

FOREIGN MATTER TESTING

Mettler-Toledo Safeline

SAFELINE

Metal Detector & X-ray Inspection

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METTLER TOLEDO

Agenda

Introduction

- X-Ray Principles
- Application Notes X-Ray
- Inspections Metal detection
- Metal detection Principles
- Q & A

Why Have Foreign Matter Inspection

- To reduce foreign objects within your product
- To protect your customers
- To protect your brand name
- To protect inline equipment

Choosing the right technology

Factors that influence inspection systems performance

| X-ray | Metal Detector |
|--|----------------------------------|
| Type and size contaminant | Moisture Content |
| Product Homogeneity | Salt Content |
| Size (thickness) of product | Temperature of product |
| Overlapping / Stacked product | Packaging |
| Complexity of image vs. complexity of inspection | Contaminant orientation |
| Processing speed (multiple inspections) | Fe, non Fe, SS |
| Product Speed | Contaminant location in aperture |
| Aluminum | Vibration |
| | Electrical Noise |

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Understanding X-ray Technology

Major components that make up an x-ray system

**X-Ray Generator
houses the tube**

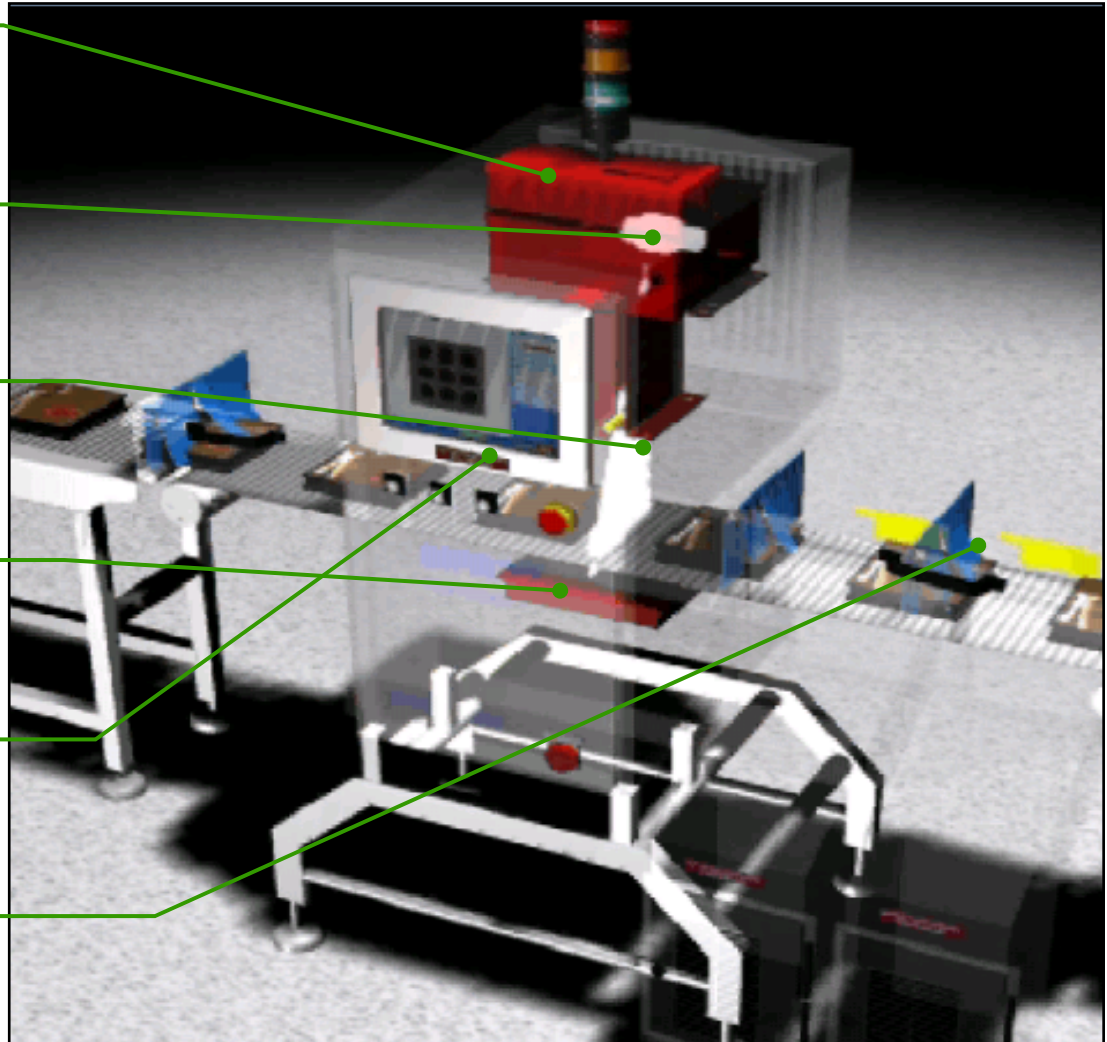
**X-Ray Tube
emits beam downward**

**X-ray Beam
passes through
product**

**Detector
collects data**

**Computer
analyses the data**

**Reject Device
removes faulty
product**



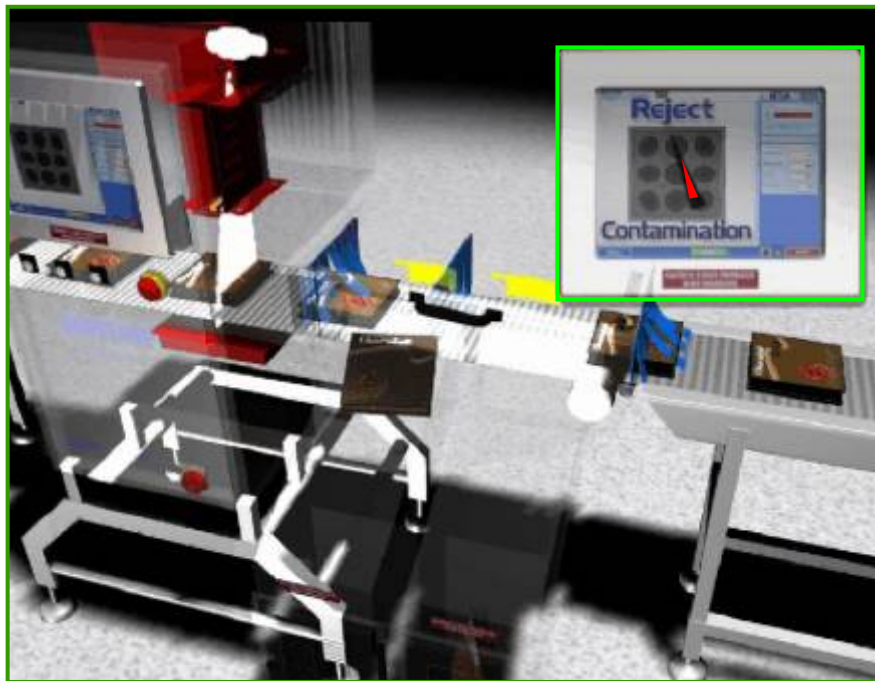
X-ray principles – what can be achieved?

Contaminated product can be rejected into bin 1.

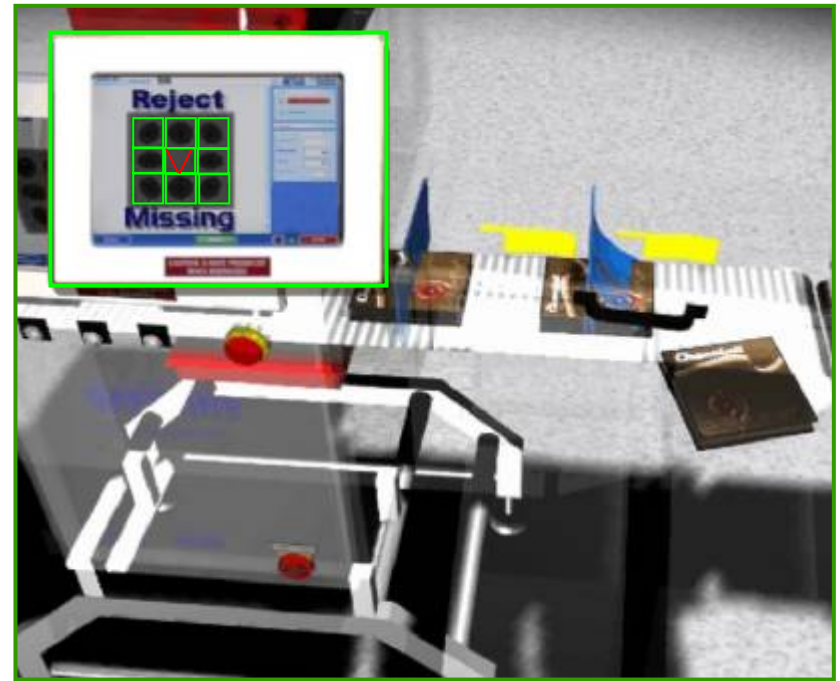
Product integrity faults can be rejected into bin 2.

