Metal contamination represents one of the most common forms of foreign body contamination in food products. In order to reduce the occurrence of metal as a hazard various control measures need to be implemented including investment in metal detection systems.

This whitepaper explains the reasons for metal detection in food production processes, the main sources of metal contamination, elements of a metal detection system, types of metal detection, metal detection programs and factors that affect metal detection.
1 THE ROLE OF METAL DETECTION IN SAFE FOOD PRODUCTION

Metal contamination of food products is a fact of food manufacturing life. Even with the most robust metal detection controls, metal contamination of food still occurs. As is the case with many aspects of food safety our objective is the reduction of metal hazards to an acceptable level where total elimination is not possible.

If we take a look at modern food manufacturing processes we see that many unit operations involve the use of metal materials such as cutting, slicing, crushing, sieving, mixing, pumping and packing. Beyond this, metal is the standard fabrication material used in machinery, utensils and handling equipment. Add to this the potential risk of contamination of ingredients purchased from suppliers we can see that metal contamination presents a significant challenge for food safety.

Over the years, food standards and large retailers have developed requirements which demand food businesses to adopt a series of controls to reduce the risk of metal contamination. The approach suggests that reliance on one single measure is inadequate to address the risk and by implementing multiple measures of control and detection the food company can offer the consumer the best level of protection. These controls typically take the form of inspection, checking, detection systems and removal of potential metal hazards.

Of these, detection systems have become an almost standard requirement for the majority of food businesses particularly those operating under global food certification schemes or supplying food retailers. Other motivations for conducting metal detection include reduction in customer complaints, improved consumer protection, protection of business and brands and improved compliance.

While metal detection involves the application of specific technologies to detect and reject/remove metal contamination, it is not an absolute method and it is subject to variation in effectiveness and sensitivity. In this regard, best practice and proper management of the metal detection system is vital to ensure maximum protection is achieved. Companies should seek the advice of expert suppliers of the technology in achieving this.

2 GFSI REQUIREMENTS FOR METAL DETECTION

The Global Food Safety Initiative’s (GFSI) group of approved schemes set out very prescriptive requirements for the control of possible foreign body hazards. The BRC Standard goes into specific requirements regarding metal detection and these can be found in section 4.10.3. The requirements set out the need to have in place metal detection equipment based on an assessment of risk. Requirements cover the location of equipment, reject systems, procedures to be followed for checking of the unit and corrective actions.

The IFS Standard requirements are less prescriptive, calling for where metal and/or other foreign material detectors are required; they shall be installed to ensure maximum efficiency of detection in order to avoid subsequent contamination. Detectors shall be subjected to regular maintenance.
Metal detection. These requirements may be found in section 4.12. Other standards set out requirements for metal contamination and some retailers maintain very prescriptive requirements which must be met. Where the company deviates from these requirements these often need to be supported by a detailed risk assessment and formal approval from the retail customers.

3 SOURCES OF METAL CONTAMINATION

Metal can enter the product and process from a variety of sources. For this reason, a range of effective metal control and detection systems should be designed and implemented based on a full assessment of risk. This will usually be conducted as part of a HACCP study which includes in its scope metal as a potential hazard. This hazard analysis and risk assessment should take into account raw materials, each process step, the nature and type of metal, size range of metal contamination and legal/commercial requirements. Potential sources of contamination may include:

- Raw Materials including shot in meat, machine parts associated with harvesting, hooks and wire
- Personal sources including pens, buttons, jewellery, coins, hair clips and keys
- Maintenance tools and effectives including spanners, wrenches, screwdrivers, nuts, bolts, washers, scarf and filings
- Processing Equipment including crushers, cutters, knives, sieves, blenders and general machine parts and materials arising from wear and tear

As you will see the first line of defence is prevention. Best practice control should be established before the detection regime is specified. These controls may include the following:

Supplier Control: A full risk assessment of suppliers and raw materials should be conducted. This can lead to criteria for the selection and monitoring of suppliers and their detection methods to ensure the burden of control does not rest solely on your final detection system. Standards for suppliers should be clearly specified and documented and be a basis for approval of the supplier.

Machine and Equipment Design: Any new item of equipment should be fully assessed for unreasonable risk of metal contamination of product. This may include the standard of fabrication and design of the item and its ability to withstand normal production operations without excess wear and tear and loss of machine parts. Utensils should be capable of withstanding robust use without breakage.

