Technews

National Dairy Development Board

For Efficient Dairy Plant Operation

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Metal Detection

This bulletin includes technical information based on latest developments on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information in different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue "**Metal Detection**" It may be understood that the information given here is by no means complete.

In this issue:

INTRODUCTION

Preventative measures and **foreign body management** have become increasingly important in the food industry. One reason for this is the changing requirements of food standards. Another reason is increased public sensitivity to contaminated and defective products. **Foreign bodies** are usually solid (physical) objects which do not belong in the product. Food products contaminated with foreign bodies often represents a health risk for the consumer.

Possible injuries include injuries to the mouth, pharynx, esophagus and the gastro-intestinal tract. These injuries may be caused by metal shavings, stones, fragments of glass and pieces of plastic or similar objects. Foreign bodies also include insects, chewing gum or hair. These can get into a product in various ways. For example, ingredients can cause a physical contamination of the products within the production and/or packaging process, for example due to metal shavings or screws.

In dairy processing industry one of the most common foreign materials occur in milk products is metal. Metal fragments can be unintentionally introduced to finished products and become a safety hazard to consumers. A dairy processor needs to minimize and control the risk of foreign materials. One approach to detect metal contamination of food products is the use of metal detectors.

Source of metal contamination:

Metal contamination sources are numerous – and even the most stringent controls cannot prevent the occasional incident in which small pieces of metal find their way into products destined for consumer consumption.

Good working practices will minimise the likelihood of metal contaminants entering the production flow; furthermore, correct equipment design and appropriate selection will maximise the likelihood of reliably detecting and rejecting any metal particles that have found their way into products.

Contamination normally comes from the following sources:

- Raw material: Typical examples include screen wires, metal chippings in case of raw chilled milk, milk powder. Machine parts associated with manufacturing, hooks and wire etc. in case of ground sugar.
- Personal sources: Buttons; pens; jewellery; coins; keys; hair-clips; thumb-tacks; pins; paper clips, etc.
- Maintenance: Screwdrivers and similar tools; swarf and welding slag (following repairs); copper wire off-cuts (following electrical repairs); miscellaneous items resulting from inefficient clean-up or carelessness; metal shavings from pipe repair.
- In Plant-Processing: The danger of contamination exists every time the product is handled or passes through a

process. Clarifiers, mixers, slicers, knifes, sieves, blenders and transport systems can all act as sources of metal contamination.

Identifying the likely source of contamination is a vitally important stage in developing a successful overall metal detection programme.

Metal Detection System

An industrial metal detection system is a sophisticated piece of equipment used to detect and reject unwanted metal contamination. When properly installed and operated, it helps to reduce metal contamination and improve food safety.

A typical metal detection system consists of four main parts:

1. Detector Coil or 'Detector Head'

Most modern metal detectors fall into one of two main categories, with respect to the 'Detector Head'.

- The first type of metal detector utilises a **'Balanced Coil'** Detector Head which is the most widely-used type of metal detector in the food industry. Detectors of this design are capable of detecting all metal contaminant types, including ferrous, non-ferrous and stainless steels, in fresh and frozen products. The products being inspected can be either unwrapped or wrapped, and can include products wrapped in metallised films.

- The second detector type utilises permanent magnets in a **'Ferrous-In-Foil'** Detector Head. These Detector Heads are capable of detecting ferrous metals and magnetic stainless steels only within fresh or frozen products which are packed in an aluminium foil wrapping

Detector Heads can be manufactured in virtually any size, in order to suit the product being inspected. They may be rectangular or round, and may be mounted horizontally, vertically or on an incline.

Each Detector Head has an opening (known as an 'aperture') through which product passes. When a metal contaminant is detected by the Detector Head, a signal is sent to the electronic control system.

2. User interface / Control panel

The user interface is the front-end of the electronic control system, and is often mounted directly on the Detector Head. However, the user interface can be mounted remotely (with connecting cables) if the

Detector Head is too small, or if the Detector Head is installed in an inconvenient or inaccessible location.

3. Transport system

The transport system is used to pass the product to be inspected through the aperture of the metal detector. The most common type of transport system is a conveyor.

Alternatives include:

- A plastic chute with the detector mounted on an incline
- A non-metallic pipe, mounted horizontally or vertically. This type of transport system is commonly used in the inspection of powders and liquids

4. Automatic Rejection System

An automatic reject device is frequently fitted to the transport system in order to remove any contaminated product from the production line. There are many different styles available including ‘air blasts’, ‘push arms’, ‘drop flaps’, etc. The style of the reject device installed will depend on the type of product being inspected.

In addition to the four main parts of a metal detection system, other important items may include:

- A lockable container fixed to the side of the conveyor, to collect and hold rejected product
- A full-length cover between detector and reject device
- A fail safe alarm which operates if the metal detector develops a fault
- A reject confirmation device, with sensors and timers, to confirm that contaminated product is actually rejected from the line
- A beacon and/or audible alarm that alerts operators to various other events, such as an automated warning that a detector is due to be tested or that the reject bin is full
- Numerous optional fail safe systems to raise level of "Due Diligence".

Use of metal detectors in the dairy industry

1. Bulk 'In-Process' Inspection

- Eliminates metal before it can be broken into smaller pieces
- Protects processing machinery from damage
- Typical examples include bulk inspection of milk powder before usage in milk standardization process, RUFT food preparation, dairy sweets etc., ingredients for dairy based desserts toppings, and dairy cereal and starch based desserts (shishu sanjivini etc.)

