Principle and Use of Inspection Systems for Food Contaminants

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[Summary] Contaminant inspection systems such as X-ray inspection systems and metal detectors must be chosen, adjusted, and maintained in order to achieve the best performance. These systems have unique characteristics depending on the detection principle. It is important to understand the detection principles for effective contaminant detection and efficient practical use.

1 Introduction

In recent years, consumers are becoming increasingly concerned about the safety of food supplies following food poisoning, food contamination, and radiation scares after the nuclear accident at Fukushima Dai-ichi Power Station. Due to changing consumer awareness, prefectural health inspectors, consumer affairs centers and food makers are receiving increasing levels of complaints about foods.

The most common complaint is about foreign contaminants in food. A single incident of food contamination can ruin a business reputation and may result in losses causing business failure. Consequently, food makers take countermeasures to prevent foreign materials entering their products during production and also implement methods to prevent an occasionally contaminated product from shipping to customers. In these circumstances, the need for contaminant detection systems is increasing year-on-year.

Metal detector and X-ray inspection systems are typical contaminant detection systems. The former detects changes in the electromagnetic field caused by metal contaminants to confirm the presence/absence of metals. Only metals can be detected by metal detectors and the relatively simple construction results in a lower price and smaller size. The latter X-ray inspection systems use the same X-ray as medical X-ray diagnostic systems to image foods and detect the presence of various contaminants, such as metals, plastics and glass. Unlike metal detectors, X-ray inspection systems can detect non-metallic items but they are relatively large and costly.

This article explains the operation principles of metal detector and X-ray inspections systems, and describes the ideal applications. Please use this article when wanting to introduce a contaminant inspection system with stable and secure operation.

2 Metal Detectors

A metal detector is a machine for detecting metal contaminants. Inspected products pass through the metal detector and changes in the electromagnetic wave field are measured to detect the presence/absence of metals in products. Metal detectors can be broadly classified into two types: metal detector and metal detector for aluminum-type packages. Figure 1 shows a typical Anritsu metal detector and metal detector for aluminum-type packages. The detection principles, contaminant detection characteristics and operation methods for each type are explained below.

Metal Detector (KDS8102BW)

Metal Detector for Aluminum-type Packages (KD8200AW)

Figure 1 External View of Metal Detectors

2.1 Principle of Metal Detector

The metal detector is a general-purpose metal detector that can detect any metal; it is characterized by its use of an alternating electromagnetic field for detection. It is composed mainly of a detector head with opening through which products pass on a belt conveyor, and a display section that controls the machine operation and displayes the detection results.

Although the metal detector can detect all metallic contaminants, it detects ferromagnetics, such as iron, nickel, cobalt, etc., and non-magnetic materials, such as stainless steel, aluminum, copper, etc., using different detection principles. In the case of ferromagnetics, the metal is magnetized by the alternating electromagnetic field generated by the Send (Tx) coil and the lines of magnetic force are drawn toward the metal side. This deviation is detected by the differential Receive (Rx) coil to assess the presence/absence of metal (figure 2b). Conversely, in the case of non-magnetic materials, an eddy current is induced by the alternating magnetic field generated by the Tx coil, in-turn creating a local magnetic field near the metal. Deviations in this magnetic field are detected by the differential Rx coil to assess the presence/absence of metal (figure 2c). The main difference from detection of ferromagnetics is that the eddy current phase is delayed by 90° compared to the Tx coil phase (figure 3). As a result, the machine detection circuits are constructed to detect the two types of phase signals.

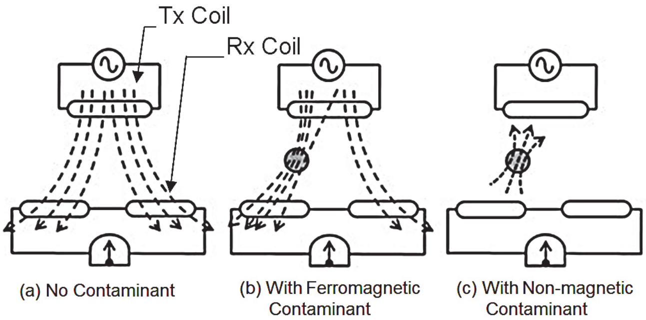


Figure 2 Principle of Metal Detector

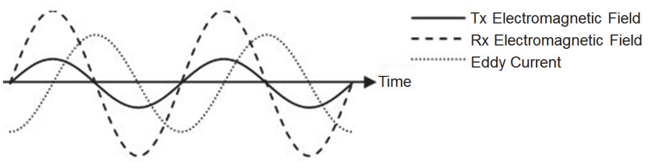


Figure 3 Relationship between Magnetic Field and Eddy Current

When using an metal detector, there is an optimum frequency for the electromagnetic field depending on the target magnetic contaminant[1]. Figure 4 shows a schematic example of the characteristics for iron and SUS. Generally, for non-magnetic materials, the detection sensitivity is higher at higher frequencies compared to ferromagnetics. To get the best metal detector detection sensitivity, the Anritsu metal detector generates dual alternating signals simultaneously and has a detection circuit that can detect two phase signals.

