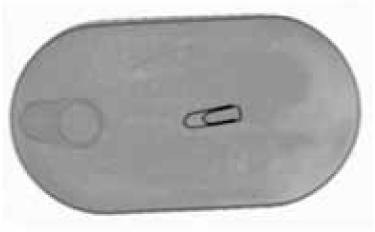
How to Guide – X-Ray Functionality

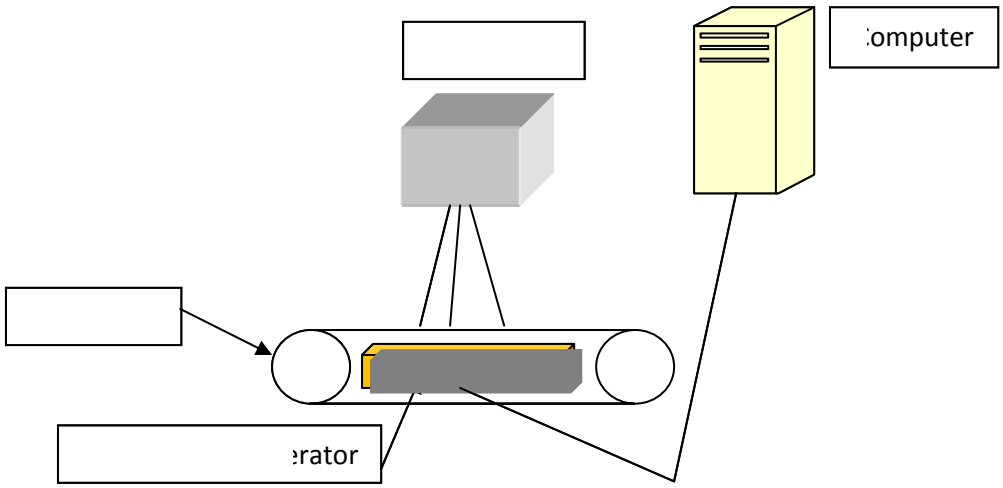
Basic principles of X-Ray

An x-ray system is essentially a scanning device. The system uses a generator to project a beam of low energy X-rays through the product onto a sensor. X-rays primarily function on their ability of the beam to be partially absorbed or to travel through materials in proportion to the density of the material or certain materials fluorescing (emitting light / electrons) when the beam strikes them. Measurement of the differences in absorption between product and contaminant is the basis of x-ray inspection. The variable absorption of the beams is then used to produce an "image".



Source: www.packaging-equipment-sales.com

X-ray systems work by the object passing along a conveyor, or through a pipeline, between the detector and the generation unit, and then sending the x-ray into an electrical signal back to the computer interface. When a product passes through the unit it captures a greyscale image of the product. The computer, using software, analyses the greyscale image and compares it to a pre-determined acceptance standard and either accepts or rejects the image. The computer sends the information back to the reject mechanism to allow the product with contamination to be ejected from the conveyor using a reject arm or similar device, or the conveyor to stop completely, so an operator can interface.

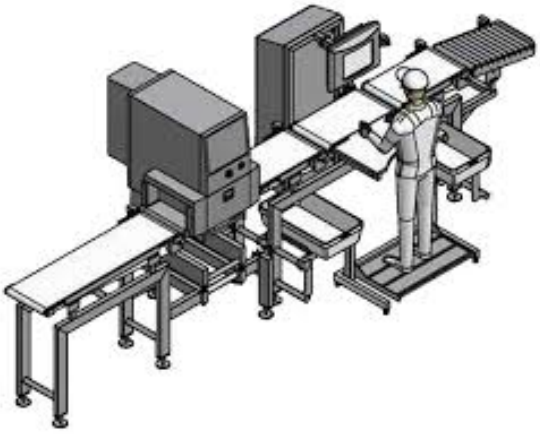


There are 3 main types of X-ray equipment:

- Conveyor System with automatic rejection for discrete / finished product inspection. This can be further defined in terms of packaged product, Glass product (Glass- in-Glass), and Canned product.
- Pipeline System with automatic rejection for inspection of pumped product
- Bulkflow with automatic rejection (loose products) for inspection of particulate product in continuous flow

Xray units have the added benefit of also being able to perform other functions including:

- Missing product detection (e.g. chocolates in a box)
- Fill levels (where checkweighing is difficult – e.g. twin pot desserts)
- Pack integrity checks
- Product integrity, shape recognition (e.g. detecting broken or missing product)
- Determining promotional material/ inserts have actually been added to each pack



Source: www.attec.co.uk

Source: www.detection-tech.com

Key factors influencing performance

The following materials are commonly able to be readily detected by X-ray:

- Iron/steel
- Non ferrous materials
- Stainless steel
- Bone
- Calcified cartilage
- Glass
- Stone
- Some high density plastics

But the ability of the unit to detect any of the above will vary and relies on the physical size of the contaminant, the product being inspected, and the sophistication of the system. The environment in which it is located is another factor that needs to be considered, with equipment design needing to be suitable to the task. Unlike metal detection, X-ray units do not suffer from product temperature, moisture levels or salt content drift.

