FOREIGN MATTER TESTING
Mettler-Toledo Safeline

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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

<table>
<thead>
<tr>
<th><strong>X-ray</strong></th>
<th><strong>Metal Detector</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type and size contaminant</td>
<td>Moisture Content</td>
</tr>
<tr>
<td>Product Homogeneity</td>
<td>Salt Content</td>
</tr>
<tr>
<td>Size (thickness) of product</td>
<td>Temperature of product</td>
</tr>
<tr>
<td>Overlapping / Stacked product</td>
<td>Packaging</td>
</tr>
<tr>
<td>Complexity of image vs. complexity of inspection</td>
<td>Contaminant orientation</td>
</tr>
<tr>
<td>Processing speed (multiple inspections)</td>
<td>Fe, non Fe, SS</td>
</tr>
<tr>
<td>Product Speed</td>
<td>Contaminant location in aperture</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Vibration</td>
</tr>
<tr>
<td></td>
<td>Electrical Noise</td>
</tr>
</tbody>
</table>
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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:
X-ray Generator - **Circuit Design**

- **Filament Transformer**
- **Control Module**
- **-VE Multiplier Stack**
- **+VE Multiplier Stack**

Connections:
- $+4V$
- $kV$ actual
- $mA$ actual
- $Hv$ Enable
- $Kv$ Demand
- $mA$ Demand
### Foreign Material Detection

#### Materials - Relative Detection

**Density Chart**

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>1.0</td>
</tr>
<tr>
<td>Hair</td>
<td>0.32</td>
</tr>
<tr>
<td>Cherry Pit</td>
<td>0.56</td>
</tr>
<tr>
<td>Insects</td>
<td>0.59</td>
</tr>
<tr>
<td>Wood (Oak)</td>
<td>0.65</td>
</tr>
<tr>
<td>PP</td>
<td>0.9</td>
</tr>
<tr>
<td>Ice</td>
<td>0.92</td>
</tr>
<tr>
<td>UHMW</td>
<td>0.94</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.15</td>
</tr>
<tr>
<td>PVC</td>
<td>1.7</td>
</tr>
<tr>
<td>Teflon</td>
<td>2.19</td>
</tr>
<tr>
<td>Bone</td>
<td>2.2</td>
</tr>
<tr>
<td>Stone</td>
<td>2.52</td>
</tr>
<tr>
<td>Glass</td>
<td>2.6</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.71</td>
</tr>
<tr>
<td>Iron</td>
<td>7.15</td>
</tr>
<tr>
<td>Steel</td>
<td>7.86</td>
</tr>
<tr>
<td>SS</td>
<td>7.93</td>
</tr>
</tbody>
</table>

Most food products, 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.

Not Detectable

Detectable

Typically, if a contaminant floats in water, it is not detectable.
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.
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).

Detector

Product flow

0.8 x 0.8mm

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

<table>
<thead>
<tr>
<th>Contaminant type</th>
<th>Plastic or paper</th>
<th>Metalized film or foil</th>
<th>Metal Can</th>
<th>Glass Jar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal *</td>
<td>0.8mm</td>
<td>0.8mm</td>
<td>1.2mm</td>
<td>1.2mm</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.0mm</td>
<td>2.0mm</td>
<td>2.5mm</td>
<td>2.5mm</td>
</tr>
<tr>
<td>Glass</td>
<td>2.0mm</td>
<td>2.0mm</td>
<td>3.0mm</td>
<td>3.0mm</td>
</tr>
<tr>
<td>Stone</td>
<td>2.0mm</td>
<td>2.0mm</td>
<td>3.0mm</td>
<td>3.0mm</td>
</tr>
<tr>
<td>Bone</td>
<td>3.5mm</td>
<td>3.5mm</td>
<td>5.0mm</td>
<td>5.0mm</td>
</tr>
<tr>
<td>Dense plastic</td>
<td>3.5mm</td>
<td>3.5mm</td>
<td>5.0mm</td>
<td>5.0mm</td>
</tr>
</tbody>
</table>

* Excluding aluminium
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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 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
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
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
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
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
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
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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

<table>
<thead>
<tr>
<th>Metal Type</th>
<th>Magnetic Permeability</th>
<th>Electrical Conductivity</th>
<th>Ease of Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous (Iron)</td>
<td>Magnetic</td>
<td>Good Electrical Conductor</td>
<td>Easily Detected</td>
</tr>
<tr>
<td>Non-ferrous (Copper, Lead)</td>
<td>Non-magnetic</td>
<td>Generally Good or Excellent</td>
<td>Relatively Easily Detected</td>
</tr>
<tr>
<td>Stainless Steel various Grades</td>
<td>Usually Non-magnetic</td>
<td>Usually Poor Conductors</td>
<td>Relatively Difficult to Detect</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Frequency Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No product Effect:</strong></td>
</tr>
<tr>
<td><strong>Significant product effect:</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Wet or conductive products produce signals that can cause a detection.
Factor #4 - Position of metal in product

Signal Strength Across Aperture

- 1.00-1.10
- 1.10-1.20
- 1.20-1.30
- 1.30-1.40
- 1.40-1.50
- 1.50-1.60
- 1.60-1.70
- 1.70-1.80
- 1.80-1.90
- 1.90-2.00
- 2.00-2.10
- 2.10-2.20
- 2.20-2.30
- 2.30-2.40
- 2.40-2.50
- 2.50-2.60
- 2.60-2.70
- 2.70-2.80
- 2.80-2.90
- 2.90-3.00
Factor #5 – Packaging Material

- Paper and Plastic materials: No effect
- Metallic Films: Testing required
- Aluminum Foil Packages: Use X-Ray system
Vibration
Belt contamination
Moving metal outside metal detector
Conductive loops
Radio frequency interference
Drift
Thank You
Questions?