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A practical guide to .....

Metal Detection in the Food Manufacturing Industry

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STEALTH DETECTOR & VECTOR CONVEYOR

BIG BAG DETECTOR

GRAVITY DETECTOR

PIPELINE DETECTOR

Simple Operation | Outstanding Reliability | Exceptional Performance
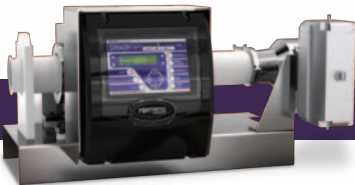
Metal Detection in the Food Manufacturing Industry

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 optimize 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 and Critical Control Points) has more influence and now has widespread acceptance throughout the food industry, so do the requirements for more stringent metal detection.

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 tubes 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.

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 metallized 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.

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.

SIGNAL PROCESSOR

USER INTERFACE

TRANSMITTER COIL   RECEIVER COIL
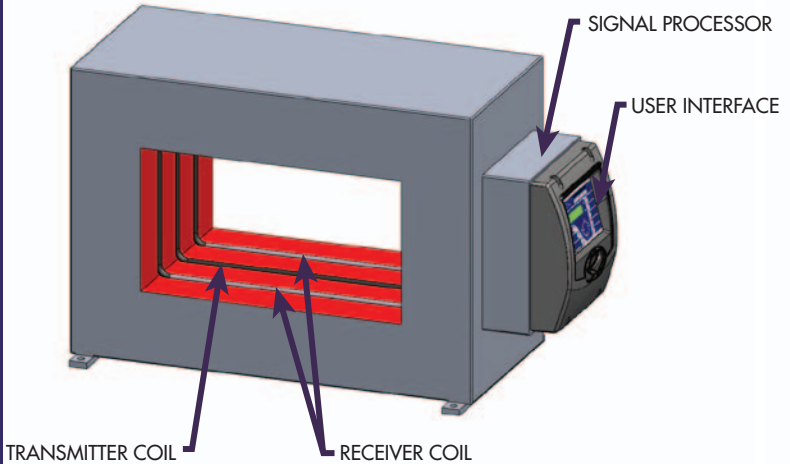
The Digital Signal Processor is highly sophisticated. When a typical metal particle is 'illuminated', the signal value at the receiver coils could be as little as one millionth of a volt. Firstly this is amplified by a high-performance RF amplifier, then modulated down to low frequency. This provides amplitude and phase information. Finally the signals are digitised and digitally processed to optimize 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.
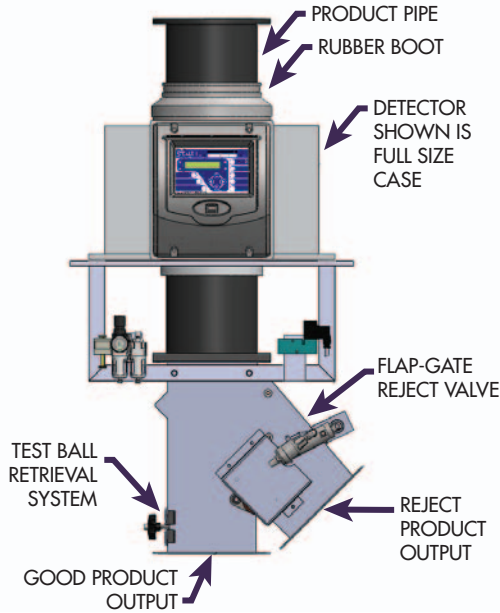
These systems operate on a totally different detection principle. They work by incorporating a tunnel or passage which is subjected to a strong magnetic field. As a result, any magnetic material (such as a metal fragment with a ferrous content) is magnetised as it passes through. Incorporated in the 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 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 use of software and USB connectivity has made available 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.
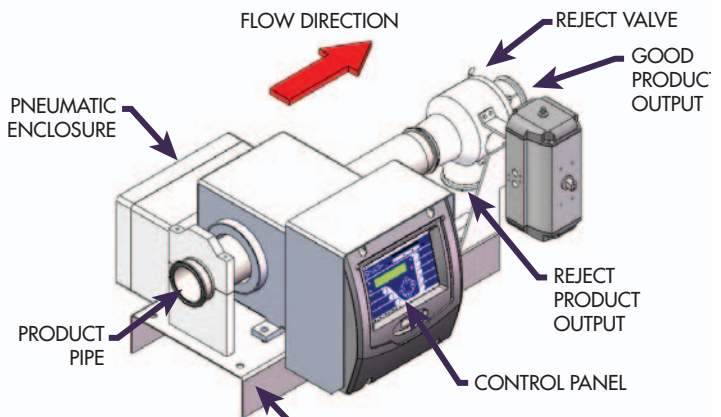
Metal Detectors can be used in a variety of configurations. The most common type, (shown below), is mounted on a driven conveyor which is either fixed or variable speed. When a contaminated product is detected, it is rejected automatically.