2. Finished Product Inspection

- No danger of subsequent contamination
- Ensures compliance with retailer and consumer brand quality standards
- Typical examples include cheese milk and related fresh dairy items, yogurt, ice cream, novelties, milk powder/whey protein concentrates, milk chocolates

The most common types of metallic contamination include:

- Ferrous (iron)
- Non-ferrous (brass, copper, aluminium, lead)
- Various types of stainless steel (magnetic and non-magnetic

Of the three types listed above, ferrous metal is generally the easiest to detect – and relatively simple detectors (or even magnetic separators) can perform this task well

In dairy industry stainless steel alloys are extensively used, but are often the most difficult to detect, especially common non-magnetic grades such as 316 and 304.

Non-ferrous metals, such as brass, copper, aluminium and lead, usually fall between these two extremes, although in larger metal detectors operated at higher frequencies, non-ferrous metal may be harder to find than non-magnetic stainless steel

Only metal detectors using an alternating current 'balanced coil' system have the capability to detect small particles of non-ferrous and non-magnetic stainless steel.

Balanced Coil System

1. Basic principles of operation:

Three coils are wound onto a non-metallic frame or 'former', and each coil is exactly parallel with the other two. The centre coil (the 'transmitter') is energised with a high-frequency electric current that generates a magnetic field. The two coils on each side of the centre coil act as receivers. Since these two coils are identical and are the same distance from the transmitter, an identical voltage is induced in each. When the coils are connected in opposition, these voltages cancel out, resulting in 'zero output.

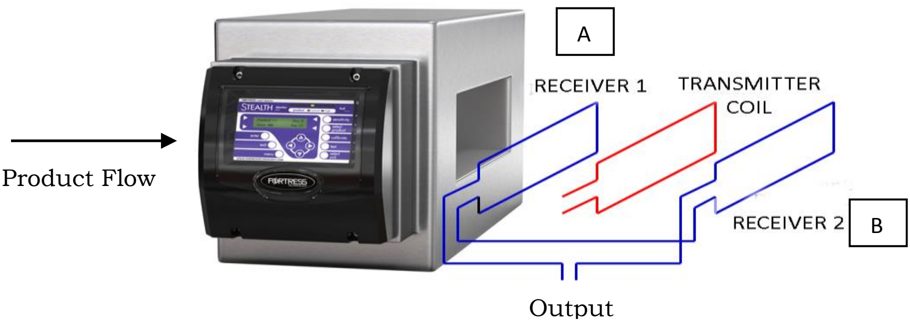


Figure 1.1 Balanced Coil System

As a particle of metal passes through the coil arrangement, the high-frequency field is disturbed at the 1st receiver coil (point A) and then at the 2nd receiver coil (point B). This action changes the voltage generated in each receiver (though by a matter of only $1x10^{-9}$ nano-volts). Despite the very small change in voltage, this alteration in balance generates a signal that can be processed, amplified and subsequently used to detect the presence of unwanted metal.

To prevent airborne electrical signals, or to prevent nearby metal items and machinery from disturbing the detector, the complete coil arrangement is mounted inside a metal case. This has an opening (‘aperture’) to allow passage of the product.

Several special mechanical and electrical techniques are essential to the design of stable, reliable metal detectors:

2. Mechanical techniques:

- The metal case affects the magnetic field’s state of balance, and any movement relative to the coils can cause a false detection signal as small as 1 micron).
- The design of devise shall be totally rigid and stable system, unaffected by vibration from motors, pulleys, auto-reject devices, temperature changes, transportation and machinery located in close proximity

- It is vitally important to select the right kind of material for detector head coil specifications
- To increase mechanical rigidity further, most manufacturers fill the detector case with a material to prevent relative movement of the metal case to the coils frequently referred to as ‘potting’. This helps produce a unit that is able to operate at maximum sensitivity under typical factory conditions. The quality of the potting is critical to the performance of the metal detector

3. Electronic techniques:

There are various factors can contribute to an out-of-balance voltage. These include:

- Temperature changes
- Metal close to the aperture
- Ageing of electronic components
- Slow changes in the mechanical structure

- Automatic Balance Control continuously monitors out-of-balance voltage and automatically corrects it.
- Quartz Crystal Control, now standard on most metal detectors, accurately controls the frequency of the oscillator in order to prevent ‘drift‘.

Note: Automatic Balance Control and Quartz Crystal Control will not, themselves, enable the detector to detect smaller pieces of metal. They will, however, enable the detector to permanently maintain this level of sensitivity without operator attention and without the generation of false reject signals.

- Temperature compensation control circuitry automation manages the effects of external temperatures variation that may affect the performance of the detector by eliminating balance drift.

4. Metal free zone:

Most of the detector's high-frequency magnetic field is contained within the metal case of the detector unit. There is some unavoidable leakage of the magnetic field from the aperture of the detector – and it is the effect of this leakage on the magnetic field of the surrounding metalwork that may influence the detector's performance, resulting in inconsistencies in detection capability.

To achieve optimum metal detection results, the aperture of the detector should be surrounded by an area known as the 'Metal-Free Zone', this area should be kept free of all metals.

The size of the Metal free zone is dependent upon:

• The aperture size
• The type of detector
• The operating sensitivity

The MFZ will normally be specified within the manufacturer's installation instructions. Typical quoted values are in the region of 1.5 x aperture height for stationary metal and 2.0 x aperture height for moving metal.

