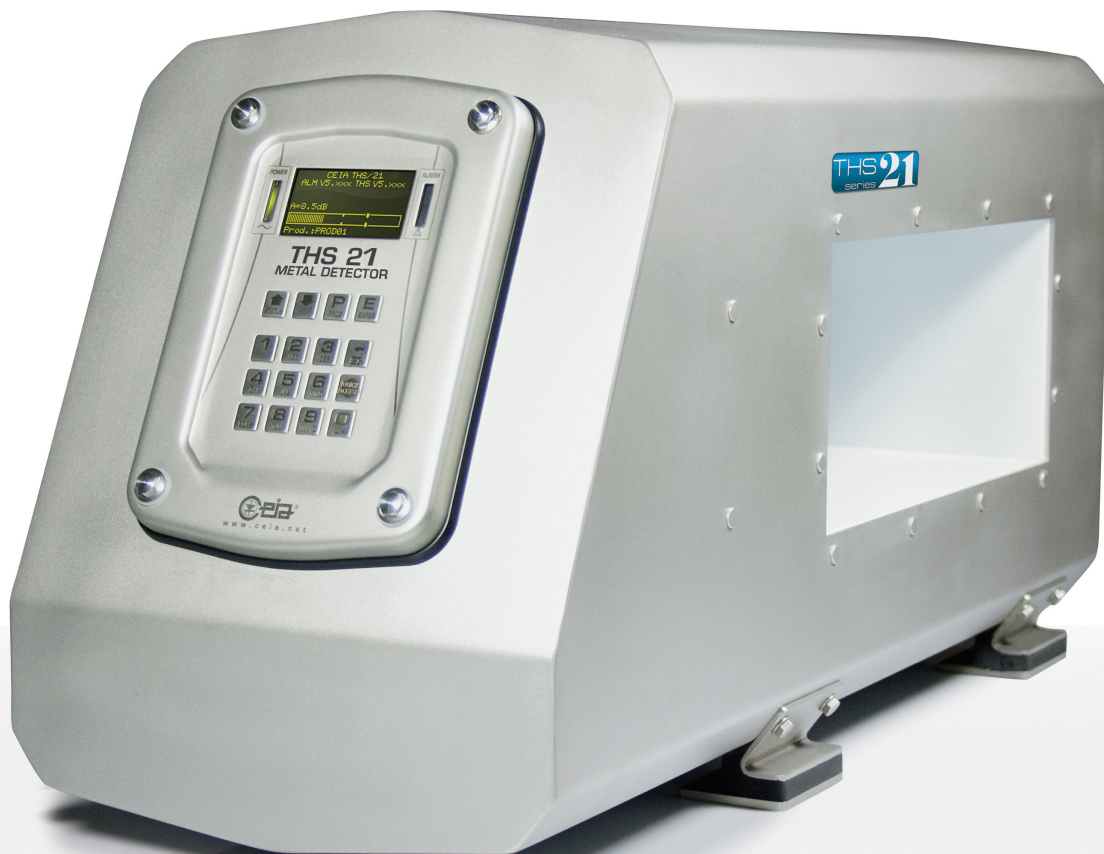# Metal Detector Technology

Which metal detector is right for you

How does Multi-Spectrum™ differ from multi-frequency:
Which is right for your application?

We live at a time when new technologies emerge so quickly and this can sometimes create confusion and even scepticism, as with the recent invention of Multi-Spectrum metal detection. It is frequently confused with existing multi-frequency technology, and some even question how it can prevent false rejects with no "de-tuning" of sensitivity.

To understand the differences and appropriate applications for each method of metal detection, let's first review the basic function of a metal detector in the food industry. To protect consumers and downstream processing equipment, metal detectors are used to detect metal objects and particles that become accidentally included in food products.

Three different types of metals are common in the food industry:
Ferrous, Non-Ferrous and Stainless Steel AISI 304 and 316.

- **Ferrous metal** is mainly detected due to its magnetic properties, which remain practically constant with variations in frequency. AISI 304 stainless steel can also have small amounts of magnetic properties.
- **Non-Ferrous metals** and **Stainless Steel AISI 316** are conductive, but do not possess magnetic properties, and therefore the signal they generate when passed through an electromagnetic field is similar to that caused by conductive products, also known as product effect.

Under normal conditions, as particles of ferrous and non-ferrous metal pass through a metal detector, they alter its electromagnetic inspection field. This disturbance is what is detected by the metal detector and the contaminated product is eliminated from the line, typically by an automatic ejection device or manual intervention after a line stoppage.

