



ADDITIVE MANUFACTURING IN THE CHARACTERIZATION OF HIGH-ENERGY TOMOGRAPHIC SYSTEMS

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Special Process Level 3 (PT – RT Film – RT Non Film)

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CAMPOGALLIANO, (MO)



87 PERSONNEL

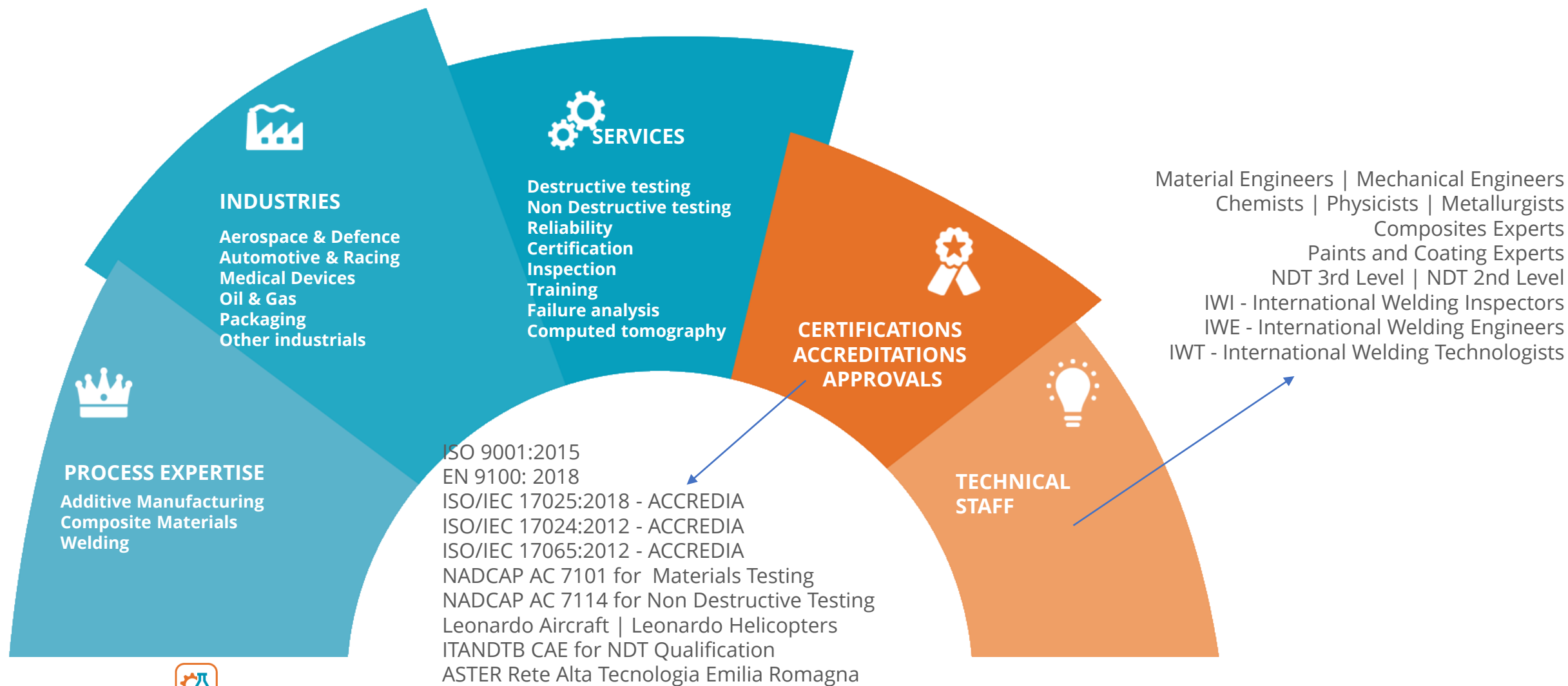


MORE THEN 5000 S.M. OF TESTING AREA





COMPANY PROFILE





2013

NSI X5000 CT SYSTEM

Scan volume: D = 500 mm, H = 1200 mm

Max payload: 90 kg

Max resolution: 5 μ m

SOURCE: X-Ray WorX 240

X-Ray Tube Typology	Open, microfocus
Maximum Voltage	240 kV
Maximum Power	350 W
Focal Spot Size	5 μ m

FLAT PANEL DETECTOR: Varian 2520 DX

Pixel pitch	127 μ m
Sensible Surface	250x200 mm
Maximum Acquisition Speed	12.5 fps - 30 binning
Greyscale resolution	16 bit
Scintillator	Cesium



NSI X7500 CT SYSTEM

Scan volume: D = 1500 mm, H = 3000 mm

Max payload: 250 kg

Max resolution: 70 μ m

SOURCE: Varian HPX 450-11

X-Ray Tube Typology	Closed, minifocus
Maximum Voltage	450 kV
Maximum Power	1500 W
Focal Spot Size	0.4 mm

FLAT PANEL: PE XRD 1621 AN14 ES

Pixel pitch	200 μ m
Sensible Surface	400x400 mm
Maximum Acquisition Speed	15 fps - 30 binning
Greyscale resolution	16 bit
Scintillator	DRZ + (Gadox)