See the diagram below:

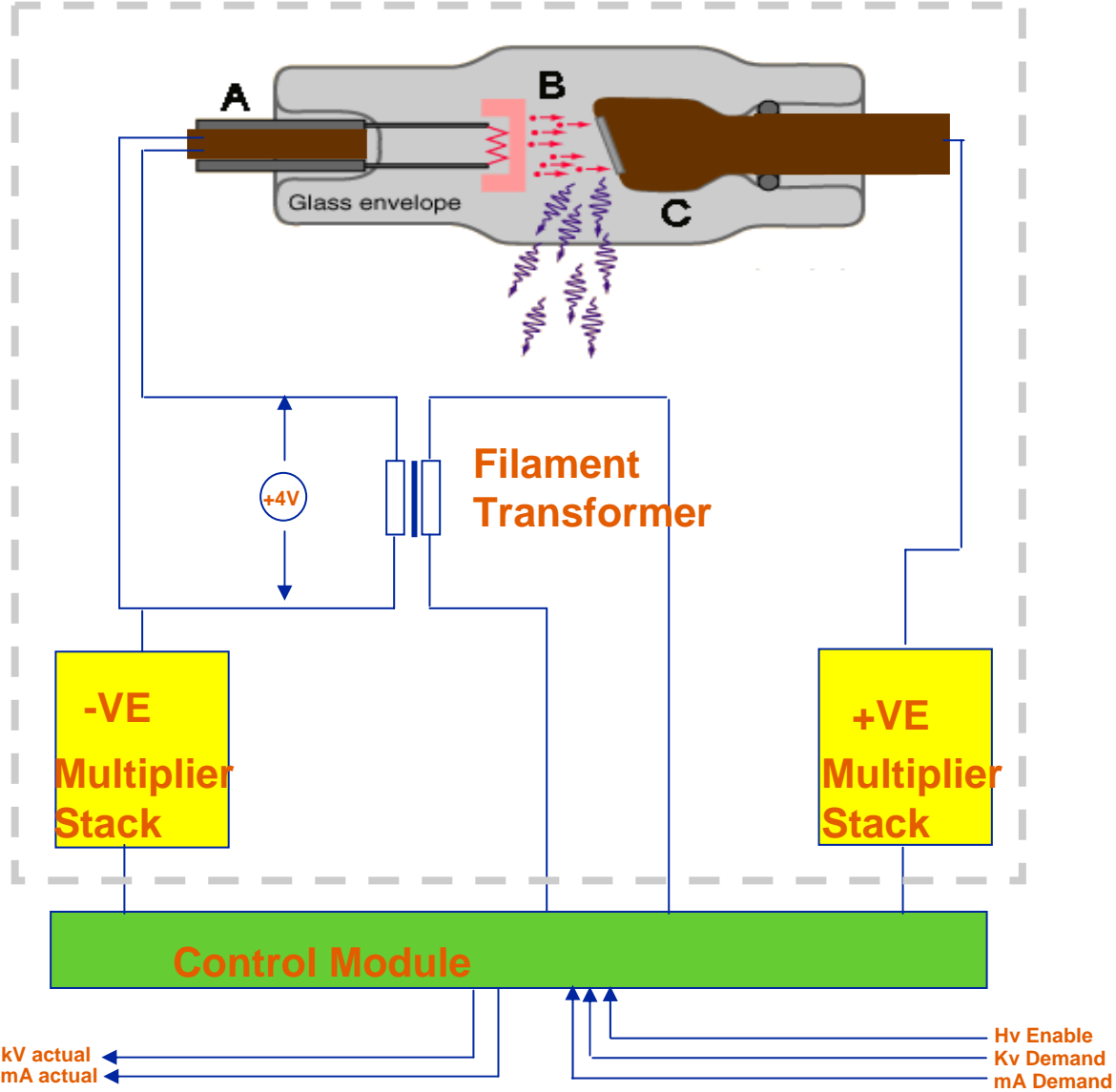
Contaminated pack in bin 1



Non conformity pack in bin 2



X-ray Generator - Circuit Design



Foreign Material Detection

Materials - Relative Detection

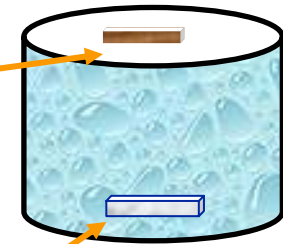
Density Chart

(kg/m³)

| | |
|------------|------|
| Water | 1.0 |
| Hair | 0.32 |
| Cherry Pit | 0.56 |
| Insects | 0.59 |
| Wood (Oak) | 0.65 |
| PP | 0.9 |
| Ice | 0.92 |
| UHMW | 0.94 |
| Nylon | 1.15 |
| PVC | 1.7 |
| Teflon | 2.19 |
| Bone | 2.2 |
| Stone | 2.52 |
| Glass | 2.6 |
| Aluminum | 2.71 |
| Iron | 7.15 |
| Steel | 7.86 |
| SS | 7.93 |

Most food product,
slightly more than
1.0

Not Detectable



Detectable dependent on products
thickness/homogeneity/density and
size of contaminant

Rule of Thumb:
Typically, if a contaminant floats
in water, it is not detectable

X-ray Detection – Contamination detection

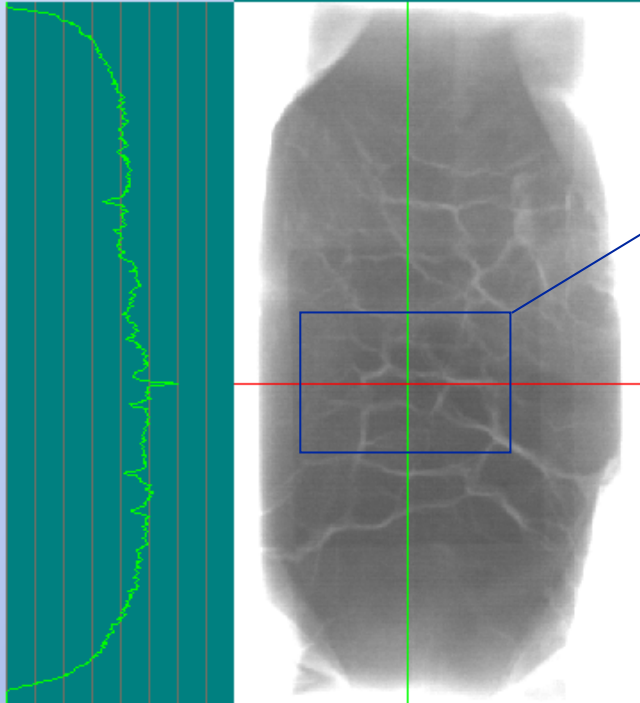
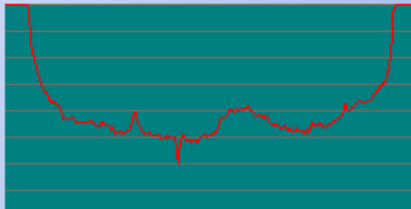


