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Introduction

The purpose of the Paper is to provide an overview of the application of XSpectra®, our proprietary inspection technology, in the food segment of spreadable creams (the image on the side is indicative) to show on a preliminary basis the capacity of XSpectra® Detector to identify the presence of foreign bodies (also "**FBs**").

The product inspected is a spreadable cream in a 400-gram oval jar (the "**Product(s)**")

Tests were executed using both low- and high-density FBs and specifically foreign bodies that are hard if not impossible to be detected by conventional inspection systems (like X-ray, metal detector, etc) generally used on processing lines for this type of product.

The Equipment

Tests were carried out at the Xnext Demo Center using a demo machine, equipped with XSpectra®, placed on a 6-meter conveyor loop. The aim was to recreate the typical operating conditions of a processing line for this type of product in order to carry out realistic tests.

The Products were inspected mainly using a geometric configuration of the inspection system in which the X-ray generator and the detector are placed in a lateral position with respect to the direction of movement of the Product.

The demo-machine used for testing has fixed distances in terms of source-product and product-detector. Therefore, when a dedicated machine is built, the geometric configuration can be further optimised, facilitating the operation of the foreign body detection software. We also do not rule out the use of an X-ray source more suitable for the type of product being inspected.

FBs used for testing

We used **15 different types of FBs**, to our knowledge, quite common for this type of production.

Also, we focused more on **low-density FBs** (from around 1.7 g/cm^3 down) **which are difficult if not impossible to be detected with conventional inspection technologies**.

FB1
EPDM
4,6 x 4,8 x 5,3 mm

FB2
POM
4,1 x 19 x 24 mm

FB3
PU
8,7 x 10 x 10 mm

FB4
Stainless Steel
Ø 1,5 mm

FB5
Rubber
11 x 10 x 8 mm

FB6
Rubber
20 x 11 x 8 mm

FB7
Rubber
33 x 8 x 5 mm

FB8
Wood
50 x10 x 8 mm

FBs used for testing

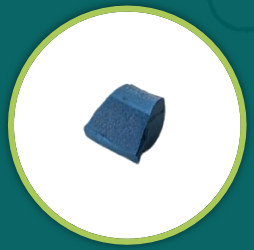
We used **15 different types of FBs**, to our knowledge, quite common for this type of production.

Also, we focused more on **low-density FBs** (from around 1.7 g/cm^3 down) **which are difficult if not impossible to be detected with conventional inspection technologies**.

FB9
Plexiglass
27 x 22 x 4 mm

FB10
Plexiglass
24 x 20 x 3 mm

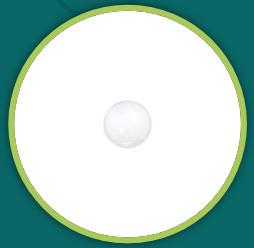
FB11
Copper
122 x 0,25 x 0, 25 mm



FB12
EPDM
5 x 4 x 4 mm

FB13
Glass
2,7 x 2,7 x 2,7 mm

FB14
Glass
14 x 4 x 3 mm



FB15
Glass
Ø 2 mm

Background of the *testing process*

The purpose of these tests was to show the capability of XSpectra® to identify the selected low density foreign bodies, undetectable by conventional X-ray systems

Xnext's proprietary inspection system, under normal operating conditions, performs the inspection analysis first of all by exploiting the properties of the XSpectra® detector. Compared to conventional X-ray inspection systems, operating on energy levels above 25 keV, XSpectra® is capable of analyze the entire X-rays spectrum and operate even at low energies (up to 5 keV). This represents a significant competitive advantage, since product non-conformities can become more evident at low energies.

The detector is integrated and supported by XInspector, the proprietary automatic detection software of the non-compliant Product. It is a self-learning software which, starting from a consolidated background, is adapted from time to time to specific application needs through dedicated training.

In practice, the data relating to the number of photons for each energy band of the X-rays spectrum are crossed with a specific time range. The same dataset is then used to generate an integral image of the contaminated product, such as the images shown in the following slides.

Background of the *testing process*

XSpectra® detects foreign bodies not by analysing a picture but by processing a “cube” set of data generated by the detector

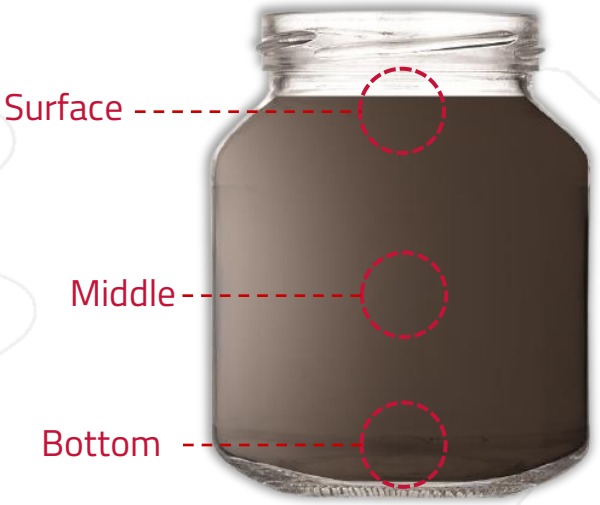
In addition to the images, which are provided in the following section, which provide "visual" evidence of the system's ability to detect selected foreign bodies, the performance of the inspection system is measured through the Probability of Detection (**PoD**): with reference at 100 Product passages for each single FB, we measure how many times XInspector correctly detects the presence of the FB, in correspondence with each inspection of the single Product.

It should be noted that the accuracy of this measurement is affected by the geometric arrangement of the FB in the Product, in cases where the fragment is of irregular size. The best condition for the test would be the use of spherical contaminants, which however are not very representative of reality.

During the tests all the Product-FB combinations were tested (see also the details shown in slide 8) but the following slides provide evidence of a subset of these tests, judging the results that will be shown as representative of the results achieved for the whole sample.

Background of the *testing process*

Each foreign body was manually inserted into the package and placed in different positions (mainly on the surface and in the middle), as shown in the photo on the side, to take into account the possible impact of the position of the contaminant.



The PoD results for the single foreign bodies will therefore be reported separately, depending on the position, in the final summary tables.

The product was inspected with a conveyor belt speed of 40 cm/sec.

Finally, it should be noted that the quality of the images, through which in this document the presence of contaminants is given, is influenced by the conversion of the file to PDF and by the compression of the images generated by the inspection system.

