

LINAC ORIATRON

Missile Inspection Using High-Energy X-ray Non-Destructive Testing Systems

Real-time non-destructive testing and analysis of industrial missiles to detect defects (cracks, porosities, inhomogeneities) and therefore to determine structural conformity of the test object, using X-ray radiography inspection.

The Challenge

As utterly important, complex assets, with high quality requirements, components and machines used in the aerospace and defense industries must **undergo very thorough inspection** to detect any type of defect, flaw or other potential inconsistencies. In these sensitive sectors, quality control is a significant process, requiring the most **accurate and careful analysis**.



Computed Tomography (CT) scanning can reveal internal discontinuities in any type of component and is a completely non-destructive method: the test-object is placed between the radiation source and a flat-panel. The radiation produced by the high-energy linear accelerator will then penetrate the material and the test-object's density and thickness differences will attenuate that radiation, absorbing and/or scattering it. These differences are then recorded and displayed on computer through the CT technique, providing both cross-sectional and 3D volume images of the test-object, allowing its structure and internal components to be fully and thoroughly inspected in great detail. A missile can also be inspected with the classical radiography method, using film instead of a flat-panel.

This technique:

- **Can automatically isolate defects** in complex structures and assembled components,
- Detects **any changes** in thickness and density,
- Provides a **user-friendly software interface**,
- Keeps a valuable **record** of the inspection

Industry: Aerospace, Military, Defense

Technology: High-Energy X-ray Imaging System / Digital X-ray Radiography

Product & Services: High-Energy Electron Accelerators able to Produce X-Rays (standard ranges + customizable options) / Qualified Maintenance

Our Solution

PMB's expertise lies within our ability to design, develop and manufacture linear electron accelerators in-house, capable of generating high-energy X-rays.

PMB is capable of providing an entire high-energy X-ray imaging and handling system, composed of the following:

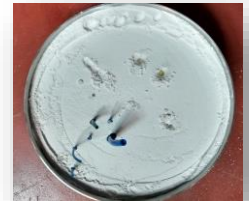
- A high-energy LINAC completely designed and manufactured at PMB
- A flat-panel, its shielding and fixture bracket
- An object manipulator (the interface with the object to inspect being excluded)
- A software suite, to monitor the whole system and for 3D-reconstruction and volume visualization



Standard NDT System (engine inspection)

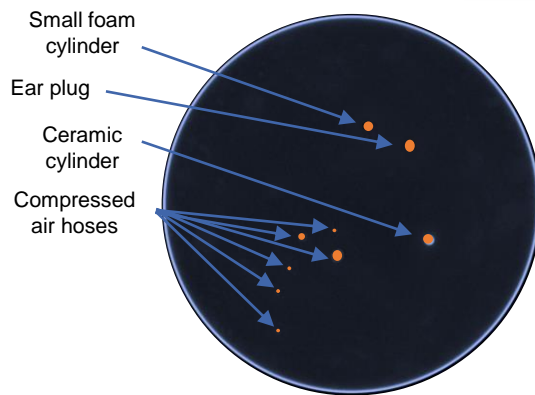
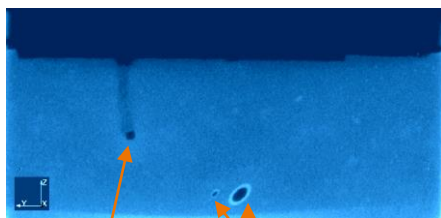
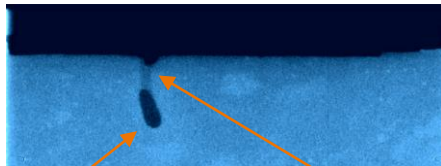
Test Inspection on a Propellant Tank Phantom using CT Inspection

Using an **Oriatron LINAC** with an energy of 3.5MeV, an object of 320mm diameter, 200mm height and 3-5mm wall thickness, containing calcium oxide powder (used as a type of propellant), underwent CT inspection. Some elements which don't originally belong to the component's filler were added and those inhomogeneities were quickly picked up using CT inspection.