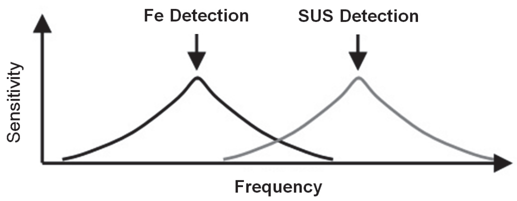


Figure 4 Relationship between Magnetic Field Frequency and Signal Levels

2.2 Principle of Metal Detector for Aluminum-type Packages

If an metal detector is used to inspect foods packaged in aluminum foil such as retort pouches, candies, etc., it is difficult to assess the presence/absence of metal contaminants in the food due to the effect of the aluminum packaging materials. Consequently, the metal detector for aluminum-type packages is used to inspect aluminum-packaged foods. It magnetizes the metal with a permanent magnet and detects changes in the magnetic field with a pickup coil. Figure 5 shows the basic structure of the metal detector for aluminum-type packages and its detection principle. The metal detector for aluminum-type packages is mainly composed of a belt conveyor, a magnetizer with a permanent magnet, and a detection head with a pickup coil. Inspected products are carried on the belt conveyor through the magnetizer which magnetizes any ferromagnetic contaminants in the product while leaving non-magnetic materials such as aluminum pouches unmagnetized. Next, the inspected product passes on the belt conveyor through the detection head creating an electromotive force in the pickup coil due to the Faraday effect. This voltage is detected to assess the presence/absence of metal contaminants. Non-magnetic stainless steel is used in many food-processing plants. Worn stainless steel parts can be magnetized, so the metal detector for aluminium-type packages can detect those.

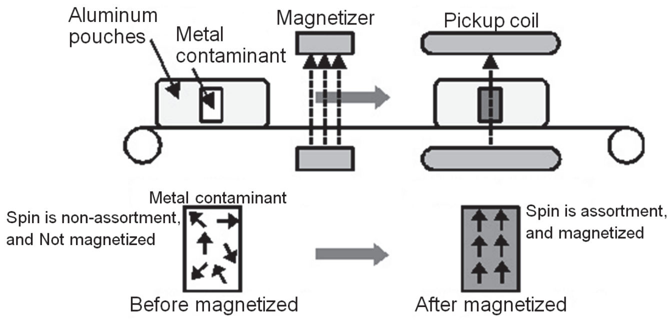


Figure 5 Detection Principle of M Series Metal Detector

2.3 Contaminant Detectability

The detection sensitivity of a metal detector changes according to the contaminant material, shape, orientation, and position. The contaminant detection characteristics of the metal detector and metal detector for aluminum-type packages are described below. It is important to have a good understanding of the contaminant detection characteristics when purchasing and using a metal detector.

2.3.1 Contaminant Materials

When performing contaminant inspection using an metal detector, the detection sensitivity is highest for ferromagnetics, such as iron, and drops successively for non-magnetic materials in the order of aluminum and SUS. Since the detection sensitivity of non-magnetic materials is determined by the flow of the eddy current, materials with low resistivity have higher detection sensitivity and can be detected more easily (table 1).

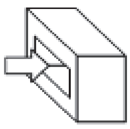
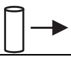
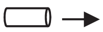
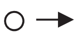
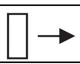
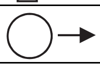
Table 1 Electrical Resistance of Non-magnetic Materials

Element	Electrical Resistance (μΩcm)	Detection Sensitivity
Cu	1.72	Hi ↑
Al	2.75	
Zn	6.1	
Pb	21	
SUS	55	↓ Lo

2.3.2 Contaminant Shape

The detection sensitivity of the metal detector changes with the contaminant shape and orientation in the inspected product. For example, a needle-shaped iron contaminant oriented in the conveyance direction has high detectability, whereas a disc-shaped contaminant oriented at right angles to the horizontal plane has high detectability (table 2).