Main Test Findings

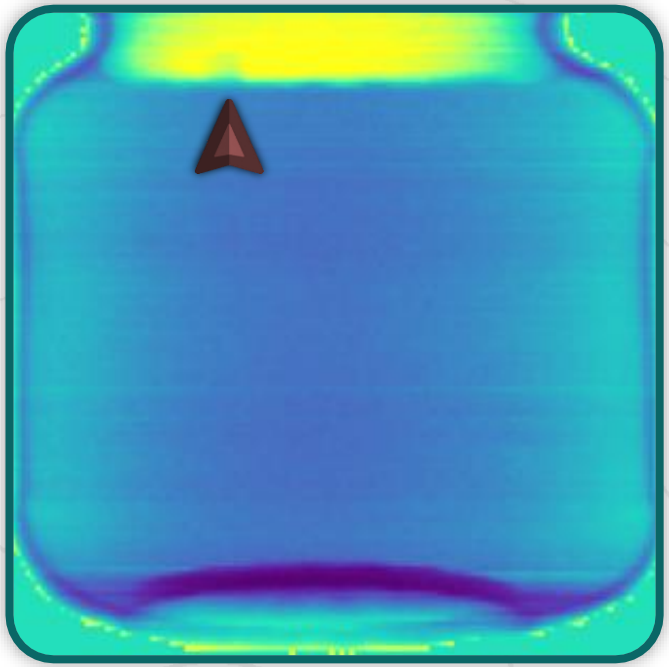
XNEXT
ADVANCED INSPECTION TECHNOLOGY

Surface

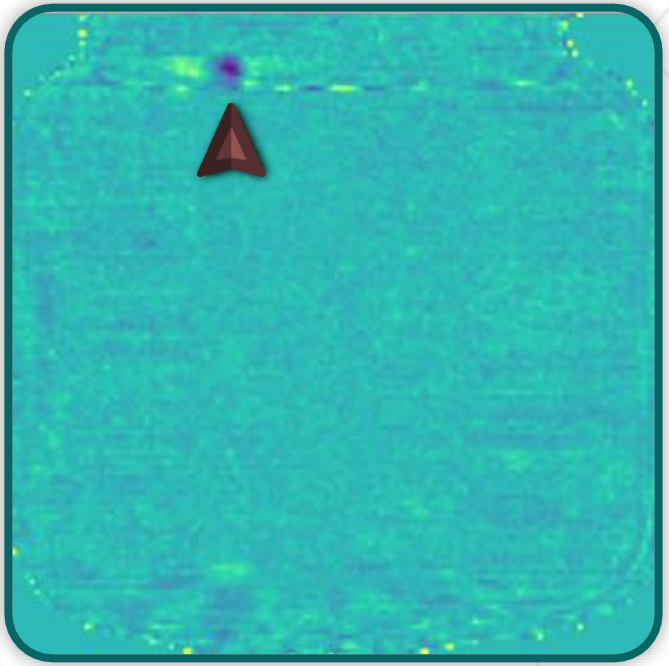
XNEXT
ADVANCED INSPECTION TECHNOLOGY

Evidence of Test Results

FB1
EPDM



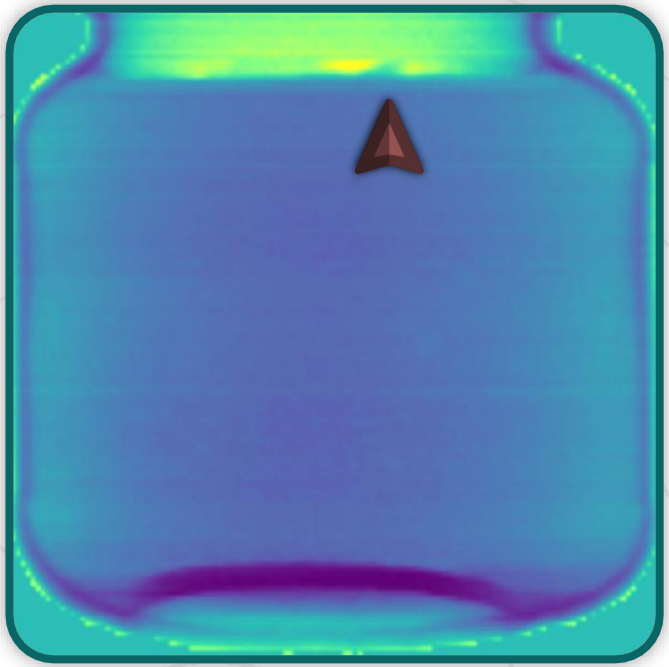
X image



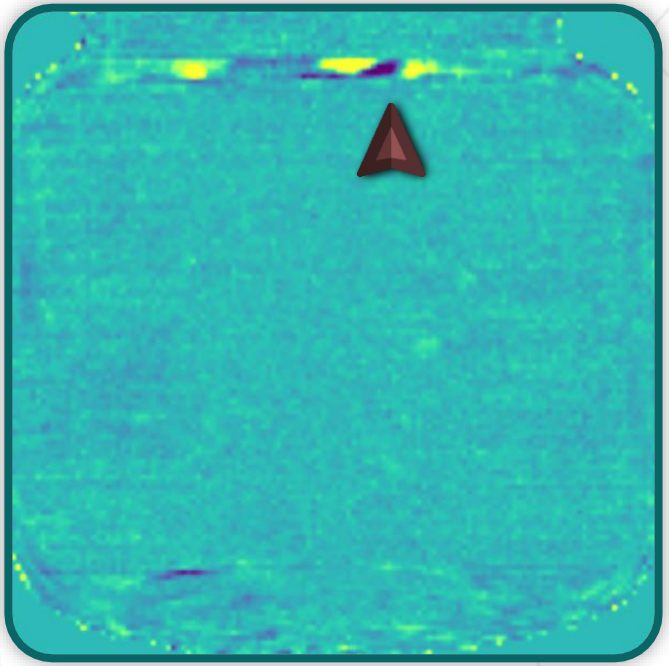
Xinspector image

Evidence of Test Results

FB2
POM



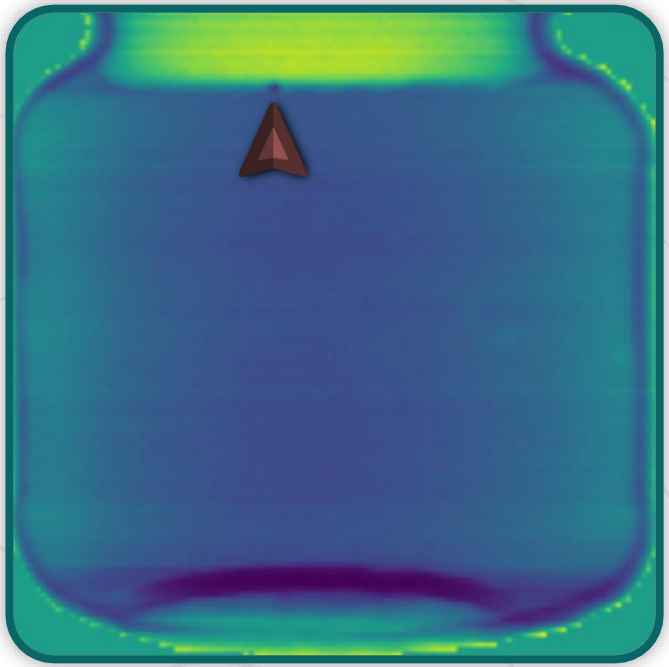
X image



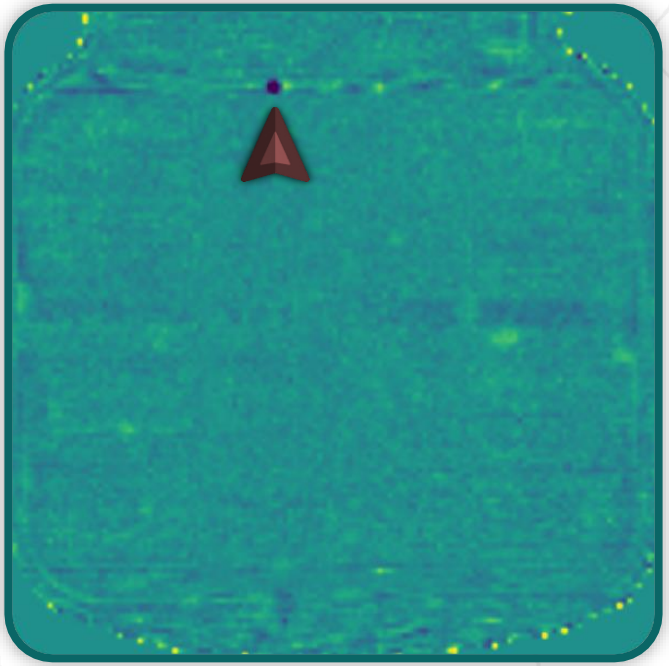
Xinspector image

Evidence of Test Results

FB4
Stainless Steel



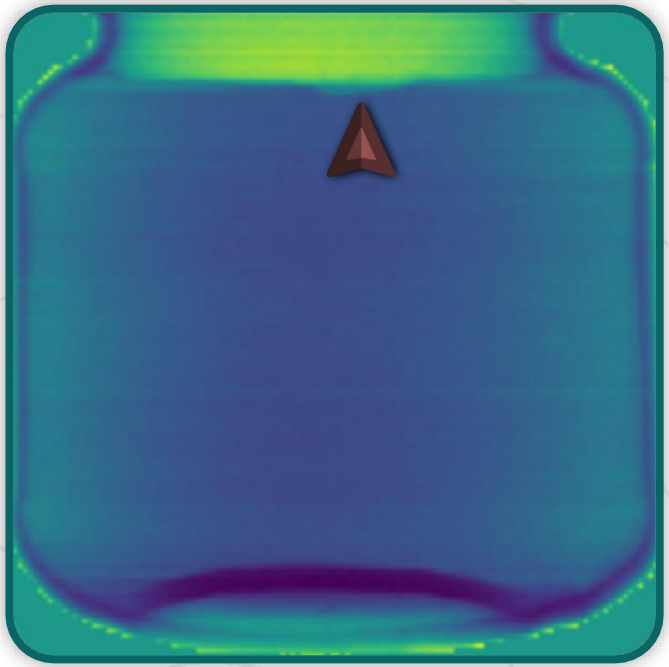
X image



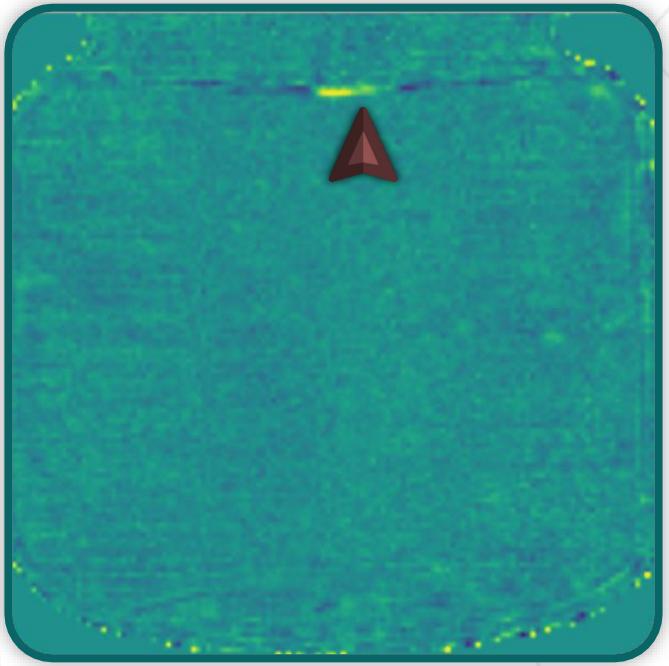
Xinspector image

Evidence of Test Results

FB6
Rubber



