend themselves much better to milling than x-ray

Contact

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