July 2014

Technical information note

# X-ray detection of extraneous matter

Dairy manufacturing operations have traditionally relied on metal detection devices in an attempt to reduce the risk of physical contamination of products. X-ray systems offer an alternative technology that can be used to screen for a range of physical contaminants in addition to metals, or in dairy products that are unsuited to the use of metal detectors. This note provides guidance for dairy manufacturers on evaluating their operations using hazard analysis to determine the practical benefits and possible need for an X-ray detection system.

## The need for a detection system

Manufacturers of dairy foods must ensure products manufactured for human consumption are free from foreign matter that would render product unsafe, as prescribed under the *Code of Practice for Dairy Food Safety*,[1] and in accordance with their approved food safety program (FSP). The type of foreign matter contaminant and the possible health effects it has caused or may cause would define whether a product is unsafe.

In addition to the public health implications, the presence of extraneous matter in product can result in considerable cost to a business, including:[2]

- loss of business (either wholesale clients or consumers at the retail level)
- product recall
- replacement of product stock
- product rework or disposal
- adverse publicity (perceived threat to public safety)
- potential law suits
- liability for inability to supply to customers.


Strategies used by manufacturers to minimise the likelihood of product becoming contaminated with extraneous matter can include:

- stringent ingredient supplier specifications
- strict control of personnel access into production areas within the plant
- personnel clothing, jewellery and stationery restrictions within production areas
- product filtration and sieving steps
- installation of in-line high intensity magnets
- routine plant maintenance procedures
- staff awareness training, particularly for maintenance personnel and plant operators.

Making the decision to install a detection device in any particular operation will depend on consideration of a number of factors, including:[3]

- likely hazards
- possible risks
- the types of process operations, and the potential dangers to consumers if adequate checks and controls are not in place.

This assessment should include an examination of previous customer complaints, which will help identify what type of contaminants (if any) have been a problem.

When selecting the ideal stage of production to install a detection device, areas where product is exposed prior to packaging and the potential for deliberate adulteration should be taken into account.

The decision whether to adopt an extraneous matter detection system as a critical control point (CCP) or as a control point under the company's HACCP-based food safety program will be determined through the hazard analysis process, as described in the *Guidelines for Food Safety: Dairy Food Manufacturers*.[4]

## The process

The production of X-rays for detection devices is provided by a generator applying high voltage current to an X-ray tube. The rays produced are converted from a conical beam into a thin, flat, fan-shaped beam. Electronic photodiodes are used to detect the amount of X-ray light being emitted from the beam, which is recorded on a scale of 0 – 100% (0 = black; 100 = white).

When product passes through the beam, a proportion of the X-ray is absorbed, dependent on the product density, and the resultant 'grey colour' penetrating is measured by the diodes. The rapid scanning and recording of the diodes is converted through computer software to produce a 3-D image of the product. Contaminants can be highlighted by exhibiting a difference in the 'grey scale' (density change) generated, which is then detected by computer.

As with all equipment used for the detection of foreign matter, an automated product rejection device is also used to isolate any contaminated product.

The critical operational parameters that will be used on a day-to-day basis are set up during the installation and commissioning of the system. Regular validation checks of the detection capability and rejection accuracy should be carried out using certified test samples of various materials with known dimensions. Adjustment of the detection sensitivity limits should be restricted to authorised staff or maintenance personnel only. Regular servicing of equipment must be carried out to verify efficient operation, and identify any potential faults.

## Limitations

Although X-ray detectors will generally have an advantage over metal detectors in being able to identify contaminants such as glass, stones, calcified bones and high-density plastics and ceramics, there are still particular materials which have densities close to that of the product which make them indistinguishable by X-ray detection.[5] Examples of these include:

- low-density plastics, such as polyethylene (perspex) and wound dressings (Bandaids)
- thin glass, such as fluorescent tubes
- low-density stones
- insects
- wood
- hair
- cardboard and paper.

Additionally, rubber fragments from seals and gaskets commonly used in dairy plants will generally not be detected.[6]

As with metal detectors, the likelihood of detection is affected by the orientation or way the contaminant is positioned within the product.

Detection sensitivity is reduced as the size of the product is increased, making detections in bulk products more difficult than in small consumer packs. An increase in product size also requires more power to generate X-rays able to pass through the product. Higher energy costs can also be expected for cooling the generator in such cases. With bulk products, such as 20kg cheese blocks, there is a small proportion of the product along the top outer edges that is scanned at much lower levels of sensitivity, due to the fan-like spread of the X-ray beam from above.