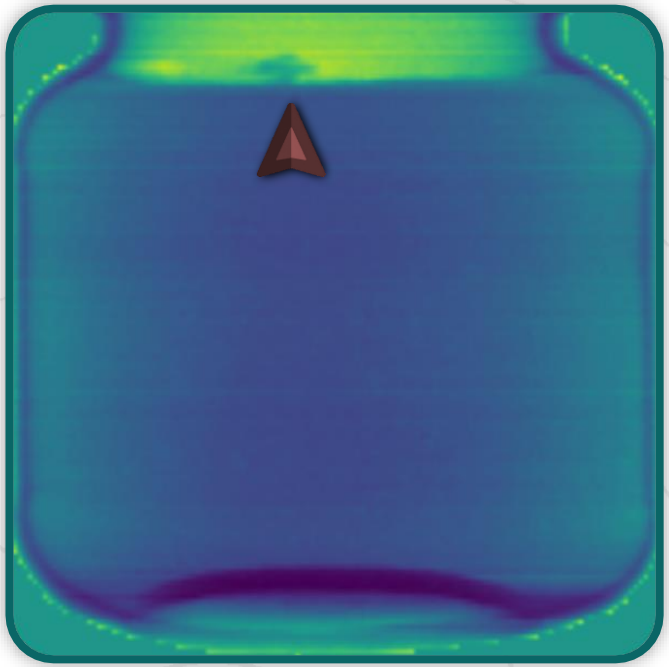
X image



Xinspector image

Evidence of Test Results

FB7
Rubber



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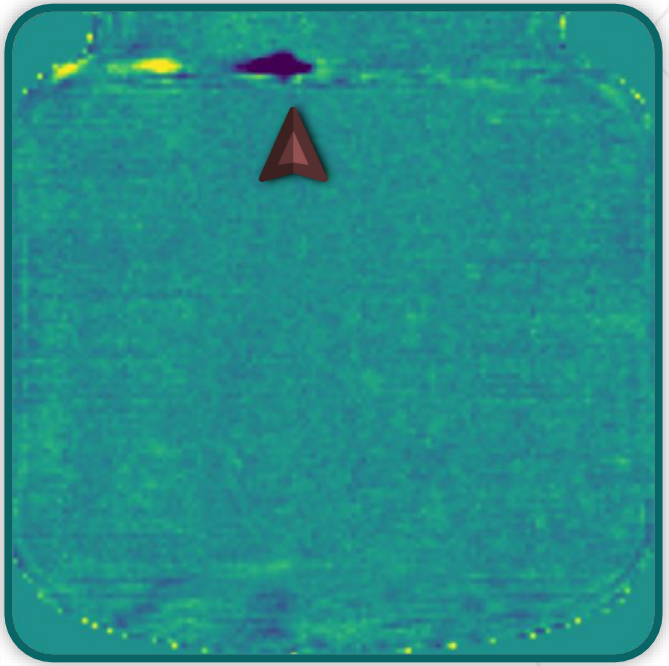
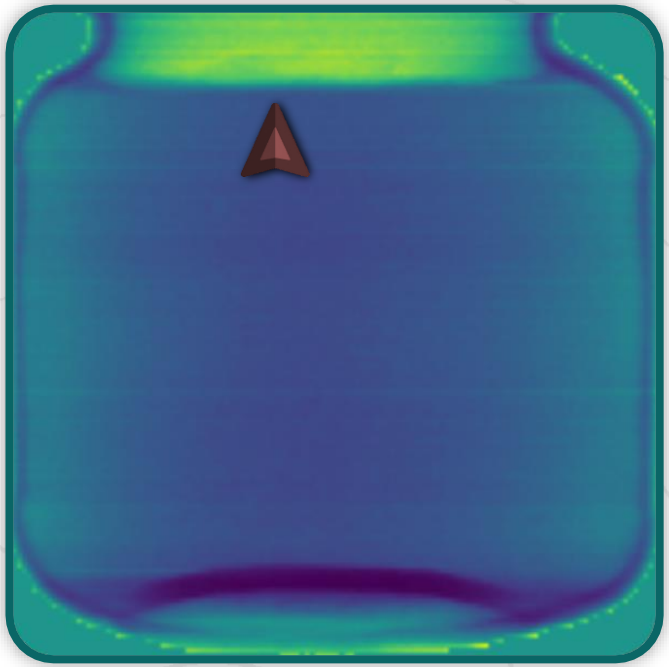


Xinspector image

Evidence of Test Results

FB8
Wood



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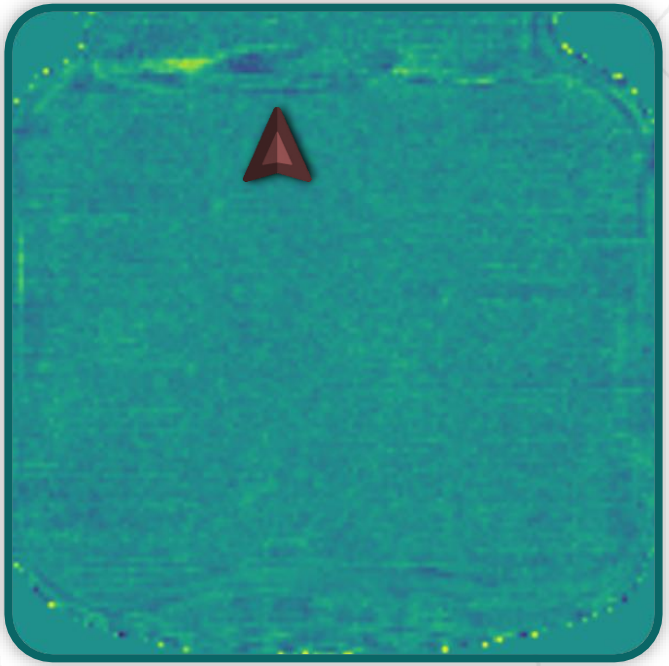
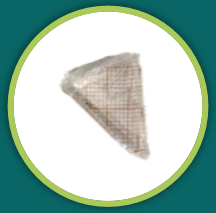
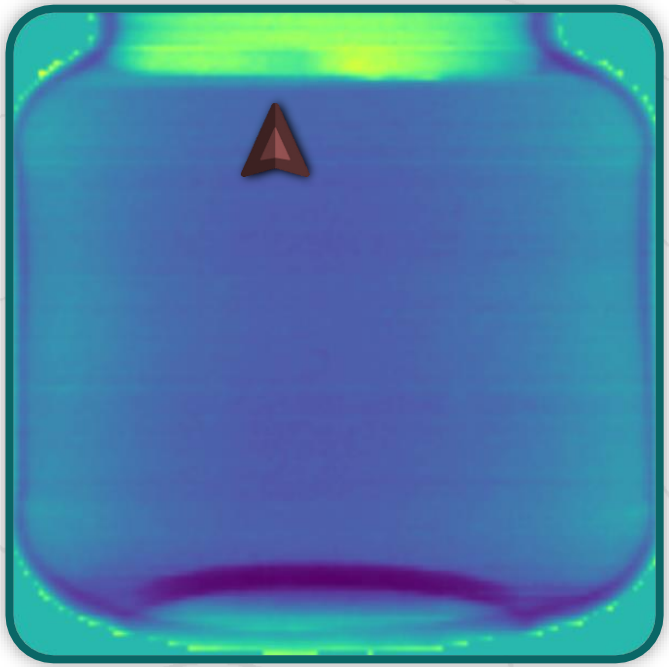


Xinspector image

Evidence of Test Results



FB9
Plexiglass



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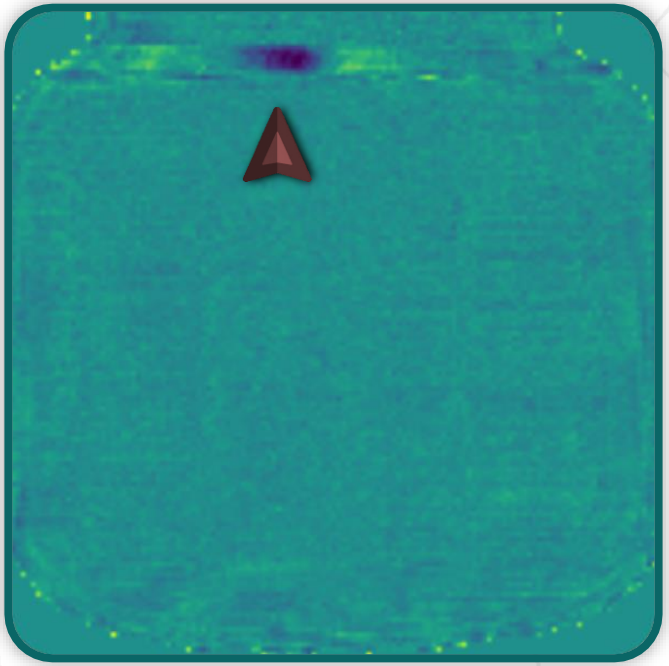
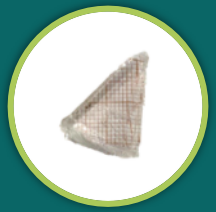
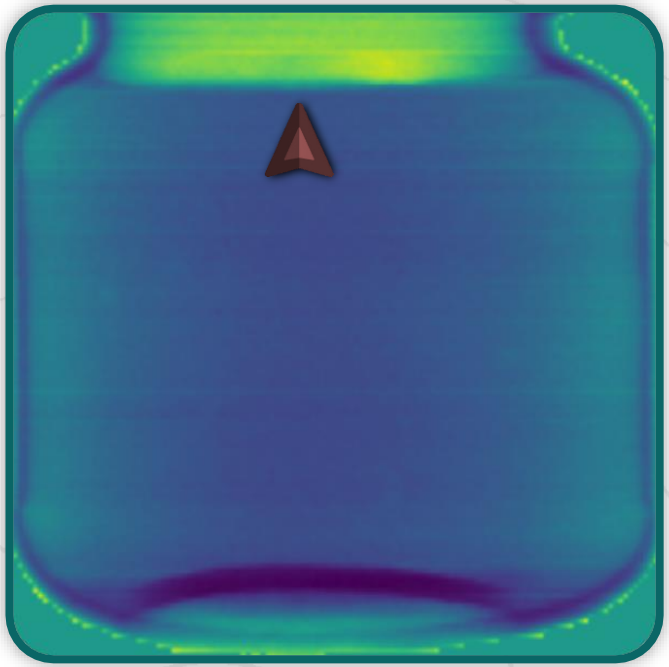