Commonly Detected Contaminants


Metal


Glass


Stones


Bones


Rubber


Certain Hard Plastics

Due to their relative nature and density, the following potential contaminants may not be able to be reliably detected

- Dust
- Wood
- Debris
- Insects
- Hair
- Low density rubber and plastics (such as tubing and plastic bags)
- Plastic cling film
- Fabric and fibres
- Oil

Sensitivity

To accommodate larger products, the x-ray generator has to be moved further away to create an x-ray beam wide enough to inspect the whole product. Increasing the distance between generator and detector reduces the sensitivity of the system. In general, contamination detection is only possible on contaminants that are denser (i.e. have a higher specific gravity) than the product in which they are embedded.

Also it must be also considered that conventional 'metal detectable' products (hair nets, bags, pens or other materials) may not necessarily be X-ray detectable, depending on the 'contaminant' added to the material.

The sensitivity and therefore accuracy of the equipment is essential in determining the type and size of pieces of object detected. The equipment sensitivity is appropriate if all of the following parameters are met:

- The products with more uniform consistency (and therefore density) will perform better than those that vary or are particulate in nature.
- The unit is able to maintain an appropriate balance of detection in regards to line speed.
- The sensitivity can be maintained without periodic adjustment.
- The detector gives minimal false signals and does not reject good product.
- Detection in different orientations: *the resulting disturbance signal can be one to two orders of magnitude greater in one orientation than the other. Most test pieces use a spherical object, so the signal they give off is the same in any orientation; but when testing a returned foreign object, such as a needle or piece of wire, it needs to be tested in different orientation to ensure maximum effectiveness.*

Reject Mechanisms

There are a variety of reject devices available which may include:

- Carriage retracting band/ Sweep/diverter arm (product <5kg)
- Air blast (product <1kg). *These can be unreliable if you have a drop in air pressure. Ensure that the air pressure is sufficient to cope with any potential metal contaminants e.g. metal bolts.*
- Pusher (product <10kg)
- Stop on detect (product <60kg)

Detector fail safe systems where fitted, must be challenged at regular intervals (eg: start and end of shift/ day) to make sure they are effective.

Reject confirmation system: automatic belt stop fail safe system, to confirm contaminated products have successfully entered the reject bins.
As most x-ray conveyors are relatively short, with the reject system close to the conveyor out feed, it is not possible to ensure any contaminated product not rejected will be retained on the detector conveyor when it stops. It is therefore imperative to stop the following conveyor (or equipment) at the same time and additional outputs on the detection system should be available to facilitate this. After Reject Confirmation Alarm all product should be removed from the detector conveyor and following conveyor

(or equipment) and rejected or re inspected.

Bin full system: an automatic belt stop fail safe system which activates should the reject product collection box become full.

Air pressure system: an automatic belt stop fail safe system to cover air pressure failures to the rejection mechanism. The access to adjusting the air pressure should be restricted.

Search head failure: an automatic belt stop fail safe system to confirm detection head fault.

Back up sensor: an automatic belt stop fail safe system, to activate should product back up under out the feed belt of the detector. Where appropriate a back up sensor should be installed to ensure product is prevented from backing up onto the detector conveyor.

Bin door unlocked alarm: an automatic belt stop fail safe system to activate should the reject bin door be left open/unlocked for longer than a preset time.

Product Testing – Test Packs

Different products and contaminants will have different possibility of detection (POD) depending on placement of product and contaminant. When defining a contaminant specification it is important to locate the contaminant in both high and low density areas of the product, above, below and embedded within the product to determine the location with the lowest POD. Different orientations should also be used.

The test packs must be representative of the products going down the line e.g. shape and density. Actual product should be used as test packs. The packs used to make up test packs should be passed through the X-ray before they are used to ensure that they do not contain foreign objects. Testing ensures that all product variations are taken into account and each variant (including combinations of food and foreign object) are tested and validated separately.

Detectors must be checked using clearly identified test packs at the same temperature (and therefore maintained at same temperature) as standard product passing down the line and test pieces of a defined size. X-ray systems may be sensitive to ambient temperature variation, and therefore the system tested immediately after start-up may be considerably inaccurate at a later point in time.

The test pieces must be passed through the detector in the centre of the aperture with the test pack.

Consecutive leading and trailing checks must be completed in long packs to ensure the reject mechanism can successfully reject. The test must be representative of how products would normally travel through the detector during normal production.

The site should only use test pieces which are controlled and the size of the object can be verified e.g. they are manufactured with a serial number or issued with a certificate. Test pieces are available in various sizes/shapes e.g. sticks or cards. The most appropriate type for the products and contaminants

should be chosen.

Test packs should be made up on an hourly basis with product from the line (same product). If it is not practical to do this and test packs are made up in advance, the test packs must be controlled and labelled with product, date, test piece size and type.