## Finding the balance

The decision to install any method of extraneous matter detection will be influenced by the outcome of the hazard analysis described above.

Although the technological advances, reliability and user friendliness of X-ray detectors have improved in recent times, they are still an expensive investment in comparison to metal detectors. Overcoming the problems of incomplete product coverage, and minimising the orientation effect can be achieved by including a second X-ray beam from a different angle, however this will add considerably to the cost.

Extra capabilities of X-ray systems that may be useful include:

- seal defect detection
- check weighing
- counting capabilities.

Some products, such as cheese, are not ideally suited to metal detection due to their conductive composition. Such product conductivity does not impact as greatly on X-ray detection systems. X-rays are similarly not affected by the environmental conditions, such as plant vibrations, electrical interference and temperature fluctuations, that metal detectors are prone to. However, for X rays to function most effectively they require products to be of a consistent dimension and relatively homogenous composition throughout (for example, cheese blocks of uneven shape, with splits and eyes, or that are freshly brined with the salt content varying as a gradient in the block, will all make the detection of extraneous matter more difficult).

A metal detector used in conjunction with an X-ray system is an option in some cases. Although expensive, it provides greater assurance by utilising the advantages offered by both systems.[7] (Refer also to the DFSV technical information note *Metal detection*).[8]

## Further considerations

Additional factors that should be considered include:

- the capital cost for all equipment required (including rejection equipment)
- on-going operational costs (particularly energy, plus the replacement of X-ray tubes and detectors)
- maintenance/service time, frequency and cost
- space available for installation
- equipment capacity (i.e. rate of product throughput)
- suitability of the operating environment
- training of operators, maintenance, and management staff
- product composition, plus package size and dimensions.

The capabilities, practicalities and limitations of the various systems available need to be understood, so that objective comparisons between equipment suppliers can be made. Where possible, it is recommended that 'in-house' trials be carried out with these suppliers, using current and/or planned products and packaging, so that a more realistic assessment can be made before committing to a purchase.

## Records

Keeping records of all checks, calibrations and rejections will help to identify any trends in contamination by foreign material within the process. Any necessary corrective actions can then be implemented, which will minimise the likelihood of unsafe product entering the marketplace. It will also provide evidence that due diligence is being undertaken to prevent the sale of unsafe product to consumers.

## Key points to consider

- Dairy manufacturers should closely examine their operations using hazard analysis to evaluate the level of risk, which will help determine whether installation of a system to detect extraneous matter is justified.
- An X-ray detection system offers some distinct advantages over other methods, such as metal detection. There needs, however, to be confidence that the system selected will be suited to the product(s) manufactured, and can consistently perform to the levels expected to provide the risk protection required.
- Regular verification testing of the detector effectiveness using certified test samples must be carried out, along with routine maintenance and calibration checks by authorised personnel.
- Keeping appropriate records will help to identify any contamination trends within the process.

## References


1. Dairy Food Safety Victoria, Code of Practice for Dairy Food Safety, Section 5.2.1 – Physical contaminants, DFSV, Melbourne 2002.

2. A Lock, The Guide to Reducing Metal Contamination in the Food Processing Industry, Safeline Ltd., Montford Street, Salford. UK 1996.

3. A Campbell, *Guidelines for the Prevention and Control of Foreign Bodies in Food - Guideline No 5*, Campden & Chorleywood Food Research Association, Gloucestershire 1995.

4. Dairy Food Safety Victoria, Guidelines for Food Safety: Dairy Food Manufacturers, Section 4 – The application of the HACCP System, DFSV, Victoria 1996.

5. Loma Systems, A Guide to Metal Detection in the Food Manufacturing Industry, Spectrum Inspection Systems, Southwood, Farnborough UK 2006.

6. D Irwin, *Dairy Processing Engineering Centre newsletter*, Issue 33, December 2006 – Inspection systems for detection of extraneous matter in foods. Dairy Processing Engineering Centre, Werribee 2006.

7. K Higgins, 'Beam me through Scotty', *Food Engineering*, Jan, 2006.

8. Dairy Food Safety Victoria, Technical information note Metal detection.


## Further information

Further food safety technical information is available at **www.dairysafe.vic.gov.au**

Or contact Dairy Food Safety Victoria on **(03) 9810 5900** or **info@dairysafe.vic.gov.au**