The Product Effect

The qualities of certain foods (such as moisture, salt, and iron content) can alter the electromagnetic inspection field and trigger a detection even when the products contain no metal particles. In this case, the electrical conductivity of the food product itself alters the detector's electromagnetic field, proportional to the quantity of product among other factors. This is called product effect, and it increases as the operating frequency of the metal detector increases. Common in foods that are not frozen solid, and product containing a certain moisture level, product effect accounts for significant losses of product and labor required to re-test suspect product. Users of multi-frequency metal detectors sometimes reduce the operating frequency to reduce product effect interference and false rejects. Unfortunately this practice significantly reduces metal detection sensitivity to non-ferrous metals and 316 stainless steel.
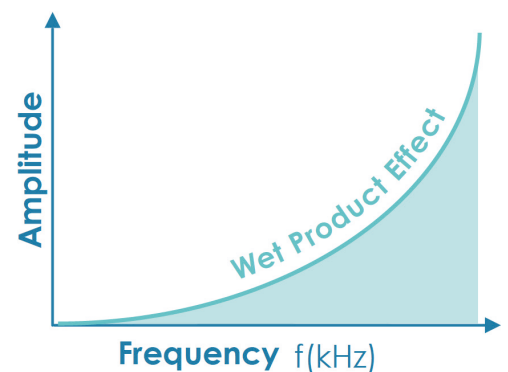
Among other factors, Product Effect interference increases with higher inspection frequencies, which are typically used to detect smaller particles of stainless steel and non-ferrous metals

Single Frequency Metal Detectors

The most basic metal detection technology utilizes one available operating frequency to generate the electromagnetic inspection field. That frequency is determined by the supplier based on the application and product. For example, a single frequency metal detector for dry, neutral products like potato chips or hard candy would not utilize the same frequency as a unit sold for fresh meat. Although they are cost-effective, single-frequency detectors are limited in the range of products they can be used to inspect. They are also more difficult to optimize on lines that run products having varying levels of product effect based on water content, temperature, certain ingredients, and packaging. For example, a metal detector configured with frequency A for fresh meat would deliver poor performance if used for fully frozen meat, which would normally require frequency B for optimal sensitivity.
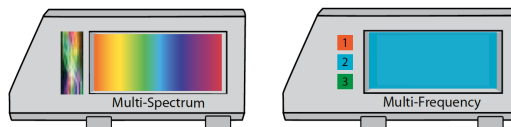
In short, single frequency systems are not suited for use on lines that run products with varying product effects, nor are they optimal for conductive products in general, such as those packaged in foil containers.

Multi-Frequency Metal Detectors

In 1998, CEIA SpA of Arezzo, Italy, introduced the first three-frequency metal detector, the model THS/3F, to eliminate the limitations of single-frequency detectors. This device automatically selected the best of three possible frequencies for each product during the autolearn procedure. This made it possible to inspect neutral and conductive products with different characteristics on the same inspection line. Although they are an improvement on single-frequency models, multi-frequency detectors still use only one electromagnetic field per inspection. It is selectable from a choice of two or more frequencies, but still limits inspection to a single electromagnetic field at a time. This characteristic imposes a technical limitation on the performance that can be obtained in food product applications, especially those with product effect. Ideally, to overcome that product effect, a metal detector should operate with differentiated inspection fields, each at one or more suitable frequencies acting simultaneously on the product being inspected.

Types of Metal Detectors

Multi-Spectrum Metal Detectors

While multi-frequency detectors use just one frequency from a range of choices, Multi-Spectrum detectors utilize an entire spectrum of frequencies. These frequencies are simultaneously and continuously applied to produce vastly more detailed inspection. Invented by CEIA in 2009, this is the world's first and only metal detection technology that both optimizes sensitivity to all metal contaminants and minimizes product effect. By recognizing the different frequency response of conductive products and metals, this innovative technology cancels product effect and maintains high performance levels for all types of metal contaminants, both magnetic and non-magnetic. The autolearn function used by CEIA Multi-Spectrum metal detectors equates to the repetition of hundreds of conventional transits. It explores the whole spectrum of available frequencies in order to determine the best operating frequencies to make up the product inspection spectrum. The chosen operating frequencies will then be transmitted simultaneously and continuously within the metal detector resulting in unsurpassed detection performance.
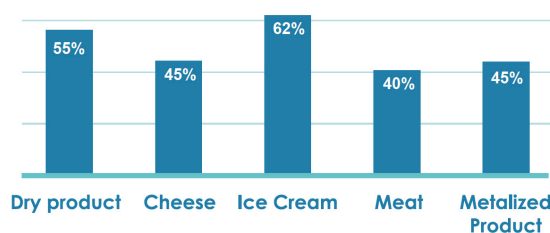
Multi-Spectrum v's Multi-Frequency

Multi-Spectrum detectors use a wide range of many frequencies simultaneously and continuously.

Multi-frequency metal detectors use one inspection frequency at a time from a selection of three or more choices.

MS-21 Multi-Spectrum average % of improvement over multi-frequency systems

Dry product	Cheese	Ice Cream	Meat	Metalized Product
55%	45%	62%	40%	45%

Multi-Spectrum Advantages

Increases in Productivity & Cost Savings

Multi-Spectrum technology, combined with other feature included on CEIA MS-21 metal detectors, improve detection stability. This can increase productivity in a number of ways:

- Increased detection sensitivity
- Reduced product waste
- Fewer operator interventions
- Fewer product acquisition procedures
- Higher productivity
- Reduction in line stoppages
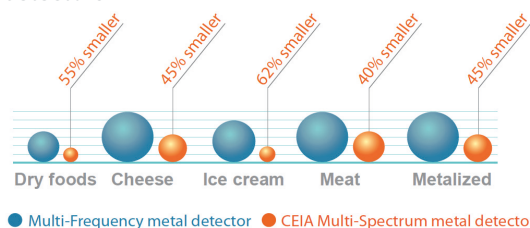- No periodic calibration

Non-Homogeneous Food Products

Conventional metal detectors, even the latest multi-frequency models, have great difficulty inspecting non-homogeneous products. These metal detectors attempt to minimize product effect by choosing the phase at which the signal generated by the product has the minimum amplitude.