Ferrous in Foil (FIF) Detection System

When the product to be inspected is packaged inside an aluminium foil pack or dish, a metal detector using a balanced coil system cannot be used. However, there is an available detector design which suppresses the effect of the aluminium foil, but is still sensitive to small pieces of ferrous and magnetic stainless steel contamination.

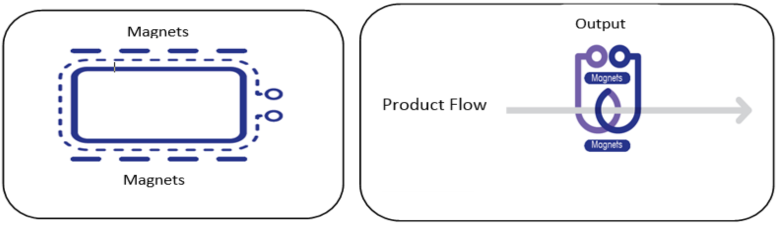


Figure 1.2 Ferrous in Foil Detection System

As a metal particle approaches the detector, it moves into a powerful magnetic field that magnetises the particle. As this magnetised particle passes through the single coil (which is wound around the former), a small voltage is generated and subsequently amplified.

Ferrous-in-Foil metal detectors show much greater sensitivity to magnetic material than to non-magnetic material, but in practice, the sensitivity of the detector may have to be reduced due to some product signal from the aluminium foil. These kinds of operating conditions often impose a limit on efficient performance.

The limitations of this technology are clear and unless the only metallic contamination likely to be present is ferrous (or magnetic) it is recommended that other technology is investigated i.e. X-ray. For example Cheese chiplets wrapped in aluminium foil.

Detection Modes

As a metal particle passes through a balanced coil detector, an output signal is generated which increases to a maximum as it passes under the first coil. It then falls to zero as it reaches the centre coil, and increases again to a maximum as it passes under the third coil. The signal will start to build up when the metal contaminant is some distance from the coil – and with a large piece of metal contaminant, it could be influencing the coil before it even arrives at the detector.

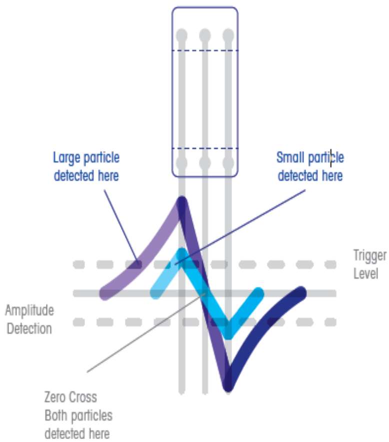


Figure 1.3 Detection Mode

There are, however, two different methods of interpreting or processing this output signal, which results in different detector characteristics; one is known as **'Amplitude** Detection', the other is known as **'Zero Crossover'** (or 'Narrow Zone') Detection.

1. **Amplitude Detection:** When the signal from the metal particle exceeds a predetermined 'trigger' level, the detector operates. Figure 1.3 shows how a large piece of metal breaks the trigger level and so is detected earlier than a small piece of metal. With Amplitude Detection, a large metal piece is detected earlier, and so a greater amount of 'good' product is rejected.

2. **Zero Crossover Detection:** This method gives a 'detect' signal from the metal when the signal changes polarity from a positive to a negative or vice-versa. Figure 1.3 shows that this always occurs at the same point (under the centre coil) independent of metal size. With this method, the point of detection can be accurately determined, regardless of metal size, and the volume of rejected product can therefore be minimised.

The major drawback of the Zero Crossover method is that it is not fool-proof for rejection of multiple metal pieces at once. For example in a typical production line, when a sieve or mincer breaks up. Then, if one metal piece follows a second piece and the metals are of a different size, then the Zero Crossover detector may not detect the smaller piece.

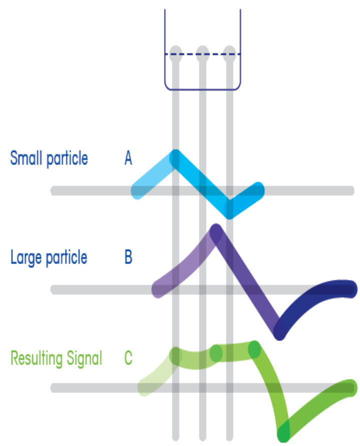


Figure 1.4 Multiple piece metal effect

Figure 1.4 shows the signal from a small piece of metal ('A'), followed by a larger piece, ('B'). The detector does not see the two separate signals, but it does see the combined signal ('C') formed by the signals of both metal piece A and metal piece B coming together as one.

Before signal C has a chance to change polarity (and therefore be detected), it is overpowered by the effects of the second piece of metal and as a result, the first piece of metal is not detected. If a third large piece of metal arrives, the first two pieces of metal may not be detected − and so on. This is a serious limitation of the Zero Crossover method.

3. **Inverse Detection:** Some packaged products deliberately include a metal object as part of the packaging or part of the product itself. This might be a specific component or a free gift – but whatever its form or function, metal detectors can also be used to verify that such a required metal object is present in a packaged product. This is usually achieved by reversing the action of the reject timer so that product containing no metal is rejected, whilst product containing metal is accepted.

