Ensuring Food Safety Through the Prevention of Physical Contamination

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Executive Summary

Physical contaminants in food are a global safety concern. In key markets such as the US and the UK, there have been high-profile cases of foreign bodies such as metal, plastic and glass entering the food chain. Such incidents, accidental or intentional, are rare, yet they can represent a considerable risk to consumer health.

Incidents of physical contaminants in food can also have a detrimental impact on brand reputation. The resulting bad publicity and loss of customer confidence is hugely damaging and can be extremely difficult to repair. Furthermore, if contaminated food reaches the market, it can lead to costly recalls, and result in expensive fines.

Often, the quality and safety of food products depends on the level of due diligence exercised during the production process to exclude physical contaminants from the finished goods. The choice of protection and inspection equipment has a significant impact on product quality, safety, and consumer confidence. Of the inspection choices manufacturers face, a key one is whether to install a metal detection system, an x-ray inspection system, or both.

This white paper describes the many different types of physical contamination in food and explains how they can occur. It also outlines the types of product inspection equipment that can be used to prevent foreign bodies from entering the food chain, while providing food manufacturers and processors with some best-practice guidance on how to select the right kind of equipment for the application at hand.

1 The Perils of Physical Contamination in Food

Physical contamination in food is first and foremost a safety issue. If fragments of metal, bone, plastic, glass or any other foreign body are allowed to enter the food chain, there is a chance that they could cause serious harm. That’s the primary concern for food manufacturers and processors as they seek to ensure that contamination doesn’t occur.

But there’s more to it than consumer protection alone. Product recalls caused by physical contamination are also a considerable risk to reputation. Food safety scares make national and international headlines, and a well-publicized incident can destroy the worth of a brand name in an alarmingly short amount of time. There’s a more tangible financial impact, too: product recalls caused by physical contamination can cost millions of dollars to execute, and if a company is subsequently found guilty of a health and safety breach it can result in the imposition of significant fines. In short, physical contamination in food must be avoided at all costs. Even with this knowledge, it is surprising to see that cases of contamination are on the rise. The reinsurance company Swiss Re Report Food Safety in a Globalised World\(^1\) publicized that in 2015, the number of US food products recalled and the costs associated with those recalls had nearly doubled since 2002.

In more than half of the food recalls in the US, the entire recall process cost the affected company more than $10 million, and some companies lost more than $100 million in direct costs associated with the recalls. Moreover, according to the findings of a recent food recall strategy report published by Emerald Insight\(^2\), they often triggered a chain reaction effect throughout the supply chain and society as a whole. The story is similar in other key markets. In the UK, food safety incidents from foreign body contamination as reported by the Food Standards Agency (FSA) and Food Standards Scotland (FSS), increased by 7% in 2016/17\(^3\) compared to the previous period.

The rise in the regularity of contaminants in food can be attributed to several key factors with longer supply chains, more complex food production environments, and better reporting methods all playing a part. However, this climb in the number of incidents is a trend that food manufacturers and processors are obviously eager to reverse.

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\(^1\) http://www.swissre.com/library/expertise-publication/314518531.html
\(^2\) https://www.emeraldinsight.com/doi/full/10.1108/IMDS-10-2016-0464
2 Different Types of Food Contamination

The most common overall cause of food recalls is from biological contamination (microorganisms and toxins), which mainly affects fresh or raw food supplies such as nuts and vegetables. This type of contamination can have many causes, including the use of contaminated water by a producer or unsanitary food handling practices along the supply chain. Allergenic products such as nuts or dairy that have not been declared on the label are another major cause of product recalls. These can be ingredients of the final product or cross contamination from residues in the machinery from a previous production run. There is currently no machines available to aid food manufacturers in detecting biological contamination; the best way to avoid such incidents is to implement a robust hygiene regime.

Foreign matter is the second most common cause of food contamination in the UK and third in the US. This includes many different items, such as metal, plastic and glass, along with wood from production lines or packaging. With such a wide range of possible foreign bodies, food contamination incidents can be extremely varied in their nature.

In the US for instance, a well-known meats provider recently needed to recall several thousand pounds of ground beef following fears that it might have been contaminated with blue string. During routine cleaning, it was discovered that a cotton/poly blend of material had become stuck in one of its production machines. The company believed that some of the string could have ended up in the final product, all of which had already been distributed to warehouses across the US.