Table 2 Relationship between Detection Sensitivity and Orientation of Contaminant

Conveyance Orientation	Shape	Contaminant Orientation	Fe	SUS
Metal Detector (Coaxial)  Detection head	Needle		△	△
			◎	△
			○	△
	Disc		◎	○
			△	◎
			○	△

2.3.3 Detection Position

As shown in figure 6, detection sensitivity differs with product orientation, so if the detector head opening is too large for the inspected product, it causes a drop in detection sensitivity, it is important to choose a metal detector with and detection head opening matching the size of the inspected product. Using the metal detector (coaxial), the detection sensitivity is high at positions A, C, G, and I, but low at position E. Conversely, using the metal detector for aluminum-type packages, the detection sensitivity is high at positions A, B, C, G, H, and I, but low at positions D, E, and F.

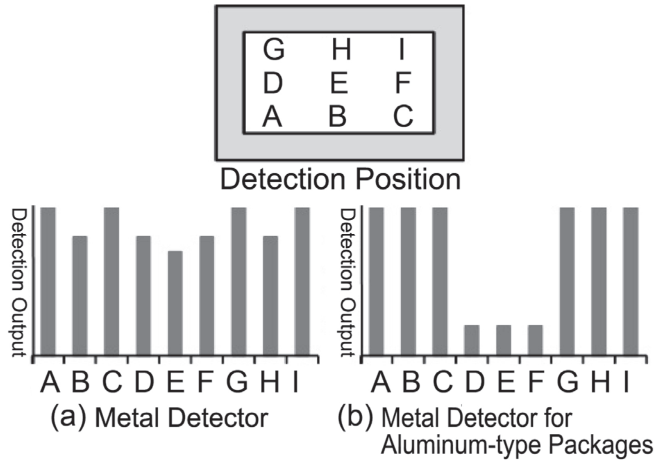


Figure 6 Relationship between Detection Sensitivity and Position

2.3.4 Effect of Inspected Product

At contaminant inspection using an metal detector, sometimes an eddy current may occur in the inspected product and the detection sensitivity changes according to the type and shape of the inspected product. On the other hand, at contaminant inspection using a metal detector for aluminum-type packages, since the inspected product is not magnetized, the detection sensitivity is constant irrespective of the type and shape of the inspected product. The following describes the relationship between the type and shape of the inspected product and their impact on the metal detector.

- Conveyance Orientation
  As an inspected product enters the head, a larger eddy current flows in the product as the aperture of a planar product increases, having a larger impact on detection sensitivity.
- Packaging Shape
  A larger eddy current flows in larger inspected products, having a larger effect. Even when the inspected product is small, if similar small products are in contact with each other, there may be a large product effect.
- Water and Salt Contents
  Since less eddy current flows at lower inspected product water and salt contents, the product effect is smaller and detection sensitivity is higher (figure 7a).
- Temperature
  Since less eddy current flows in colder inspected products, the inspected product effect is smaller and detection sensitivity is higher (figure 7b).

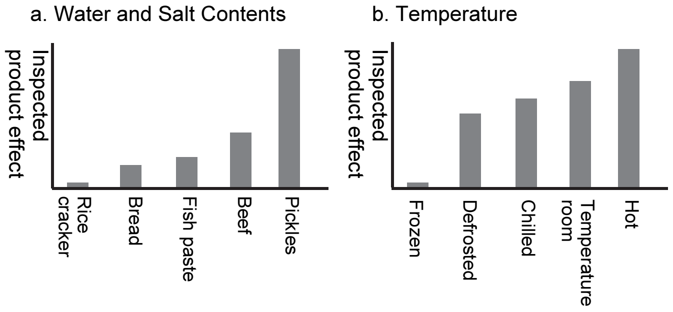


Figure 7 Effect of Inspected Food

2.4 Selecting Metal Detector and Best Operation Method

This section describes how to choose an metal detector for stable and high sensitivity operation as well as the setting and maintenance methods.

2.4.1 Selecting Metal Detector

Note the points in table 3 to select the best metal detector matching the characteristics of the inspected product.

Table 3 Selecting Metal Detector

Item		Details
Inspected Product	Packaging Conditions	To inspect products using an aluminum foil, choose a metal detector for aluminum-type packages such as the KD8200AW.
	Size	Detection errors are caused by the inspected product touching the detection head, so it is important to choose a slightly larger aperture size than the inspected product while remembering that sensitivity drops if the size is too large.
	Conveyance Conditions	If the conveyed inspected product is liquid, choose a pipe-type MD.
Metal Detector Functions	Changes in Conveyor Speed	When the conveyor speed must be changed to meet the need to inspect different product types, choose an MD with an adjustable conveyor speed.
	Waterproofing	When the inspected product is a raw material or prepackaged item, choose a waterproof MD that can be washed.