Xinspector image

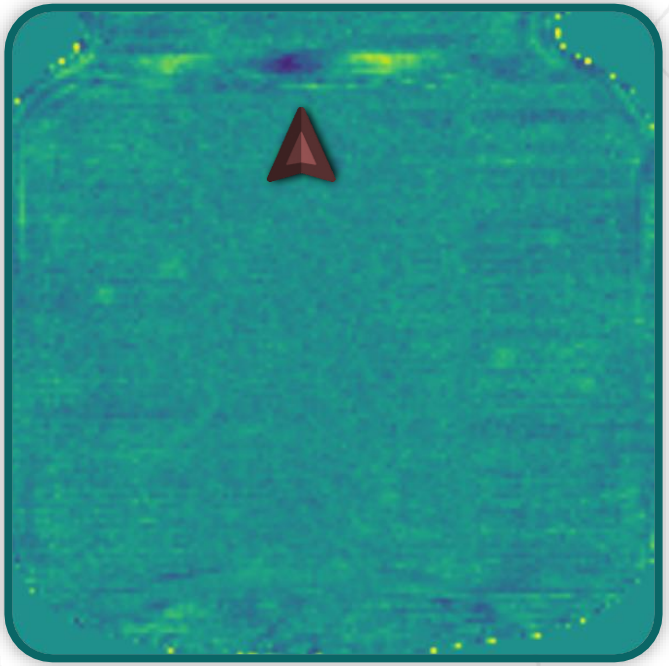
Evidence of Test Results



FB10
Plexiglass



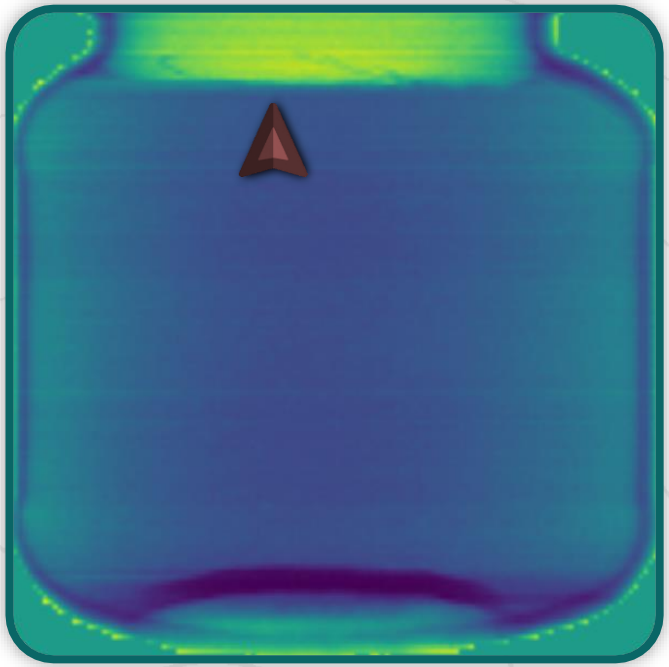
X image



Xinspector image

Evidence of Test Results

FB11
Copper



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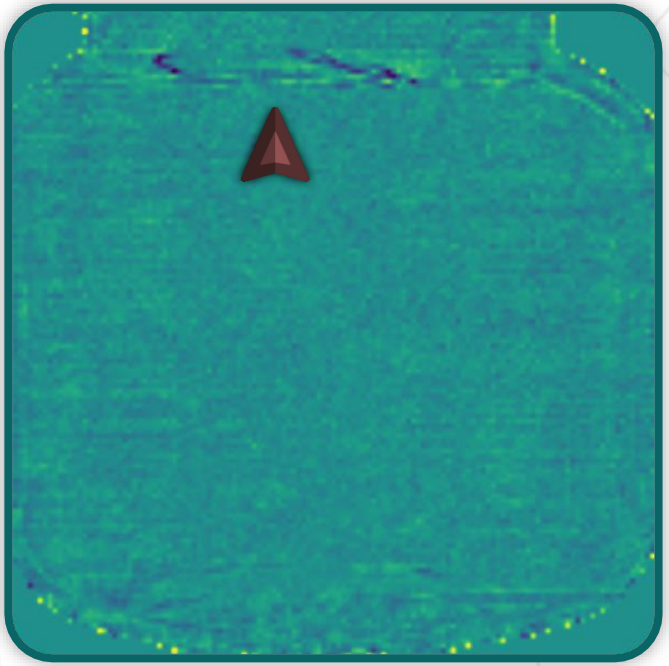
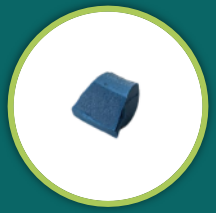
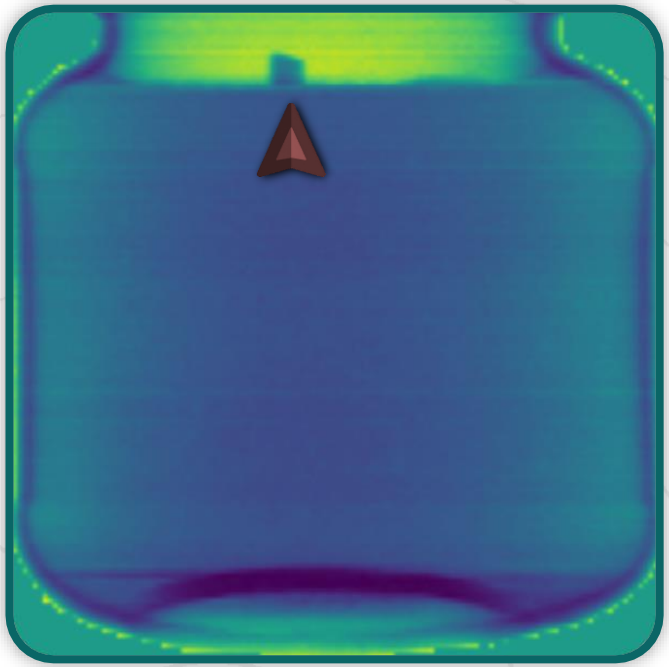


Xinspector image

Evidence of Test Results



FB12
EPDM



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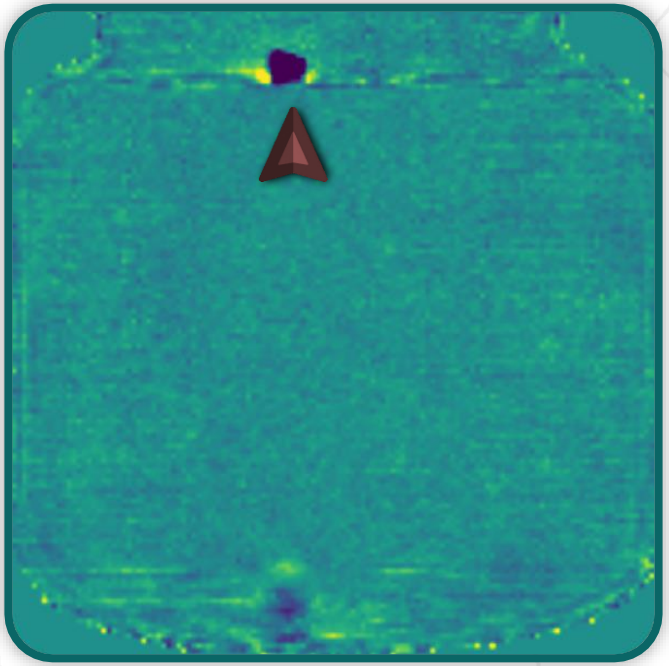
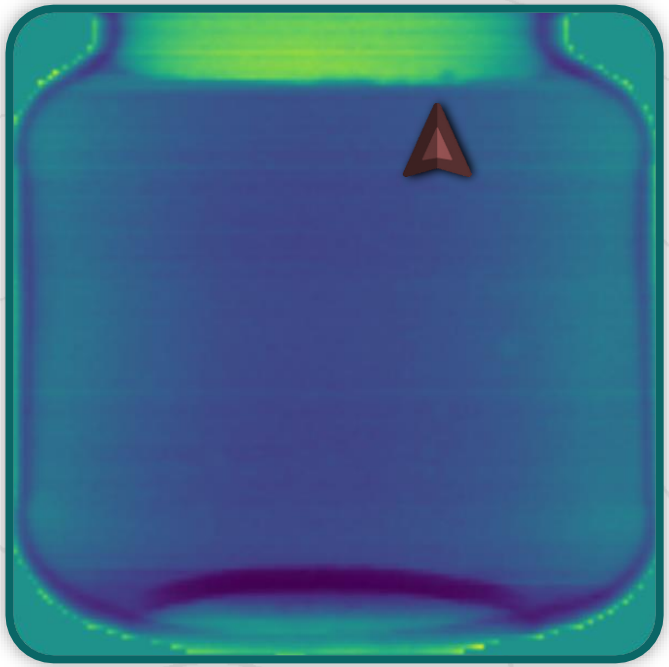