Maintenance Programs: These should be designed to ensure equipment remains in an acceptable state of repair and include regular inspection of moving parts for signs of excessive wear and tear.

Removal System: Other methods for the removal of metal from the product or ingredients may include magnets and sieves.

Knife and Sharps Control: A specific system should be considered for the issue and checking of these items which present a higher risk of breakage. The control system should include a register, issue and reconciliation record, integrity check and control procedures in the event of damage.

The above systems are collectively designed to reduce the risk of metal contamination and ensure that the implemented detection system is not the only line of defence. However, once metal contamination has occurred it is important that the metal detection system is capable of detecting and
removing from the line the suspect product. Depending on the product, process, risk and specific requirements, metal detection systems can be installed in two main stages of the operation:

**In-Process Inspection:** This concerns the detection and removal of metal in bulk product prior to the consumer unit.

**End of Line Inspection:** This concerns the detection and removal of metal contamination in consumer units at the end of the production line. It is usually a requirement of food retailers and has widespread application in the food industry.

## 4 ELEMENTS OF METAL DETECTOR SYSTEMS

### 4.1 Detector Head

The majority of metal detectors used in the food industry are balance coil systems. The system generates a field which illuminates any metal particles present which in turn can be detected. Metal detection heads can be of various shapes and sizes depending on the product which passes through the opening in the head or aperture. When metal is detected by the head a signal is sent to a control system designed to alert personnel and remove the product from the flow. Whichever system is used it must have the capability of detecting ferrous, non-ferrous and stainless steel. For foil packed products or similar metalized films an appropriate system will be required.

### 4.2 Transport System

The system employed passes product through the head aperture. There are three main types of metal detection systems based on the means of transport:

- Conveyor Mounted
- Vertical Packaging
- Pipeline Systems

### 4.3 Reject System

Following the detection of metal an automatic reject system is often used to remove the contaminated product. Various methods are used depending on the product and transport system and include:

- Push arm
- Air blast
- Drop Flat
- Value divert

Standards and retailers increasingly require additional controls in regard to the reject system. These include employing a rejected product collector/container which has a secure/locked monitor. Control may be by physical lock and key or code pad. In addition, a failsafe alarm to signal faulty oper-
ation should be fitted and a sensor to confirm contaminated product is rejected. Staff should be alerted to a reject through a beacon and/or alarm which can also be used to signal scheduled tests or when reject bins are full.

5 METAL DETECTOR TYPES

5.1 Conveyor Mounted

Conveyor mounted systems are usually located at the end of the line or as close to the end of the line as practical. A continuous conveyor runs through the aperture carrying with it product packs or units. Each is checked individually and rejected if metal is detected. The sensitivity of the detection head is important in determining the type and size of metal pieces detected.

Sensitivity Requirements

The equipment must achieve the following:

- Sensitivity must be stable and require infrequent adjustment
- Not reject good product or provide false positive results
- Be capable of detecting metal in various orientations relative to the detection head

It is important to work with your equipment supplier in determining and establishing these conditions. Sensitivity levels must be realistic and attainable and your supplier will be best placed to provide guidance. In some cases customer technical standards will also provide suggested sensitivity levels for their products. The following are sample sensitivities (mm) based on pack size

<table>
<thead>
<tr>
<th>PRODUCT HEIGHT</th>
<th>DRY PRODUCT INCLUDING NON-METALLISED FILM PACKED PRODUCTS</th>
<th>WET PRODUCTS and METALLISED FILM PACKED PRODUCTS</th>
<th>ALUMINIUM FOIL PACKED PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ferrous</td>
<td>Non-Ferrous</td>
<td>Stainless Steel 316</td>
</tr>
<tr>
<td>Up to 50mm</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>50mm – 100mm</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>100mm – 150mm</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>150mm – 200mm</td>
<td>1.8</td>
<td>2.2</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Reject Systems

Reject systems typically employed in conveyor mounted systems are carriage retracting band and air blast, sweep/diverter arm and pushers. It is best practice to fully enclose the area around the search head and rejection box. The reject box should be locked with access control for those authorised to retrieve suspect product. To ensure staff are alerted to a detection a visual or audible alarm system should be fitted. Belt stop systems are employed; however, should be avoided for conveyor mounted as they increase the risk of contaminated product reaching the consumer.