Sample's picture

Vertical cross sections



Horizontal cross-section of a propellant tank phantom sample

About PMB: As part of the industrial group **ALCEN**, PMB's expertise is mainly focused on all technologies relating to particle acceleration (ultra high vacuum, electromagnetic simulation, particle matter interaction). We are capable of providing customized components and systems for a variety of industries, as well as preventive and corrective qualified maintenance of all machines.

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LINAC ORIATRON

Non-destructive Inspection of Traditional and 3D-Printed Industrial Components

Using high-energy X-ray non-destructive systems, inspection of industrial components to detect porosities, delamination, shrinkage, cracks, inclusions...

The Challenge

In the competitive and challenging world of industrial parts, **quality assurance** is essential and it seems necessary for players to choose the most effective and accurate inspection method for their products. Moreover, industrials need to **optimize and modernize their production** methods, and to enhance the decision-making process on a global production level.

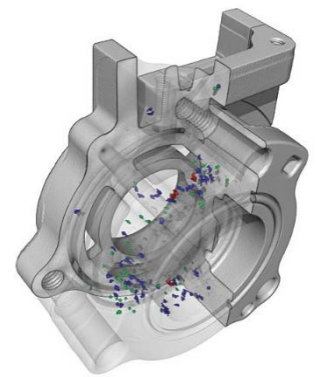
The use of **Computed Tomography inspection** provides means of decision throughout many steps of the production process. It allows the removal of defective parts at an early production stage. Using an **X-ray generator and a detector**, an image is created and converted into a digital one, processed by a specific software capable of automatically recognizing defects.

This technique is efficient because:

- It detects a **large diversity of casting anomalies** (delamination, gas porosities, cracks, internal shrinkage)
- It can be used in **high volume** detection environments to reduce dependency on a human operator to make decisions and for materials such as iron, aluminum, magnesium, zinc...
- It **provides additional information** (measurements, internal structure, wall thickness), necessary to qualify prototypes, or to modify conception if need be

Additionally, **three-dimensional printing technology** allows the production of **highly complex products** and its role is becoming increasingly important in many industries.

However, the additive manufacturing process has its drawbacks in terms of quality control: **geometrical and dimensional inaccuracies** can emerge, undermining the structural stability of the component. Moreover, unlike in traditional manufacturing, dimensions of 3D-printed products cannot be measured during fabrication. These issues are all addressed with **CT scanning**.



Computed Tomography of an Industrial Aluminum Casting

Industry: Industry, Automobile, Aeronautics, Space, Military
Technology: High-Energy X-ray Imaging System / Digital X-ray Radiography
Product & Services: High-Energy Electron Accelerators able to Produce X-Rays (standard ranges + customizable options) / Qualified Maintenance

Our Solution

PMB's expertise lies in our ability to design, develop and manufacture linear electron accelerators in-house, capable of generating high-energy X-rays.

Most of the radiography imaging systems designed for this particular application require:

- A LINAC (linear accelerator), producing X-rays, with an energy of 1 to 7 MeV
- A digital detector
- Object manipulators
- A software suite able to store and analyze digital radiography imaging at high speed

PMB can provide **customizable high-energy LINACs** for this specific need, with a **reduced focal spot size** down to 0,5 mm which greatly enhances the image resolution, allowing a more meticulous casting inspection. An increased dose rate can also be obtained by placing the object closer to the X-ray source.



Standard X-ray LINAC integrated in a complete NDT System

Your Needs, Our Priority

After defining precisely your desired product & features, we provide **recommendations**, based on our experts' advice, to maximize the use of the system and integrate it efficiently in your industrial production process.

The LINAC is entirely tested in our bunker on site before it is integrated in the total NDT system and we provide **warranties and service** for years to come, to ensure the system's **sustainability** and **reliability**.

This system can be used on **3D-printed objects** as well, especially in the automotive and aerospace industries, for complex and large objects which require a high-energy X-ray radiography.

A common misconception about 3D-printing is assuming the technology works perfectly every time, although both traditional and 3D manufacturing are subject to accurate quality control, especially in the case of large and costly products.