Meanwhile, in another high-profile incident, one of the US’s leading suppliers of bread products voluntarily removed a number of its popular brands over fears that they had been contaminated with fragments of glass caused by a broken light bulb at one of its bakeries. The company announced the recall after receiving three consumer reports of small pieces of glass found on the outside of the bread. Although there were no reports of injury, the incident received widespread coverage across multiple media channels.

There have been many similar incidents in Europe. A baked goods provider in the UK recently recalled several meat and vegetarian pasty product ranges over fears of glass fragment contamination, with the products pulled from the shelves of large retail chains including Asda and Lidl.

3 How Physical Contamination in Food Occurs

In terms of the main causes of physical contamination, experts distinguish between two types of foreign bodies: endogenous foreign bodies that could originate from the product (e.g. cores or bones), or exogenous foreign bodies that do not belong to the product (e.g. plastic parts). In terms of the latter, metal, plastic and glass are by far the most common types of contaminants, and there is a multitude of ways that foreign bodies can enter the food chain. These include accidentally being introduced by employees (e.g. personal effects such as jewelry), maintenance procedures taking place on or near the production or processing line, and equipment malfunction or breakage during the manufacturing and packaging processes.

These differences however, as noted in a recent foreign body management guide by food standards group IFS, is irrelevant to the consumer as they do not accept foreign bodies even if they do not pose a direct risk to health, such as small scraps of paper in the product. The consumer expects to receive the product as it has been described and as it is expected – no more and no less.

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4 https://www.rentokil.com/blog/the-cost-of-product-recalls-to-food-businesses/#WqJR0MrKUk
7 https://www.food.gov.uk/sites/default/files/petersfoodservicerecallnotice_0.pdf
To minimize the chance of foreign bodies, IFS recommends good-practice working within food environments, including ensuring that all production and storage areas (such as product packaging, machine design and manufacturing procedures) are regularly examined for potential sources of contamination. Structural and infrastructure defects (e.g. ceilings, covers, cables, lights, etc.) are often the cause of contamination. During repair and maintenance work, special care should be taken to ensure that materials such as screws, cable parts and metal shavings cannot unintentionally enter the production process. Both the product and equipment must be inspected before starting operations again. However, accidents do happen, and contamination still does occur.

4 Technology and the Fight Against Physical Contamination

Fortunately, advances in product inspection technologies mean that most types of foreign body contamination are now detectable. Metal, glass, dense plastics, mineral stone, calcified bone and rubber contaminants can be readily found using equipment such as metal detectors and x-ray systems on fast moving production lines. The performance of such equipment depends on a range of factors that impact sensitivity. Factors may include the size and location of the contaminant, the speed of the production line, the comparative density of the contaminant to the product being inspected and the type of product packaging material being used.

The type of foodstuff is also a major factor. In many food production processes, raw and incoming materials arrive in liquid, paste and slurry format and are pumped through pipework systems before being mixed and blended. Detecting contaminants in such incoming materials early in the production process has many benefits. Liquid, paste, and slurry formats are often more homogenous and easier to inspect, and contaminants tend to be larger and easier to spot. Early detection also protects valuable processing equipment from further damage downstream, and eliminates the contaminants before additional production value has been added, minimizing product waste.

When it comes to detecting contamination in unpackaged bulk, loose and granular products, inspection technology that is positioned over a horizontal conveyor or as the product falls under gravity conditions directly before processing or packaging is an efficient way to remove contaminants. Typical bulk products which allow for this inspection method include sugar, flour, grains, cereals, dried fruit, nuts and vegetables, snack foods and confectionery, meat, poultry, fish and seafood. Once processing and packaging has taken place, the final inspection of products at the end of the production line is the last line of defense to detect any contamination by a foreign body before shipping the finished product to retailers and supermarkets. In this environment, the type of packaging and the potential type of contamination dictate the type of product inspection system which should be used.

5 Choosing the Best Technology for Your Application

Broadly speaking, there are two mainstream physical contamination detection technologies – metal detection and x-ray inspection. Both are used by food manufacturers and processors at Critical Control Points (CCPs) in many production processes where a Hazard Analysis and Critical Control Points (HACCP) audit has identified the risk of contamination.

Modern metal detection systems can identify all metals including ferrous (chrome, steel, etc.), non-ferrous (brass, aluminum, etc.) and both magnetic and non-magnetic stainless steels in food, non-food and pharmaceutical products. X-ray inspection systems are also capable of detecting metal but can also detect non-metallic contaminants such as glass, minerals stone, calcified bone, high-density plastics, and rubber compounds. These inspection systems can be installed at CCPs to inspect incoming raw materials prior to processing. They can also be installed at mid-way points, or at the end of the production or packaging line.

