Understanding Sensitivity in Metal Detection
How to Maximize Performance of Your Metal Detector
Sensitivity is a Key Contributor to Metal Detection Program Effectiveness

There are a number of factors that affect the sensitivity of a metal detector and the ability to find different types of metal. It’s important to understand these factors to get the most out of your metal detection program.

This guide explains the concept of metal detector sensitivity, key factors that impact it, and why a small difference in spherical sensitivity performance can mean a big difference in the length of wires or other irregular-shaped contaminants that can be detected.
What is Sensitivity?
How is it Measured?

Sensitivity is the measure of a metal detector’s ability to detect a specific type and size of metal contaminant. The better the sensitivity of the metal detector, the smaller the pieces of irregular-shaped metal it can detect.

Performance is usually expressed in terms of the diameter of a test sphere made from a specific type of metal, such as ferrous, non-ferrous, aluminum or stainless steel. Sensitivity should always be measured at the center of the metal detector’s aperture, as this is the least sensitive point.

When comparing the performance of different metal detectors, you can examine the individual sensitivity for specific types of metal. In some cases, the clear winner is the metal detector with the best spherical sensitivity across all metal types, when measured in the center of the aperture. However, in other cases, it may not be so clear, with one detector outperforming the other on one metal type, and vice versa for another. In this case, it may be better to use the 'mean sensitivity' performance measure.

To calculate the mean sensitivity for each metal detector add up each of the sensitivities for all metal types for one detector then divide this total by the number of metal types. Repeat this process for each metal detector. You can then compare the mean sensitivity performance across multiple metal detectors, to determine which one will deliver best overall performance.

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Factors that Contribute
To Metal Detector Sensitivity Performance

When measuring the sensitivity of a metal detector, a test piece must be reliably detectable when passed through the center of the aperture of the metal detector. However, there is a significant difference between the test piece’s spherical sensitivity and the actual length of an irregular-shaped or wire-type contaminant that can be detected due to the metal contamination’s ‘orientation effect’. Orientation effect and a number of other factors can affect the sensitivity of a metal detector.

- **Metal type**
  A HACCP audit may identify a risk of various metal types, including ferrous, non-ferrous and stainless steel. However, the sensitivity of the metal detector can vary depending on the type of metal contaminant present.

- **Orientation effect**
  Orientation effect occurs when the diameter of a wire contaminant is less than the spherical sensitivity. We measure sensitivity in ball size because some metal contaminants, which are often wire, are more difficult to detect depending on the direction of travel through the metal detector.

- **Aperture size and position**
  The closer the contaminant is to the wall of the metal detector, the higher the detection sensitivity. The larger the aperture, the less sensitive the metal detector. In order to get a consistent reading, products should pass directly through the center of the metal detector aperture.
Packaging material
The packaging material used to pack a product undoubtedly affects sensitivity. Any metal in the packaging will affect the metal detector, reducing sensitivity and possibly creating a false metal signal. However, modern metal detectors using Multi-Simultaneous Frequency technology can be used to successfully inspect products in metallized film.

Environmental conditions
Plant vibrations and temperature fluctuations can also affect the metal detector’s sensitivity. The affects are more acute when operating at a higher frequency, which can result in reduced performance and increased false triggering.

Product characteristics
Some products have certain characteristics that behave in the same way as metal when passing through the detector. For example, products with high moisture or salt content, such as meat and poultry, can often create a ‘false’ signal, making it difficult to distinguish the difference between metal and product.

Process speed
This is not necessarily a limiting factor for conveyorized metal detectors where product passes through at a consistent speed. However, performance is hindered when inspecting product passing through vertical metal detection systems and pipelines, due to variations in the speed and flow of the product.

Detector frequency
Metal detectors operate at different electromagnetic frequencies depending on the type of product being inspected. For dry products such as snack foods, metal detectors are more effective at high frequencies, but for wet products such as meat and poultry, a lower frequency is the better option.
How Direction of Travel Can Lead to Orientation Effect

Orientation Effect is when a non-spherical piece of metal such as wire passes through a metal detector, and is easier to detect when passing in one particular orientation, compared to another. A metal detector’s ability to identify a contaminant is partially determined by the type of contaminant, as well as the metal object’s orientation. Orientation effect only occurs when a wire contaminant’s diameter is less than the spherical sensitivity of the metal detector.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Ferrous</th>
<th>Non-Ferrous</th>
<th>Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Permeability</td>
<td>Magnetic</td>
<td>Non-magnetic</td>
<td>Usually non-magnetic</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>Good electrical conductor</td>
<td>Generally good or excellent</td>
<td>Usually poor conductors</td>
</tr>
<tr>
<td>Ease of Detection</td>
<td>Relatively easy to detect</td>
<td>Relatively easy to detect in dry applications; Harder to detect in wet applications</td>
<td>Relatively difficult to detect</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Position A</th>
<th>Position B</th>
<th>Position C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Ease of Detection When Orientation Effect Applies:</td>
<td>Easy</td>
<td>Difficult</td>
<td>Difficult</td>
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<td></td>
<td>Difficult</td>
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<td>Difficult</td>
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A Small Change in Spherical Sensitivity Equates to a Big Difference in Wire Length Detection

Operating at the highest spherical sensitivity level will provide maximum protection to your brand and company’s reputation, dramatically improving your detection capability to real life contaminants such as wires and swarf.