LDA: Detection Technology 0.4iHE2-922

Pixel pitch	400 μ m
Length	92 cm
Integration time	30-1550 fps



2016



PERSONNEL EVOLUTION

2013



CT personnel qualified 2rd & 3rd level EN 9712

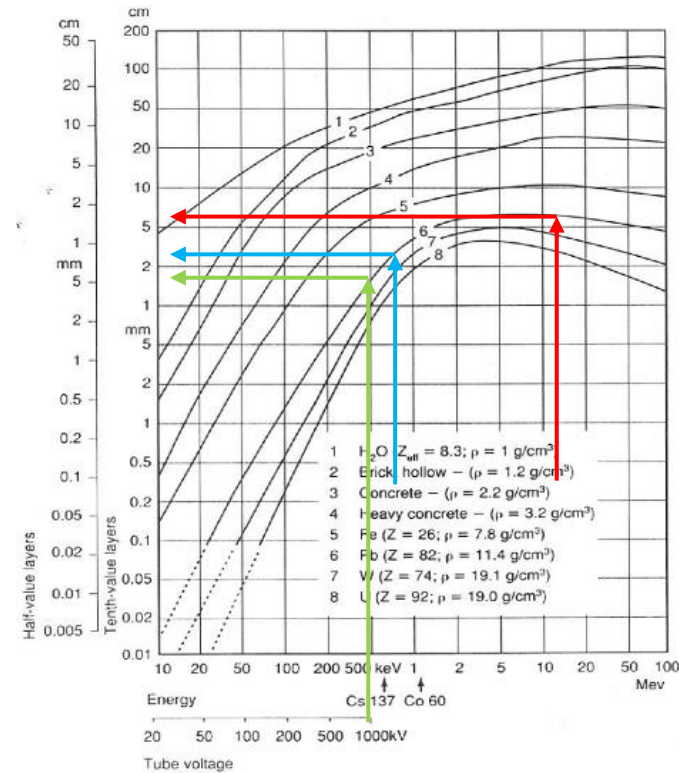
4

2019

Personnel qualified training 2rd & 3rd level EN 4179



2019: D7 6 MEV LINAC



Manipulator:	6-Axes granite-based
Variable FDD:	1500 – 4000 mm
Scanning envelope:	D = 1000 mm, H = 2000 mm
Max payload:	200 kg
Max dose rate:	2.5 Gy/min @ 3 MeV, 9.0 Gy/min @ 6 MeV
High resolution Line Detector Array:	length 600 mm, pixel pitch 200 μm
3K Flat Panel Detector 4343 HE:	active area 417 x 417 mm, pixel pitch 139 μm

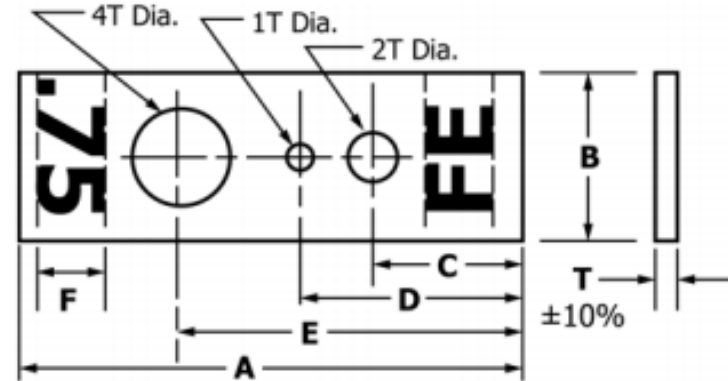




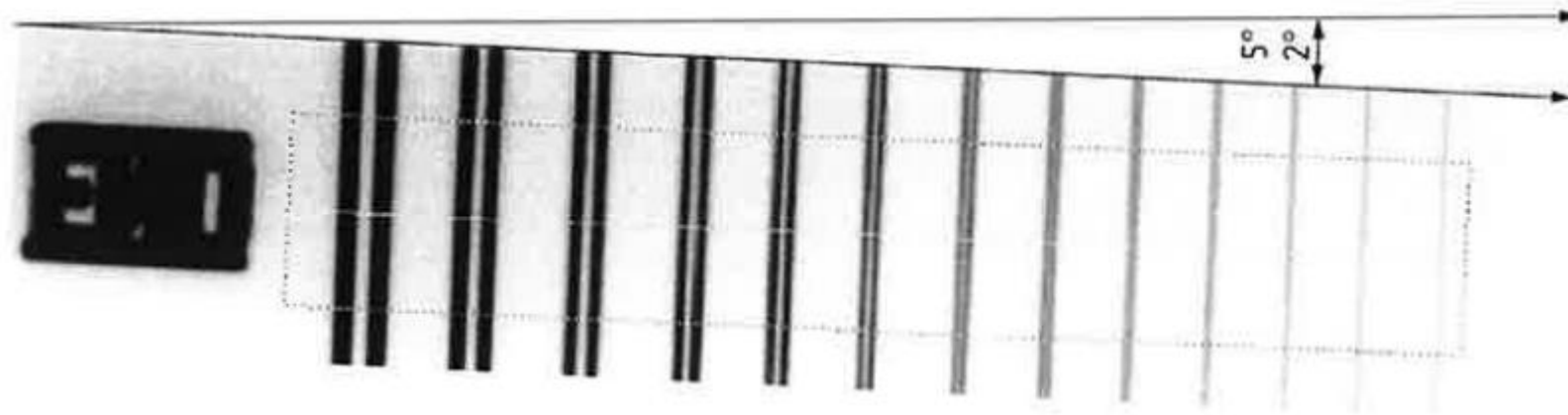
NON DESTRUCTIVE TESTING...