Analyse

Back

Image

x:137 y:325
pixel:64



Pixels

| | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 119 | 119 | 115 | 115 | 109 | 109 | 106 | 105 | 104 | 101 | 102 | 101 | 104 | 100 | 99 | 101 | 106 | 98 | 96 | 96 | 96 | 93 | 96 |
| 114 | 115 | 114 | 113 | 113 | 111 | 112 | 106 | 105 | 106 | 104 | 102 | 99 | 101 | 103 | 109 | 105 | 102 | 101 | 98 | 99 | 97 | 97 |
| 112 | 113 | 113 | 115 | 113 | 113 | 109 | 109 | 109 | 109 | 107 | 108 | 106 | 104 | 110 | 113 | 108 | 105 | 105 | 103 | 100 | 98 | 97 |
| 113 | 114 | 113 | 112 | 112 | 111 | 108 | 107 | 109 | 109 | 109 | 110 | 108 | 111 | 113 | 114 | 111 | 110 | 110 | 109 | 106 | 102 | 102 |
| 112 | 111 | 110 | 112 | 112 | 114 | 111 | 111 | 112 | 112 | 110 | 112 | 115 | 112 | 113 | 115 | 114 | 111 | 110 | 116 | 115 | 112 | 114 |
| 109 | 112 | 110 | 113 | 112 | 112 | 113 | 111 | 113 | 116 | 111 | 112 | 112 | 109 | 109 | 109 | 107 | 107 | 109 | 111 | 115 | 116 | 117 |
| 110 | 110 | 109 | 113 | 117 | 117 | 117 | 115 | 118 | 117 | 115 | 113 | 110 | 110 | 109 | 110 | 107 | 104 | 108 | 111 | 112 | 121 | 123 |
| 104 | 106 | 108 | 111 | 114 | 114 | 117 | 118 | 118 | 118 | 118 | 115 | 114 | 112 | 111 | 114 | 108 | 103 | 105 | 103 | 106 | 109 | 111 |
| 100 | 101 | 100 | 101 | 103 | 105 | 110 | 111 | 114 | 115 | 112 | 111 | 111 | 112 | 114 | 111 | 108 | 106 | 103 | 102 | 102 | 104 | 102 |
| 99 | 97 | 98 | 101 | 101 | 103 | 103 | 103 | 105 | 109 | 106 | 111 | 110 | 106 | 109 | 107 | 106 | 106 | 104 | 98 | 97 | 96 | 100 |
| 97 | 98 | 98 | 97 | 97 | 99 | 101 | 98 | 99 | 100 | 104 | 107 | 105 | 104 | 106 | 108 | 108 | 104 | 101 | 97 | 96 | 93 | 95 |
| 97 | 99 | 98 | 96 | 97 | 97 | 97 | 98 | 98 | 100 | 100 | 101 | 99 | 100 | 102 | 105 | 102 | 97 | 96 | 94 | 92 | 94 | 97 |
| 97 | 96 | 97 | 96 | 98 | 96 | 96 | 99 | 97 | 97 | 94 | 85 | 90 | 97 | 99 | 101 | 105 | 99 | 96 | 93 | 93 | 94 | 94 |
| 96 | 94 | 98 | 95 | 98 | 96 | 93 | 96 | 96 | 93 | 83 | 64 | 81 | 95 | 96 | 100 | 97 | 94 | 91 | 92 | 93 | 90 | 93 |
| 98 | 97 | 97 | 97 | 97 | 97 | 96 | 97 | 97 | 96 | 88 | 76 | 87 | 99 | 98 | 104 | 102 | 96 | 95 | 91 | 92 | 88 | 89 |
| 97 | 102 | 99 | 97 | 99 | 97 | 95 | 93 | 97 | 98 | 96 | 91 | 92 | 99 | 98 | 101 | 100 | 94 | 94 | 93 | 92 | 90 | 91 |
| 96 | 98 | 96 | 98 | 97 | 98 | 95 | 95 | 95 | 96 | 96 | 97 | 93 | 96 | 98 | 101 | 95 | 94 | 100 | 95 | 92 | 95 | 90 |
| 97 | 99 | 102 | 97 | 99 | 96 | 96 | 98 | 97 | 100 | 99 | 99 | 96 | 97 | 100 | 100 | 104 | 99 | 98 | 96 | 95 | 96 | 97 |
| 98 | 101 | 101 | 99 | 100 | 101 | 101 | 101 | 99 | 98 | 99 | 97 | 102 | 100 | 100 | 103 | 100 | 98 | 96 | 93 | 95 | 95 | 94 |
| 97 | 98 | 97 | 96 | 97 | 96 | 99 | 97 | 98 | 97 | 99 | 97 | 97 | 98 | 100 | 104 | 101 | 98 | 93 | 96 | 96 | 95 | 94 |
| 97 | 100 | 99 | 98 | 97 | 97 | 102 | 101 | 98 | 98 | 98 | 100 | 100 | 99 | 99 | 99 | 95 | 94 | 95 | 96 | 97 | 97 | 97 |
| 95 | 99 | 98 | 99 | 96 | 96 | 98 | 96 | 97 | 100 | 96 | 96 | 96 | 94 | 93 | 98 | 94 | 91 | 91 | 94 | 90 | 93 | 91 |
| 99 | 101 | 98 | 99 | 102 | 101 | 99 | 100 | 102 | 102 | 102 | 98 | 100 | 103 | 101 | 103 | 103 | 98 | 98 | 98 | 97 | 97 | 92 |
| 98 | 97 | 99 | 96 | 98 | 101 | 99 | 100 | 102 | 102 | 99 | 99 | 104 | 102 | 101 | 100 | 104 | 98 | 95 | 96 | 94 | 96 | 95 |
| 102 | 102 | 101 | 101 | 104 | 103 | 103 | 102 | 104 | 104 | 100 | 100 | 102 | 100 | 104 | 105 | 99 | 97 | 97 | 94 | 97 | 100 | 98 |
| 103 | 106 | 105 | 102 | 104 | 103 | 101 | 103 | 105 | 100 | 96 | 96 | 97 | 99 | 100 | 102 | 100 | 96 | 95 | 97 | 97 | 98 | 96 |
| 103 | 104 | 105 | 105 | 101 | 98 | 101 | 102 | 103 | 99 | 97 | 94 | 97 | 97 | 97 | 99 | 97 | 97 | 94 | 96 | 96 | 94 | 94 |

The computer sees the product, as a grid of grey values ranging from 0 (black) to 255 (white). Notice the contaminant is the lowest value at 64 in the centre due to the contaminant absorbing more of the x-ray energy.

Tools

Anchor

Zoom

Histogram

X-ray Detector – Image scanning

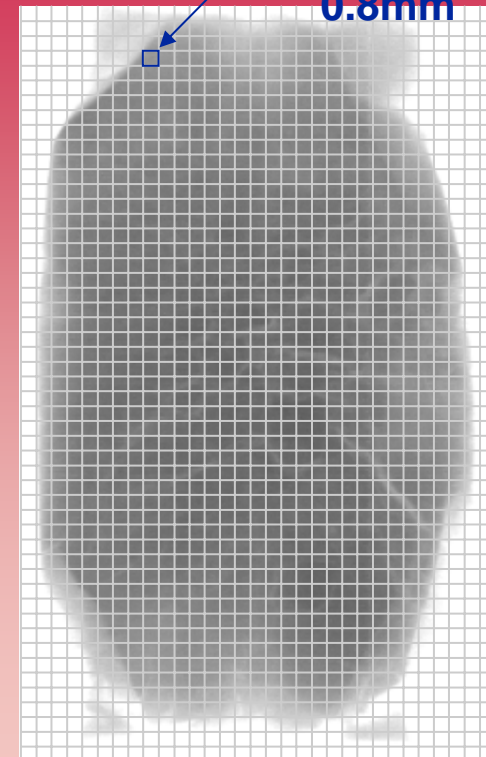
As the product passes over the detector each line of grey level data is rebuilt back into a complete pack image:

- Each image is made up of 'pixels'.
- Each pixel can have a value which goes from black to white (0 to 255)



Product flow →

Detector



X-ray image

X-ray Principles – Typical Contaminants sizes

Typical contaminants which can be identified by x-ray inspection are:-

| Contaminant type | Typical Detection sizes in various Packaging Types (sphere diameters) | | | |
|----------------------|---|------------------------|-----------|-----------|
| | Plastic or paper | Metalized film or foil | Metal Can | Glass Jar |
| Metal * | 0.8mm | 0.8mm | 1.2mm | 1.2mm |
| Aluminum | 2.0mm | 2.0mm | 2.5mm | 2.5mm |
| Glass | 2.0mm | 2.0mm | 3.0mm | 3.0mm |
| Stone | 2.0mm | 2.0mm | 3.0mm | 3.0mm |
| Bone | 3.5mm | 3.5mm | 5.0mm | 5.0mm |
| Dense plastic | 3.5mm | 3.5mm | 5.0mm | 5.0mm |

* Excluding aluminium

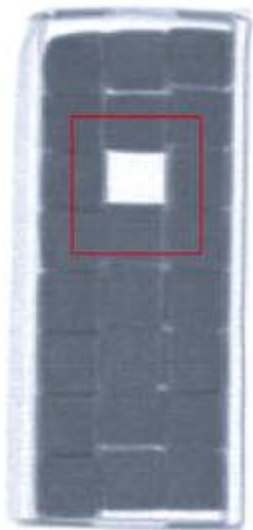
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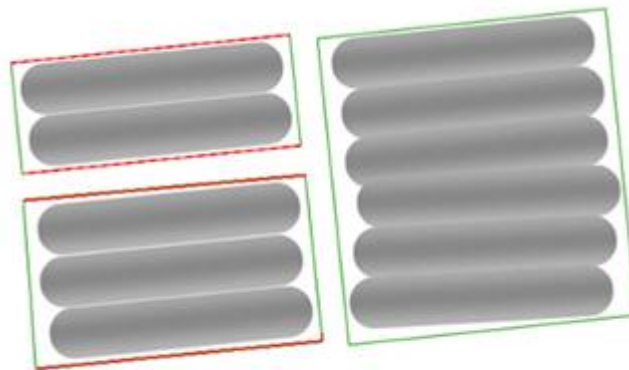
Missing Component

Detection of Missing Products – Object Tool

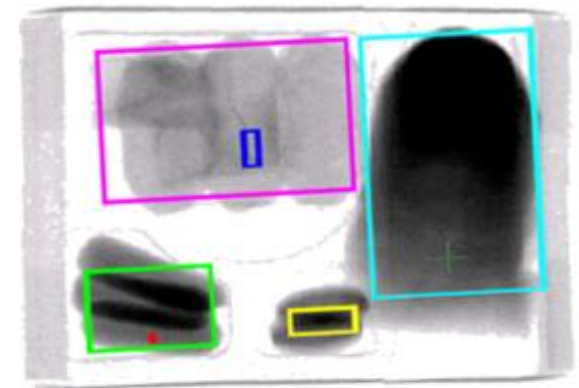
X-ray systems can use an object finder tool to count individual parts / components in a sealed package to ensure it meets specifications