2.4.2 Setting Metal Detector

As explained in section 2.3.4, since the type and shape of the inspected product has an effect on detection sensitivity, it is necessary to adjust the inspection and evaluation conditions according to the product to achieve the best detection prior to commercial operation of the metal detector. The key points are listed in table 4.

Table 4 Metal Detector Setup

Item	Details
Inspected Product	Use the same inspected product as the manufactured product.
	Use an inspected product at the same product temperature as a manufactured product.
	Feed inspected products in the same orientation as manufactured products.
	Determine the inspection conditions using one inspected product. However, at adjustment of detection limits, use multiple inspected products in consideration of random inspected product effects.
	When the inspected product is frozen, since the product effect increases as the temperature rises, it is better to use an inspected product that has been left at normal temperature for a short time.
	When the inspected product size is inconsistent, it is best to use a large product because larger products have a larger product effect.
Environment	Use the same temperature as at manufacturing.
	Operate peripheral equipment in the same way as at manufacturing.
Checking	After adjusting the inspection and evaluation conditions, use pass products to confirm there are no detection errors.

2.4.3 Checking Metal Detector Sensitivity

The detection sensitivity should be checked before starting and after finishing inspection to ensure accurate detection and it is important to allow the metal detector to warm up for at least 30 minutes after power-on (60 minutes for metal detector for aluminum-type packages) to allow it to stabilize first. Moreover, it is important to pay attention to the location of test pieces (figure 8). As explained in section 2.3.3, since the relationship between the inspection location and detection sensitivity differs according to the metal detector type, test pieces are attached to the positions with the lowest detection sensitivity based on the characteristics of the metal detector model to confirm the sensitivity.

When confirming the sensitivity of a metal detector for aluminum-type packages, it is critical to demagnetize the test pieces. Since the magnetization of test pieces magnetized by the metal detector for aluminum-type packages magnetizer does not decrease very much, use the following procedure to demagnetize them.

(1) As shown in figure 9, place the test piece close to the degausser, switch on the degausser power, pull the degausser about 1 meter away from the test piece, and switch off the power.

(2) Pass the test piece between the magnetizer and detection head and check that it is not evaluated as a contaminant (confirms it is demagnetized).

(3) Confirm that the test piece is detected when attached to the inspected product.

Figure 8 External View of Test Pieces for Metal Detector

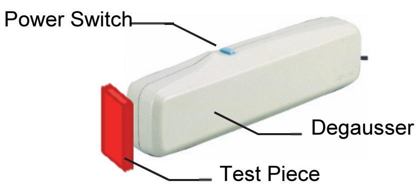


Figure 9 External View of Degausser

2.4.4 Maintaining Metal Detector

Table 5 lists the inspection points to assure normal metal detector operation.

Table 5 Maintenance of Metal Detector

Item		Details
Before Starting	Contact Points	Check for any contact points with upstream and downstream belt conveyors.
	Conveyor Belt misalignment	Check that the conveyor belt misalignment.
	Sensitivity Check	Note the points in section 2.4.3 and confirm the detection sensitivity.
After Finishing	Sensitivity Check	Same as before starting.
	Cleaning	Always power-down and disconnect the power plug before washing down with water or a neutral detergent and cloth. When washing down a waterproof model with water, use water no hotter than 40°C. NEVER use a metal brush or organic solvent such as thinners.
Weekly	Conveyor Belt	Remove the conveyor belt and check that that there is no fraying at the belt edges or peeling, etc.
	Motor, Rollers, Conveyor Belt	Rotate the belt conveyor and check that there are no abnormal noises, belt misalignment, etc.

2.4.5 Causes of Metal Detection Errors

Table 6 lists probable causes of detection errors or unstable metal detector operations.

Table 6 Causes of Detection Errors

Item	Details
Physical Shock	Conveying of heavy products can cause detection errors if the detection head is hit by products.
	Detection errors can be caused by the upstream and downstream belt conveyors touching the metal detector belt conveyor.
	Detection errors can be caused if the metal detector is rattling or shaking due to loose lock nuts on the legs.
Electrical Interference	Detection errors can be caused be nearby electrical noise from nearby inverter controlled equipment.
	EMI from nearby inverters, etc., can cause detection errors. Install the metal detector well away from external noise sources and run power cables, etc., in metal duct to shield noise.
	Detection errors can be caused by electrical interference from other nearby metal detectors. Either change the send coil frequency or ensure that the metal detectors are at least 2 to 5 meters apart.
Other	Detection errors can be caused by debris accumulating between the detection head and conveyor belt. Clean regularly to prevent debris accumulation.