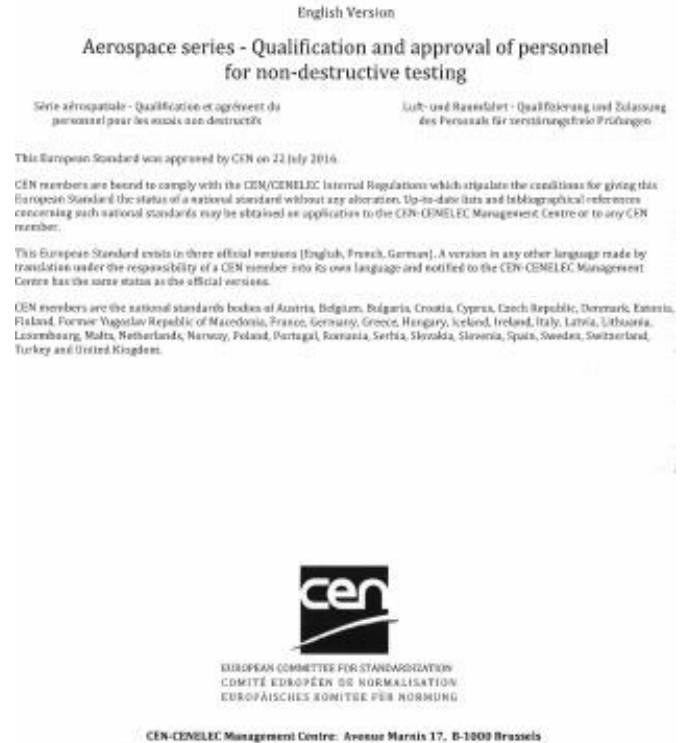
ASTM E 1417 - TAM Panel 146040



ASTM E 1742 - Hole Type IQI



Duplex Wire - Non Film Radiography



EN 4179 - Qualification and approval of personnel for non destructive testing



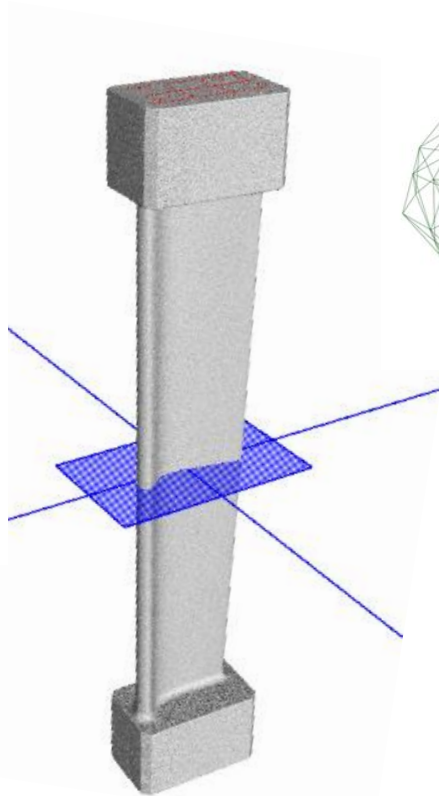


- **ASTM E 1695:** standard test method for Measurements of Computed Tomography (CT) system performance
- **ASTM E 1441:** Guide for Computed Tomography (CT) Imaging
- **ASTM E 1570:** Practice for Computed Tomography (CT) examination
- **ASTM E 1316:** Terminology for Non Destructive Examination
- **Customer specifications**
- Absence of a clear regulatory framework and method framing as well as other Non-Destructive Controls
- There is a lack of unique requirements for the definition of the quality of the tomographic image, ensuring that proper control is carried out for the purpose of dimensional or defective detections
- Additive Manufacturing is the fabrication process which, with the manufacturing of samples containing artificial defects, can help characterizing a tomographic system and checking for their stability

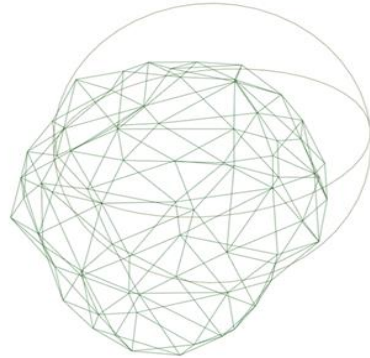




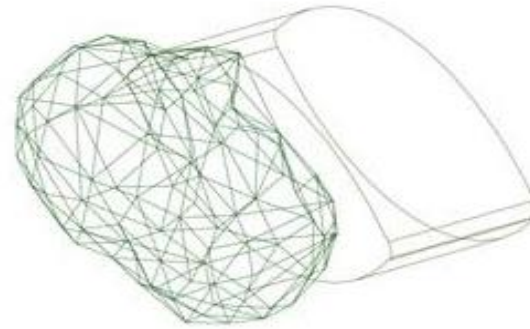
RQI PART 1



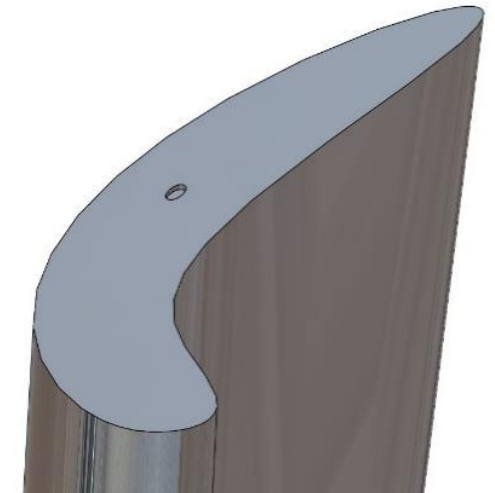
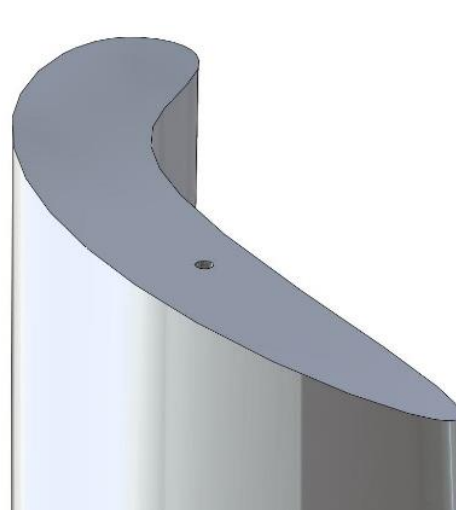
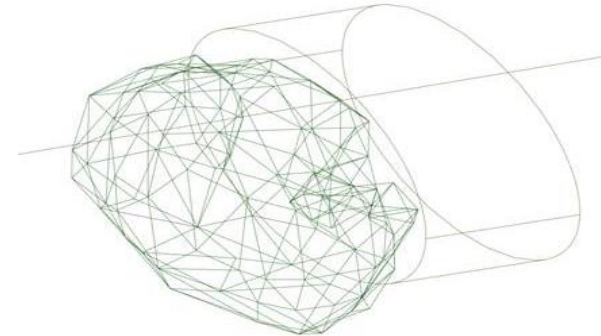
Gas Hole



Gas porosity (elongated) – Notch effect

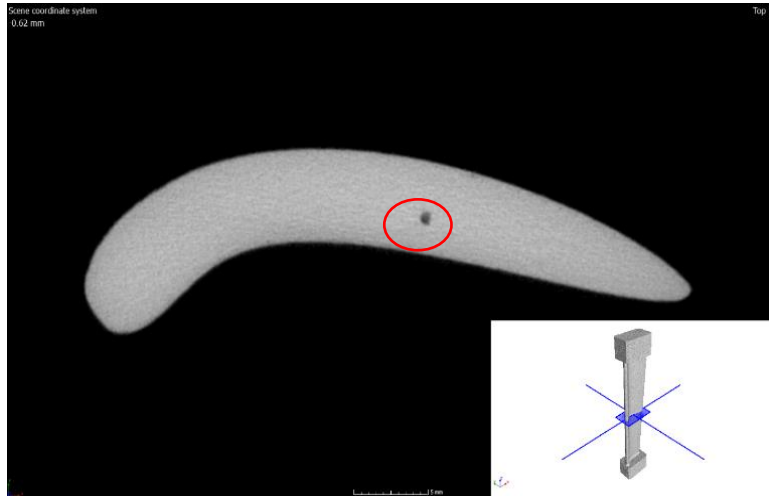


Gas porosity (Round)



