

A practical guide to....



Metal Detection in the Food Manufacturing Industry



FORTRESS
TECHNOLOGY

Metal Detection in the Food Manufacturing Industry

Introduction

The aim of this document is to provide a brief overview of the types of metal detection systems encountered in production environments, and to provide practical advice on how to optimise the performance of such systems. Metallic inclusions are still the number one contaminant in food products, causing product quality and consumer safety issues. As HACCP (Hazard Analysis of Critical Control Points) has more influence and now has widespread acceptance throughout the food industry, so do the requirements for more stringent metal detection.

How a Metal Detector Works

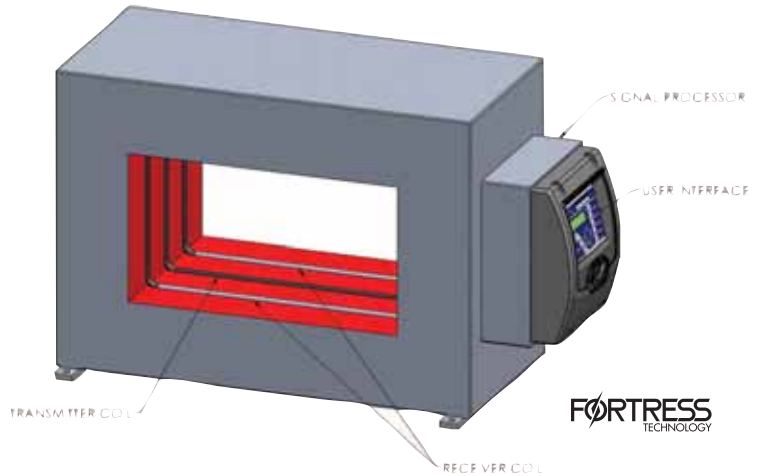
The most widely used type of metal detector in the food industry functions on the principle known as the '*Balanced Coil*' system. This was first registered as a patent in the 19th century, but the first industrial metal detector was not produced in the UK until 1948. The progress of technology has taken metal detectors from valves to transistors, to integrated circuits, to microprocessors and into faster DSPs (*Digital Signal Processors*). Naturally this has increased their performance, giving greater sensitivity, stability and flexibility, as well as widening the range of output signals and information they provide. Even so, modern metal detectors are still unable to detect every particle of metal passing through them. The physical laws applied in the technology limit the absolute capability of the instrument. Consequently, as with any measuring instrument, metal detectors have restrictions on accuracy. These restrictions vary depending on the application, but the main criterion is the size of the detectable metal particle. Nevertheless, metal detectors perform a valuable and essential role in process quality control.

Types of Metal Detector

Modern metal detectors generally fall into two main categories. The first category consists of '*Balanced Coil*' systems with a general-purpose search head. These are capable of detecting ferrous and non-ferrous metals as well as stainless steels in fresh and frozen products - either unwrapped or wrapped, even in metallised films. The second category consists of magnetic field systems with a '*Ferrous-in-Foil*' search head. These are capable of detecting ferrous metals only within fresh or frozen products which are packed in a foil wrapping.

The General Purpose System
'Balanced Coil'

All general-purpose metal detectors essentially work in the same way. The typical detector is encased in a metal box which houses the coil components and provides a shield to protect them. The aperture - the tunnel through which the products pass - is lined with a non-metallic material (usually resin) which provides a hygienic environmental seal for the internal components. Construction techniques ensure that independent mechanical movement of the search head components and the ingress of water and dirt are prevented. Controls can be mounted on the search head or remotely, depending on the design and the application of the system. In all, there are three coils in the system. The transmitter coil generates a field, rather like a radio transmitter. This process, designed to make a metal particle identifiable, is called '*illuminating*' the metal particle. The second and third coils are receivers, connected together to detect the presence of an '*illuminated*' metal particle. The response is related to the conductive and magnetic properties of the metal.