Xinspector image

Evidence of Test Results

FB13
Glass



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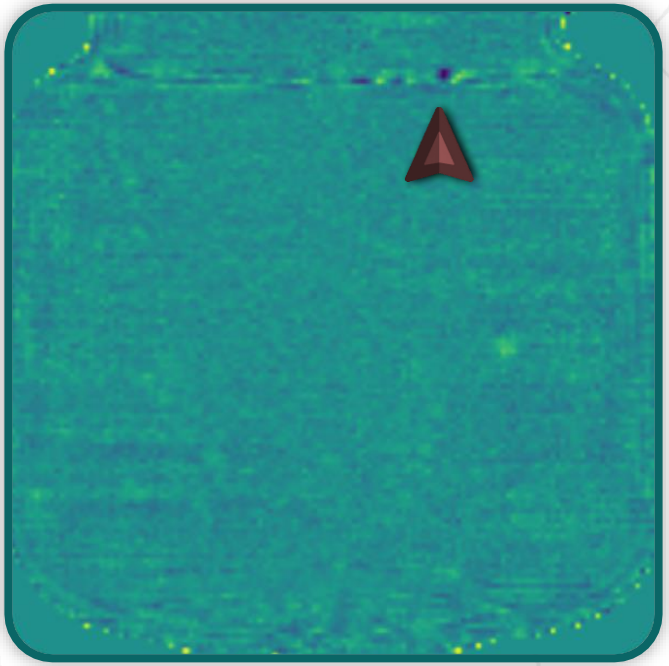
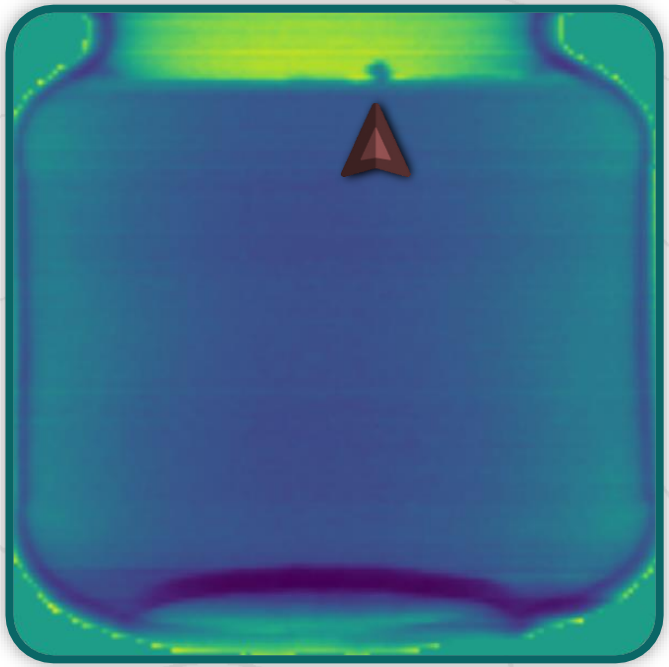


Xinspector image

Evidence of Test Results

FB14
Glass



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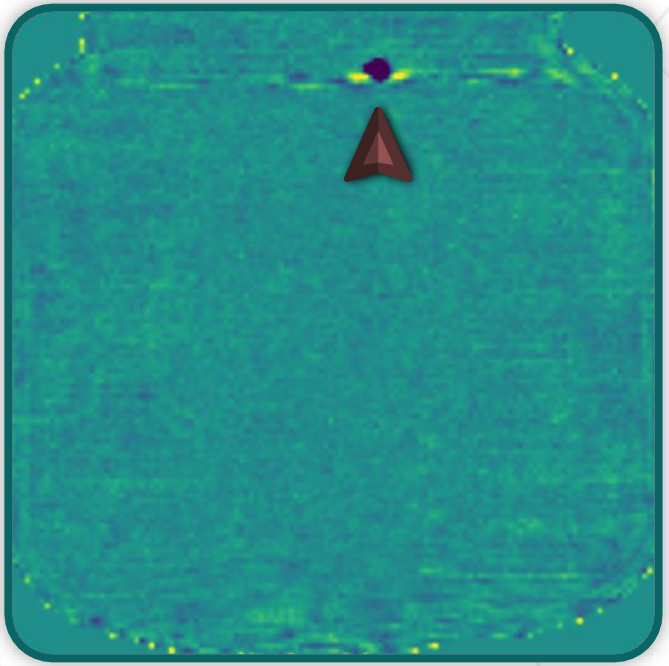
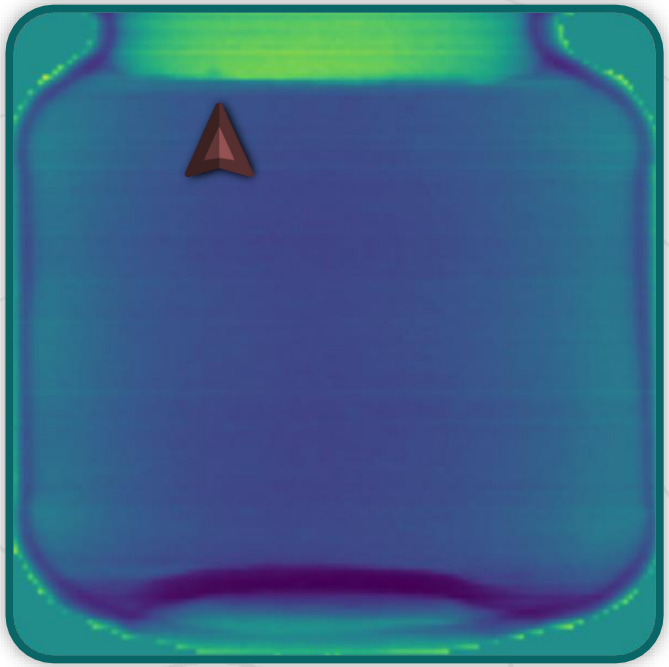


Xinspector image

Evidence of Test Results

FB15
Glass



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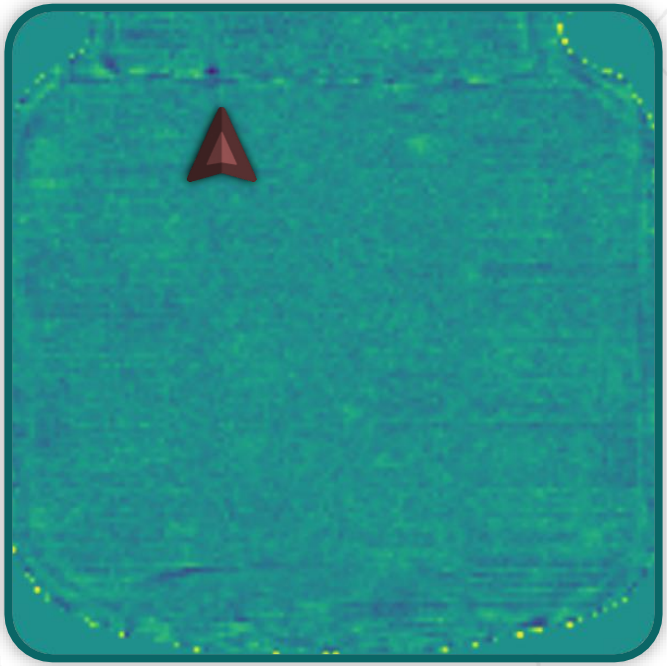


Xinspector image

Surface PoD

FB Code	Foreign Body	Material	PoD
FB1	White EPDM fragment	EPDM	100%
FB2	Piece of modular tape	POM	100%
FB4	Steel sphere	Stainless Steel	100%
FB6	Gasket	Rubber	100%
FB7	Red rubber gasket		100%
FB8	Piece of wood	Wood	100%
FB9	Plexiglass splinter	Plexiglass	100%
FB10	Plexiglass splinter		100%
FB11	Copper wire	Copper	100%
FB12	Glass fragment	Glass	100%
FB13	Glass sube (packaging fragment)		90.5%
FB14	Glass fragment		100%
FB15	Soda lime glass		100%

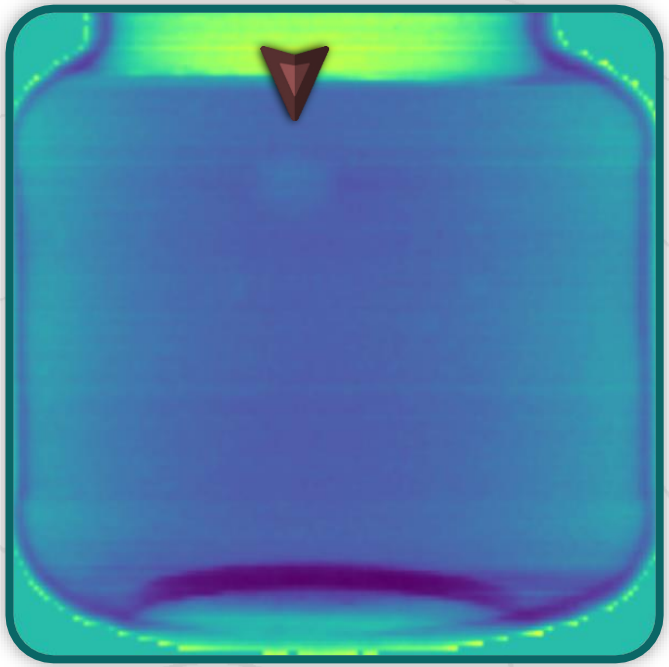
For some foreign bodies (for example FB3 and FB5) it was possible to detect them "visually", by analyzing the image produced by the system, as highlighted also in the relative slide, but the PoD was very low compared to the applicable standards