Key factors for to be considered when selecting / installing the Detector:

1. **Electronic design consideration:**

- **Stability:** to operate consistently without false rejects or erratic detections, and should not require periodic adjustment

- **Electronic drift:** Frequency and phase stability of highly-tuned electronic circuits within the metal detector are key to minimising electronic drift.

- **Electrical Noise and Radio Frequency Immunity (RFI):** In the manufacturing environment, there are numerous Radio Frequency Interference sources, such as fluorescent lighting, mobile devices, inverter (and variable frequency) drives etc. These kinds of items all have the potential to interfere with the operation of metal detection systems. Hence metal detector shall incorporate design features with high degree of immunity towards RFI

- Metal detection systems with **self-checking and continuous condition monitoring features** can offer significant benefits by providing early warning of a potential system failure.

2. Mechanical design consideration:

- **Environmental Protection**: If the product is high-risk, the metal detector should be constructed to withstand harsh conditions, deep cleaning and sterilisation routines. Example dairy products.

- **Vibration immunity:** Very small movements in mechanical construction (such as expansion due to temperature, mechanical shock, vibration etc.) can cause a coil system imbalance that may cause the metal detector to false-trigger, drift or go out of balance Good mechanical design (such as enhanced potting techniques) go a long way to minimising these potential failure modes.

- **Conveyer system design:** Metal detectors emit a high-frequency signal which causes tiny eddy currents to flow all around the metal structure of the conveyor. These eddy currents have no effect on the detector if they remain constant; however, if the conveyor structure has an intermittent joint of variable resistance (even at a remote distance from the detector), the eddy currents change. This creates an intermittent signal that can be then picked up by the detector and result in a false trigger.

  Typical sources of eddy current loops are any intermittent metal-to-metal contact such as bolted conveyor assemblies non-insulated supports, pulley shafts and bearings, chain drives and guards, reject supports and metal conduit clamps.

To obtain the best and most reliable performance, fully welded structures are required. These should incorporate:

- Correct metal-free zones
- Properly insulated rollers and pulleys
- Fully welded cross-structures
- Insulated detector head mountings

Conveyor belting materials should be metal-free and manufactured to a very high standard, using suitable contaminant-free joints. Anti-static belting materials should be avoided.

- **Reject Mechanism Design:** A correctly specified system should be fool-proof and capable of rejecting all contaminated product under all circumstances, no matter how frequent the occurrence, and no matter what the location of the metal within the product.

- **Hygienic design:** Hygienic design principles should be applied to every aspect of the system, with the aim of eliminating dirt traps and ensuring easy cleaning, so design features should include:

  - Elimination of cavities/bacterial traps
  - Sealing of all hollow sections
  - Avoidance of ledges and horizontal surfaces
  - Hygienic management of electrical cables, trunking and pneumatic services

Factors limiting the Sensitivity

1. Types of Metal

Metals can generally be categorised as being either ferrous, non-ferrous or stainless steel. The sensitivity of a metal detector will vary dependent upon the type of metal contaminant present. The ease of detection depends on the magnetic permeability of the metal contaminant (i.e. how easily it is magnetised), as well as the electrical conductivity of the metal contaminant.

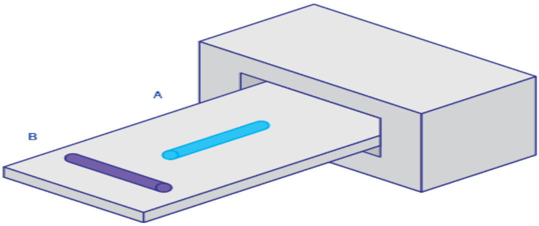
Metal Type	Magnetic Permeability	Electrical Conductivity	Ease of Detection
Ferrous (chrome steel)	Magnetic	Good Electric Conductor	Easily Detected*
Non Ferrous (brass, lead copper)	Non Magnetic	Generally Good or Excellent	Relatively Easily Detected**
SS (various grades)	Usually Non Magnetic	Usually Poor Conductors	Relatively Difficult to Detect

Characteristics of various types of metal

Notes:
* Typically the easiest metal to detect in both wet and dry applications, due to the magnetic properties
** Relatively easily detected in dry applications; however; more difficult to detect in wet applications due to non-magnetic properties

2. Shape of Metal and Orientation Effect

If a non-spherical particle of metal, such wire passes through a metal detector, it will be easier to detect when passing in one particular orientation, compared to another orientation. This is known as the 'orientation effect'.



	A	B
Ferrous	Easy	Difficult
Non-Ferrous	Difficult	Easy
Stainless Steel	Difficult	Easy

Figure 1.5 metal orientation

The orientation effect is only evident when the diameter of the wire is less than the spherical sensitivity of the metal detector. For example, with the detector sensitivity set at 1.5mm diameter, only wires thinner than 1.5mm diameter will show the orientation effect. If the detector sensitivity is increased to 1.0mm, only wires less than 1.0mm diameter will cause a problem. If the diameter of a wire is only about 1/3 the diameter of the detectable sphere, the wire may not be detectable, no matter what its length.