While metal detection and x-ray inspection offer differing capabilities, when it comes to contamination detection, neither approach is infallible. Often there is an area of overlap between the two technologies, and careful consideration must be given as to which is the most appropriate for the application and budget at hand.
For example, when it comes to aluminum contaminants in non-metal packaging, metal detection would be deemed the most suitable technology. Aluminum is a lightweight metal and a good electrical conductor. Since its radiographic absorption is lower compared to other metals such as ferrous and stainless steel, this causes a reduction in the sensitivity on an x-ray inspection system. This means that aluminum is detected at twice the size of ferrous or stainless steel. In contrast, due to its good conduction properties, aluminum can often be detected at smaller sizes using metal detection, which makes it the better solution.

But when attempting to detect metal contaminants in aluminum foil packaging, the choice swings the other way. Metal detectors struggle to spot the contaminants amid the packaging. However, due to the way in which the x-ray system works, aluminum packaging has a negligible impact on detection levels. X-ray inspection can see straight through the low-density foil to get a better view of the metal contaminants within and offers the better solution in this case. The easiest means of choosing between metal detection and x-ray inspection is to start with the application. The first step is to carry out either a Hazard Analysis and Critical Control Points (HACCP) audit or a Hazard Analysis and Risk-based Preventive Controls (HARPC) audit. A detailed explanation of the differences between HACCP and HARPC10 is available separately, but essentially HARPC also includes planning for potential terrorist acts and/or intentional adulteration and food fraud.

The audit will help to understand the requirements of any customer or compliance-related issues driven by the Global Food Safety Initiative (GFSI) and/or major retail groups. A HACCP audit will identify the risks of contamination being introduced in the manufacturing process, and the types of contamination likely to be encountered. Critical Control Points (CCPs) should be established to mitigate the risks, and product inspection equipment needs to be installed at these points to reduce the risk of contamination to acceptable levels. A HARPC audit also covers contamination in the manufacturing process, but will take into account additional security, such as visitor access and control. Supplier and recall programs are also more formal and the HARPC system requires food facilities to identify and implement science or risk-based preventive controls, rather than Critical Control Points (CCPs).

Whether HACCP or HARPC methodology is used, the means of selecting an appropriate technological response to contamination risks during production are the same. If the audit determines that metal is the only likely contamination to be found, then a metal detector is the best solution. However, if other contaminants like glass, stone or dense plastics are identified as likely to be encountered, then x-ray may be a more suitable solution. It is always advisable to conduct product testing to establish the most appropriate technology. In many cases, there is only one suitable solution – either metal detection or x-ray inspection. However, there are occasions in a food environment where it could be necessary to install both metal detection and x-ray inspection at different points on the same production line.

6 Product Acceptance – the Need to Meet Retailer Expectations

The ever-changing nature of the food sector means that both metal detectors and x-ray systems are increasingly found in food processing and manufacturing environments. Food production is becoming more complex, with consumers demanding a wider variety of products packaged in ever more intricate styles. A desire to improve operational efficiency in food plants means there is also a trend towards faster running production lines, where products are spaced closer together. These factors mean that product inspection systems are now vital components in the modern food production environment.

These factors are not the only drivers behind the growing usage of product inspection equipment. Increasingly, major supermarket brands have implemented uncompromising codes of practice which are often more demanding than international food safety regulations. These self-imposed standards put additional expectations of quality and performance on suppliers, and those organizations which fall short are automatically excluded from the supply chain.

Food retailers expect suppliers to be “trusted partners” and to work in unison with them to ensure that codes of practice are met at all times. This is particularly true when it comes to physical contamination. Retail chains expect suppliers to commit to achieving the highest standards of food quality through investment in the latest inline inspection technologies, enabling them to secure customer loyalty and repeat purchases.

Marks and Spencer acts as a case in point. This UK-based retailer has an incredibly complex supply chain with direct contracts placed with 400 suppliers who produce products at over 800 sites located in 44 countries. Raw materials and commodities are sourced from more than 70 countries, and the company estimates that its suppliers source raw materials from around 30,000 farms around the world. Against this backdrop, Marks and Spencer has developed a comprehensive Technical Terms of Trade which sets out its minimum technical requirements for suppliers in order to meet its commitment to customers to deliver products that are safe, legal, and high quality. Increasingly, food producers see product inspection as the most efficient means of ensuring those terms of trade are met.