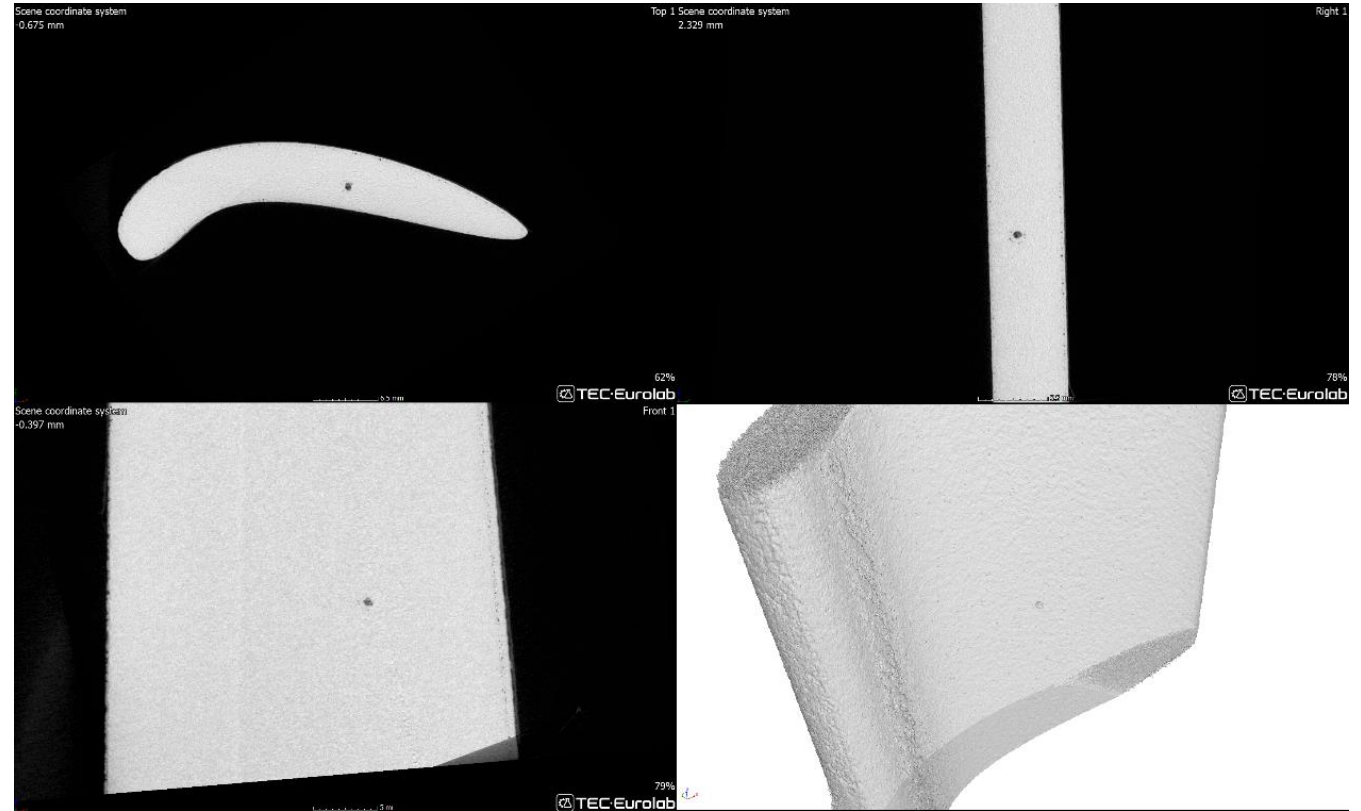
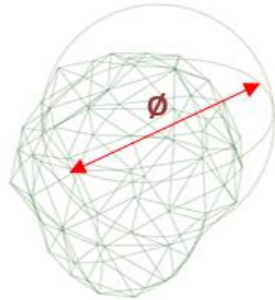


RQI PART 2



Gas Hole

• $\varnothing$ 0,8mm

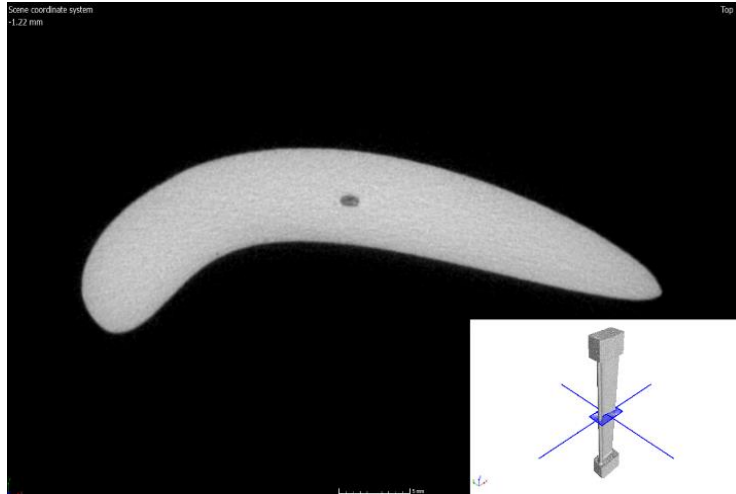


- Maintaining the rounded geometry of the defect
- Partial collapse of printed geometry