Missing cheese cube
in a small retail pack



Detected missing
sausage

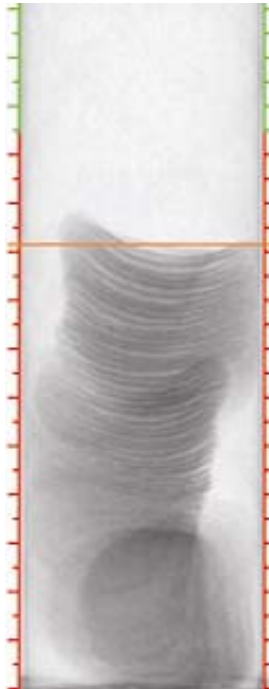


Component count in a
lunch box

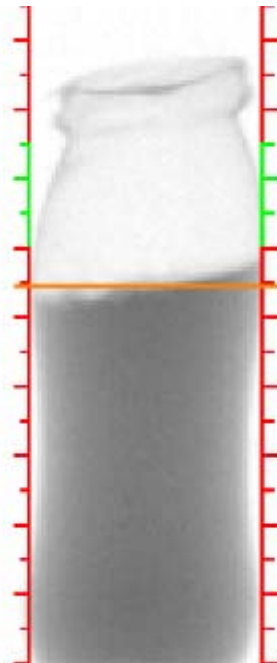
Fill Level

Fill Level Control

X-ray inspection systems can detect over fill and under fill in different types of packaging with (a filler) feedback to the filling machine saving costs and minimizing product waste



Under-Fill in a canister of potato chips



Fill level control in a drinking yogurt pet bottle



Fill level control in a yogurt cup

Application Note - Baby Food

Powdered Baby Formula, Composite Canisters

Customer Requirements:

Packaging: Composite containers

Sizes: 8-oz to 38-oz

Throughput:: 700-ppm

Detect 1.0mm SS and 3.0mm Glass or better



Application Note - Baby Food

Baby Food, Glass Jar

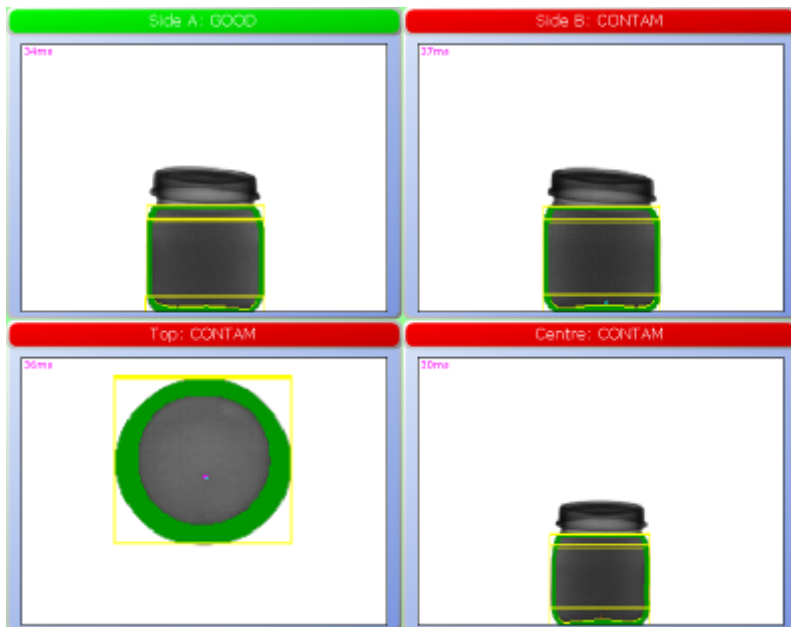
Customer Requirements:

Packaging: Glass Jar

Sizes: 213-ml

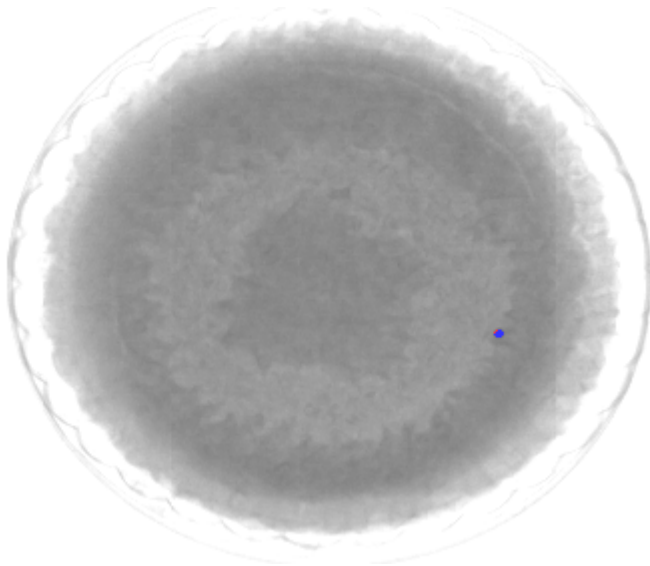
Throughput:: 850-ppm at 250-fpm

Detect 1.2mm SS and 3.5mm Glass or better



Same jar 4 views

Pies, Foil Tray



Customer Requirements:

Packaging: Foil tray with Plastic overwrap

Sizes: 4-oz to 16-oz

Throughput:: 55-ppm

Detect 1.0mm SS and 3.0mm Glass or better

Application Note - Beverages

Powdered Beverages, Stick Pack in a Carton

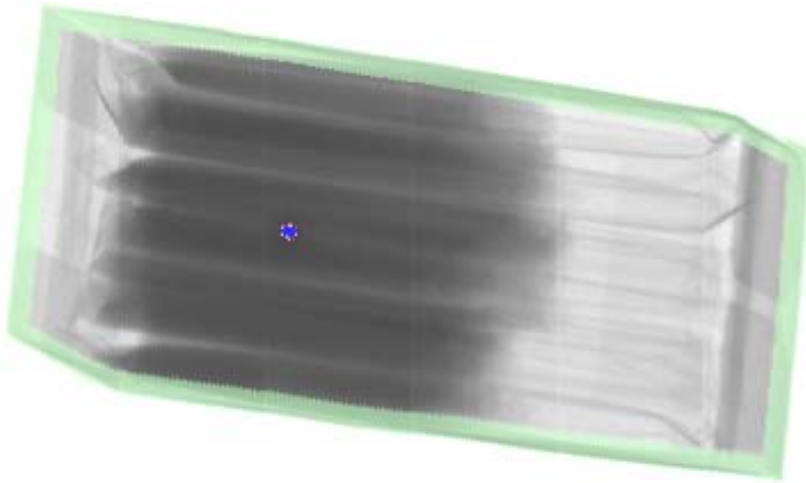
Customer Requirements:

Packaging: 16-ct Stick Pack in Carton

Sizes: 1136-g

Throughput:: 10-cpm

Detect 1.2mm SS or better and 3.0mm
Glass or better



Application Note – Dairy

Cheese, Plastic Wrapped

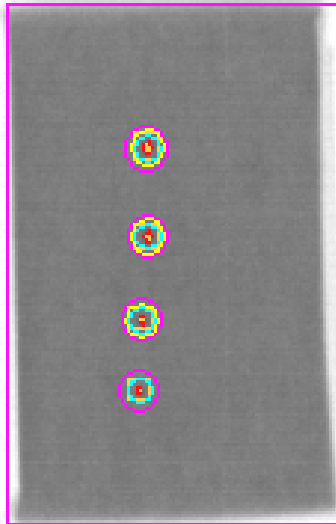
Customer Requirements:

Packaging: Plastic pouch

Sizes: 1-oz

Throughput: 375-ppm per lane, 2 lanes

Detect: 0.8mm SS, product in seal and packaging flaws



Application Note – Dairy

Yogurt, Poly Cup

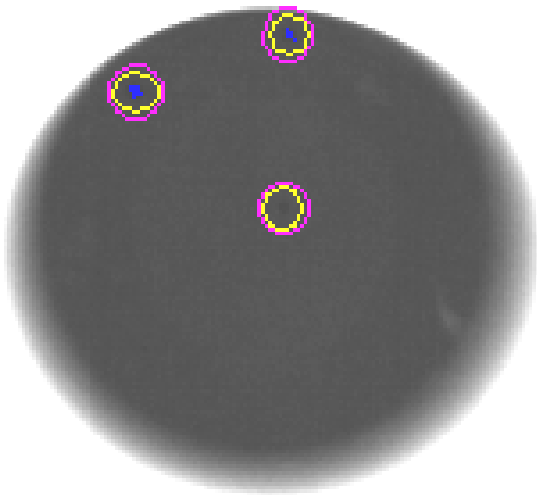
Customer Requirements:

Packaging: Poly Cup

Sizes: 4 to 16-oz

Throughput: 120-ppm per lane, 2 lanes

Detect: 1 to 1.5mm SS or better, 3 to 4.5mm Glass or better, Weight accuracy +/- 1% at 2 STD dev