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LINAC ORIATRON

Space Rocket Solid-Fuel Engines, Hull and Frame Control Non-Destructive X-ray Inspection

Non-destructive testing of solid rocket motors, to detect defects such as cracks, voids, porosities, and to examine the integrity of propellant mass and bond-line integrity of propellant and insulation, using high-energy X-ray radiography

The Challenge

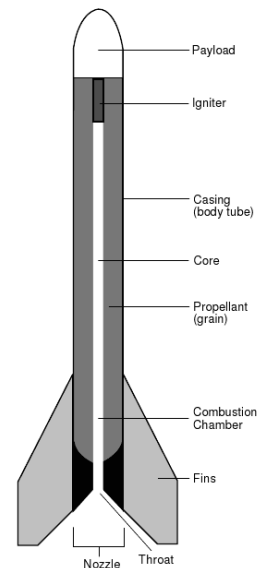
Solid-fuel rocket engines are particularly complex systems that require extreme precision and stringent quality control, as it is essential to the proper propulsion and acceleration of a rocket or a spacecraft.

Good quality assurance in the case of space projects is crucial to the stakeholders' satisfaction as well as the mission's success: errors have critical effects in terms of cost, risk and can even have consequences on human life.

Using X-ray Radiography imaging systems, an aerospace or defense firm can control the quality of some of the rocket's components during manufacture.

The large object we wish to inspect rotates between the high-energy X-ray source and the detector, typically a flat-panel or a linear diode array in the case of digital radiography.

- In a **tangential configuration**, the peripheral part of the booster is the inspected section, the technique allows us to detect delamination defects between the propellant and the external metal envelope
- The **propellant radiography** allows us to detect any flaws in the solid-fuel



Solid Propellant Rocket

Industry: Aerospace, Government

Technology: High-Energy X-ray Imaging System / Digital X-ray Radiography

Product & Services: High-Energy Electron Accelerators able to Produce X-Rays (standard ranges + customizable options) / Qualified Maintenance

This technique is able to detect:

- **Delamination** of composite systems
- **Voids**: these defects can cause cracks, and whether there are single voids or a cluster of voids, porosity or moisture in the propellant can be observed
- **Propellant entrapment**: as rocket engines are insulated with rubber to prevent surfaces from burning, voids may appear between the loose flaps and the fixed insulation
- **Separation between propellant and insulation**: this defect is considered critical and is usually due to poor storage conditions
- **Porosity**: severe porosity observed at the propellant interface jeopardizes the proper functioning of the inhibition, which prevents abnormal burning of the propellant

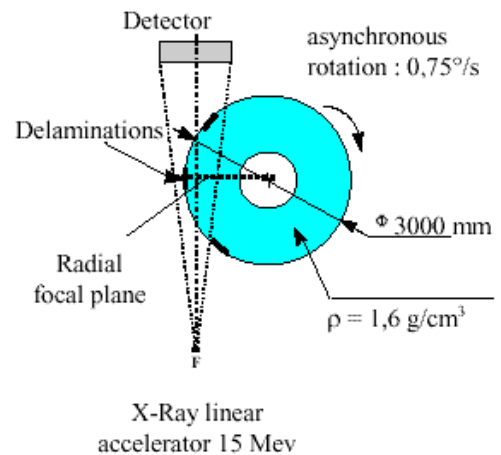
This method can analyze **solid-fuel rocket engines** as well as the very **structural integrity of the system**.

Our Solution

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Most of the radiography imaging systems designed for this particular application require:

- A LINAC (linear accelerator), producing X-rays, with an energy up to 7 MeV
- A detector, whether it is a 2D detector, a flat panel or a linear diode array
- A software able to store and analyze digital radiography imaging at high speed (in the case of digital imaging)
- Object manipulators (rocket, LINAC and imaging system)



Example of a geometrical configuration for tangential control

PMB can provide **customizable high-energy systems** for this specific need, including the Oriatron LINAC up to 7 MeV, with a **reduced focal spot** down to 0.6 mm which enhances greatly the image resolution, allowing a more meticulous analysis.

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