The Digital Signal Processor is highly sophisticated. When a typical metal particle is '*illuminated*', the signal value at the receiver coils could be as little as one millionth of a volt. Firstly this is amplified by a high-performance RF amplifier, then modulated down to low frequency. This provides amplitude and phase information. Finally the signals are digitised and digitally processed to optimise the sensitivity. The ratio of the aperture size to the size of the product is important for achieving optimum performance. The sensitivity of the detector is measured at the geometric centre of the aperture, which is the least sensitive point. This is inversely proportional to the size of the aperture - in particular, to the smaller of the two sides.

**Magnetic Field
Systems
'Ferrous In Foil'**

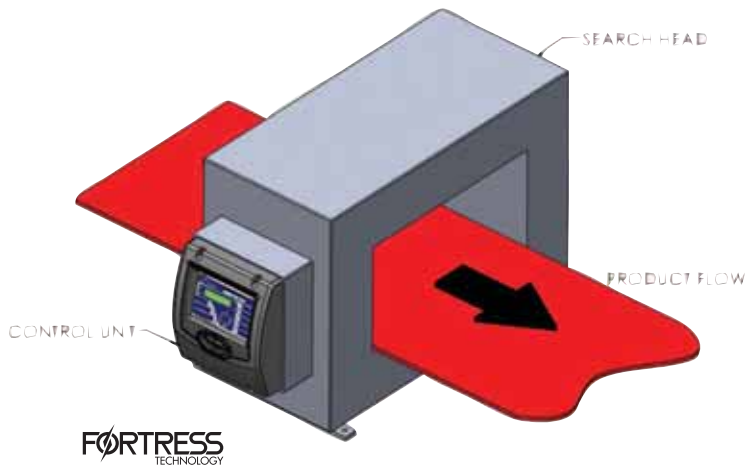
These systems operate on a totally different detection principle. They work by incorporating a tunnel or passage which is subjected to a strong magnetic field. As a result, any magnetic material (such as a metal fragment with a ferrous content) is magnetised as it passes through. Incorporated in the tunnel are a series of coils. When the magnetised particle passes under them, a current is generated which is then amplified by the electronics of the detection system, and this is used to trigger the detection signal output. Secondary effects, due to the movement of any conductive material in a magnetic field, will also generate signals for non-magnetic metals. However, these are small compared to the effect generated by materials with a magnetic content. Consequently, only the largest pieces of non-ferrous metals and stainless steel can be detected. So in the vast majority of applications, this technology is only applicable to the detection of ferrous metals.

The User Interface

The user interface provides the means of communication with the system, allowing it to be set-up and optimised to operate with the application, environment and mechanical handling system. The introduction of touch screens and USB have also enabled a wide range of communication links, statistical analysis and system information. For example, it is possible to network a number of metal detectors and connect them to a network or PC to provide co-ordinated operational and management information. This information covers not only the detection of metal but also the quality of the detectors' performance.

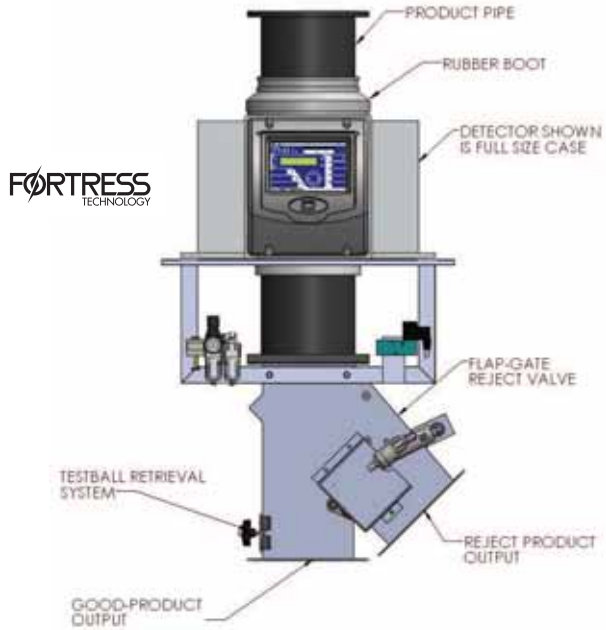
**Search Head
Configurations**

Search heads can be used in a variety of configurations. The most common type, (shown below), is mounted on a driven conveyor which is either fixed or variable speed. When a contaminated product is detected, it is rejected automatically.