Middle

XNEXT
ADVANCED INSPECTION TECHNOLOGY

Evidence of Test Results

FB3
PU



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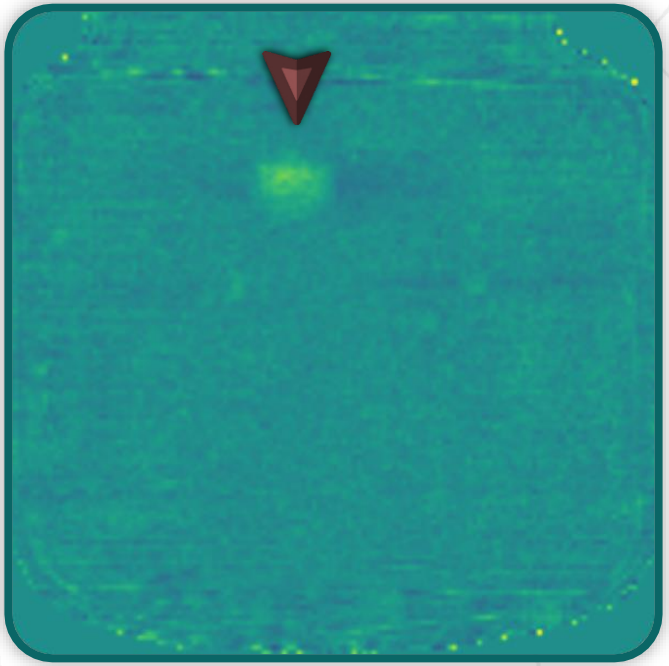
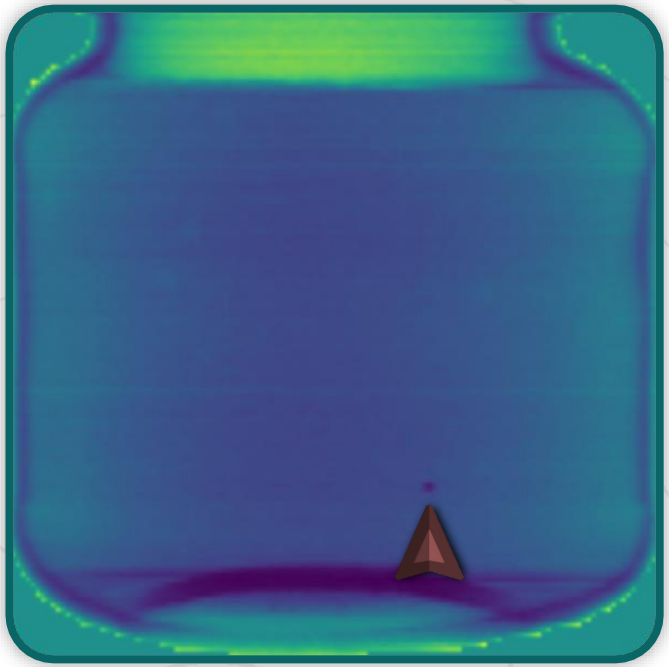


Xinspector image

Evidence of Test Results

FB4
Stainless Steel



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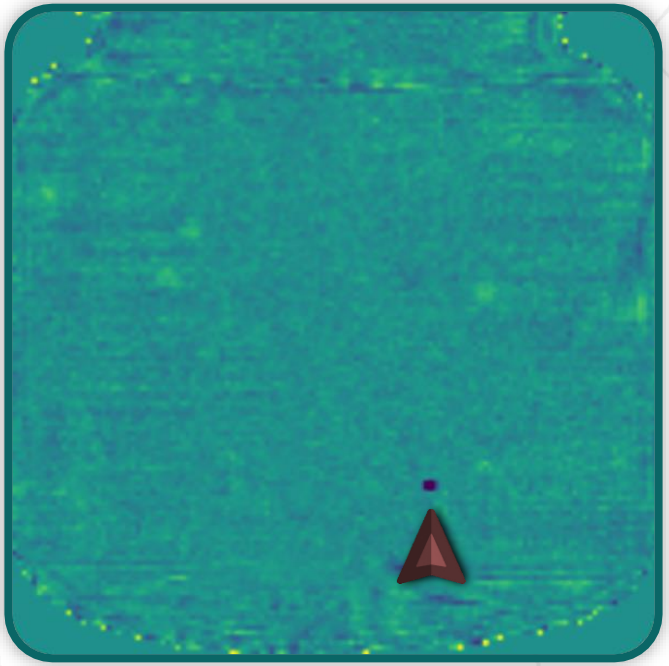
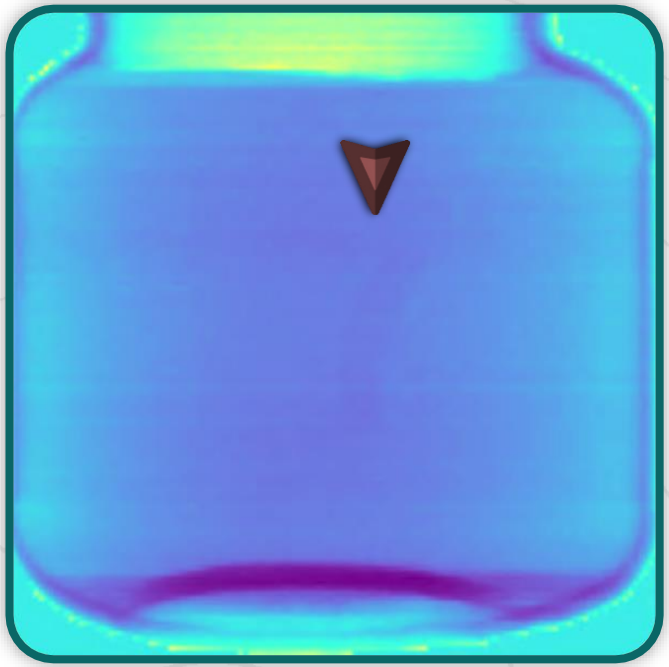


Xinspector image

Evidence of Test Results

FB7
Rubber



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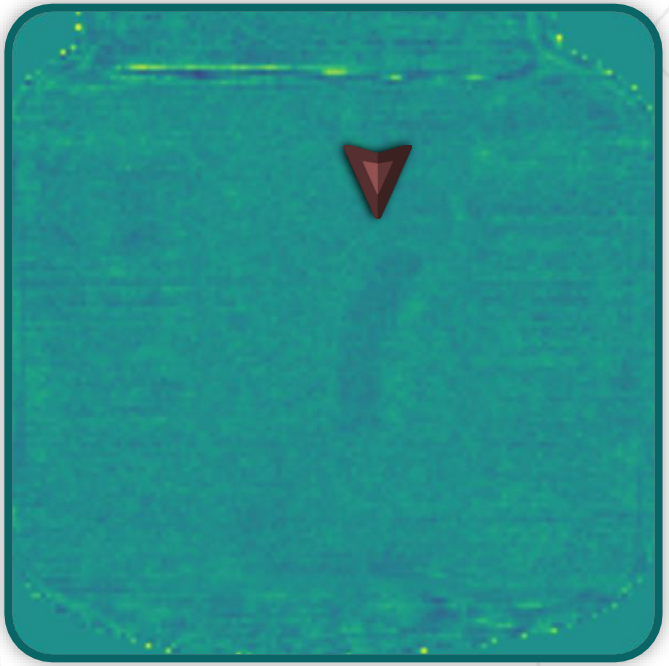
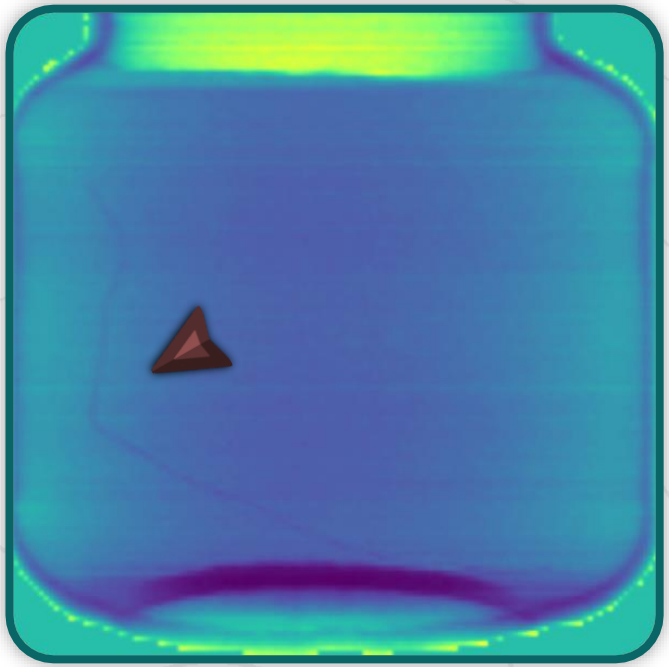