Sensitivity Levels of Different Sized Spheres and Lengths of Wire

Below table compares a detector's ability to detect four different wire samples at various detector sensitivities. The left-hand column shows four different sensitivities

Spherical Sensitivity	Steel Paper Clip Dia 0.95mm (0.037")	Tinned Copper Wire Dia 0.91mm (0.036")	Copper Wire Dia 1.37mm (0.054")	Stainless Steel Wire – EN58E (304) Dia 1.6mm (0.063")
1.2mm	1.5mm long	3.5mm long		
1.5mm	3.0mm long	9.0mm long	3.0mm long	8.0mm long
2.0mm	6.0mm long	26.0mm long	8.0mm long	24.0mm long
2.5mm	11.0mm long	55.0mm long	18.0mm long	64.0mm long

As an example, when operating at 1.5mm diameter, the piece of tinned copper wire would need to be 9mm long to guarantee detection. At 2.0mm sensitivity, this would increase to 26mm in length before detection could be guaranteed. It can be seen that a small change in detector sensitivity (in terms of ball diameter) will make a great difference to its sensitivity with respect to wire pieces.

3. Aperture dimension / position of metal in aperture

A large-aperture detector is less sensitive than a detector with a smaller aperture. Both aperture width and aperture height have an influence on the detector's sensitivity, but changes in the aperture height (or the smaller aperture dimension) will have a greater effect. Typically, the detectable ball size at the centre of a rectangular aperture is approximately 1.5 to 2.0 times greater than the size of the ball detected at the aperture corners; however, this may vary dependent upon the manufacturer and specific design.

4. Environmental condition

Metal detectors can be influenced, to varying degrees, by adverse environmental conditions such as airborne electrical interference, plant vibration and temperature fluctuations. Ovens, freezing-tunnels and hot water wash-down all create thermal shock that can result in false reject signals. Unless good design techniques are employed to eliminate the problem, the only solution may be to reduce the sensitivity of the detector.

5. Inspection speed

The upper limit of inspection speed will vary from manufacturer to manufacturer, but ultimately, it will be determined by the detector aperture height. Typically this will be a maximum of around 4m/sec (26 ft/sec) for an aperture of 125mm (5”) in height. Minor modifications are usually possible to extend this range further

6. Inspecting Dry Non Conductive Products (Milk Powder)

Dry product are however it is likely to be neither conductive nor magnetic and therefore has a negligible product signal. Any signal it could possibly have will be so close to zero (or zero phase angle) it will be insignificant. Detectors operating at high and ultra-high tuned frequencies (typically in the region of 800 Khz and 900 Khz) are available which deliver high levels of overall sensitivity and are especially good at detecting stainless steel type contamination.

Milk powder Inspection diagram:

The vibration signal (vector) is represented by the dark **blue arrow** and it is noted that the vibration signal is aligned to the zero phase point along the reactive axis. Vector representation diagram explain how the signals from metals are generated and why ferrous metal is generally easier to detect than stainless steel.

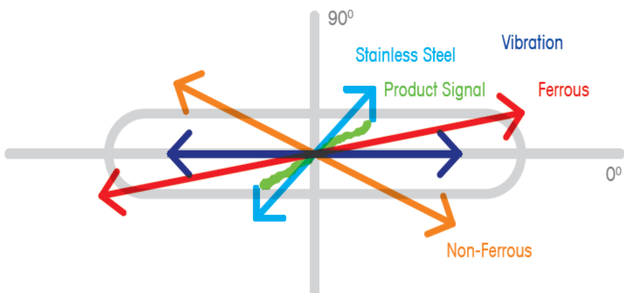


Figure 1.6 Vector diagram for Milk Powder

There are two types of signals created by various metals as they pass through the coils of a metal detector: these are known as *'reactive'* and *'resistive',* according to the conductivity and magnetic permeability of the metal. The signal from ferrous metal is primarily reactive, while the signal from stainless steel is primarily resistive.

- The signals increase to a maximum as they pass through the first coil
- The signals decay to zero as they pass through the centre coil
- The signals again increase to a maximum when passing through the third coil
- The signals have varying 'phase angles' primarily determined by the metal type (reactive and resistive components

Depending on the operating frequency of the metal detector and its aperture size used signals from pieces of ferrous metal are larger than signals from pieces of non-ferrous or stainless steel metal of the same size. To improve the metal detector's ability to detect metal and to reduce the impact of vibration, special circuits can be used to amplify the signals by differing amounts, according to phase. This technique is known as '***Phase-Sensitive Detection (PSD).***

The PSD is shown as a long thin **grey oval** called the 'detection envelope', and for a signal to be detected, it must pass outside the detection envelope.

If using tuned high or tuned ultra-high frequencies and detectors with the right size aperture for the product being inspected the achievable sensitivity levels will be excellent especially with respect to stainless steel detection levels

Below table shows the typical sensitivity level for dry product inspection when using tuned and ultra-high frequency technology:

Aperture size	Ferrous metal	Non-ferrous metal (brass, copper and aluminium)	SS 316 grade non magnetic
350mm X 50 mm	0.50 mm	0.40 mm	0.60 mm
350mm X 125 mm	0.70 mm	0.70 mm	0.90 mm
350mm X 200 mm	0.85 mm	0.95 mm	1.10 mm

From the Figure 1.6 one can see that both the vibration signal (**dark blue arrow**) and the product signal (**green vector**) are contained with the detection envelope and as such go undetected. The metal signals however all appear outside the boundary of the detection envelope and are therefore are detected by the metal detector

When inspecting wet or conductive dairy products such as yoghurt, icecream, cheese and metallised film packed products, the situation is different. The wet product itself creates a 'product effect signal' in the detector and this signal needs to be cancelled out before inspection can begin.