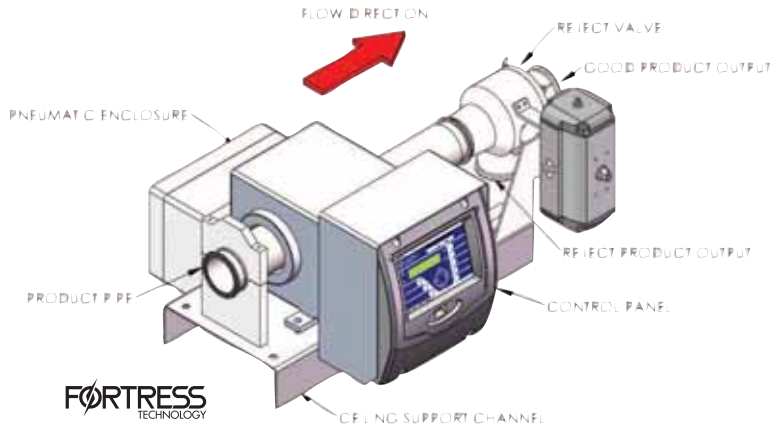


Search Head Configurations

A search head can be configured to operate in a 'free fall' mode, where the product moves down through a gravity-based system (shown below) and contamination is diverted from the flow through the 'Trousers Leg' reject.



Also... a search head can be configured to operate in 'Pipeline' mode, where the product is generally pumped through the system (shown below) and contamination is diverted away from the product flow through the 'Reject Valve'.



Search Head Configurations

Other search head configurations include:

- High performance systems, for large dry bulk products for items like disposable nappies or bulk ingredients.
- Web systems, for paper, carpet or products that come in widths in excess of 2m.

Optimising the Performance of Metal Detectors

The following guidelines are from Fortress Technology's extensive experience of 'best practice' and are designed to help users conform to the industry's most rigorous demands for quality control.

Siting and Composition of the Metal Detection System

The metal detection system needs to be sited in line with the main production flow, after, or at the end of, the finished packing point. The system will be unaffected even if there is excessive water or steam at that point.

Conveyor-based detectors must include the following for the most efficient performance:

- An efficient automatic rejection system.
- A lockable box to receive the rejected product.
- A full enclosure between the search head and the rejection bin.
- A device to confirm that contaminated products have been successfully rejected into the bin.
- An automatic belt stop failsafe system which will activate if there is air pressure failure, a detector fault, failure of the reject system, the reject product collection bin is full, or when there is a product back-log on the line.

Pipeline and Gravity systems must include an audible and visual indication of rejection.

Dealing with Foil-Packed Products

Ideally, products to be foil-packed should pass through a conventional detector system before they are packed in the foil. Where this is not possible, products packed in aluminium trays or wrapped in aluminium foil must go through a 'Ferrous-in-Foil' detector. There is now some justification to explore the use of X-ray however, there is still some question over the cost and reliability of these type of systems within the food environment. For products wrapped in metallised film, conventional detectors, specified correctly, should be used to detect both ferrous, non-ferrous and stainless steel metals.

Sensitivity

For optimum sensitivity, the search head must be of a size appropriate for the specified food product. It is important that the best attainable sensitivities are established and set for each product, relating to product size, type and packaging. At the same time a balance needs to be struck between maximising the sensitivity of the detection system and guarding against potential instability, where the

Sensitivity

effects of product/environment could cause false rejects. This process should always be carried out in consultation with the manufacturer of the metal detector. Sensitivity adjustment controls must not be accessible to untrained employees. Access should only be given to nominated, fully-trained staff, and for additional security the controls should be password protected. If the detection systems are moved within the premises, or if new products are introduced, the system must be re-evaluated in consultation with the manufacturer of the system. Many leading retailers will insist that their suppliers of private label goods agree any changes in metal detection sensitivity settings with them in writing. For private label manufacturers it is advisable to clarify the preferred policy with each of their retailer customers.

Equipment Testing Procedures

Metal detection testing procedures must be clearly documented and communicated to all relevant staff. Testing should take place at the start of each shift, between each change of product, and in any case, at least hourly. Intervals between tests need to be sufficiently short so that if a fault is found, products potentially affected have not left the premises and can be identified, recalled and retested. In the case of private label manufacturers, it is advisable to agree in writing with the retailer customers any variation made to the testing procedure.

Conducting Test Routines in General

When testing conventional metal detection systems, it is necessary to use Ferrous, non-ferrous and stainless steel test packs. These should be made up from packs that are proven to be free from metal, and should be clearly marked and labelled so they cannot be inadvertently packed for despatch. Fresh test packs need to be made up at a frequency that reflects the nature, durability and shelf life of the product concerned. If 'stale' test packs are used, they will not reflect the same properties as the products which the metal detector is inspecting.

Conveyor Systems

Testing procedures can vary slightly from retailer to retailer so it is always advisable to refer to your customers Code of Practice (COP) document. However, when testing finished, packed products on a conveyor system you can use this as a general guide.

Location of Test Pieces

The test packs need to be made up to '*worst case scenario*'. The test pieces should be located in the centre, leading and trailing positions for the 3-pack consecutive test, and the leading and trailing edge for the 2-pack '*Ferrous in Foil*' test. The test packs should be marked with the location of the metal if it is not visible. The leading and trailing positions would not be considered a requirement if the product is a small pack (i.e. less than 100mm). Tests on packs greater than this size should be done in the leading and trailing positions.

Product Testing - Consecutive Test

All three test packs (Ferrous, Non Ferrous & Stainless Steel) should pass through the detector one after each other with normal spacing/line speed. The line should be running and the test packs introduced in the places of three un-inspected packs where possible.

Product Testing - Memory Test

The test packs should be sent through the metal detector with a standard pack in-between (which has already passed through the metal detector). This should be carried out at the start and end of a shift and should be documented. The objective of the test is to challenge the effectiveness of the reject system so that it does not blanket reject. It is a failed test if any of the test packs are not rejected. If a standard pack is rejected the line must be stopped and the issue should be investigated e.g. timing of reject mechanism. If a machine struggles to not reject good packs, advice should be sought from the equipment manufacturer. The capability of the machine may be dependant on the line speed. If the system is not capable of complying with this requirement, documentary evidence is required from the equipment manufacturer. If the testing procedure is not achievable to the guides set out in the COP it is strongly advisable to agree the testing routine in writing with the retailer concerned.

Gravity and Pipeline Systems

With gravity and pipeline systems test pieces should ideally be placed in the product flow and successful rejection observed. In instances where placing a test piece in the product flow is not practical, the system may be tested by inserting test pieces between the pipe and the detection head (in the direction of product flow) and observing the operation of the reject system. Sensitivity standards set in these instances should reflect that the test piece is not passing through the centre of the aperture (sensitivity is therefore higher). In these instances, the size of the test piece used should be adjusted to compensate (e.g. smaller test piece size) consult equipment manufacturer for advice.

Auto Test Devices

There are a number of 'auto test devices' emerging onto the market which offer some distinct advantages over manual testing but these should be checked with your COP or retail customer as to the degree of use and acceptance as a testing method.

Test Fail

Should any part of the test fail, isolate all products produced since the last satisfactory test and re-screen them, using another detector functioning to the same standard as the original system on test.

Dealing with Rejected Products

Needless to say, no rejected product must ever be returned to the production line. However, this does not include products rejected during normal test procedures. If these are in a sound condition, they can be replaced in the product flow for re-detection. Rejected packs must be investigated within one hour of rejection by a suitably trained member of staff. Frozen products must still be frozen, or re-frozen. The investigation should be carried out using the metal detector system which initially rejected the products, but not while it is being used in production. If the production line cannot be stopped, use an off-line detector with the same or higher sensitivity. Pass the rejected products through the detector in the same positioning as they had when they originally went through the search head. Then pass the same products through the search head twice more, each time positioned in different ways. If at any stage the products are rejected again, it is essential to find the contaminant and identify it. Then take any necessary action to ensure similar contamination does not recur.

Detecting more than one metal-contaminated product on a single production line within one shift is a matter of great concern. Every effort must be made to identify and eliminate the cause. Manufacturers of private label goods should inform their retailer customers about the incident in writing.