Product Testing - Location of Test Pieces & Consecutive Tests

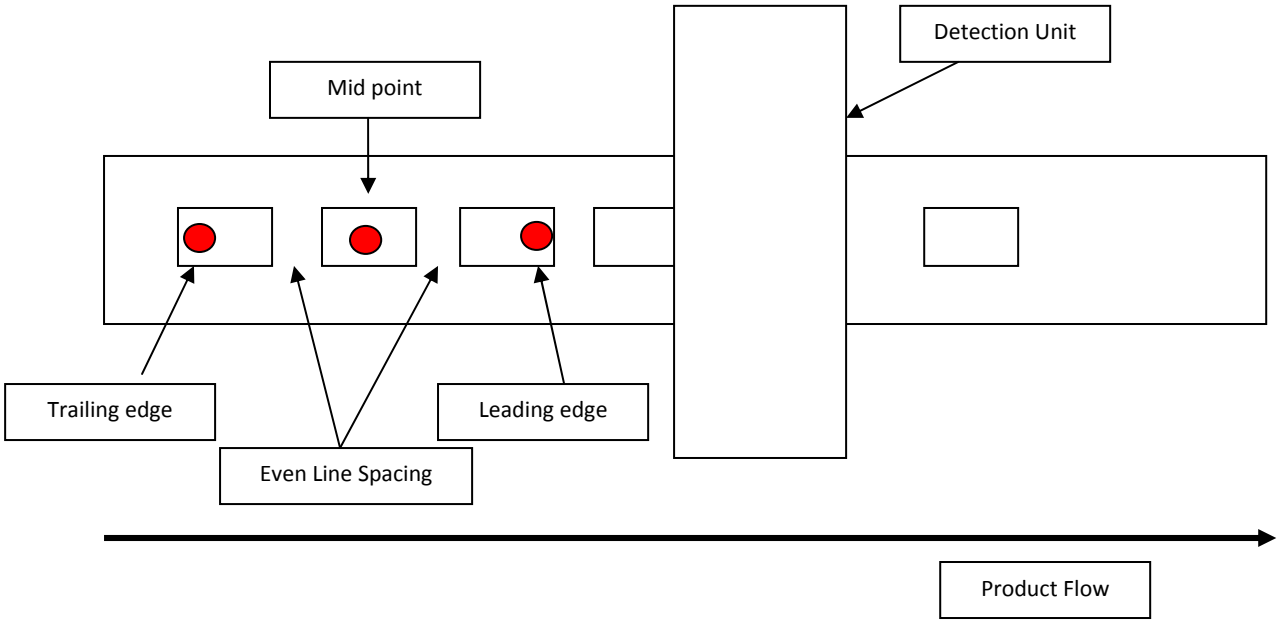
The test packs need to be made up to worst case scenario. The test pieces should be located in the leading, centre and trailing positions as per diagrams below for the 3 pack consecutive test. The leading and trailing positions would not be considered a requirement if the product is a small pack (i.e. less than 100mm).

The test packs should be marked with the location of the metal if it is not visible.

Where a pack contains products of different density, the location of the test pieces in the pack should be based on worst case scenario. The worst case location for the test pieces is likely to be underneath product.

If the location of the test piece is not visible additional controls/checks need to be in place to ensure that the test pieces remain in the required locations if the packs are used for multiple locations e.g. after being rejected the test pieces may have moved.

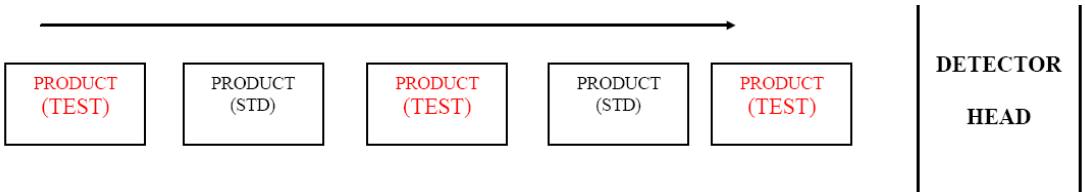
All test packs should pass through the detector one after each other with normal spacing/line speed and should cover at a minimum 3 metal pieces (ferrous, non ferrous and stainless steel) and bone, glass, ceramic and stone where there is additional risk identified. The line should be running and the test packs introduced in the places of the un-inspected packs where possible.



Product Testing - Memory Test

The objective of the test is to challenge the effectiveness of the reject system so that it does not blanket reject.

The test packs should be sent through the detector with a standard pack in between (which has already successfully passed through the xray unit).



It is a failed test if any of the test packs are not rejected. If a standard pack is rejected the line must be stopped and the issue investigated e.g. timing of reject mechanism.

If a machine struggles to not reject good packs, advice should be sought from the equipment manufacturer. The capability of the machine may be dependent on the line speed.

If a site wishes to combine the consecutive and memory test into one test, the procedure below is recommended: