Choosing the Right X-ray Technology for Poultry Bone Detection

CONTENTS

e∢gle

QUALITY. ASSURED.

Choosing the Right X-ray Technology for Bone Detection

Poultry processors, who typically handle a variety of items in harsh environments, must protect their products and brands from potentially damaging contaminants that can be easily missed at various points on the line. X-ray technologies are an effective tool in reducing hazards and risks. Determining where and how to place inspection technologies at critical control points depends on the type and nature of the product and the potential/ likely contaminants that pose hazards. Not all systems will deliver the same results.

This white paper highlights different poultry presentations and accompanying bone detection challenges. It provides insights into the most effective placement of x-ray systems on the line and the factors to consider when choosing an x-ray system, including the machine, image processing software and detector. Three different kinds of energy absorptiometry x-ray technologies — single energy, dual energy and performance x-ray technology (PXT) — will be defined and explored.

1. Poultry Detection Challenges

Poultry processors know the challenges they face on a daily basis to produce sanitary, high quality, contaminant-free and bone-free poultry products.

There are many levels of variability to consider when it comes to detecting bone in poultry and managing hygienically controlled environments. Today, younger birds are often slaughtered before they reach maturity, which means that bones are not fully calcified and hence harder to detect in an x-ray image. This is particularly true for rib, fan and wish bones.
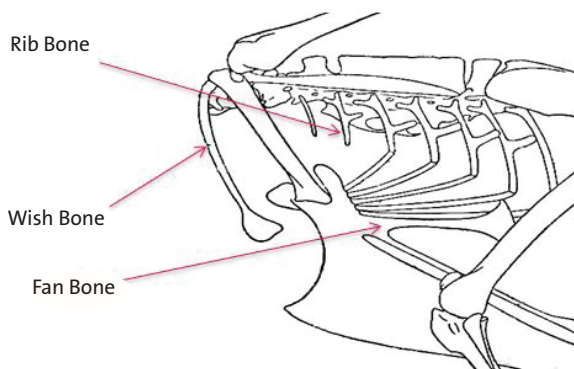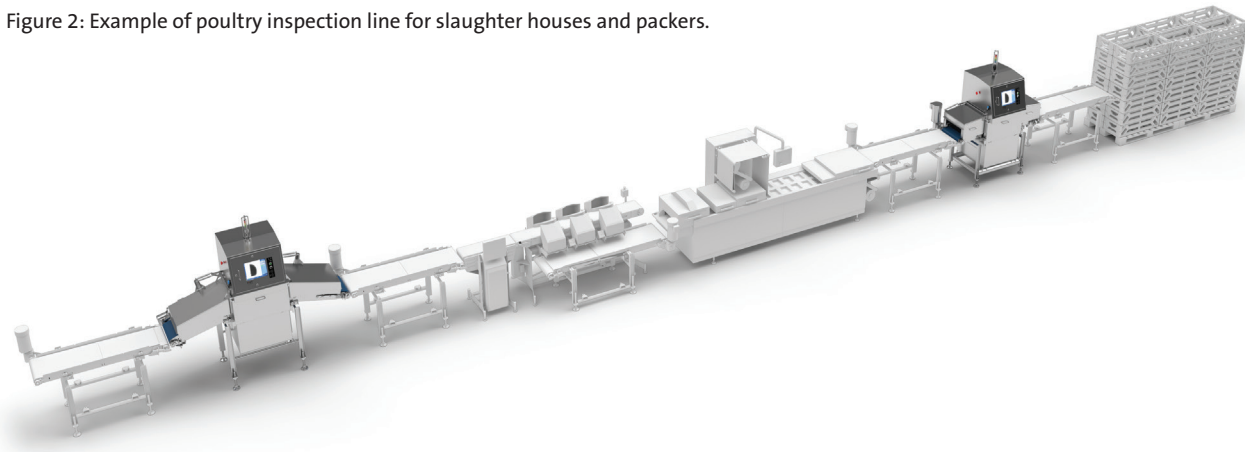
Rib Bone

Wish Bone

Fan Bone

Figure 1: Chicken bone diagram

In addition to maturity, processors face other unique application vulnerabilities. Many poultry manufacturers produce several items of varying shapes, sizes, densities, and packaging; such variety amplifies the need for closer and more careful inspection for safety and quality purposes.