2.5 Summary of Metal Detectors

This first section has explained the types of metal detectors, operation principles, detection characteristics, and operation methods. To purchase and use metal detectors without problems, it is important to fully understand their features and functions.

3 X-ray Inspection Systems

The X-ray Inspection System irradiates the inspected product with X-rays and detects the presence of contaminants by measuring the penetrated amount of X-ray. Figure 10 shows a typical X-ray inspection system which can be used to detect a wider range of contaminants, such as stone, glass, bone, plastics, etc., that cannot be detected by metal detectors. In addition to detecting contaminants, the X-ray inspection system can be used to check for missing items, broken parts, etc., by checking the shape of the X-ray image, which is a key difference from the metal detector.

X-ray inspection systems can be divided into two types: single energy types using one X-ray energy band (single XR hereafter) and dual energy types using two X-ray energy bands (dual XR hereafter). This detection principle and the performance of each type are described below.

Figure 10 External View of X-ray Inspection System

3.1 Principle of Single X-ray Detection

Figure 11 shows a schematic diagram of the single XR. It is composed of an X-ray generator, a X-ray linear array detector, and a belt conveyor. At inspection, X-rays are irradiated from the source and measured continuously by the X-ray detector. The inspected product carried on the belt conveyor passes through the X-ray beam to take a X-ray image at the X-ray detector. Figure 12 shows a schematic of a single cross section of the X-ray image taked by a single XR. As shown by the diagram, the presence of a contaminant in the inspected product changes the penetrated amount of X-ray and this data can be used to detect the presence of the contaminant.

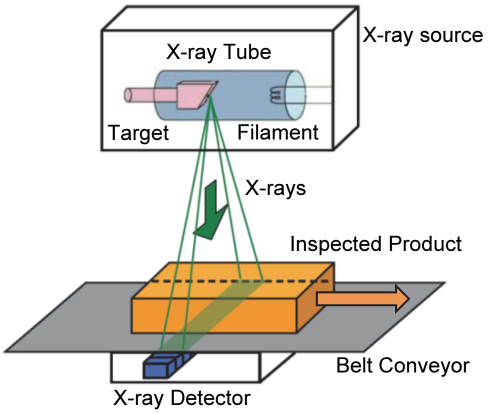


Figure 11 Principle of X-ray Inspection Systems

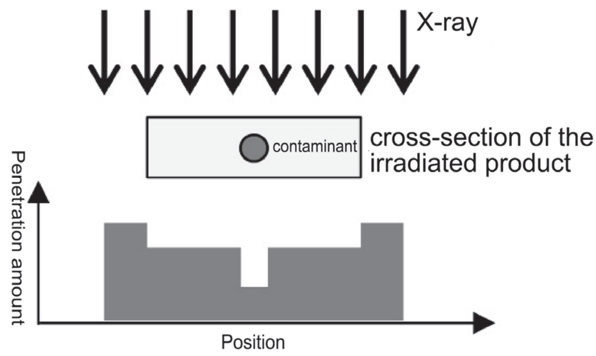


Figure 12 X-ray irradiation on a product with contaminant

As long as the inspected products have uniform characteristics, contaminant detection can be achieved with measuring difference of X-ray penetration rate. However, inspected products often have uneven characteristics in some level. The unevenness can affect X-ray penetration rate to make contaminant detection much harder. Therefore all captured images are subjected to image-processing using various combined algorithm to reduce the product effects and emphasize the contaminant to be detected easier. For example, when discriminating a contaminant from product concavity and convexity, contamination is determined by difference in penetrated area size recognized in a product or different penetration amount measured between where the contaminant may be and products irregularity. Then the best suitable combined algorithm corresponds with the product and contaminants would be selected and used to achieve contamination detection. An example is shown in figure 13. This example uses the best algorithms for minute contaminants, for needle detection and for contaminants with large areas. When there are several contaminants in a product, there is a best algorithm for each one, depending on the contaminant area and size. The detection objective is divided between these algorithms and then finally integrated to increase the contaminant detection performance.