As the chart on the left shows, improving detection sensitivity by 25% (going from a ball size of 2.0mm to 1.5mm for example) will significantly improve the length of the wire that can be detected, and decrease the risk of undetected metal reaching, and potentially causing harm to, consumers.

Stainless steel is used in this example since it is typically more difficult to detect than ferrous and non-ferrous metals.

In challenging applications - where products contain high moisture or salt content, are subject to varying temperatures, or are wrapped in metallized film - sensitivity performance will generally be worse than for dry products. Achieving the best possible sensitivity requires use of the latest metal detection technology specifically for wet applications.

METTLER TOLEDO offers in-house product testing to give you an indication of the sensitivity results that can be achieved on your products. Contact us to request a test today - visit: www.mt.com/contact.

The FDA states that a hard or sharp foreign object measuring between 7mm to 25mm in length may cause a traumatic injury or present a choking hazard.

Factors That Lead to
Product Effect in Metal Detection Applications

Product effect occurs when a product’s own characteristics inhibit the inspection device’s ability to distinguish between the product being inspected, and a particular contaminant type. Often referred to as a challenging application, this can result in potentially high false reject rates, unless the technology in use is able to overcome product effect using innovative software algorithms.

1. Product temperature
2. Moisture or salt content
3. Product format
4. Product consistency
5. Orientation on the production line
6. Product size and shape
To protect consumers, maximize efficiency and meet industry standards, manufacturers and processors have an important role to play in identifying, implementing and maintaining an optimum level of metal detector sensitivity.

Metal detectors may use a range of different technologies to suit the product being inspected. For example:

- The optimum technology for inspecting dry products such as snack foods is a metal detector with ultra high-tuned frequency. This will deliver exceptional sensitivity to detect smaller pieces of metal.
- In challenging applications with product effect - where products are hot, wet, chilled or cooling - a metal detector with Multi-Simultaneous Frequency and Product Signal Suppression technology is more effective than tuned technology.

Choosing a stable, reliable metal detector that delivers enhanced sensitivity levels is an integral part of a food safety program to minimize metal contamination going undetected. However, having a metal detector is not enough - it must also be correctly installed, operated and maintained for optimal performance.
When to Test
The Performance of Your Metal Detector

Routine performance testing is essential to meet the requirements of food safety standards and retailer codes of practice.

The frequency of testing should consider the following stages:
- At the start and finish of daily production / shift
- At regular intervals during the production run
- At changes in production batches
- After changes to machine settings
- After downtime for repairs
Validation, Verification and Monitoring
Ensuring Correct Equipment Performance

Validation, Verification and Monitoring are distinct processes. Each has a clear purpose and role to play at different points within the equipment lifecycle to support.

**Validation** is the initial qualification of a product or process against the stated design specification and aims to answer the question “will this piece of equipment meet the specified objectives?” Re-validation may also be required if substantial modifications to the equipment, or the products being inspected (size, packaging material, etc) are made at any point after installation. The equipment manufacturer should be able to offer you expert guidance on this process.

**Verification** is the periodic qualification that the equipment continues to be effective. It uses standard, formal processes to answer the question “is the specified equipment under control and operating as expected?” Best practice is to use a third party - ideally the equipment manufacturer - to conduct your annual performance verification. METTLER TOLEDO’s qualified service technicians can support you with this to make compliance easier.

**Routine performance monitoring** (or “monitoring” for short) differs from the processes of validation and verification in that it is a series of performance verification checks completed at frequent, regular intervals by a trained operator. These checks are designed to determine if processes are under control. METTLER TOLEDO offers operator training to ensure your staff understand how to correctly perform these tests.

Download the White Paper ‘Validation, Verification and Monitoring for Product Inspection Equipment” for a detailed overview of each process.

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Increase your Understanding
Of Metal Detector Testing

Looking to understand more about how to test your metal detector to ensure you comply with food safety standards and retailer codes of practice? METTLER TOLEDO has produced a guide on ‘How to Correctly Test Your Industrial Metal Detector.’ This document highlights key differences between validation, verification and routine monitoring; explains test processes for different types of metal detectors; offers guidance on retailer requirements; and explains recent innovations that make routine testing processes easier.

Request your FREE guide on
‘How to Correctly Test Your Metal Detector.’ Visit:
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