Advanced x-ray systems equipped with the latest technologies can improve the detection of bone and other contaminants, while also preventing damage to downstream processing equipment. Inline x-ray inspection offers operational benefits, such as increased throughput and speeds, reduced product waste and a faster return on investment (ROI).

2. Placement of Inline X-ray Inspection Systems for the Best Bone Detection

Given the many ways in which poultry is processed, including different methods that may be used in one poultry operation, the optimal placement of x-ray detection systems for bone detection depends on the application. Common presentations include pumped, bulk, raw and packaged products.

2.1 Pumped Products

Pumped poultry, such as ground meat or trim, can be reliably inspected with a pipeline x-ray machine, ideally one with a round pipe that transitions to a rectangular inspection manifold and then back to the round pipe diameter upon exit. Using a pipeline machine to find bone contaminants at the beginning of the process or after grinding removes contaminants early and protects downstream machinery from damage.

2.2 Bulk/Raw Products

Bulk-flow (loose) poultry, such as filets, is a common presentation in the industry, and x-ray systems can be deployed to inspect such products for any bone fragments or metal contaminants introduced during either manual or automatic deboning. When performed at this placement before further processing, inspection effectively prevents contaminants and bone from moving downstream.

Figure 2: Example of poultry inspection line for slaughter houses and packers.

2.3 Packaged Products

X-ray systems can detect contaminants in a variety of packaged poultry products, such as chicken breasts in trays, value-added cuts like kievs or nuggets.

In addition to bone fragments, x-ray systems find a range of other potentially harmful foreign materials in packaged poultry items, including metal fragments, glass shards, stone and some plastic and rubber compounds. These versatile systems can be used for quality inspection, too, like mass measurement. Using this function, poultry processors can ensure that no overweight or underweight packages reach the retailer of food service operators.

3. Elements to Consider When Choosing an X-ray System for Poultry

In addition to product type and application, poultry processors should consider other elements when selecting an x-ray inspection system. Considerations include the components of the x-ray system itself.

To deliver the best bone detection in a range of applications, from raw/bulk to packaged items, x-ray machines are designed with components that work together: the machine, energy generator/detector and image processing software.

3.1 Physical Machine Design

A robust machine can withstand challenging environments such as poultry processing facilities with often-harsh conditions.

Processors should look for x-ray machines with a sanitary and hygienic design:

- Mass measurement
- Component count
- Fill level inspection
- Identify missing or broken products
- Package integrity

- Hygienic construction: Systems in poultry facilities should be built to meet North American Meat Institute (NAMI), NSF/ANSI/3-A 14159-1 & 3 and European Engineering & Design Group (EHEDG) standards for sanitary construction and operation. This ensures that design diligence has been followed and that the machine is in line with critical elements of HACCP.

Among other features, machine parts should be welded together instead of bolted to eliminate food debris collection points. Processors can also look for interlocked hinged louvers that enable easy access to the conveyor, eliminating the need to dismantle traditional heavy louvers to clean the inside of the machine.