Checking System

Due to the inherent variation in sensitivity the test regime should be designed to fully challenge the metal detector system. A number of tests can be employed to achieve this. Best practice is to check the system using clearly identified test packs under the same conductions as standard products passing through the detection head with test pieces of a specified size. The test packs should be passed through the detector successfully before using the test pieces. This is to ensure they do not contain metal.

Following this, the test pieces must pass through the centre of the aperture with the test pack and allowed to reject fully into the secure bin. It is also good practice to conduct consecutive leading and trailing checks in long packs to ensure the reject mechanism can successfully reject. The test must be representative of how products would normally travel through the detector during normal production.

Test pieces should be controlled and ensure the size of the metal can be verified, e.g. they are manufactured with a serial number or issued with a certificate which is held on file for inspection. Test packs can be made up in advance by a designated person, controlled and labelled with product, date, test piece size and type. Test packs must be maintained at the same temperature as the operating conditions of the process and product.

Test Piece Position

Consecutive testing should be included in your check program where all test packs (Ferrous, Non
Ferrous, and Stainless Steel) should pass through the detector one after each other with normal spacing/line speed.

**Consecutive Testing**

Memory testing should be considered whereby test packs are sent through the metal detector with a standard pack in between (which has already passed through the metal detector). This can be carried out at the start and end of a shift.

**Memory Testing**

Where the test pack is longer than the width of the detection head consecutive leading and trailing checks can be conducted to ensure the reject mechanism can successfully reject.

In general, checks should be conducted on an hourly basis. Ultimately, the frequency of checks should be set based on a full risk assessment. All checks of the metal detection system must be documented and signed by the trained individual who has carried out the check. The actual time should be recorded.
These checks should include:

- Start of production, hourly, end of production
- No. of rejects
- Fail safe checks (where applicable)
- Corrective actions for any failed checks
- Investigation of rejected product
- Confirmation of metal checks should be recorded as Pass/P or Fail/F (or equivalent in local language). Ticks and dashes should be avoided.

Sample Metal Detection Record

Fail Safe Systems

Depending on the risk assessment the following fail safe systems should be incorporated into your metal detection program. These systems are designed to ensure that metal contamination does not occur where machine failure arises or set up is incorrect. The following fail safe systems are available:

- Reject confirmation system: automatic belt stop fail safe system — to confirm metal contaminated products have successfully entered the reject bins
- Bin full system: an automatic belt stop fail safe system which activates should the reject product collection box become full
- Air pressure system: an automatic belt stop fail safe system — to cover air pressure failures to the rejection mechanism
- Search head failure: an automatic belt stop fail safe system — to confirm detection head fault
- Back up sensor: an automatic belt stop fail safe system — to activate should product back up out of the feed belt of the metal detector
5.2 Vertical Packaging Systems

In this format there is a throat metal detector and a bag former underneath. They are normally used for certain flowing products.

Sensitivity

Sensitivity values vary from process to process. You should consult your equipment supplier when setting specifications. The following are sample sensitivities (mm) based on aperture diameter:

<table>
<thead>
<tr>
<th>APERTURE DIAMETER</th>
<th>DRY PRODUCT INCLUDING NON-METALLISED FILM PACKED PRODUCTS</th>
<th>WET/FROZEN PRODUCTS and METALLISED FILM PACKED PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ferrous</td>
<td>Non-Ferrous/Aluminium</td>
</tr>
<tr>
<td>Up to 100mm</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>100mm – 150mm</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>150mm – 200mm</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>200mm – 250mm</td>
<td>1.8</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Reject System

In this system, when metal is detected a signal is sent to the bag-maker to produce a double bag or stop. An audible and/or visible alarm to indicate that the system is stopped is normally fitted.

Testing

Ferrous, non-ferrous and stainless steel test pieces should be placed in the product flow and successful rejections observed.

5.3 Pipeline Systems

These systems are designed for liquid, paste and slurry type products. Inspection is conducted as the products are pumped through a pipeline prior to being dispensed into the final pack. This method is effective where the final product is packed into materials which do not lend themselves well to metal detection, e.g. metal cans. The system will include an automated reject valve immediately after the metal detection head with an audible and visual indicator to signal when contamination is found.