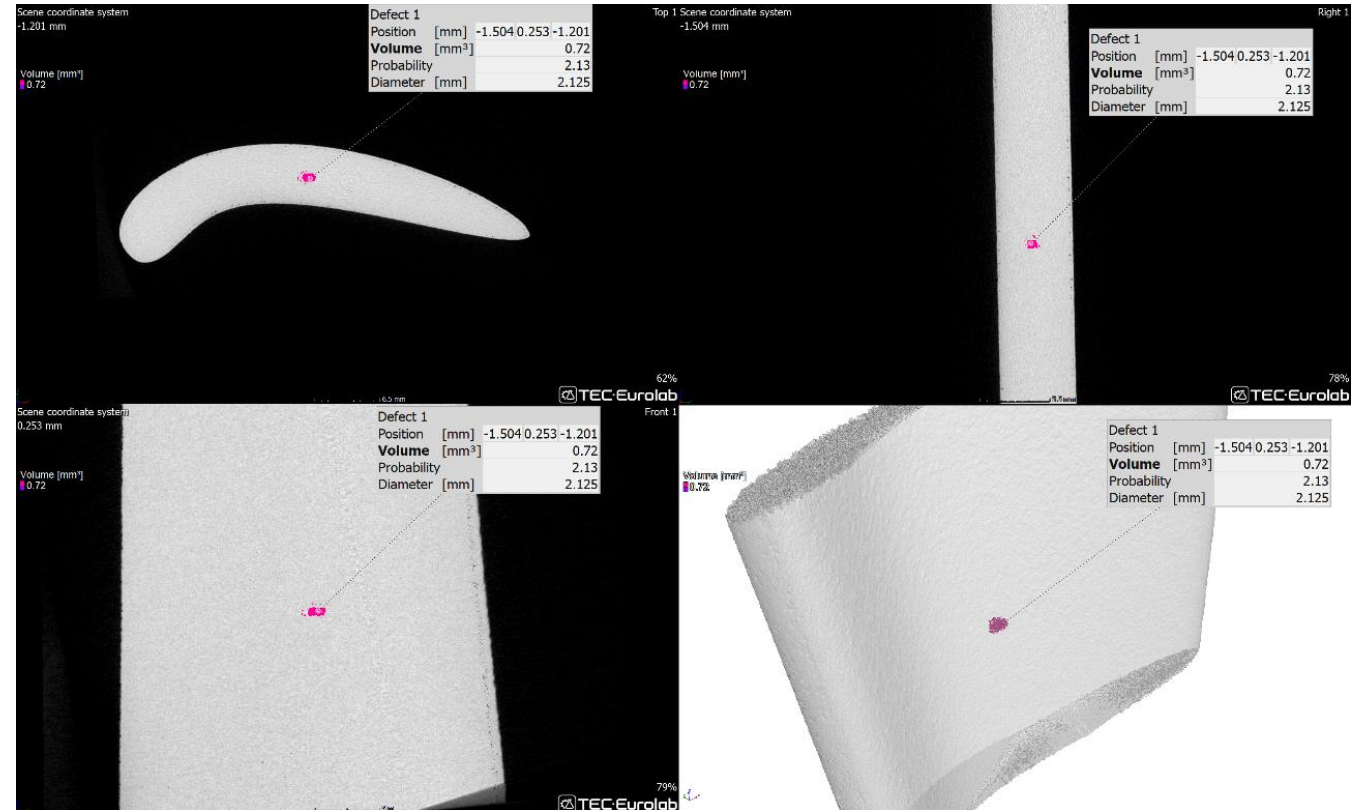
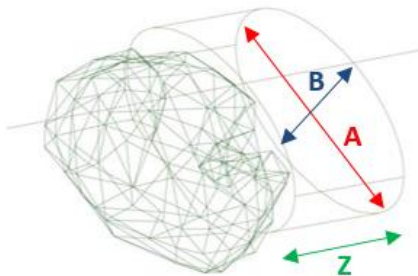


RQI PART 3



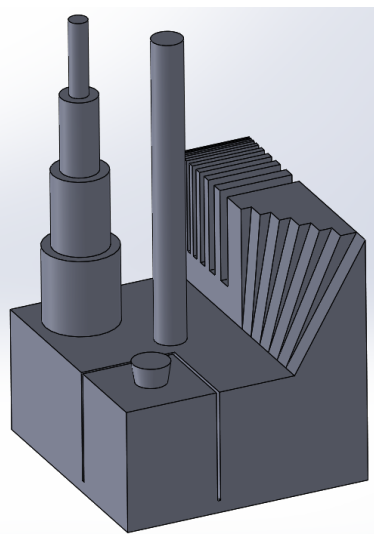
POROSITA' ALLUNGATA (rounded)

- **Z** 0,5mm
- **A** 1,3mm
- **B** 1,0mm

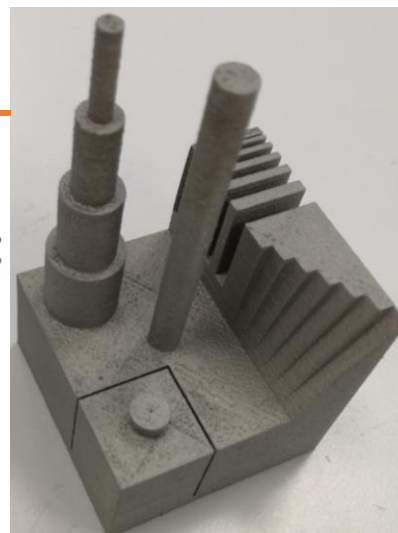




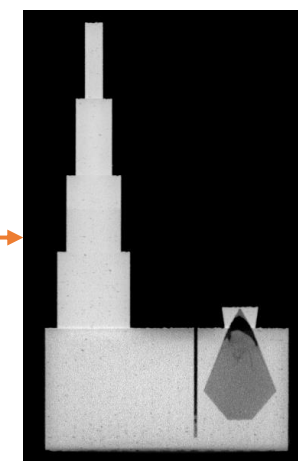
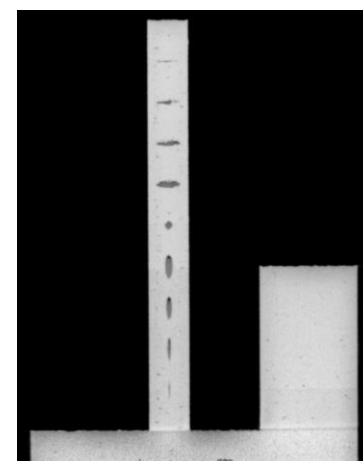
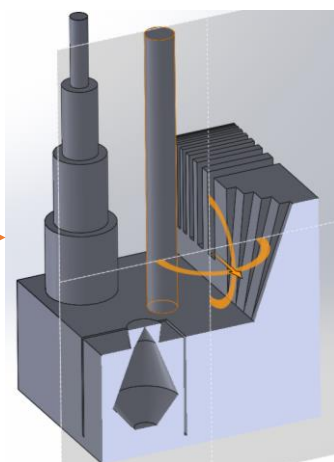
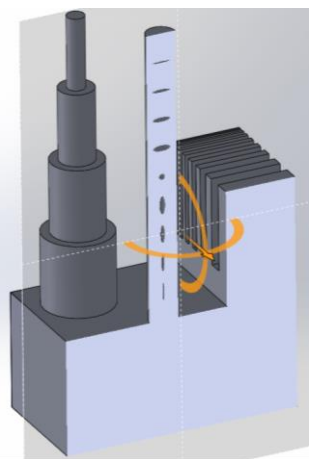
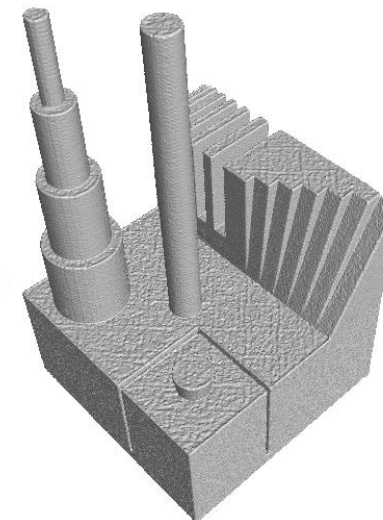
CASE STUDY 2: AL ALLOY RQI DESIGN