Physical
Machine Design

Generator and Detector
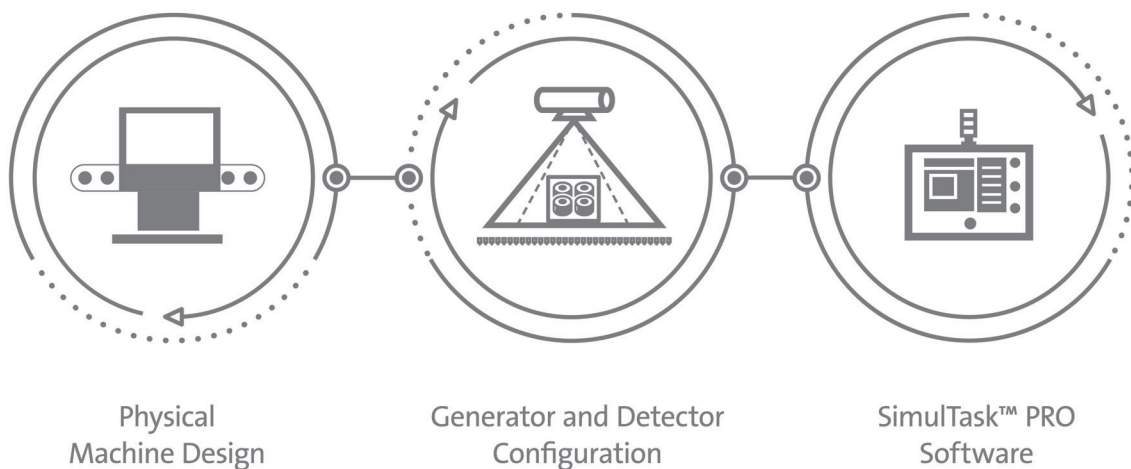Configuration

SimulTask™ PRO
Software

Figure 3: Diagram of how x-ray machines are designed with components that work together: the machine, energy generator/detector and image processing software.
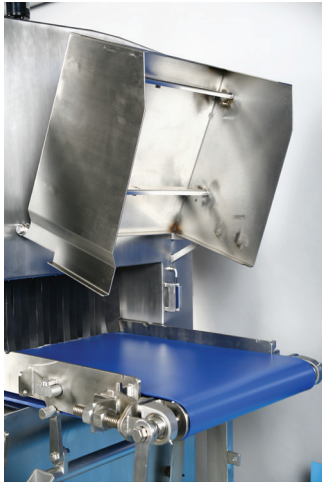
Figure 4: Hinged louvers allow easy access to the conveyor

- Fast sanitation: Unobstructed sightlines allow for quicker and easier sanitation, as does simple belt removal. The physical design of x-ray machines ensures that they hold up to the poultry industry's rigorous, high-temperature washdown procedures and adhere to the principles of sanitary design.

- Maintenance friendly: Machines that are designed to be simple to maintain also maximize uptime, in an era when speed and throughput are pivotal for poultry operations.

3.2 Generator and Detector Configurations

Generator and detector configurations in an x-ray system are the components that ensure a high quality image for superior analysis. Depending on the potential contaminants, product type, packaging and production line speed, poultry processors have traditionally selected from single or dual energy technologies to fit their inspection needs.

3.3 Software

Inspected products are analyzed via x-ray imaging analysis software that harnesses data from multiple diodes via high resolution analog to digital converter to interpret and create the most exceptional image, even in tough conditions. Such advanced x-ray platforms use sophisticated algorithms to perform grayscale analysis that find subtle changes in product composition. Images with the highest resolution provide detail for optimal bone detection as well for simultaneous quality checks such as mass measurement, component count, shape verification and other quality attributes.

4. X-ray Power Considerations

The type of poultry being processed at a facility will also impact the power settings of an x-ray system. For example, chicken has a different density than turkey; products within each of those poultry types also can have variations in density.

X-ray generators have two main settings that result in an overall power setting. One is voltage, expressed in terms of kilovolts (kV) and the other is current, measured in milliamps (mA). Because most poultry – especially chicken – is not dense, the settings must be fine-tuned to achieve the best results. Settings can be adjusted to low voltage and increased to a high current, for example. Think of it like a tuner: to increase the sound, you turn up the volume, but if you want more fidelity, you adjust the gain.

5. Detector Considerations

The detector captures detailed information about the inspected product. An x-ray detector is to x-ray as a camera is to light: a way of capturing x-ray energy and converting it to an image form that can be processed by software. When paired with the most advanced image analysis software, detectors enable greater accuracy in finding bone fragments in poultry, while also lowering false rejects.

There are three types of x-ray detector technologies used for poultry inspection today: single energy, dual energy, and the highest form of energy, PXT™ (Performance X-ray Technology). Each type has its own place in poultry inspection.

5.1 Single Energy

Single energy x-ray technology is effective at detecting foreign bodies that exhibit an x-ray absorption spike relative to the surrounding product's absorption. Single energy detectors work well for operations with faster line speeds, and with packaged or pumped products.