Xinspector image

Evidence of Test Results

FB11
Copper



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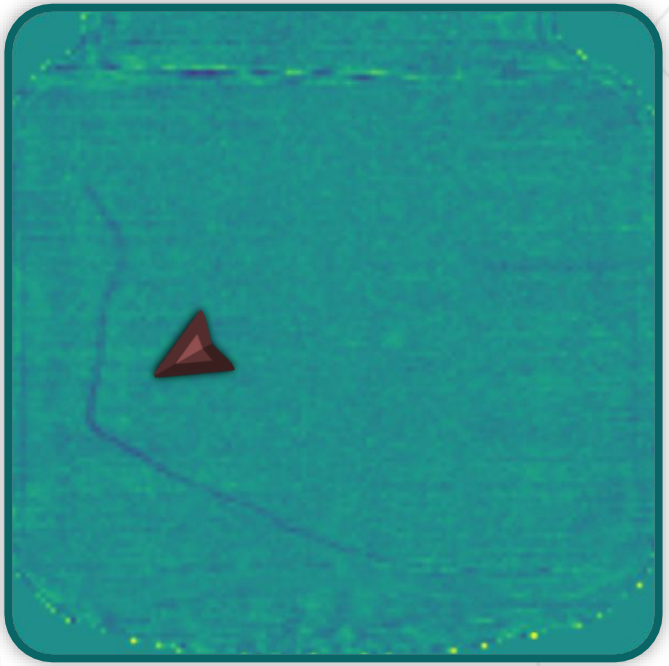
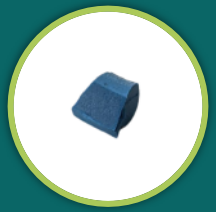
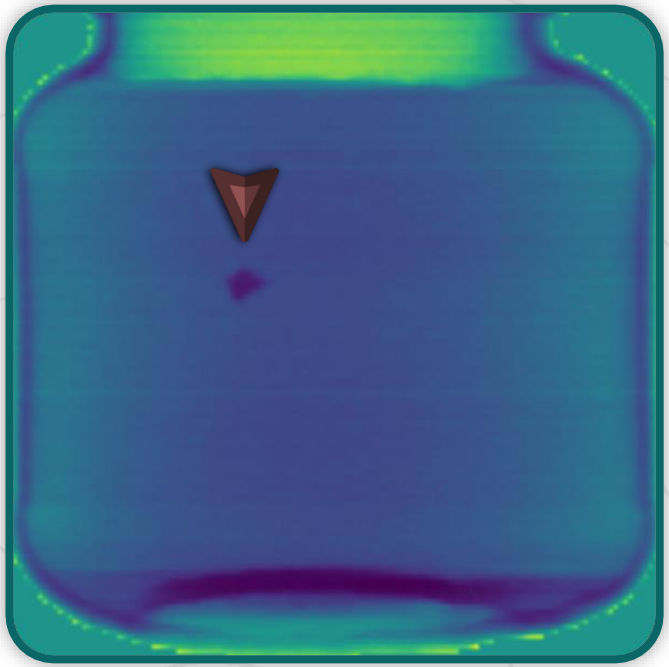


Xinspector image

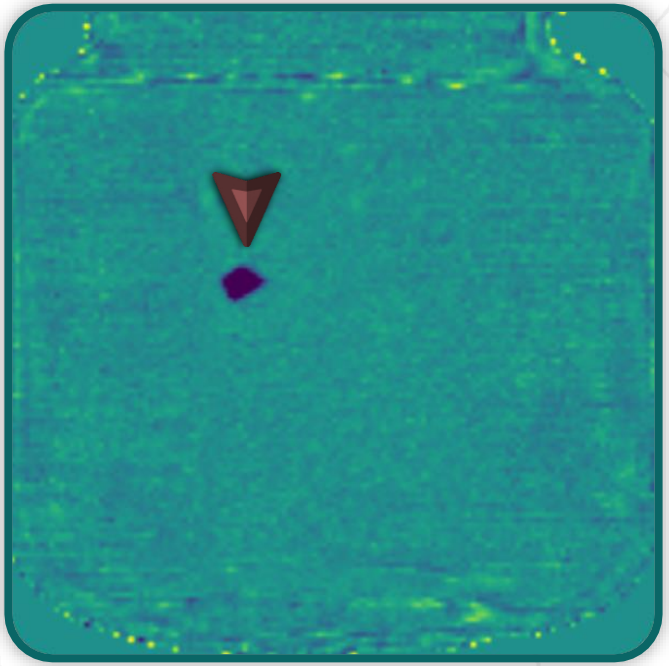
Evidence of Test Results



FB12
EPDM



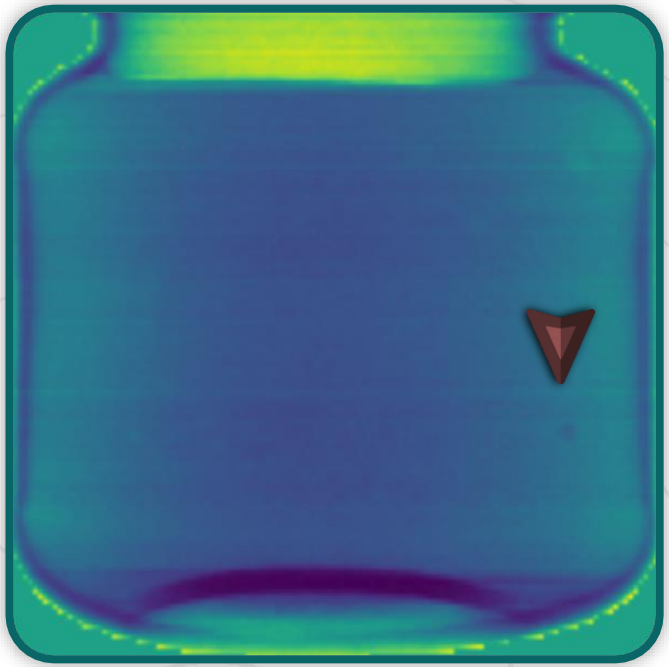
X image



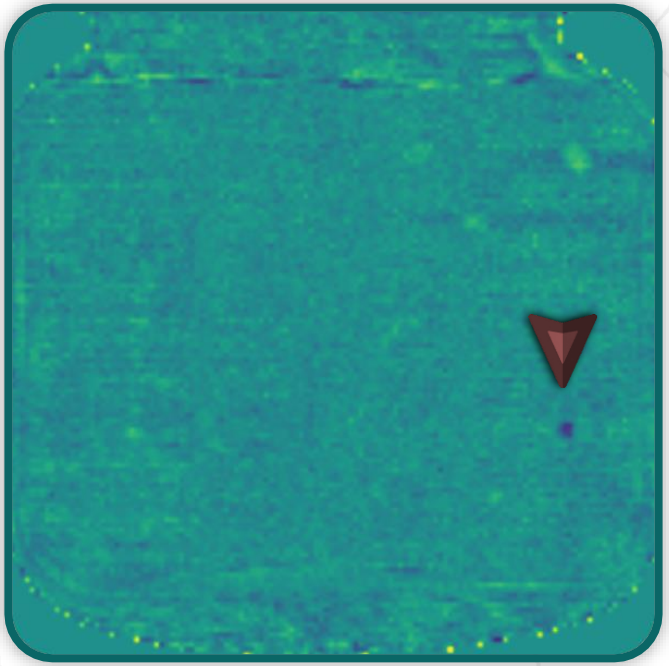
Xinspector image

Evidence of Test Results

FB13
Glass



X image



Xinspector image

Middle PoD

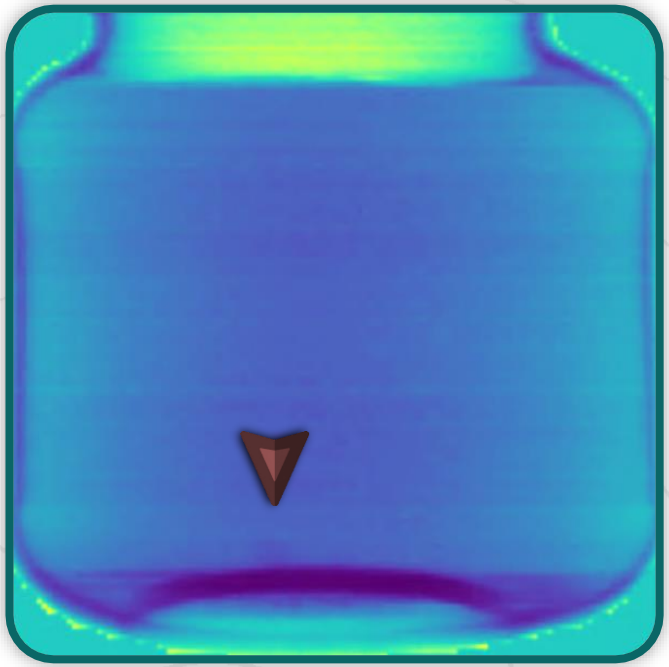
FB Code	Foreign Body	Material	PoD
FB1	White EPDM fragment	EPDM	70%
FB3	Fragment of acoustic protector	PU	100%
FB4	Steel sphere	Stainless Steel	100%
FB5	Gasket	Rubber	100%
FB6	Gasket		100%
FB7	Red rubber gasket		100%
FB8	Piece of wood	Wood	91%
FB11	Copper wire	Copper	100%
FB12	Glass fragment	Glass	100%
FB13	Glass sube (packaging fragment)		82%
FB14	Glass fragment		73%