Application Note – Dairy

Yogurt, Case

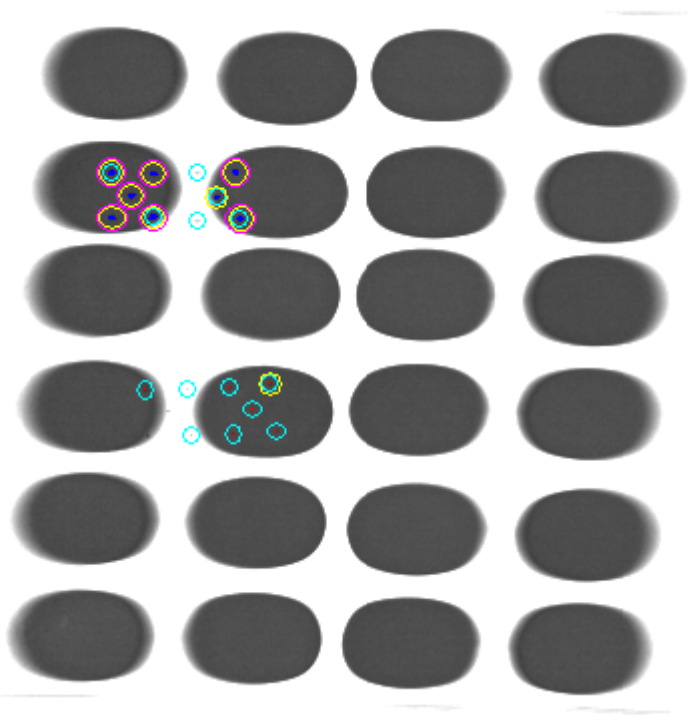
Customer Requirements:

Packaging: Poly Cups in Case

Sizes: 12-lbs

Throughput: 32-cpm

Detect: 1.5mm SS or better



Application Note – Red Meat

Pork Butt, Individual Vacuum Bag

Customer Requirements:

Packaging: Vacuum Bag

Sizes: 8-lb

Throughput::30 to 50-ppm

Detect 3.0mm SS, 16-18 gauge
inoculation needs or better



Application Note – Poultry

Chicken Pieces, Cryovac Bag Frozen

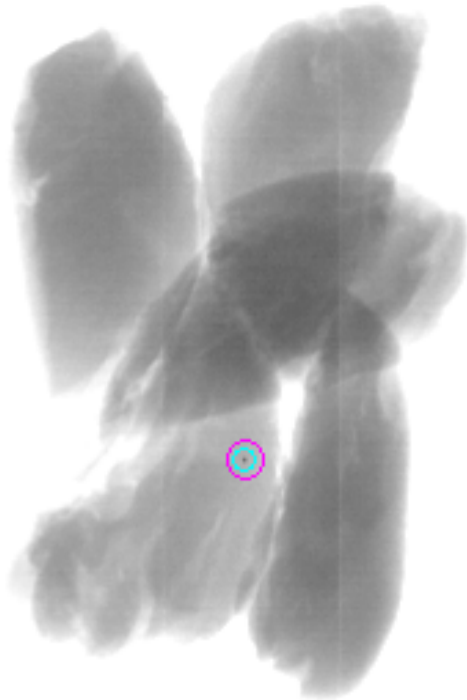
Customer Requirements:

Packaging: Cryovac bag

Size: 12-oz

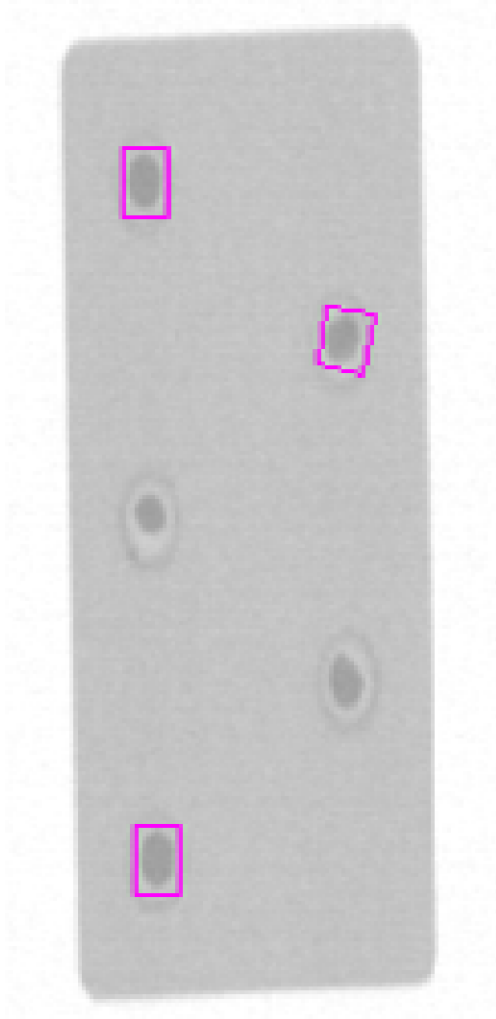
Throughput: 80-ppm

Detect: 1.0mm SS and 3mm Glass or better



Application Note – Pharmaceutical

Tablets, Blister Card



Customer Requirements:

Packaging: Blister card

Size: 3 to 6-ct

Throughput:: 100-ppm at 60-fpm

Detect: 0.6mm SS or better, missing, 15% additional, more than one, chipped, capped, broken or crushed tablets

Agenda

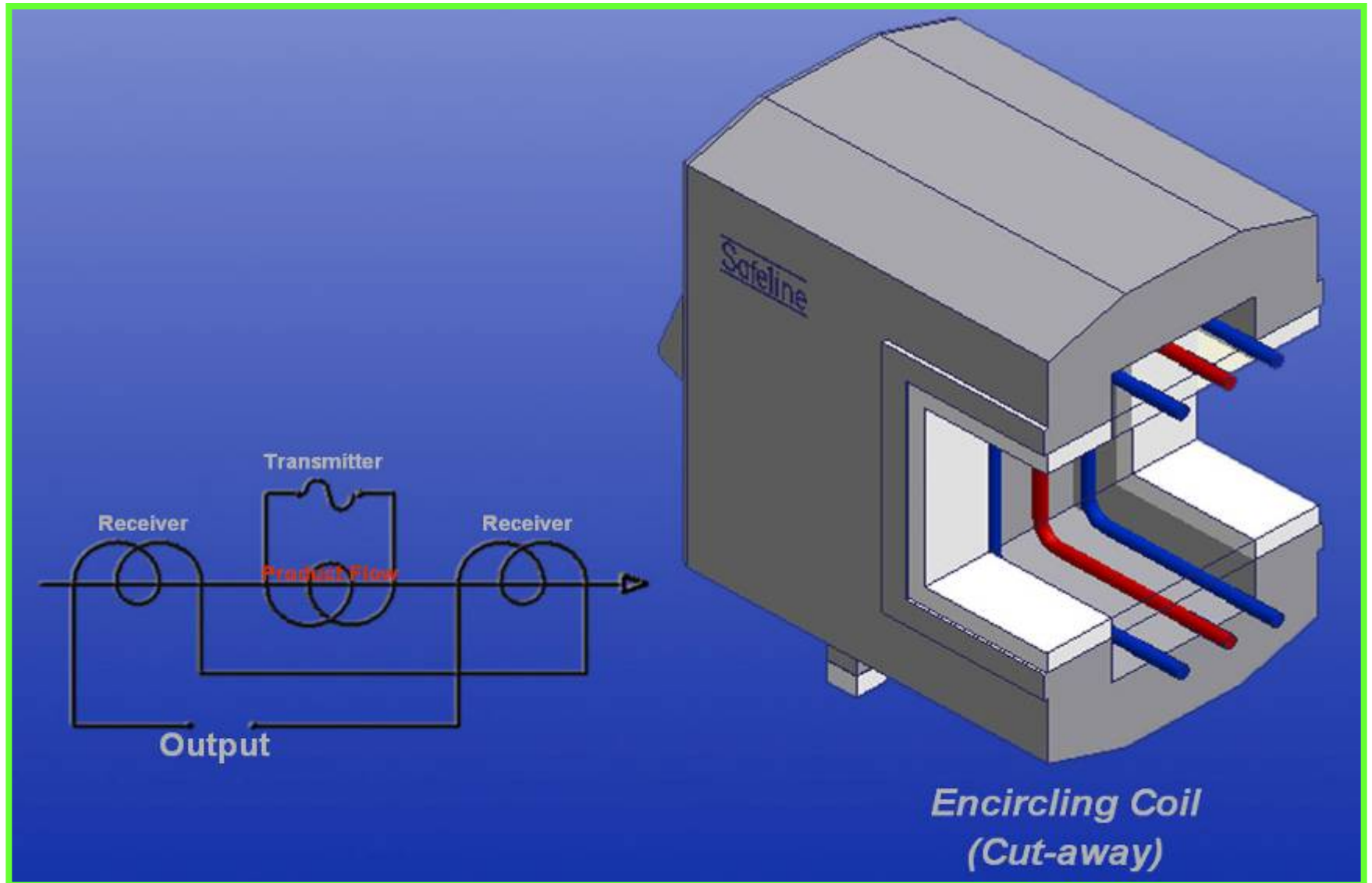
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What is a Metal Detector?