While single energy is well suited for those kinds of poultry items, it is not the ideal kind of detector for inspecting raw poultry breast. Instead, poultry breasts are best inspected by dual energy detectors – ideally, the latest PXT™ performance x-ray technology.

5.2 Dual Energy

Dual energy technologies developed in the last decade or so represent significant industry

improvement on single energy detectors. They are better at detecting objects that show a very small x-ray absorption variation, such as calcified bone. Dual energy technology essentially removes most of the effect of product thickness variations, leaving an image that shows density difference based on chemical composition, or atomic number.

Poultry processors that produce chicken breasts can deploy dual energy technologies to find bone down to 2 mm. In packaged products, dual energy x-ray technology is capable of finding inorganic contaminants in a variety of formats, including corrugated encasement that poses challenges for traditional inspection tools.

Figure 5: Example of raw chicken product in tray.

5.3 PXT™ Performance X-ray Technology

Introduced in mid-2020, Performance X-ray Technology (PXT™) is the latest advancement in detection technology. This radically enhanced detector technology, featuring smaller diodes with a smaller pitch, collects more detailed data about the product being inspected. When analyzed with advanced image analysis software, this provides images with much higher resolution.

The breakthrough PXT™ allows poultry processors to find the smallest bone fragments, down to 1 mm, with high repeatability, low false rejects (<3%) and less rework. PXT™ can be deployed to suit a wide range of applications at any product control point, including chicken and turkey intended for retail packs as well as incoming raw material bound for further processing into products like sausages, patties or nuggets. The versatile technology is successful in detecting bone and foreign contaminants in both fresh and frozen products and can handle thick products like turkey breasts or thinner products such as chicken tenderloins.

From an operational standpoint, processors can use x-ray devices equipped with PXT™ in both single and multilane setups and as stand-alone critical control points or networked to enable full process optimization and efficiency analysis.
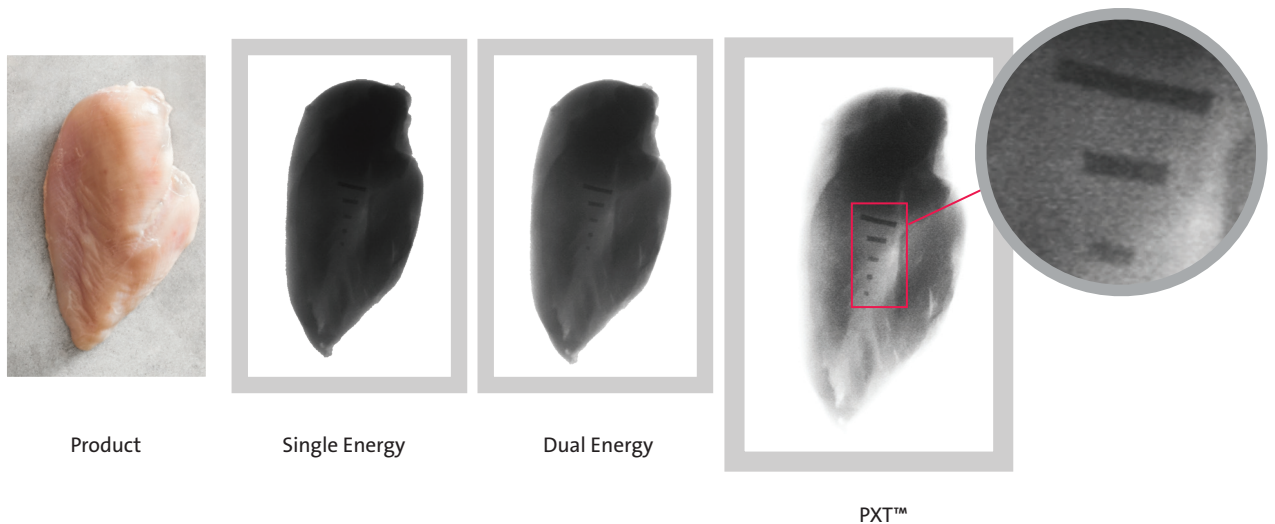

Product   Single Energy   Dual Energy

PXT™

Figure 6: Examples of single and dual energy x-ray images vs. PXT™ technology.

