FORTRESS Technology Inc.

Fortress Metal Detectors

METAL DETECTION

COMPARISON VERSUS X-RAY TECHNOLOGY

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METAL DETECTION - THE BASIC PRINCIPLES

X-Ray Inspection versus Metal Detection

Points to Consider:

- Metal detectors are built to suit the application, while the application must be changed to suit an X-ray system.
- Metal detectors are capable of handling wide temperature ranges, speeds, water, dust, etc. X-ray systems will not tolerate difficult environments; they are very speed and temperature sensitive.
- Metal detectors can detect all types of metal; X-ray systems will not detect low density metals to a useful level.
- Both systems are subject to the orientation of the contaminant, but for X-ray, all the object dimensions must be bigger than the base resolution (usually 0.8mm to 1.5 mm for dense materials).
- The performance of both systems can suffer from the effect of the product (just in different ways).
- In most applications, the detection ability of X-ray systems is limited to metals only. Bone, glass, plastics, etc., are either not detectable or not likely found in the product.
- Bone detection in processed meats is self limiting. The 10-20% rejection rate cannot be justified. In addition, the high bone content will limit the systems ability to detect metal.
- Bone detection is also becoming more difficult in the poultry industry due to shortened grow time (5-weeks) of the birds prior to processing and consequential lack of calcification of the bones.
- Production must be stopped to calibrate an X-ray system (1-2 times per shift). This is not required with a metal detector.
- The real cost of living with X-ray systems in high production facilities can be greater than 100 times the cost of metal detection.

Summary of a comparative study of two technologies used for contaminant detection in the food industry:

<u>X-ray Systems:</u>

In the past few years there has been an increased level of interest in the use of X-Ray technology for the inspection of food products in order to detect foreign contaminants. These machines have been available for decades and are not an emerging technology, in fact the discovery of X-rays dates back to the late 1800's – making metal detection a relative newcomer.

In order to understand the capability of X-ray inspection technology, it is important to look at the basic concept of X-rays which are capable of passing through low density substances but are blocked by higher density materials.

It is worthy to note that only density differences are detectable, and density should not be confused with hardness. Many contaminants that might be considered easily detectable with an X-ray system are not. Contaminants such as wood, plastic, nut shells, fruit pits, etc., are not detectable. Even glass, rock and bone detection is limited in many cases.

When X-rays pass through a fluorescent material, the material lights up; converting invisible X-rays into visible light. To create a visible electronic image, a fluorescent strip receives the X-rays and then a
photodiode strip, in turn, converts the light energy to an electric signal. The electrical signal is usually digitized and then processed by a computer system.

In essence then, these machines are density detectors and being so, let's look at what they typically can and cannot detect:

Contaminant	Detectable?
Metal	Yes: Ferrous and Stainless Steels (dense metals) No: Low density metals (aluminum, etc.).
Glass	Some: low lead and light density packaging glass are not likely detected.
Stone	Like glass, stone contaminants vary greatly in density –so hit and miss detection is the result.
Plastics	No. In real life products, plastics cannot be detected.
Wood	No and the same for feathers, string, fingernails, hair, fruit pits, etc.
Bone*	Some. Beef, pork reasonably well, chicken – not reliably.

*Bone detection has its own peculiarities. Where bone detection can be used (Beef and Pork) the normal residual bone fragment presence is very high. Even though bone detection is technically possible with an X-ray system, the high bone level often results in 10-20% reject rate of all production. In most cases this is too high to be considered acceptable. The presence of bone fragments can also limit the ability of an X-ray system to detect metal since it can't discriminate the difference between bone and metal.

Other Considerations:

Safety:

The general public is usually aware of the fact that X-rays are inherently dangerous. Intense or long term exposure poses a serious health risk.

Modern X-ray machines for the food industry are designed to shield operators from harmful exposure to X-rays and published standards exist from bodies such as the FDA. Local authorities are often required to inspect and certify installed machines. The end user should be careful to ensure that all safety codes and regulations are being complied to. There have been issues with employees refusing to work in an area where an X-ray machine is installed, and even a case where a reputable supplier shipped a machine to FDA for their own use and this machine was found to be non-compliant in five different areas.

Anyone considering the purchase of an x-ray system should make themselves familiar with FDA, state and local regulations covering this type of equipment. Do not rely on the manufacturer assurance alone, and get all commitments for safety and regulatory assurances in writing. Particular attention should be paid to the FDA regulation that states no part of the human body should be able to reach the main x-ray beam. Most low cost X-rays systems have been shortened to reduce cost and may be infracting upon this regulation.

Besides radiation, X-ray systems can be very dangerous. The internal power supply for the X-ray tube generates voltages in excess of 50,000 volts. Exposure to this potential is immediately lethal.

For the above reasons, it is not recommended that anyone other than a trained supplier representative perform any work or modifications to an X-ray machine.