METAL DETECTOR

CONTROL UNIT
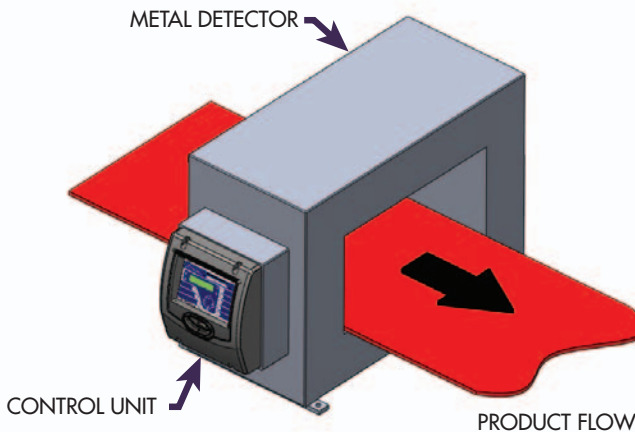
PRODUCT FLOW

A metal detector 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 reject valve.

PRODUCT PIPE

RUBBER BOOT

DETECTOR SHOWN IS FULL SIZE CASE

FLAP-GATE REJECT VALVE

TEST BALL RETRIEVAL SYSTEM

REJECT PRODUCT OUTPUT

GOOD PRODUCT OUTPUT

Also… a metal detector 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'.

FLOW DIRECTION

REJECT VALVE

GOOD PRODUCT OUTPUT

PNEUMATIC ENCLOSURE

REJECT PRODUCT OUTPUT

PRODUCT PIPE

CONTROL PANEL

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.
- Multi-Scan 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.

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.

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 Xray however, there is still some question over the cost and reliability of these types 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.

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 maximizing the sensitivity of the detection system and guarding against potential instability, where the effects of product/environment could cause false rejects. This process should always be carried out in consultation with

Sensitivity

Continued

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 and 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.

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.

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 products that are proven to be free from metal, and should be clearly marked and labelled so they cannot be inadvertently released for distribution. 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 may not reflect the same properties as the products which the metal detector is inspecting.

Conducting Test Routines in General

The test packs should be made to 'worst case scenario' standards. The test packs should travel through th approximate center-line of the metal detectors aperture. 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.

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.

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 be documented appropriately. 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 (clean) pack is rejected the line must be stopped and the issue should be investigated e.g. timing of reject mechanism. If the machine keeps rejecting good packs, advice should be sought from the equipment manufacturer. The capability of the machine may be dependent 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 confirm the testing routine in writing with the retailer concerned.

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. It should be noted that this type of test will not confirm the correct action and timing of the reject device.

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 internal standards/regulations or retail customer as to the degree of use and acceptance as a testing method.

Should any part of the test fail, isolate all products produced since the last satisfactory test and re-screen them, using another metal detector functioning to the same standard as the original system on test. Typically used is an offline portable quality assurance metal detector.

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 redetection. 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 may 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 program 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 equipment 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.

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 afterwards, where this is appropriate. Under no circumstances must welding, riveting, drilling or soldering be done on plant equipment being used for production, or on any equipment 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 equipment. 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 surrounding areas before production starts again.

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.

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

- Commissioning; sensitivity tests; 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 program and service work.
- Personnel training

Fortress Technology began in 1996; believing that through superior product design and engineering, the production of higher quality equipment with better sensitivities could be achieved. The phenomenal market response to our Fortress Phantom line of metal detectors validated that belief and the philosophy on which it is based; simple operation, outstanding reliability, and exceptional performance.

We continue to set the trend with technological advancements. Our Stealth Metal Detector is an evolutionary design that offers full backwards compatibility for existing Fortress systems. Thus ensuring our customers aren't left behind when new technology is developed, enabling them to stay up to date with food safety initiatives.

We custom design and manufacture our equipment to suit your needs. If you are running a high speed product line, you need the detector to reject test samples properly; without false rejects. We design our equipment to do that for you; without the operator requiring an engineering degree.

We have absolute confidence in our products; if they do not perform as anticipated, we will work with you to rectify the situation or provide a full refund.

For more information on our products and service, please visit our website:

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