Bottom

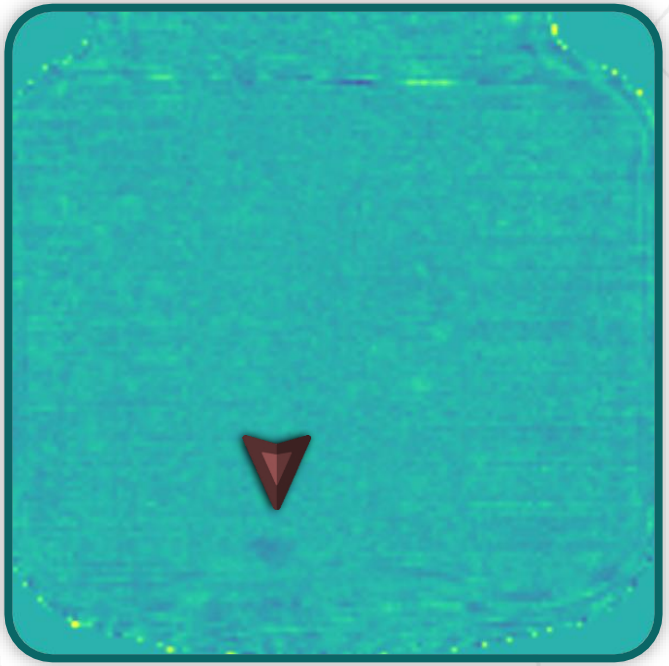
XNEXT
ADVANCED INSPECTION TECHNOLOGY

Evidence of Test Results

FB1
EPDM



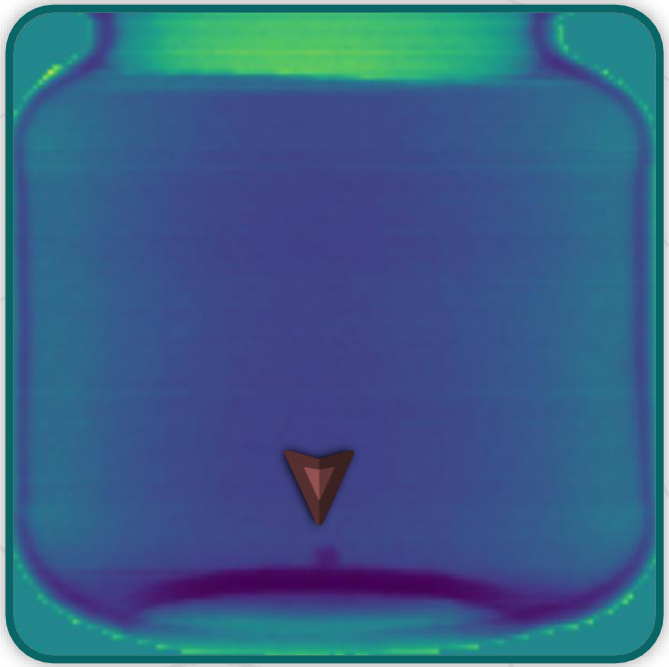
X image



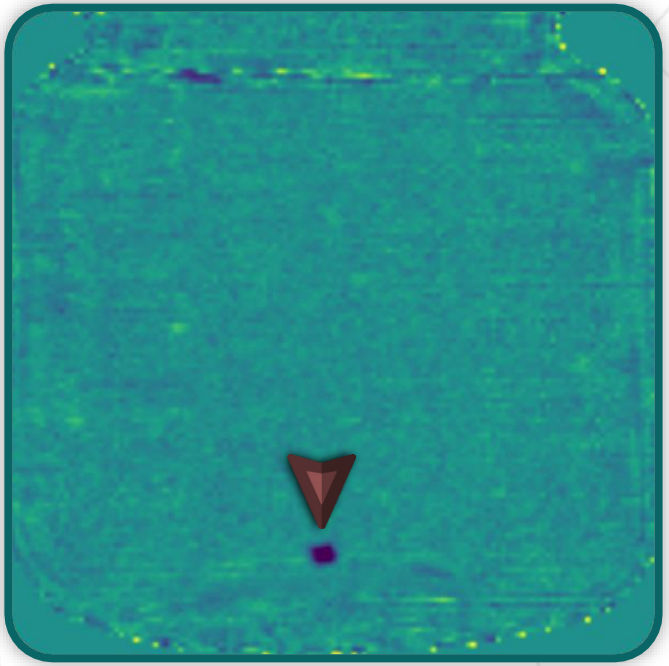
Xinspector image

Evidence of Test Results

FB14
Glass



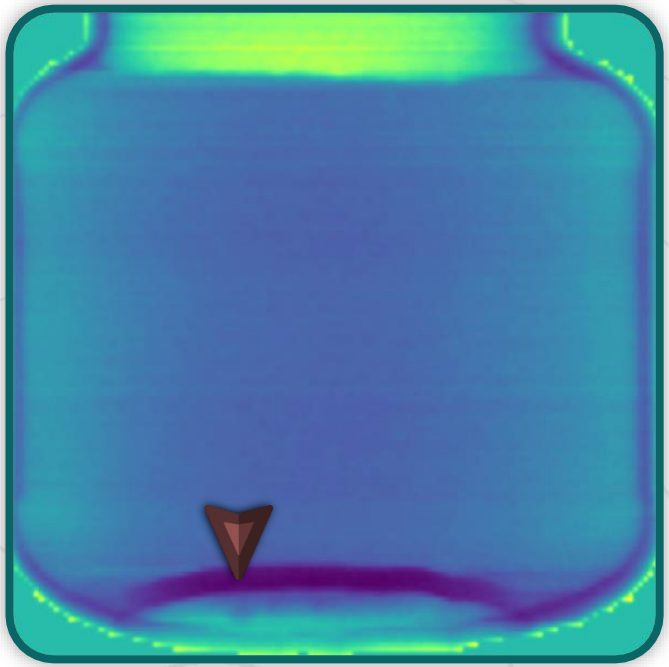
X image



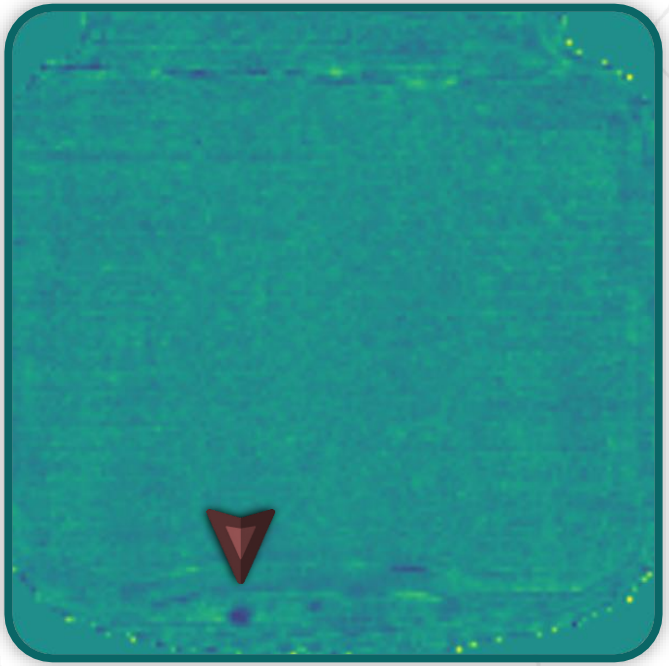
Xinspector image

Evidence of Test Results

FB15
Glass



X image



Xinspector image

Bottom PoD

FB Code	Foreign Body	Material	PoD
FB1	White EPDM fragment	EPDM	70%
FB3	Fragment of acoustic protector	PU	100%
FB4	Steel sphere	Stainless Steel	100%
FB5	Gasket	Rubber	100%
FB6	Gasket		100%
FB7	Red rubber gasket		100%
FB8	Piece of wood	Wood	91%
FB11	Copper wire	Copper	100%
FB12	Glass fragment	Glass	100%
FB13	Glass sube (packaging fragment)		82%
FB14	Glass fragment		73%

The tests did not reveal substantial differences if the foreign body is positioned in the middle of the package or on the bottom

Final remarks

Although the results achieved are already remarkable, when compared to the performance of a conventional X-ray inspection system, there is room for further improvement that could be achieved through:

- the use of XInspector automatic detection software, developed for this specific application;
- a geometric configuration of the system optimized for the product features

XInspector is a self-learning software, which means that the performance and efficiency increase as the statistical data acquired during the inspection of contaminated/non-conforming products increase. Like any AI software, the more it learns to recognize product non-conformities, the more efficient it becomes.

In relation to the above, once installed on the processing line, XInspector can achieve a continuous improvement of its accuracy.

In conclusion, we would like to emphasize the fact that the inspection system, both in its software and hardware parts, is continuously evolving. In particular, we periodically introduce technological upgrades as Xnext is primarily a technology innovator. This innovation will be made available to our customers.

About Xnext

who we are

Xnext is high-tech SME, a technology innovator with the ambition to revolutionize the quality inspection sector, overcoming the weaknesses of conventional solutions. A team of professionals made of data scientists, electronic and nuclear engineers, mathematicians and physicists, AI and software developers

what we do
(why we are so unique)

We perform a real-time (few milliseconds) chemical-physical analysis of the product to identify foreign bodies and defects or non-conformities not detectable by existing inspection technologies

how we do it

Thanks to XSpectra®, our patented technology. It is not simply innovative but rather disruptive as it performs a multi-energy analysis of the x-ray spectrum (up to 1,024 energy bands) and detects also low-density contaminants. Like no other, it is the result of a unique synergy between photonics, nuclear micro-electronics and Machine Learning software

XNEXT

ADVANCED INSPECTION TECHNOLOGY

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