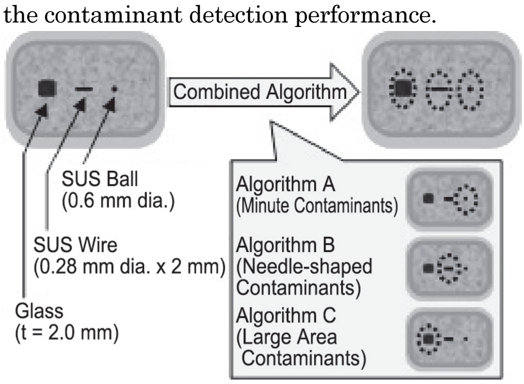


Figure 13 Concept of Combined Algorithm

3.2 Principle of Dual X-ray Inspection

The single XR measures the penetrated amount of X-ray and evaluates the presence of contaminants at parts where the penetrated amount of X-ray is small. However, if there are large changes in the inspected product thickness, or if inspected products may overlap each other (such as a pack of wiener sausages), the penetrated amount of X-ray changes greatly and any contaminant may not be detected because it is obscured by changes in the inspected product penetrated amount of X-ray. An example is shown in figure 14. It is the image of an inspected bag of chocolates. As we can see from the image, overlapping parts of the chocolates have the same dark appearance as the contaminant, making it difficult to discriminate one from the other. The dual XR is a method for solving this type of problem. Like the single XR method in which the product is irradiated with X-rays and the penetrated amount of X-ray is measured by the X-ray detector, instead of measuring the penetrated amount of X-ray for a single energy band, the dual XR simultaneously measures the penetrated amount of X-ray for two different energy bands. Since X-ray penetration rate varies with material and X-ray energy, the relationship between the contaminant and the inspected product penetration rate differs with the two energy bands and this can be used to lower the product effect and emphasize the contaminant[2].

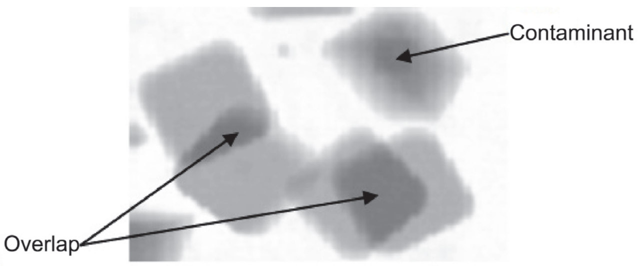


Figure 14 X-ray Image of Overlapping Products and Contaminant

3.3 Contaminant Detection Characteristics

This next section describes the X-ray inspection system detection characteristics. This system measures the penetrated amount of X-ray that pass through the inspected product and detects the presence of a contaminant from the differences in the penetrated amount of X-ray. Consequently, it has a high detection sensitivity for contaminants with low X-ray penetration rate. Table 7 shows the relationship between elements found in foods and contaminants and their atomic number, density and the product of atomic number and density. The X-ray penetration rate drops as the product of the atomic number and density increases, so a contaminant like iron with a large product can be easily detected (because it has low X-ray transmissivity and blocks the passage of X-rays through the inspected product)[3].

Table 7 Relationship between Elements and Penetration rate

Type	Common in Foods		Common in Contaminants	
Name	H_2	C	Si	Fe
Atomic No.	1	6	14	26
Density [g/cm^3]	0.1	2.3	2.3	7.9
Atomic No. × Density	0.1	14	33	204
Penetration rate	High ←→ Low			

3.4 Functions of X-ray Inspection Systems

The X-ray inspection can determine the shape of inspected products from the captured X-ray image. Not only can this shape information be used to improve contaminant detection but it also offers the possibility of inspection for things other than contaminants. This usage is explained below.

3.4.1 Masking Function

The Masking function removes parts of the output image from evaluation. For example, it can be used to remove small areas, such as food packaging and containers with a fixed known transmissivity, from the inspection area to help increase contaminant detection sensitivity. Figure 15 shows examples such as edge and can edge masks for part shapes affecting contaminant detection sensitivity.

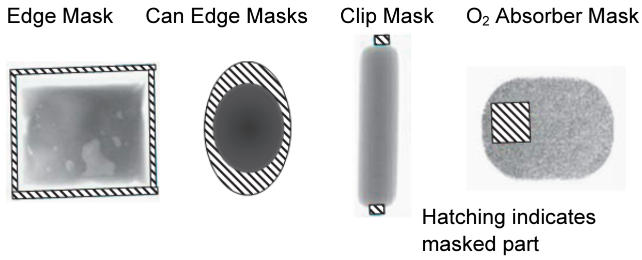


Figure 15 Mask Functions

3.4.2 Package Check

Vacuum-packed products such as sliced ham and transdermal patches can sometimes be caught in the sealed edge risking loss of the protective vacuum. The Package Check function can find such sealing errors as shown in figure 16.