7. Inspecting Wet Conductive Products (Cheese, Yoghurt, ice-cream etc.)

When a wet (or conductive) product passes through a metal detector it will exhibit a signal which can be either mainly reactive or resistive. Depending on the product. To successfully detect metal, the metal detector has to ignore the product signal at the same time as being capable of detecting the smallest pieces of metal contaminants possible.

Figure 1.7. shows a metal detector set to inspect a dry product (the PSD is set at the zero phase point) but with the signal exhibited from a wet product, which is clearly outside the confines of the detection envelope and as such would create an unacceptable false trigger from the metal detector.

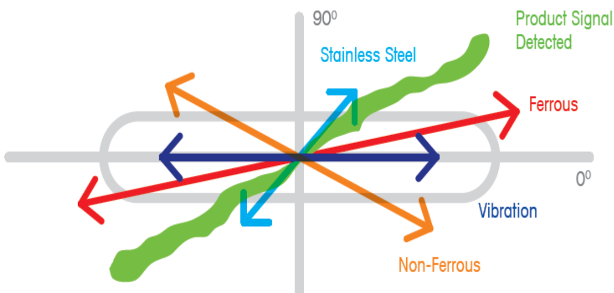


Figure 1.7 Vector diagram for wet dairy products

By reducing the operating sensitivity of the detector, all the signals will become smaller until the product signal no longer passes outside the envelope, making inspection possible. However, reducing the sensitivity will clearly impact the operating performance of the metal detector to a greater or lesser degree.

An alternative solution is that the detection envelope can be rotated electronically until it is aligned with the product signal (Figure 1.8). This is known as 'product compensation' or 'phasing out' the product signal and this can be undertaken by the user during the set-up of the metal detector. The product signal no longer passes outside the envelope, so normal inspection is again possible.

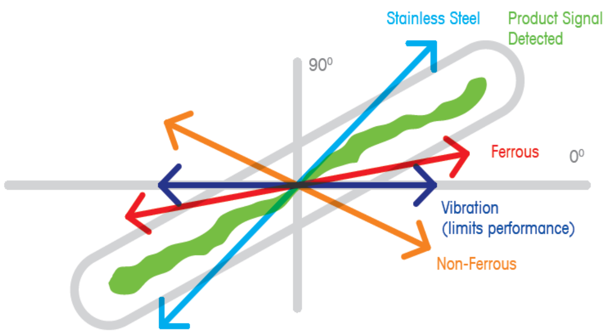


Figure 1.8 Phasing out the product signal effect

However, using product compensation can have disadvantages. It is not uncommon that the signal given off from the product has a similar phase angle to that given off by stainless steel, in that they align themselves very closely. For stainless steel to be detected, the signal from the metal needs to be larger than the signal from the product. This in turn means relatively large signals from stainless steel are needed if the signals are to pass outside the envelope. This results in the detector becoming less sensitive to these metal types. At the same time, small signals from vibration may pass outside the envelope and be detected. Undue sensitivity to vibration is often the limiting factor when inspecting with product compensation.

8. Automatic Product Compensation

If a number of different products or pack sizes are to be checked on the same production line, adjusting the detector for each new product can be time-consuming.

Most modern detectors have an automatic setup or learn facility for configuring product settings in preparation for inspecting product.

Automatic setup routines normally follow a process of requesting a pack or a small number of packs are passed individually through the aperture within specified time limits. In general these routines work fine, however in some cases additional manual adjustment is needed following setup to account for variation in product effect, which is not uncommon in wet product applications. The most sophisticated detectors on the market today have intelligent routines that account for product effect variation during setup to deliver a more optimized and trouble free setup.

9. Product Signal Suppression

In more recent times a new technique has been developed. Rather than simply masking the signal, the new technique actually attempts to remove or reduce the product signal and by doing so renders the online achievable sensitivity considerably better.

"Product Signal Suppression" uses advanced software algorithms to reduce the size of the active product signal by modifying the product signal rather than simply masking it. To do this the metal detector operates with 2 or more active frequencies simultaneously. Detectors of this type are referred to as having **Multi Simultaneous Frequency (MSF) technology.**

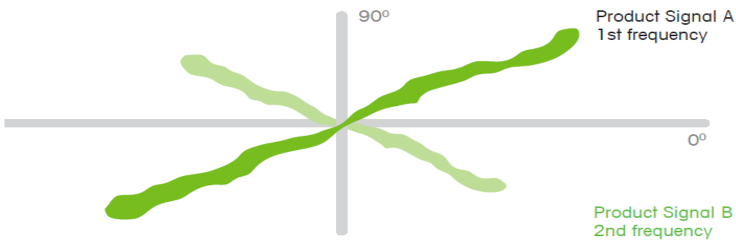


Figure 1.9a Before Product Signal suppression

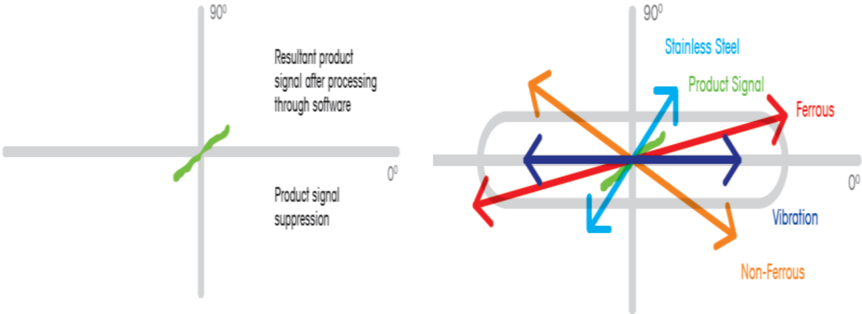


Figure 1.9b After Product Signal Suppression

As the resultant product signal (Figure 1.9b) is considerably reduced and much smaller pieces of metal are now detectable with an online sensitivity far closer to those achieved when inspecting dry products.