Future Advances – Digitization will Improve Food Traceability

The changing nature of the food sector – a wider range of products made in more efficient plants and driven by higher expectation from retailers and consumers alike – is leading to rapid advancement in product inspection technology. The capabilities of modern metal detection and x-ray equipment have evolved to enable the detection of a wider range of contaminants, in smaller shapes and sizes, with better resolution and lower false rejections. Efforts have also been made to improve the usability of such technologies, with the development of better software and more intuitive touch screen displays, allowing for faster and automatic set-up on the production line.

Other technology drivers are also coming to the fore. Digitization is a major trend across industrial sectors, and food manufacturers are increasingly looking to use more intelligent systems to improve automation and traceability within their plants. Connected manufacturing across networked infrastructures can improve production line efficiencies and management control, and contamination checks can be streamlined across operations to achieve standardization of quality control. This trend towards digitization is enabled by real time data collection, and this information can prove useful in the event of suspected contamination incidents. In the event of a product recall, manufacturers and brand owners need to demonstrate that they have exercised full diligence to authorities. The most effective way to achieve this is from real-time reporting of all contamination checks. Clearly, traceability and due diligence are becoming increasingly important should accusations of contamination be made by consumers. Product inspection systems now come with full data acquisition acting in support of audit compliance. This enables food manufacturers and processors to prove “due diligence” in their actions, taking all potential precautions to avoid/minimize contamination risk.

Also, the food industry is looking towards other best-practice sectors as a means of further improving traceability, and thus driving down the risk of contamination from unlicensed suppliers. Serialization – the process of applying a unique serial number to enable traceability and authentication of an end-selling product – is commonplace in the pharmaceutical industry and serves as a major component in track and trace activities. More and more countries worldwide are introducing legal regulations to impose mandatory serialization of prescription drugs, as an effective fight against counterfeit products and falsifications of single pharmaceutical packages.

While there are no suggestions that mandatory requirements are on their way in the food sector, it’s clear that serialization could provide a useful means of authentication for certain products like baby formula or luxury items. In some parts of the world, such as China, counterfeiting of branded food is a common problem, with such illegal activity acting as a common cause of contamination. The adoption of serialization would provide manufacturers with more accurate visibility into items and quantities at every point in the supply chain and give retailers a cast-iron assurance of authenticity.

8 Conclusion – Product Inspection Provides Peace of Mind

As this white paper has shown, the food industry is becoming more complex, with longer supply chains and a greater variety of food types combined with more intricate packaging materials to quickly accommodate consumer’s changing tastes. These factors, coupled with pressure to improve plant performance through the use of faster production lines, is resulting in an increase in the number of reported incidents of physical contamination in food in key global markets.

Contamination is an extremely serious issue, both in terms of consumer health and brand reputation, and will remain so as food, packaging, and production trends change over time. Advanced product inspection technologies are available to ensure that food manufacturers meet regulatory, retailer and consumer requirements, while at the same time future-proofing food manufacturers and processes as they prepare for the more digital factories of the future. These systems can spot a wider range of foreign bodies in smaller sizes and in sharper resolution. The correct specification, installation, and operation of such inspection technologies – be it metal detection or x-ray – is therefore widely considered as the most effective means of preventing physical contamination in food from occurring.

9 Further Reading

White Papers/Surveys:
- Metal Detection, X-ray Inspection or Both?
- Food Safety Standards and Legislations
- Seven Easy Ways to Reduce the Risk of Non-compliance
- Principles of Due Diligence
- Track and Trace Survey: Serialization Opportunities Outside of the Pharma Industry
- Serialization: The Key to Success

Technology Guides:
- X-ray, Metal Detection, Checkweighing, Vision Inspection

Case Studies:
- Zinetti Food Products: Zinetti Foods Selects Next-Generation X-ray Inspection System
- Bury Black Pudding: Metal Detection Equipment Helps Manufacturer Protect its Reputation for High-quality Puddings
- Giersch GmbH: Giersch Produce Taste and Quality With Cutting-Edge Technology
- Bell Food Group: X-ray Inspection Systems Provide Bell Food Group With Enormous Quality Assurance Benefits

Also see our Expertise Library:
https://www.mt.com/library
About Mettler-Toledo Product Inspection:

The Product Inspection Division of METTLER TOLEDO is a leader in the field of automated inspection technology. Our solutions increase process efficiency for manufacturers while supporting compliance with industry standards and regulations. Our systems also deliver improved product quality which helps to protect the welfare of consumers and reputation of manufacturers.

![Checkweighing](image1)
![Metal Detection](image2)
![Track & Trace](image3)
![Vision Inspection](image4)
![X-ray Inspection](image5)

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