Maintenance of Metal Detection Equipment

As with any piece of vital precision machinery, high performance can only be assured if the metal detector is regularly and properly maintained. This can be achieved by implementing a planned programme of preventative maintenance at regular intervals, in accordance with the manufacturer's recommendations. Maintenance can be carried out by the equipment manufacturers or by in company engineers, provided that they have been trained by the manufacturers. After any repairs, maintenance or adjustments, a full metal detector test must be carried out before the system is used again.

Preventing Metal Contamination by Maintenance and Cleaning Work

The maintenance of factory equipment needs to be planned in such a way that wear and tear can be remedied before defects occur. Ideally, maintenance work or installation of new plant should be done outside of production hours. If that is not possible, then the area must be properly screened from adjacent raw material production or packing areas.

Validation of Metal Detection Equipment

There is also a requirement for at least an annual validation visit by the manufacturer (or their trained, appointed representative) where the detector is checked independently for performance validation. The representing engineer must use certified test pieces that are traceable and thus results in validation certificates being issued relating back to the visit and sample used. This certificate is generally valid for 12 months.

Preventative Actions to Minimise Metal Contamination Risk

Repairs on production lines should be carried out by staff using an enclosed box for their tools. It helps if they use a small vacuum brush and magnet for cleaning down afterwards, where this is appropriate. Under no circumstances must welding, riveting, drilling or soldering be done on plant being used for production, or on any plant immediately adjacent to it. Slicing or mincer blades, woven wire conveyors and sieves must be inspected every day for any signs of damage. This inspection needs to be clearly documented. Maintenance and cleaning staff who dismantle equipment should carry a suitable, clearly marked container for the safe storage of nuts, bolts, washers, etc. Staff must avoid using tape or wire to make temporary repairs to plant. Missing or loose screws and damaged fittings need to be replaced or repaired promptly and permanently. Swarf, wire debris and any other potential contaminant must be disposed of safely and quickly. All welding should be continuous, and ground smooth.

It is important that all equipment repaired in workshops or in the factory is cleaned down and vacuumed (not blown with compressed air) before being returned to the production area. Workshop floors need to be swept and vacuumed at least once daily. Where workshops are within the factory building, a suitable trap should be fitted to the workshop exit, accompanied by a notice telling personnel to scrape their footwear before leaving.

Once repairs, maintenance activities and installations are completed, a member of the Quality Control or Hygiene team should inspect the plant and surrounding areas before production starts again.

Staff Training

For maximum efficiency and safety, all relevant staff should be properly trained in the principles and use of metal detection equipment and the use of testing routines. In addition, it is important that company maintenance and cleaning staff receive training on the prevention of metal contamination and on the correct procedures to adopt during cleaning and maintenance work.

Documents and Record Keeping

It is important to keep all relevant documentation and records covering a number of areas, including:

- Commissioning and sensitivity tests and records for new equipment, and also those following the movement/relocation of equipment.
- Results of routine tests showing time, result, sensitivity, product and any action taken.
- Number of rejected packs each shift.
- Number and details of detected contaminants.
- Action taken to trace source of contaminants.
- Planned preventative maintenance programme and service work.
- Personnel training.

About Fortress Technology...

Fortress Technology was created with the firm belief that through superior product design and engineering, the production of higher-quality equipment, with sensitivities that were not seen before, could be achieved. The phenomenal market response to Fortress' line of metal detectors has validated this philosophy.

Since its inception, Fortress has grown substantially and now has equipment installed globally with world-renowned customers. Starting in a garage in 1996, partners Dino Rosati and Steve Gidman, who together have more than 50 years combined experience in the metal detector market, developed a 'minimalist' metal detector designed for machinery protection which then went on to form the basis for the digital signal processing (DSP) model, the incomparable 'Phantom'.

Fortress has innovated many new features in metal detection simply by listening to its customers. Now, more than fifteen years and three manufacturing sites later since its beginning, one of Fortress Technology's defining attributes is its complete range of innovative systems for industrial inspection applications. In addition, Fortress offers customised solutions to protect customers' brand names, products and reputations.



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