However, non-homogeneous products are characterized by a range of minimum signal phases, not just one. Frequently these are not stable - they vary according to the conditions in the production process. This prevents conventional metal detectors from finding a point where it is possible to completely cancel the Product Effect. They usually select a point that is a compromise between the various samples of the same product type analyzed during the autolearn procedure.

CEIA Multi-Spectrum metal detectors are equipped with a spectrum of simultaneous frequencies which allow them to compensate for any variations in the product effect. They are not limited to a mean-point but use interpolations of multiple and simultaneous working points. For this reason, CEIA Multi-Spectrum detectors are extremely efficient in canceling product effect and detecting small metal contaminants.

Increase in Sensitivity Performance

CEIA Multi-Spectrum technology consistently detects smaller particle sizes than multi-frequency metal detectors.

55% smaller | 45% smaller | 62% smaller | 40% smaller | 45% smaller

Dry foods **Cheese** **Ice cream** **Meat** **Metalized**

● Multi-Frequency metal detector ● CEIA Multi-Spectrum metal detector

This comparison shows the results for Stainless Steel AISI 316 contaminants (the most difficult metal to detect). Results are similar for Ferrous and Non-Ferrous contaminants.

Continuous Auto-Testing & Self-Calibration

CEIA 21-Series metal detectors constantly self-test and adjust their detection characteristics during operation to ensure maximum stability and performance. Specific electronic signals are sent to the reception and transmission channels, constantly monitoring the detection characteristics. Variations are automatically compensated for to maintain stability and cancellation of product effect. This process eliminates the need for periodic calibration and ends line arrest and product waste. The result is the extreme stability of the system, with no variation in detection performance and reliable cancellation of product effect.

Continuous Detection & Calibration Check

In addition to self-test functions, CEIA 21-Series detectors continuously conduct direct and indirect checks of detection characteristics. Distinct signals sent to the reception and transmission channels generate variations in the received signal of calibrated amplitude. When compared with the reference calibration values set by the factory, this provides for a complete, certified check-up, revealing any deviation from the permitted tolerances. Anomalies trigger an alarm and are recorded as an event. This procedure reduces the need for frequent tests by the operator, reduce product waste, and increase productivity.

Vibration Immunity Reduces Detection Errors

In addition to preventing false rejects caused by product effect, CEIA Multi-Spectrum technology can also reduce errors caused by vibration. As it does with non-homogeneous products, the metal detector selects the spectrum of frequencies that increases vibration immunity, cancels product effect, and maintains high sensitivity performance.

Which Metal Detector is Right for You?

Single-frequency, multi-frequency, and Multi-Spectrum metal detectors have distinctly different functions and applications.

Single-Frequency

- Economical metal detection for dry, non-conductive products.
- Uses one electromagnetic field with a single frequency.
- Not suited for conductive foods or sequential inspection of different products on same line.
- Available with rejectors for all product forms.
- Lowest cost.
- Applications: Pills, dry snacks, crackers, hard candy.

Multi-Frequency

- Inspects using one electromagnetic field at a time.
- Can offer selection of two or more frequencies, each used one at a time.
- Provides limited differentiation between neutral and conductive products on the same inspection line.
- Ineffective at canceling product effect without reducing sensitivity to metal.
- More expensive than single-frequency.
- Applications: snacks, candy, fruits, vegetables, frozen foods, and meats.

Multi-Spectrum™

- Inspects using multiple electromagnetic fields, each containing multiple frequencies, simultaneously and continuously.
- Most effective at preventing false rejects.
- Maintains highest metal detection sensitivity.
- Automatically compensates for vibration.
- Cost competitive with multi-frequency.
- FDA 21 CFR Part 11 compliant for data security, integrity, and traceability.
- Multiple validation solutions.
- Applications: Any conductive product including cheese, fresh meat, frozen foods, and foil packaging. Provides superior metal detection sensitivity for non-conductive products like snacks, crackers, and hard candy.

Choosing a Partner

As with any equipment purchase, the buyer is not just purchasing a piece of equipment but also entering into a long-term relationship that includes pre and post-sale support such as engineering and application assistance, training, parts supply, and technical support. So it's important to choose a reliable supplier that you feel comfortable with and that offers ongoing assistance.

Before you Buy

Consider testing your products on the metal detector before you make a purchase.

In addition to evaluating the detector's performance, you can get first-hand experience with set-up and changeover simplicity, calibration and maintenance requirements, integration with other equipment (such as a checkweigher), and general construction quality.

For technical assistance, contact us at:

SF Engineering Ireland
www.sfengineering.ie
Tel: +353 (0) 71 9163334