Automatic Rejection System

1. Air Blast:

A blast of air blows the product into the reject location. This type of reject is ideal for light, single-file discrete products running on a narrow belt width. It is recommended that a 'gated timer' is used in conjunction with the air blast to ensure the air blast is directed at the centre of the product, regardless of the location of the contamination

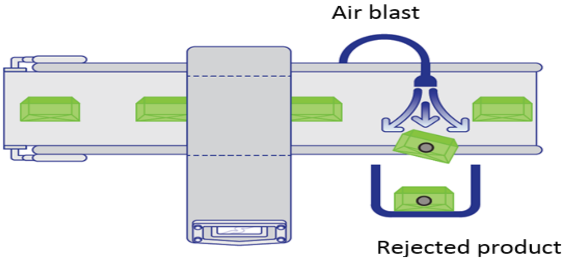


Figure 1.10 Air blast rejection system

2. Punch/Pusher:

This device operates at high speed, and pushes individual product into the reject location. This type of reject is suited to light-weight to medium-weight discrete packs, spaced and oriented on a narrow belt width. The punch/pusher must always be 'gated' to ensure that the punch strikes the centre of the product every time, regardless of the location of the contaminant.

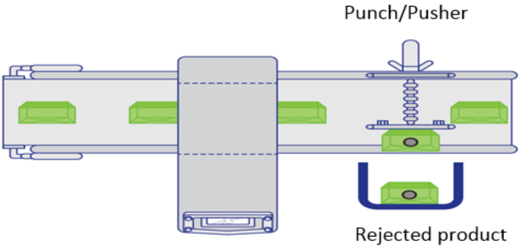


Figure 1.11 Punch / Pusher rejection system

3. End Flap/Dump:

This type of system necessitates a drop in production-line height, if necessary this can be overcome by an incline on the conveyor. The point of pivot can be varied according to the application. This type of reject is suited to small discrete items at random or loose bulk items (dry or sticky) running on a wide, flat or dished inclined conveyor belt.

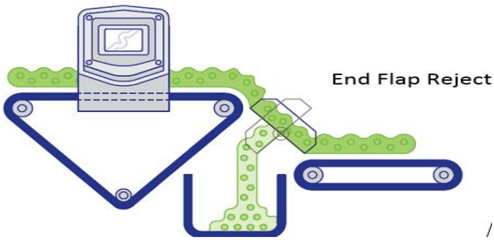


Figure 1.12 End Flap rejection system

4. Retracting Belt:

The end roller moves back to create a gap in the flow, which allows the product to drop through. After product rejection, the roller moves forward to the closed position faster than the belt speed, avoiding the danger of trapping product. End rollers can be made in a knife-edge format to ease the transfer of small items. This type of reject is very reliable for most applications. Where more than one product passes in-line across the width of the conveyor, a retracting belt rejection mechanism should be used.

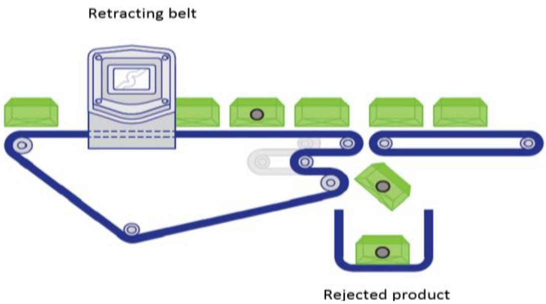
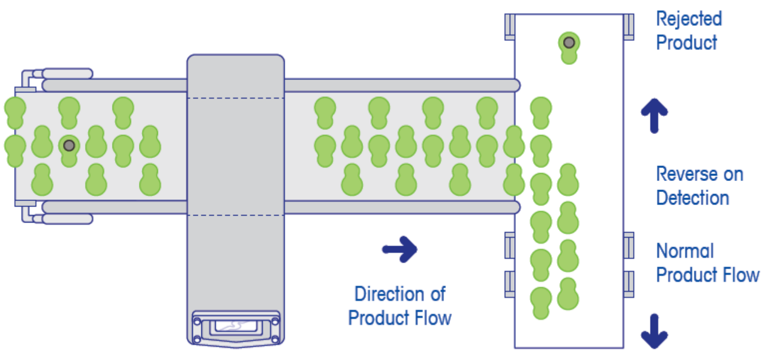


Figure 1.13 Retracting belt rejection system

5. Reverse Belt:

Two types are available. On detection of metal, either the inspection conveyor or the feed-off conveyor is reversed for a short time, so as to divert contaminated product into a reject container. This type of reject is ideal for bulk loose, dry or sticky product, or multiple random items.