Choosing the Right X-ray Technology for Poultry Bone Detection

Summary: Which X-ray Energy is Best for Your Poultry Bone Detection?

The optimal energy solution depends on your specific application and likely contaminants, as well as the packaging, production speed and customer specification.

Detector	Advantages	Applications
Single Energy	Provides detection of a wide range of dense foreign bodies, including stainless steel, ferrous and non-ferrous metals, glass, mineral stone, calcified bone and high-density plastics and rubber. Provides excellent detection of small metal contaminants.	Suitable for inspecting a range of poultry applications, apart from products with complex density levels and in some cases, those in innovative packaging. Particularly suited to inspecting homogenous products that are consistent in presentation. Single energy detectors work well for operations with faster line speeds, and with packaged or pumped products.
Dual Energy	Capable of detecting inorganic foreign bodies such as stones, rocks and low-density rubber and plastic.	Well suited for thick, high-density products. In packaged products, dual energy x-ray technology is capable of finding inorganic contaminants in a variety of formats, including corrugated encasement, that pose challenges for traditional inspection tools.
PXT™	Captures more detail about the product being inspecting than its predecessors, which provides highly accurate, high-resolution image analysis consistently detecting down to 1 mm bone fragments. Lower false rejects lead to less product rework, and maximum uptime and simplicity of operation combine for improved throughput and minimized total cost of operation.	Designed for high levels of bone detection for raw and unpackaged poultry products prior to further processing and for fresh, refrigerated or frozen poultry intended for retail.

5. Conclusion

Because of the nature of their products and the processing environment, poultry companies face challenges in safeguarding products, brands and downstream machinery from potentially harmful contaminants. X-ray systems, comprised of robust physical machines, intelligent generators and detector configurations, and next-generation software, are an effective tool in overcoming those challenges for enhanced food safety, quality and line efficiency.

Different detector technologies can be utilized for the best bone detection for a number of applications. Single, dual and PXT™ technologies share some similarities, but each have their place in poultry inspection for bone detection, based on the likely contaminant, product type (nuggets vs. raw chicken breast), packaging, production speed and customer specifications.

Some applications, like pumped products and those with high line speeds, work best with single energy. Because dual energy can discriminate materials by chemical composition and can inspect items with complex density levels, this technology works in a wide variety of poultry products. The newest PXT™ detection capability is a choice for processors looking to find the smallest bones with the least amount of false rejects in birds, including young birds, and in fresh, raw and packaged product.

To choose the best x-ray system, poultry processors should evaluate their current needs and future goals, focusing on their product portfolio and key vulnerabilities. By working with a trusted partner, processors can be assured of a product inspection program that is in line with their requirements and that delivers a lower total cost of ownership

www.eaglepi.com

advanced insights

How to Get the Best Contaminant Detection for Your Poultry Application

Advance Your Inspection of Case Ready and Value-added Meat and Poultry

How Pipeline X-ray Inspection Overcomes Challenges in Pumped Foods

3 Benefits X-ray Inspection Offers to Poultry Processors

Follow Eagle on Social

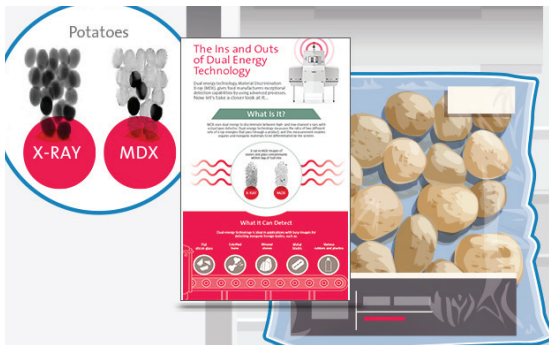

@eaglexray

Learn More About Eagle's X-ray Inspection Solutions

PXT™ - Radically Enhanced Bone Detection for Poultry

SimulTask™ PRO X-ray Image Analysis Software for Meat and Poultry Inspection

Ins & Outs of Dual Energy X-ray Technology for the Food Industry

Bone Detection in Raw Chicken Breasts with PXT™