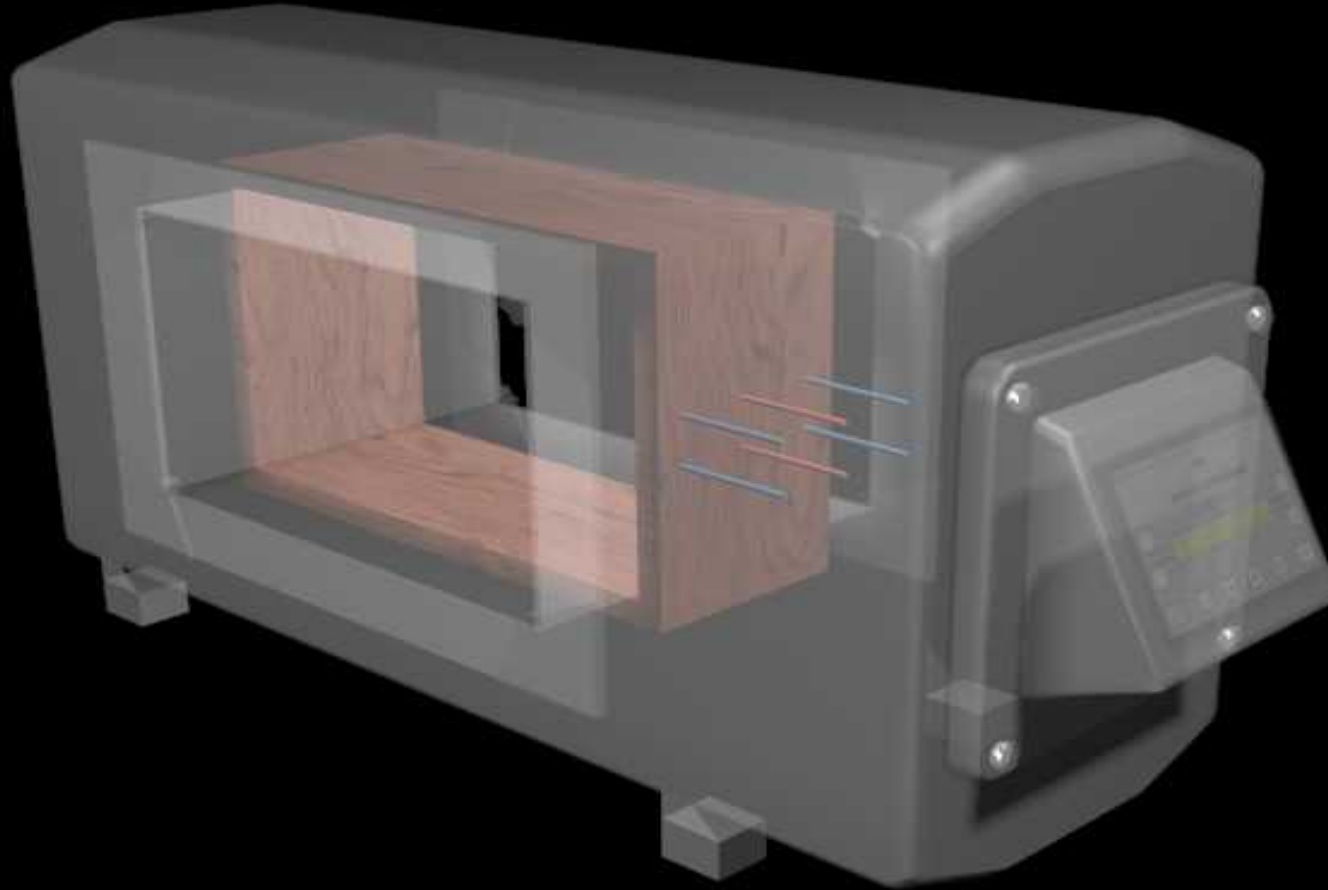
- A metal detector is a sophisticated instrument used to detect metal contaminants that have been inadvertently introduced to products through processing equipment failure and/or human error.



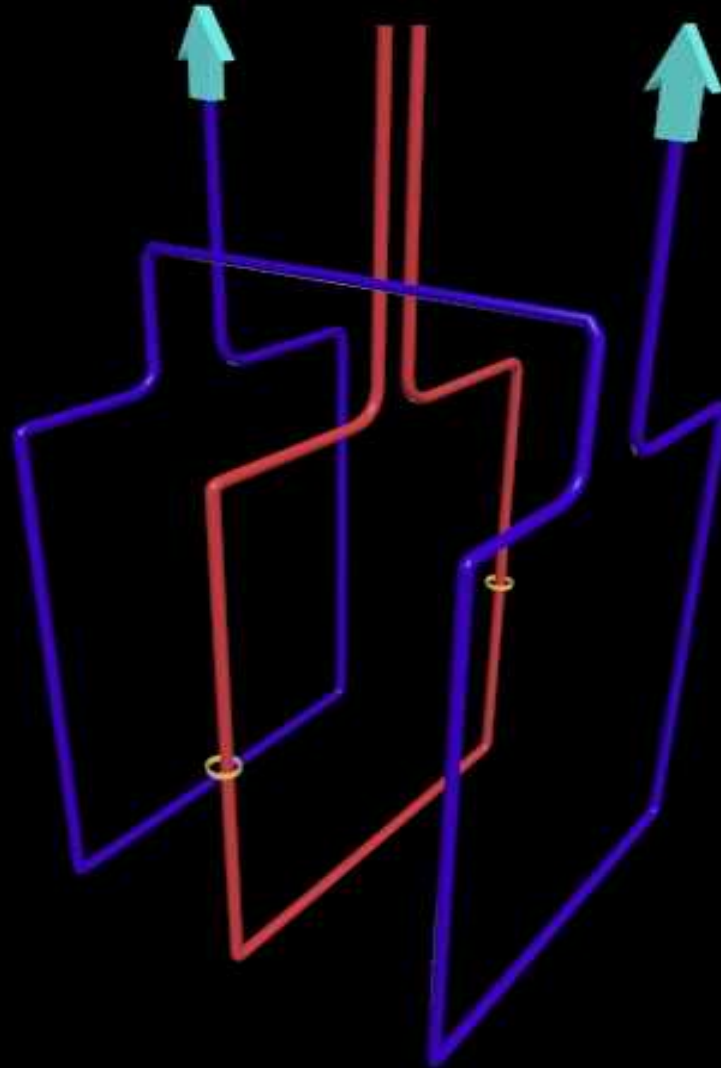
How Does a Metal Detector Work ?