Stampa 1:
AlSi12



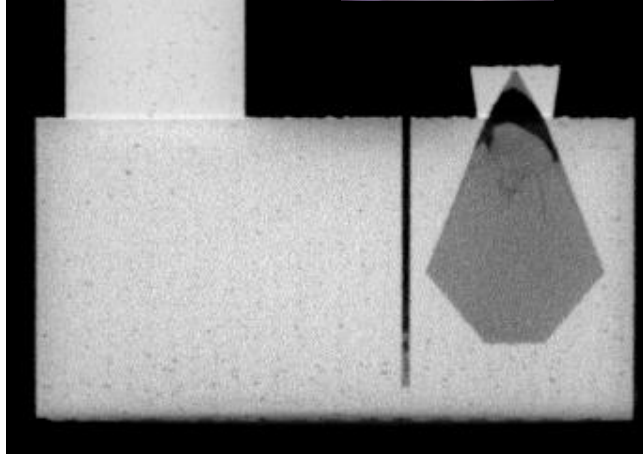
CT Scan:
X7500
System



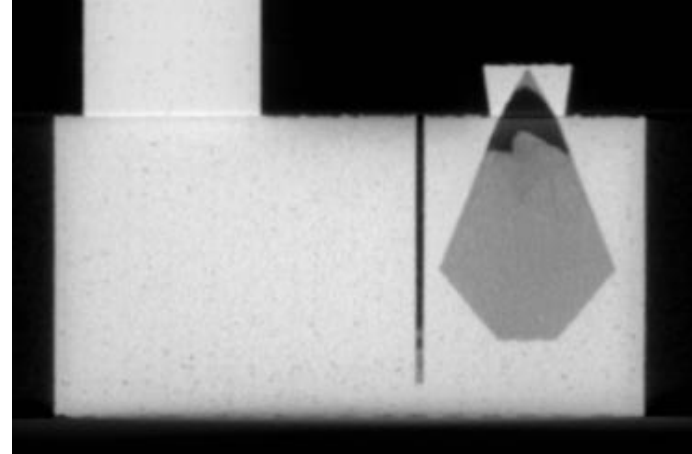


CASE STUDY 2: RQI INSPECTION WITH X7500

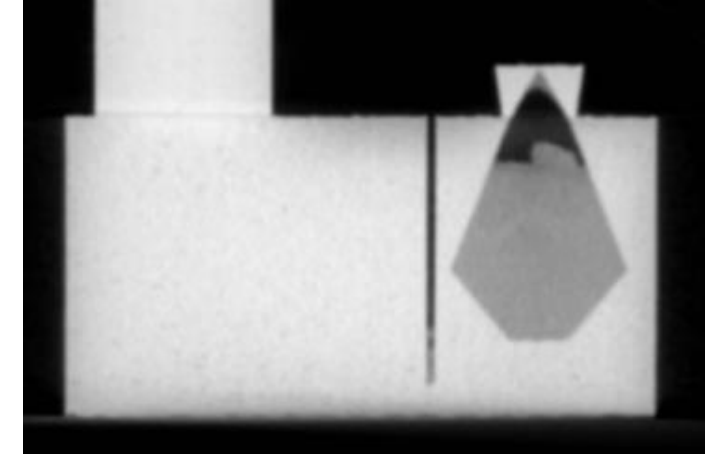
35 μm



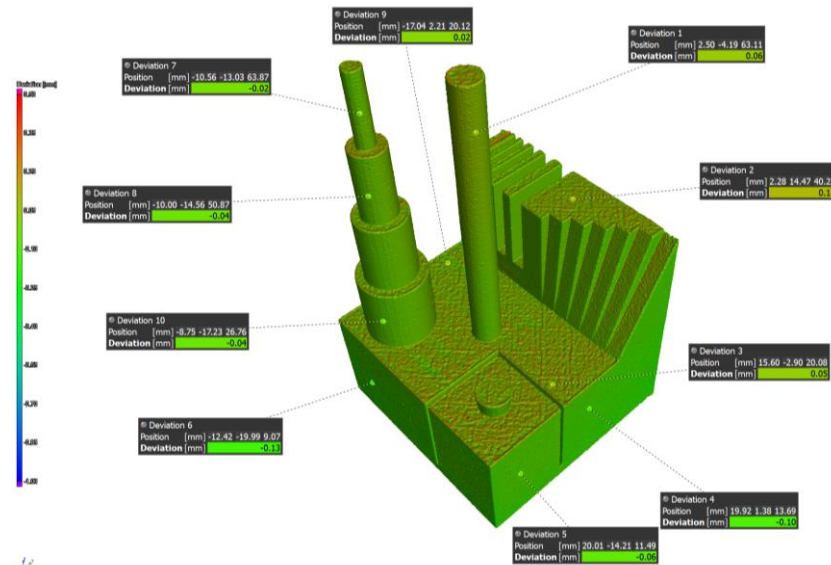