Application:

The application of x-ray technology in food operations is limited in a number of key areas:

- **Size:** Aperture sizes of lower cost machines are usually limited to inspecting products less than 4" (100mm) high and 10" (254mm) wide. Larger formats are available but at exponentially higher costs and overall size.
- **Speed:** Current machines are limited to belt speeds of less than 150 fpm.
- **Space:** Small format, low cost machines are available in lengths of under 6 ft., but note the safety issues above.
- **Environment:** Again, low cost systems are intended for dry room temperature environments. This type of technology does not favor dust, moisture, condensation or hot locations. Maintenance issues will greatly increase in non-ideal locations.

Total Costs of X-ray Systems:

Equipment Cost:

Certainly the cost of small format, limited aperture X-ray machines have become very competitive. Early versions easily exceeded $150,000, but currently machines are available in the range of $40K. These machines tend to be lower power, limited application units and are available from a number of suppliers with an aperture limit of 10"x 5" (product size - 8"x 4").

While most electronic equipment have improved in performance and dropped in price in recent years, the major components of an X-ray system have not benefited from this trend. The cost of X-ray tubes, high voltage power supplies and detector arrays have, in fact, remained constant or increased. These are very specialized components and only the computer portion of these systems has really decreased in cost.

Cost of Ownership:

The manufacturers have had to bring the margins to very low levels to make the technology attractive, but they have discovered that the spare parts, service and support side of these machines is quite lucrative. Due to the inherent danger of this technology, the end user is not likely to perform even the simplest of repair or maintenance. Add to that, the fact that the main machine components have a relatively short life expectancy and you find that the cost of maintaining X-ray inspections systems is very high – in some cases it can exceed the original machine cost over 4 years and in most cases will average over $5K per year for support.

The main cost associated with an X-ray system may actually be in the lost production due to machine calibration requirements. The diode detection array response drifts with temperature and must be calibrated on a regular basis. Depending on product and environmental conditions, this may be required every 3 or 4 hours. No products can be run during the calibration period resulting in the approximate loss of perhaps 20-30 minutes per shift. The cost of the lost time depends on many factors but could range in the $100K to over $1 million per year.

In addition, it should be noted that the cost of regular performance checks (hourly) and radiation checks (daily) with the associated record keeping is quite high. Even machine disposal after its expiry can be expensive and there is little interest from used equipment dealers to take on the liability. The table below shows comparative costs of systems from actual applications. The base calculations are shown to allow other applications to insert base costs for comparison.

Comparative Ownership Costs	X-Ray System	X-Ray System	Metal Detector system
Type / Size	Low cost -Small Aperture (10" x 5")	Mid-size aperture (18" x 5")	Either Size
Purchase Costs	$40,000.00	$85,000.00	$15,000.00
Initial install and support	$2,000.00	$2,000.00	-
Regular Tests, calibrate, safety tests (by end user)*	$37,500.00	$37,500.00	$9,375.00
Lost Production due to calibration time**	$6,250,000.00	$6,250,000.00	-
Parts costs over 5 five years (estimated)	$15,000.00	$20,000.00	$1,000.00
Service labor and travel - 5 years (estimated)	$6,000.00	$6,000.00	-
Total Cost Over 5 Years:	**$6,350,500.00**	**$6,400,500.00**	**$25,375.00**
Calculation Base:			
*** estimated using $30/ hr., X-ray 1 hour /day, MD 1/4 hour/day, 250 days per year, over 5 years**			
time per day hours	1	1	0.25
days running per year	250	250	250
Labor estimate / hour	30	30	30
years	5	5	5
Sub total:	37,500	37,500	9,375
**** Production must be down during X-ray calibration, estimated loss at $5k/ hour, 250 days per year, over 5 years**			
time per day hours	1	1	Not applicable
days running per year	250	250	
Line loss estimate per hour	5000	5000	
years	5	5	
Sub total:	6,250,000	6,250,000	0

Summary:

There are very good applications for X-ray inspection machines in the food industry – products packaged in aluminum foil or foil trays, for example. In general, though, x-ray system will not outperform a good metal detector for the detection of all types of metal. In addition, the detection of other materials is very limited or non-existent.

The cost of ownership alone will pay for a new metal detector program every year even without considering the potential safety issues.

Anyone considering the purchase or use of an x-ray system should certainly consider researching regulation, safety and long term cost of operation as well as examining what benefits the system can offer them in real detection and product protection terms.

If the contaminant risk for any product is assessed, including only those contaminants that are detectable using any technology, metal is by far the highest on the list. When comparing the cost – benefit of X-ray systems versus high performance metal detection, it would be difficult to find applications that would justify the investment in X-ray. In addition, many application conditions that are typical in the food industry do not suit X-ray technology. Moisture, condensation, dust, wide temperature variations, speeds and product size will seriously limit the usefulness of these machines.