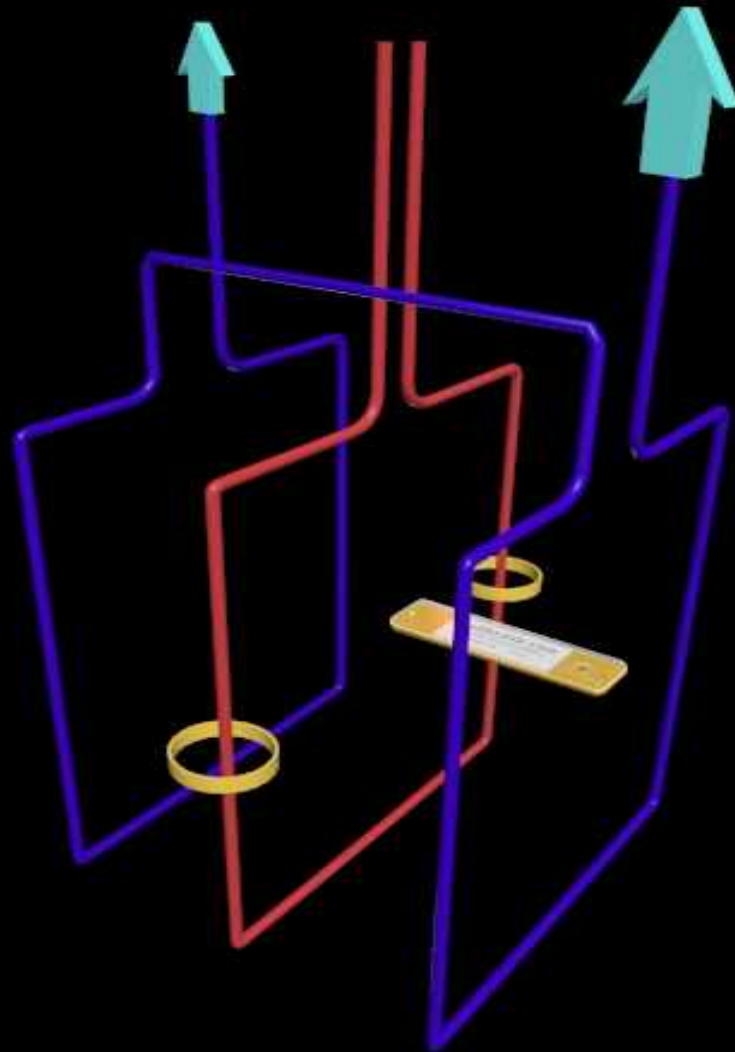
The Coil System



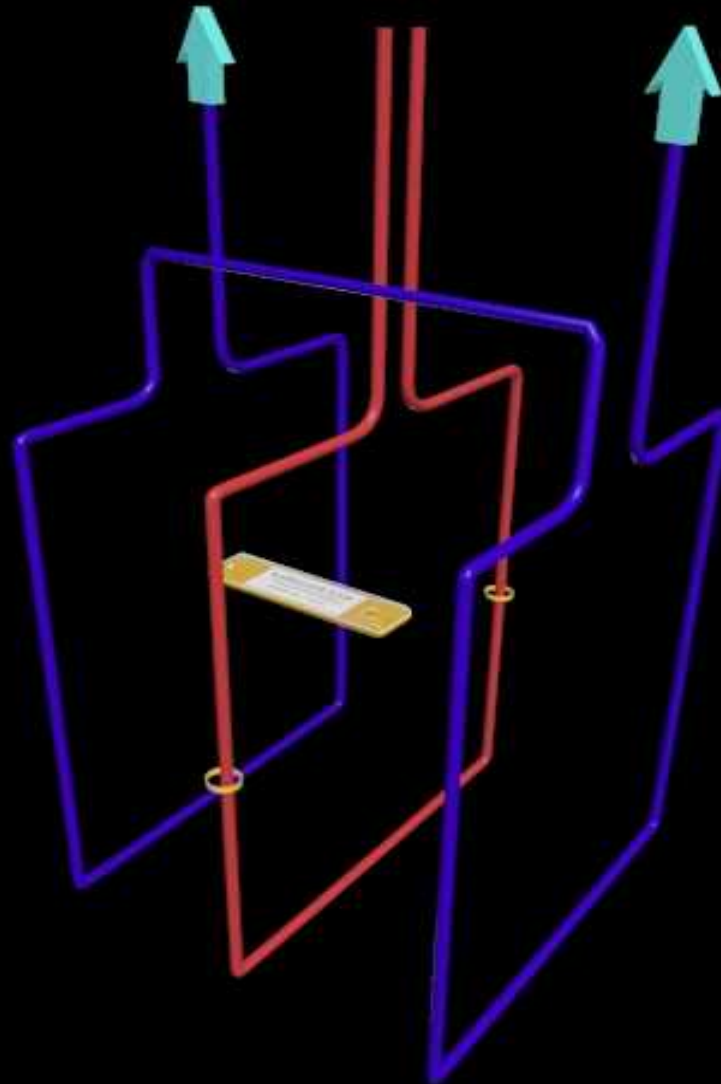
The Coil System



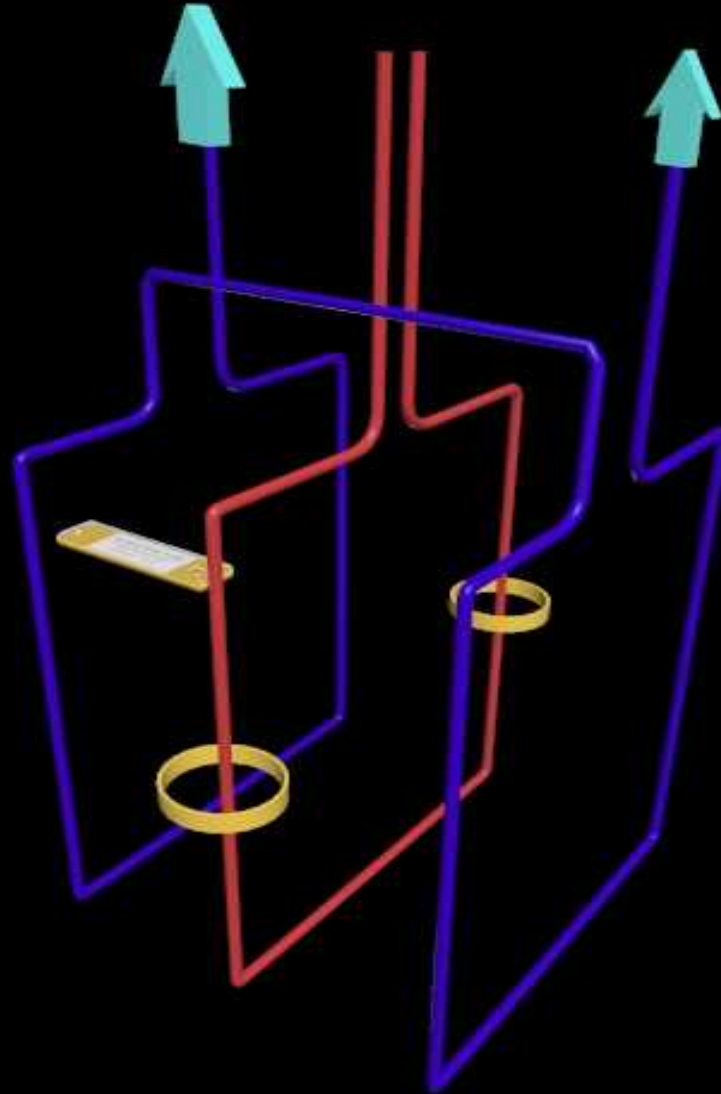
The Coil System



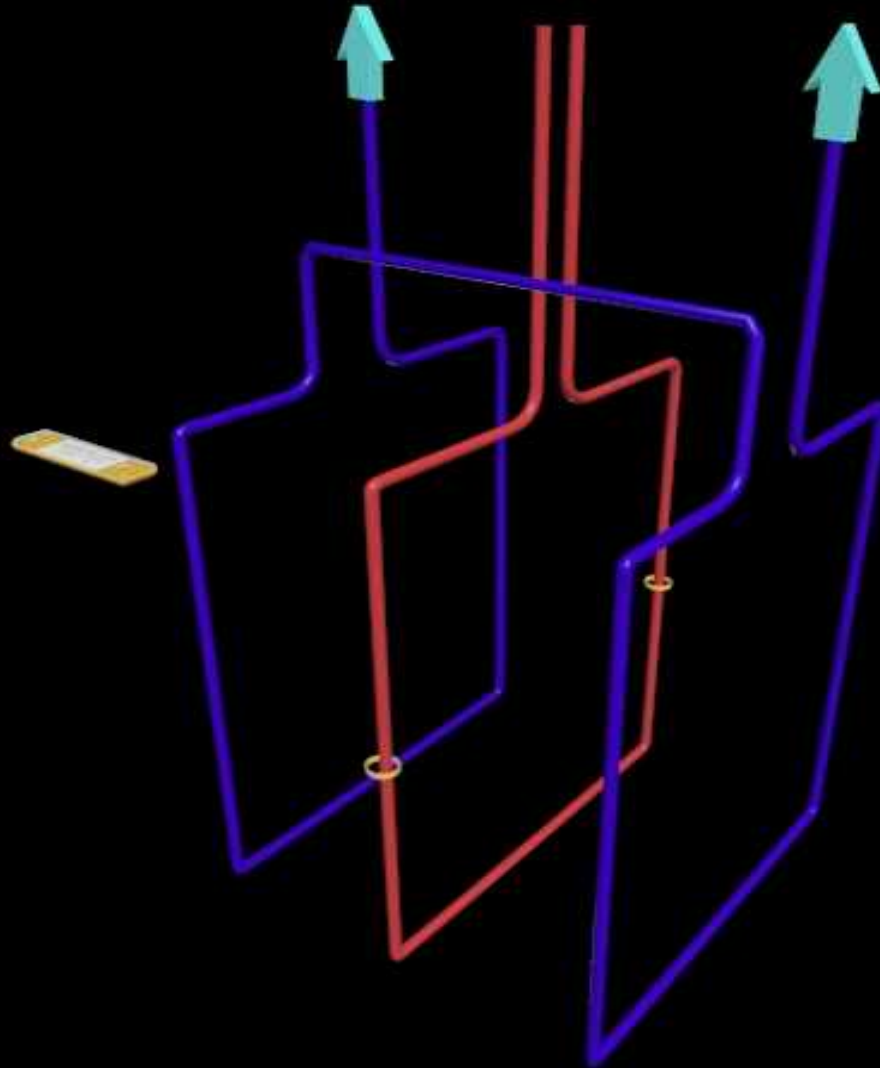
The Coil System



The Coil System



The Coil System



Factors Influencing MD Sensitivity

1. Type of metal
2. Orientation Effect
3. Product Effect
4. Metal Position in Product
5. Packaging Material
6. Environmental Interference

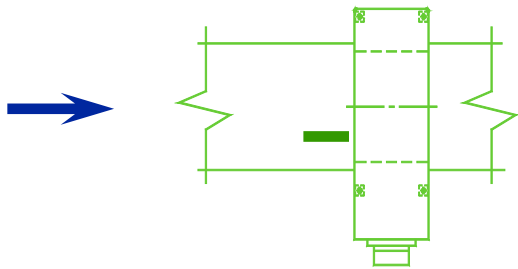
Factor #1 - Type of Metal

| Metal Type | Magnetic Permeability | Electrical Conductivity | Ease of Detection |
|---------------------------------------|------------------------------|------------------------------------|---------------------------------------|
| Ferrous (Iron) | Magnetic | Good Electrical Conductor | Easily Detected |
| Non-ferrous (Copper, Lead) | Non-magnetic | Generally Good or Excellent | Relatively Easily Detected |
| Stainless Steel various Grades | Usually Non-magnetic | Usually Poor Conductors | Relatively Difficult to Detect |

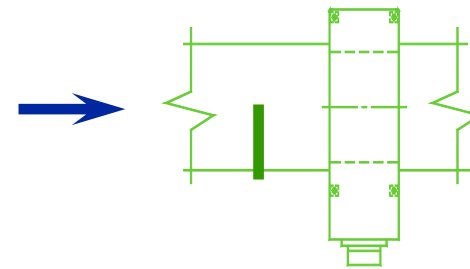
Factor #2 - Orientation Effect

The ease of detection depends on its shape and orientation

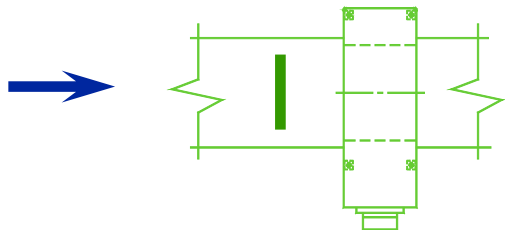
Ferrous-Easy



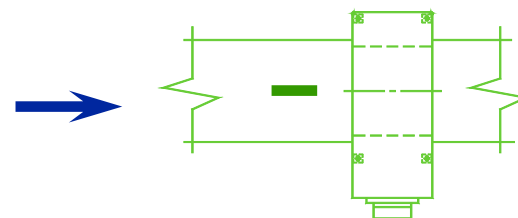
Ferrous-Difficult



Non Ferrous-Easy



Non-Ferrous Difficult



Factor #3 – Product Effect

Most food, particularly wet food, produces a signal of its own in the metal detector.

Frequency Required

- **No product Effect:**

Highest

- **Significant product effect:**

Low



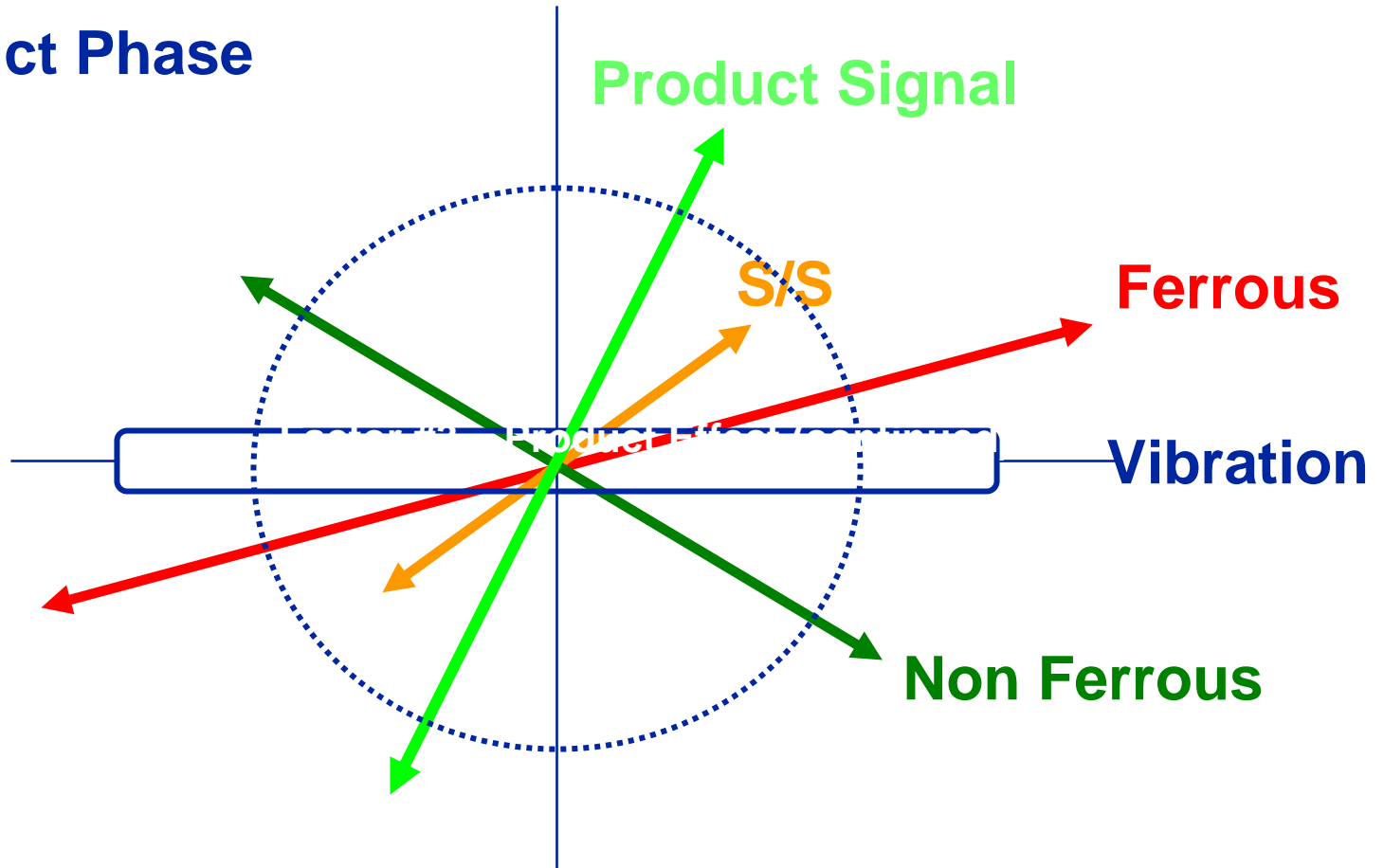
Fe

Higher



SS

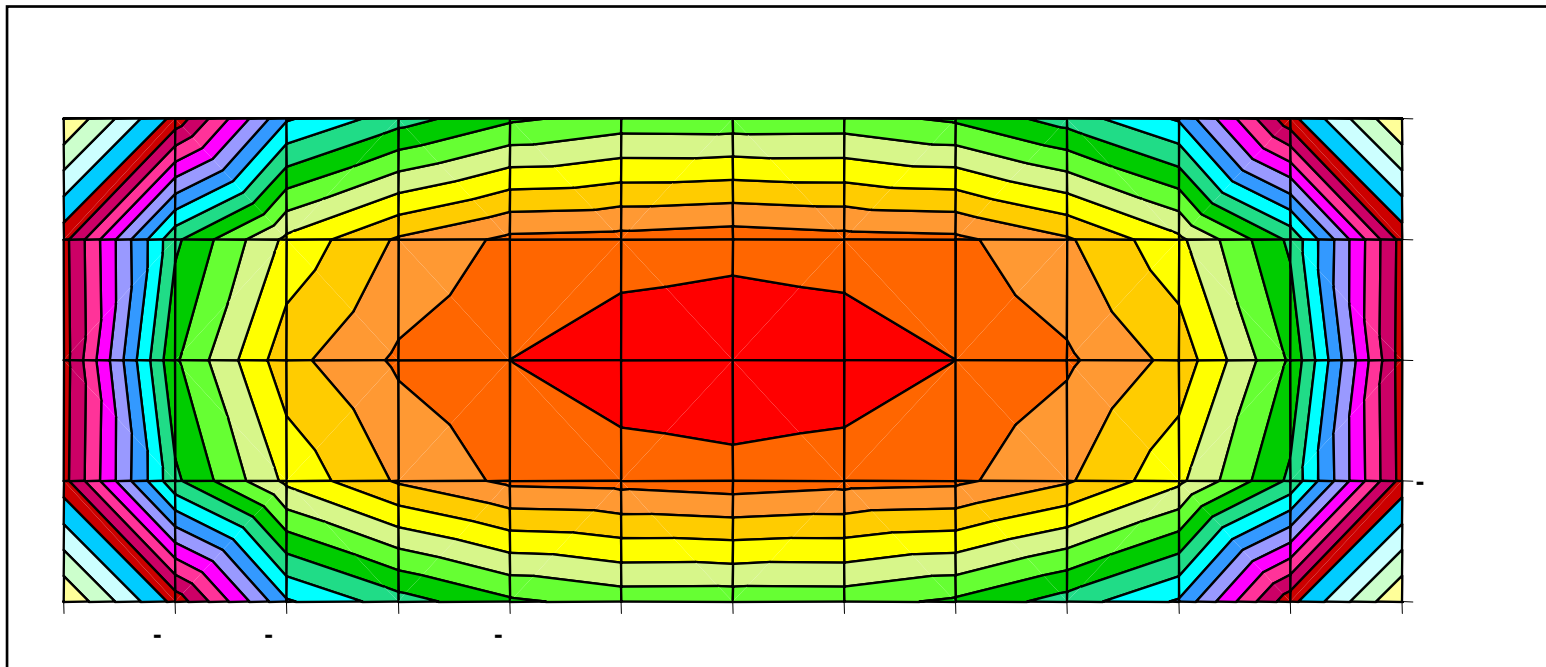
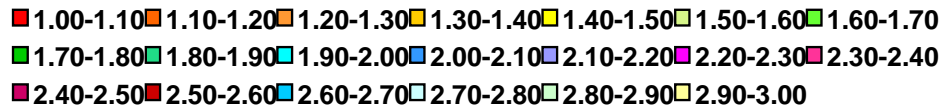
Product Phase



Wet or conductive products produce signals that can cause a detection.

Factor #4 - Position of metal in product

Signal Strength Across Aperture



Factor #5 – Packaging Material

- Paper and Plastic materials: No effect
- Metallic Films: Testing required
- Aluminum Foil Packages: Use X-Ray system

Factor #6 – Environmental Interference

- Vibration
- Belt contamination
- Moving metal outside metal detector
- Conductive loops
- Radio frequency interference
- Drift

Thank You



Questions?