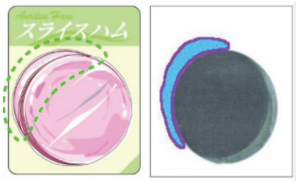


Figure 16 Product caught in the edge of sealing

3.4.3 Missing Product Detection

This function detects missing items in a product with a fixed number of contents. Missing items can be hard to detect using gross weight for products with high weight randomness, but this function easily detects missing items as shown in figure 17.

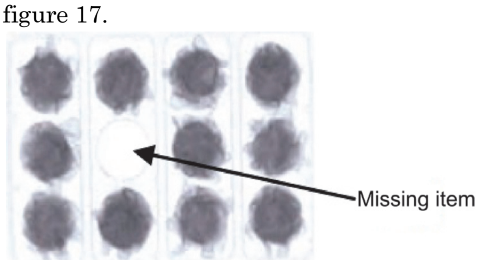


Figure 17 X-ray Image for Missing Product Detection

3.4.4 Shape Detection

This function is used to detect shape irregularities, such as missing parts as shown in figure 18 at analysis of product external shape, area, mass, etc., using captured X-ray images. It is ideal for detecting missing fillings in cream biscuits, donuts, etc.

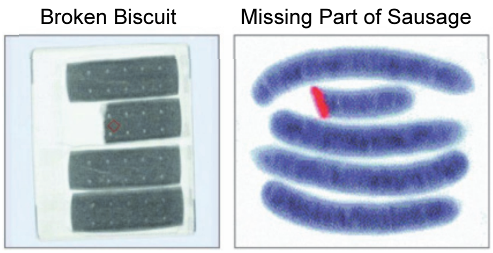


Figure 18 X-ray Image for Shape Detection

3.5 Selecting X-ray Inspection System and Best Operation Method

The next section explains how to select, maintain and operate an X-ray inspection system to assure stable operation with high sensitivity.

3.5.1 Selecting X-ray Inspection System

Table 8 shows the main points to consider when choosing the best X-ray inspection system matching the inspected product characteristics.

Table 8 Selecting X-ray Inspection System

Item		Details
Inspected Product	Size	Choose an X-ray inspection system with an opening matching the size of inspected products.
	Conveyance Conditions	Choose a pipe-type system when conveying liquid inspected products.
	Packaging Conditions	Consider an X-ray leakage prevention mechanism matching the inspected product packaging form. Normal products usually use a curtain type X-ray protection but lightweight or unpacked products may require a stainless type 1 cover while heavy products may require a stainless type 2 cover (figure 19).
Installation Location	Environment	Hot, humid, alcohol vapor, dusty, etc., environments in which forced air cooling of the X-ray source may be difficult require selection of a system with built-in air-conditioning.

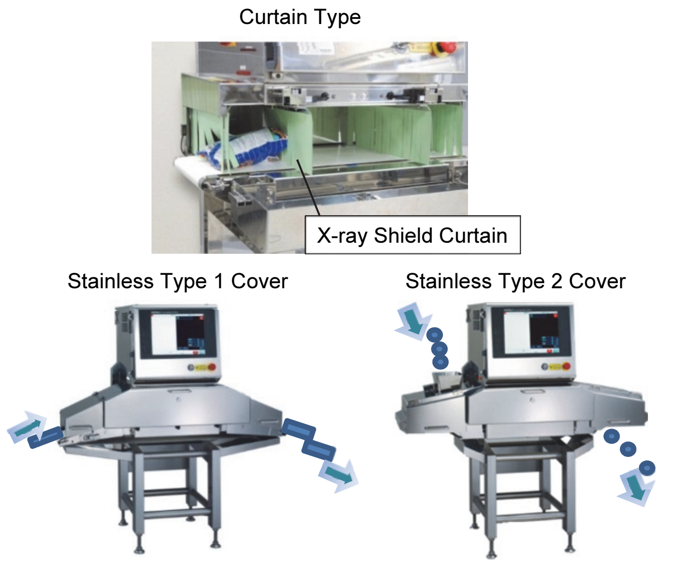


Figure 19 External View of X-ray Leak Prevention Mechanisms

3.5.2 X-ray Inspection System Setup

Before starting inspection, it is necessary to set the best algorithm matching the inspected product as well as the X-ray output and contaminant evaluation conditions. Table 9 lists these points.