70 μm



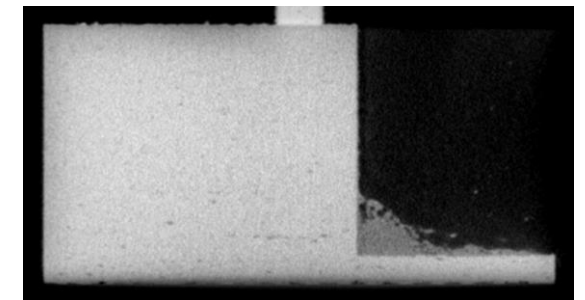
150 μm



Analisi CAD
Comparison

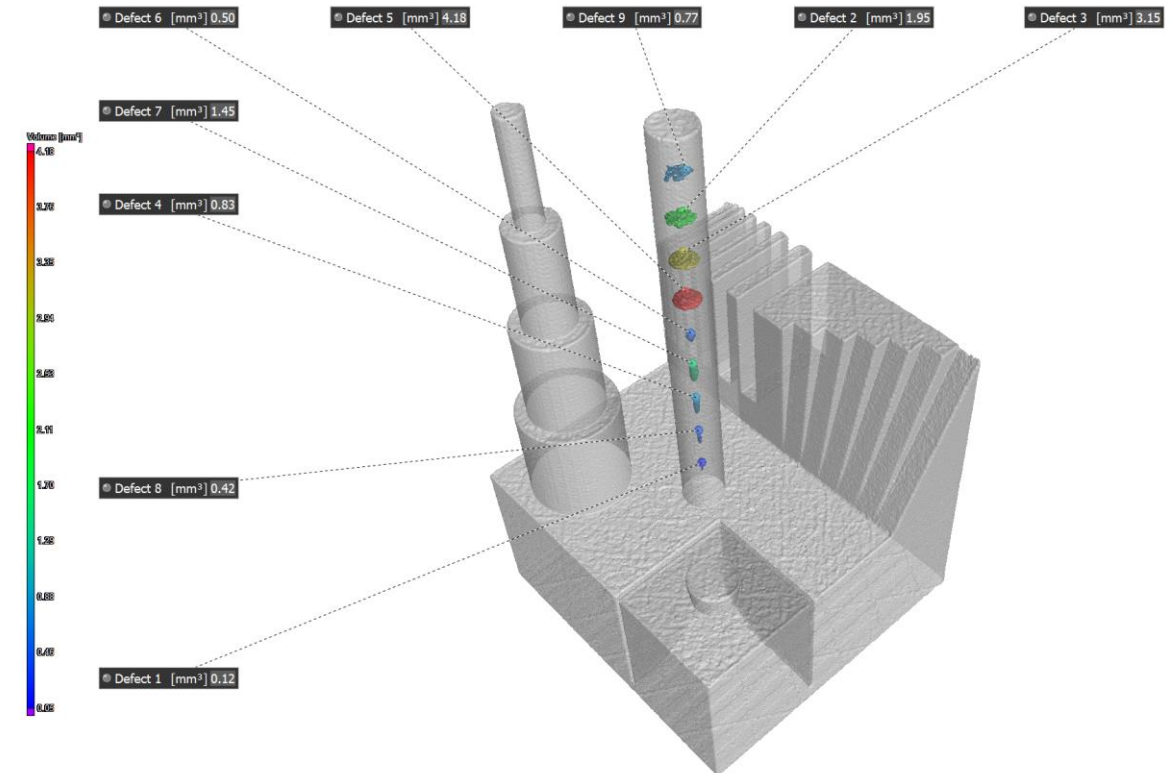
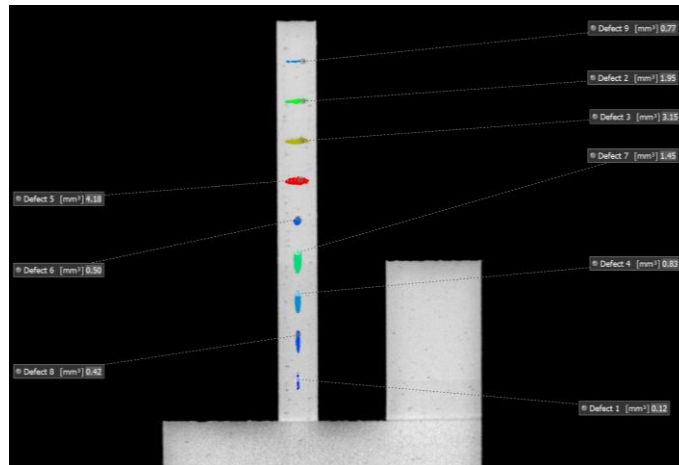
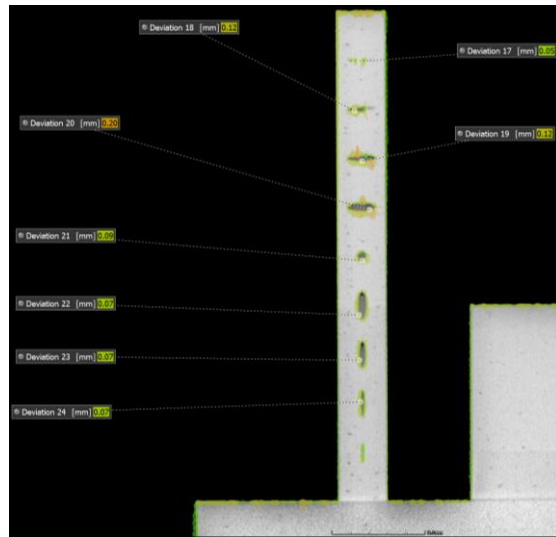
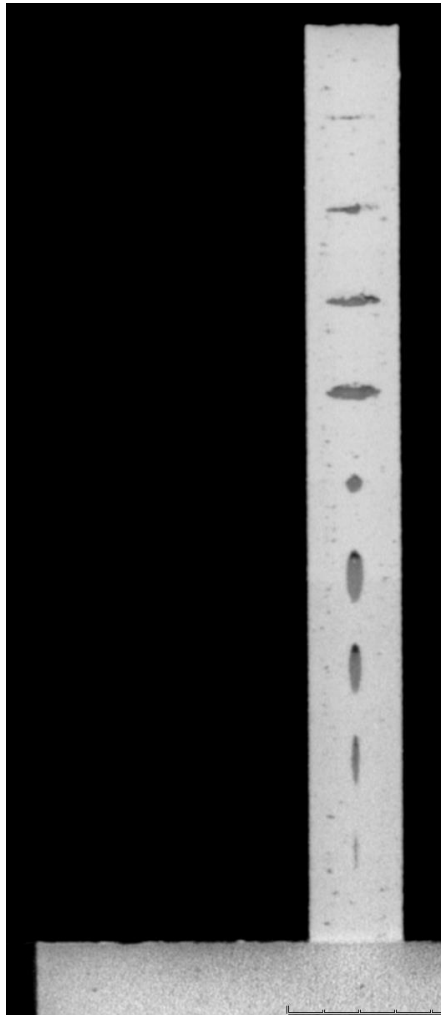