Picture: Pipeline System
**Sensitivity**

Sensitivity values vary from process to process. You should consult with your equipment supplier when setting specifications. The following are sample sensitivities (mm) based on aperture diameter.

<table>
<thead>
<tr>
<th>INTERNAL PIPE DIAMETER</th>
<th>WET PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Naval/Steel 316</td>
</tr>
<tr>
<td>Up to 50mm</td>
<td>1.5</td>
</tr>
<tr>
<td>50mm - 100mm</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**Reject System**

Systems of this type should incorporate an automated reject valve immediately after the metal detection head with an audible and visual indicator to signal when contamination is found. Contaminated product should be rejected into a suitable secure container.

**Testing**

With 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 pipeline and the detection head (in the direction of product flow) and observing the operation of the reject system.

Picture: Test piece in product stream

Picture: Test piece between pipe and detector
6 OTHER SYSTEM REQUIREMENTS

6.1 Detection Failures (All Metal Detection Systems)

Any test piece which fails to be detected is considered to be a failed test. The line must be stopped (where possible) and product isolated (using hold procedures) from the last good check. The equipment must be fixed by an engineer prior to production re-starting. The re-testing of product which has been isolated after a test failure must be documented on the metal detection records.

6.2 Rejected Product (All Metal Detection Systems)

If product is rejected it must be investigated for metal contamination. If the product is temperature controlled or delicate it should be disposed of due to the risk of temperature abuse. Ideally all rejected product should be disposed of; however, if there is a high level of rejected product it should be successfully passed through the detector 3 times in different orientations. If it fails on one of these occasions it should be investigated for metal contamination and disposed of. If the product successfully passes 3 times it can be accepted. Rejected product collection box release keys should be held by nominated staff only. If multiple rejects are observed the line should be stopped for investigation.

6.3 Training (All Metal Detection Systems)

All staff involved with foreign body detection must be trained not only in the technical and operational aspects but also the principles of metal and foreign body detection to ensure full understanding of the purpose. Personnel in the factory who monitor CCPs must have an understanding of HACCP and have specific training against the latest version of the relevant monitoring procedure.

7 FACTORS AFFECTING METAL DETECTION

Metal Type
Depending on the type of metal passing through the detection head the ease of detection will vary. Ferrous metals are easily detected while stainless steel is relatively difficult to detect. Non-ferrous metals such as copper and lead are relatively easy to detect.

Metal Shape & Orientation
The shape and orientation of the metal passing through the head also affects the ease of detection. Ferrous metals orientated in line with the head can be difficult to detect; however, if presented at a 90° angle are easier for the head to pick up.

Non-ferrous metals, however, display the opposite properties, being easy to detect in line with the head and difficult at 90°.

Picture: Aperture Size / Position in the Aperture
Environmental Conditions

Specification should be developed in conjunction with the equipment supplier to ensure the system can perform effectively in the intended working environment. Performance should not be adversely affected by external electrical interference or by plant operating conditions – e.g. wet environments, areas of high vibration, and extremes of temperature or harsh hygiene procedures.

Product Characteristics

Dry products such as sugar, flour, snacks, confectionery and cereals have a high sensitivity while wet products such as ready meals, meat, fish, sauces and preserves display a reduced sensitivity.
Product Benefits

- Easily record and manage all elements of your food safety system including HACCP and CCP monitoring, PRP’s, management systems and documents
- Eliminate paper using the 30 integrated modules that come as standard
- Access and work with your system from any location at anytime
- Stay up to date and fully compliant with software that updates automatically in line with changes to global food standards
- Improve compliance and audit outcomes through the action driven features of the software
- Accelerate compliance with all of the international food safety standards including the BRC, SQF, IFS & FSSC 22000.
- Spend less time managing your food safety system and more on value adding activities

Product Features

- Dashboards & KPI’s
- 100’s of reports as standard
- Notifications
- Multi-site management & oversight
- Real-time legal and alert updates to dashboard
- Roles & security
- Actions management
- Safe and secure web based solution
- No internal IT support or data back-up required
- Unlimited Users
- 24/7 world class customer support
- Covers in complete detail the requirements of the SQF, BRC, IFS, FSSC 22000, retailer standards and legislation
- FDA 21 CFR Part 11 –Technical Compliance
- Automatic audit log
- One click data export

Safefood 360° FOOD SAFETY MANAGEMENT SOFTWARE

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