Table 9 Setup of X-ray Inspection System

Item	Details
Algorithm	Select the best algorithm for inspected products.
Inspected Product	Use the same inspected products as manufactured products.
	Use inspected products at the same product temperature as manufactured products.
	Feed inspected products in the same orientation as manufactured products.
	Before conveying the first products, feed inspected products with the maximum thickness or adjust the shape of inspected products to feed at the maximum thickness to determine the best X-ray output.
	Deviation in consideration while using multiply products.
Confirmation	After setting, feed normal products and confirm that there are no detection errors.

3.5.3 Confirming X-ray Inspection System Sensitivity

To assure normal detection, it is important to confirm that the required sensitivity is achieved before during and after operation. Figure 20 notes the precautions about the positioning of test pieces for confirming sensitivity. Unlike metal detectors, since surface irregularities and changes in density of inspected products affect the detection sensitivity of the X-ray inspection system, the sensitivity performance must be confirmed by attaching test pieces at various positions on the inspected product.

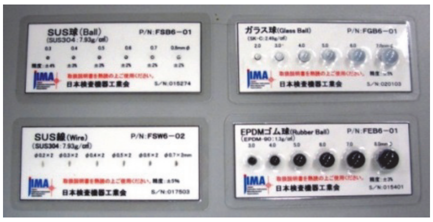


Figure 20 External View of Test Pieces for X-ray Inspection System

3.5.4 Maintenance of X-ray Inspection System

Table 10 lists the inspection items required to assure normal operation of the X-ray inspection system.

Table 10 Maintenance of X-ray Inspection System

Item		Details
Before Starting Work	Emergency Stop Switch	Check that X-ray radiation stops when the emergency stop switch is pressed.
	Contact Points	Check that the X-ray inspection system belt is not touching the belts of upstream and downstream conveyors.
	Sensitivity Check	Note the points in section 3.5.3 and check that the designated sensitivity is achieved.
	Shield Curtain	With the X-ray inspection system off, open the conveyor covers and check the shield curtain for wear and tear. Replace it immediately if any damage or deformation is found.
	Air Filter	Remove the filters and wash and dry them thoroughly before refitting. If the air-conditioning option is installed, clean those filters too.
During Operation	Sensitivity Check	Periodically check (about every 2 hours) that the designated sensitivity is being achieved.
After Finishing Work	Cleaning	Remove the conveyor belt and use a soft cloth to remove any debris stuck to the center of the belt while ensuring that the resin cover is not damaged. Clean off any debris under the conveyor belt or stuck to the shield curtain using a damp cloth.
Weekly	Conveyor Belts	Remove the conveyor belt and confirm that the edges are not frayed.
	Motor, Rollers, Conveyor Belt	Turn the belt conveyor and confirm that there is no belt misalignment or abnormal noise and that the belt is correctly tensioned.
Monthly	Conveyor Roller Cleaning	Check the belt for looseness and clean off any soiling on the rollers with a damp cloth.
	X-ray Resin Cover Inspection	Check the resin covers for any degradation, cracks or damage to ensure that nothing can fall into the belt conveyor.
Annually	X-ray Leaks	Measure the X-ray leakage from all surfaces of the X-ray inspection system and confirm that the levels are in compliance with the regulations.
	X-ray Source Airbag	Check the X-ray source airbag for damage and oil leaks and confirm that the X-ray source connection tube has not been removed.
As Necessary	X-ray generator and X-ray Detector	Since the X-ray source and X-ray detector suffer from aging deterioration, the detection sensitivity may decrease with long-term use. To assure continued high-sensitivity operation, the X-ray source and X-ray detector must be changed periodically. The X-ray Inspection System displays a message at startup requesting replacement when either is about to wear out.

3.5.5 Causes of X-ray Inspection Errors and Solutions

If detection errors may occur due to the effect of wrinkles in aluminum packaging and overlapping inspected products, it is best to feed products so that such errors do not occur. However, if this cannot be avoided, adjusting the noise filter level can prevent detection errors. The noise filter level is an adjustment value that reduces the inspected product effect; if the value is too large, although the product effect is reduced, the contaminant effect is also reduced as well, so it is important to adjust the value correctly.

3.6 Summary of X-ray Inspection Systems

This section has outlined the types of X-ray inspection system, the detection principles, detection performance and best operation methods. Since X-ray inspection systems have more functions than metal detectors, it is important to have a good understanding of their features and functions to achieve the best possible performance. Maintenance, inspection and cleaning are also key ingredients in assuring safe and stable operation.

4 Summary

The upgraded features of contaminant detection equipment are improving detection performance, but the highest performance cannot be achieved unless the best contaminant detection system matching the inspected product and contaminant materials is selected. In addition, daily maintenance and inspection are a key part of reliable stable inspection. Please refer to this article to assist with your contaminant inspection work.

References

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