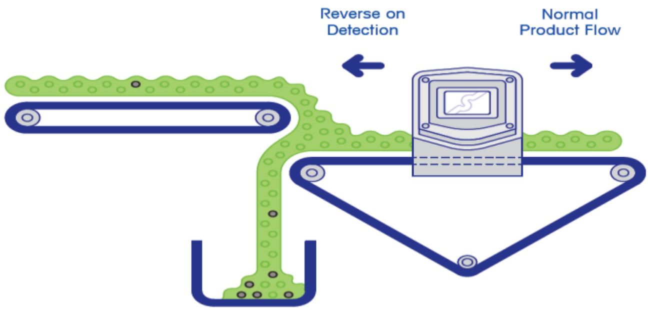


Figure 1.14 Reverse belt rejection system

6. Stop alarm system:

Typically, they are used on large bags or boxes where rejection is difficult. When metal is detected, the conveyor should stop immediately and all products on the conveyor belt should be removed for investigation.

The system should also be fitted with an audible and/or visual alarm. It should only be possible to restart the system using a key held by a nominated person or have a controlled reset as an option. These solutions are generally considered high-risk, and depend entirely on the competence of the line operator.

Gravity feed inspection system- Milk powder

The milk powder falls under gravity and with the relatively high volumes that can pass through a small detector aperture delivering, very high sensitivity can be achieved. The detector and auto-reject should be mounted on a rigid framework with sufficient space between them to ensure that metal contamination is always rejected.

Consideration should be given to the design of the reject mechanism with regard to the potential for product leakage through the reject position. There can be an accumulation of product dust in the reject device that can potentially leak out of the reject position, resulting in unacceptable product waste. In such applications, a sealed reject type is recommended.

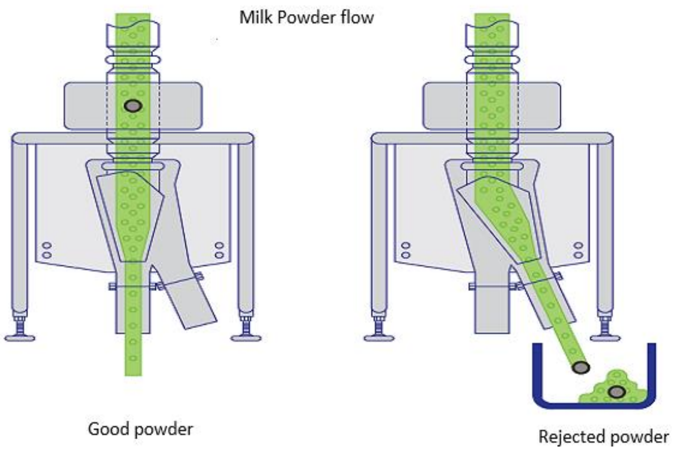


Figure 1.15 Gravity feed inspection for Milk powder

Initial fall height of the Milk powder:

The fall-height of the detector is normally expressed from the point at which the product begins to fall to the top of the detector flange. This height will determine the product's velocity at the point of inspection. Ideally, the fall height should be reduced to a minimum by locating the equipment as close as possible to the point of initial fall.

By way of general guidance, the maximum fall-height for a 150mm diameter-aperture detector would be approximately 800mm; however, this may vary depending upon the actual detector specification. As the fall-height is increased, the distance between the detector and the reject valve must also be increased in order to maintain adequate time for the valve to respond.

System Response Time:

This covers the speed of response of the relay or solid-state output, air solenoid or air cylinder. It also covers the time taken to move the reject diverter to the reject position.

Reject Angle:

The reject angle must not be so large that it creates a blockage or bridges the product. As the length of the reject flap is reduced, the reject angle increases. An angle of between 25° to 30° is considered a maximum for most products.

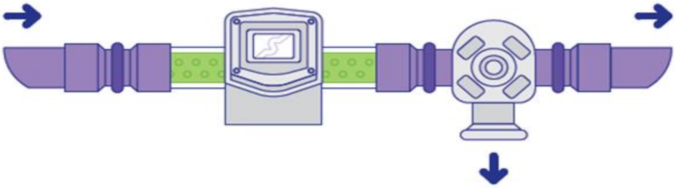
An audible and visual indication of system status e.g. product has been rejected shall be notified to the operator.

Inspection of liquids/slurries/pastes in pipeline system

Inspection of pumped liquids, slurries and pastes such as yoghurt, cheese spreads, ice-cream etc., can be achieved by replacing a short section of metal the transport pipe with a food-grade non-metallic pipe, and then passing it through a metal detector. The choice of the pipe will be influenced by:

- The style of the pipe connection required
- Product type and viscosity
- Nature of the product
- The product temperature
- The pipe pressure expected

When metal contamination is detected, a sanitary three-way valve can operate to divert the contamination. Alternatively, the pump can be stopped and the contamination flushed out manually. The choice of the valve will be influenced by product type (inclusion of product solids) temperature and viscosity.



When product passes through the detector coils and any product effect tends to cancel out signals, and the detector can be adjusted to give high-sensitivity readings. If, however, a void or bubble appears as it passes through the first coil, the detector will sense a large product difference and a false reject may occur with conventional balanced coil metal detectors. But with the development of MSF technology and Product Signal Suppression this effect is reduced and the instance of false rejects is virtually eliminated.

An audible and visual indication of system status e.g. product has been rejected shall be notified to the operator.

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Dr. D.K Sharma
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National Dairy Development Board
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Anand 388001
Gujarat.

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Email: dksharma@nddb.coop /
FSQ-milkcoops@nddb.coop