Polvere residua



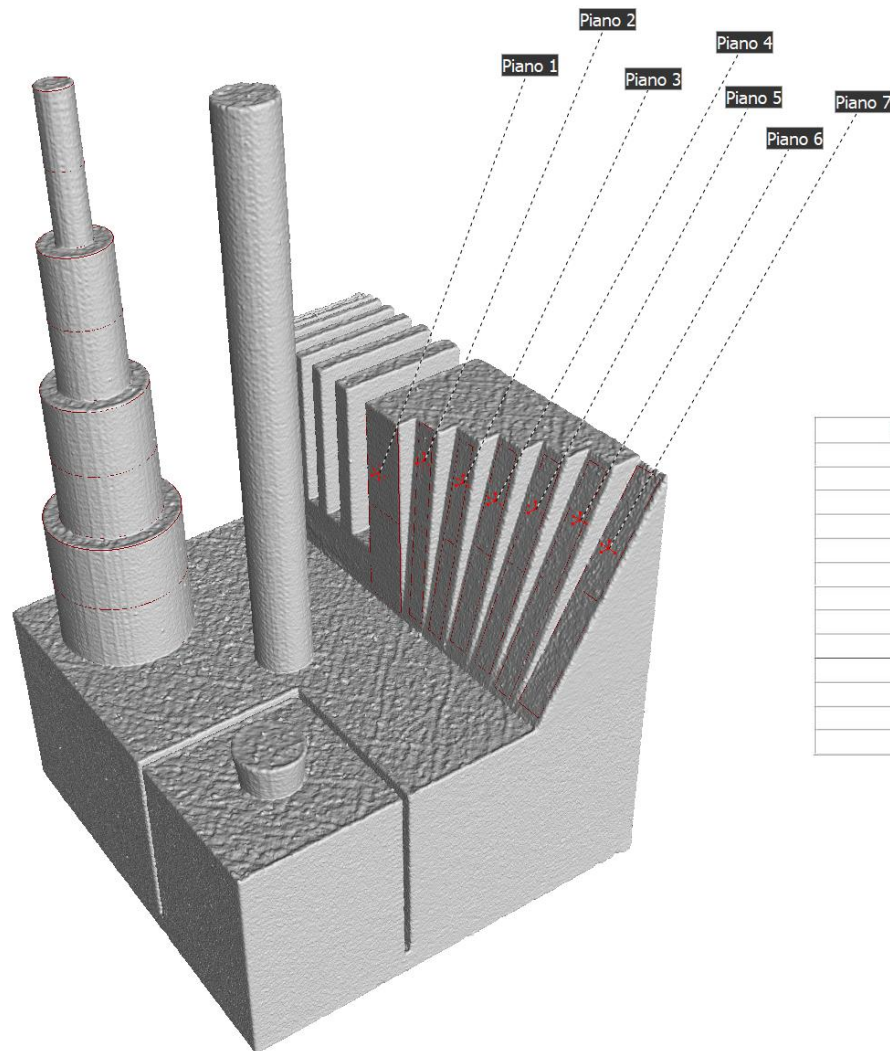
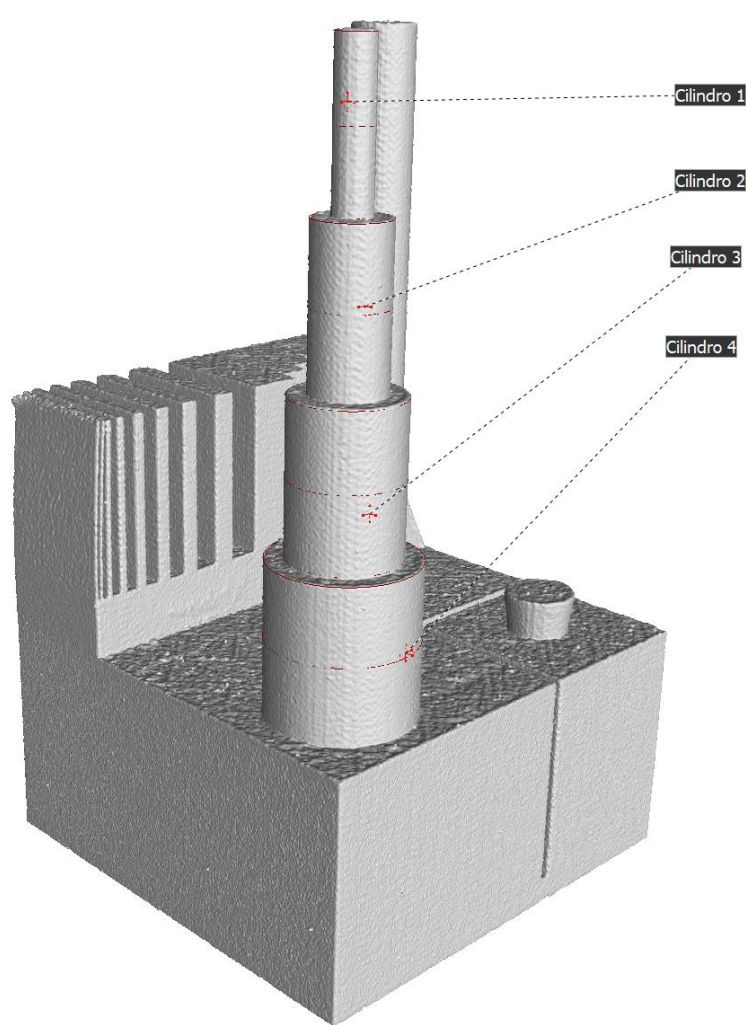


CASE STUDY 2: POROSITY EVALUATION





CASE STUDY 2: DIMENSIONAL EVALUATION

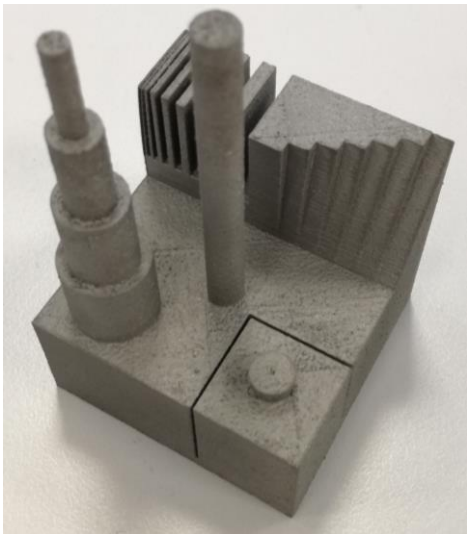


Name	Type	Source A	Act. value [mm/deg]
Feature 1	Diameter	Cylinder 1	3.01 mm
Feature 2	Diameter	Cylinder 2	6.00 mm
Feature 3	Diameter	Cylinder 3	8.99 mm
Feature 4	Diameter	Cylinder 4	11.97 mm
Feature 5	Coaxiality	Cylinder 2	0.09 mm
Feature 6	Coaxiality	Cylinder 3	0.19 mm
Feature 7	Coaxiality	Cylinder 4	0.23 mm
Feature 8	Angle	Plane 2	4.99 deg
Feature 9	Angle	Plane 3	9.99 deg
Feature 10	Angle	Plane 4	14.98 deg
Feature 11	Angle	Plane 1	19.96 deg
Feature 12	Angle	Plane 1	24.93 deg
Feature 13	Angle	Plane 7	30.88 deg

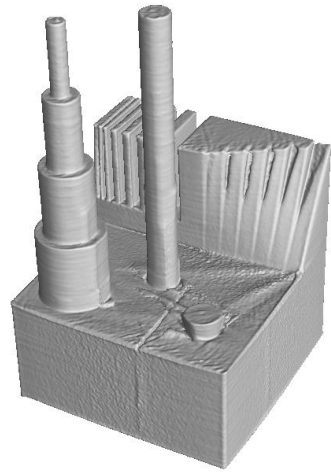




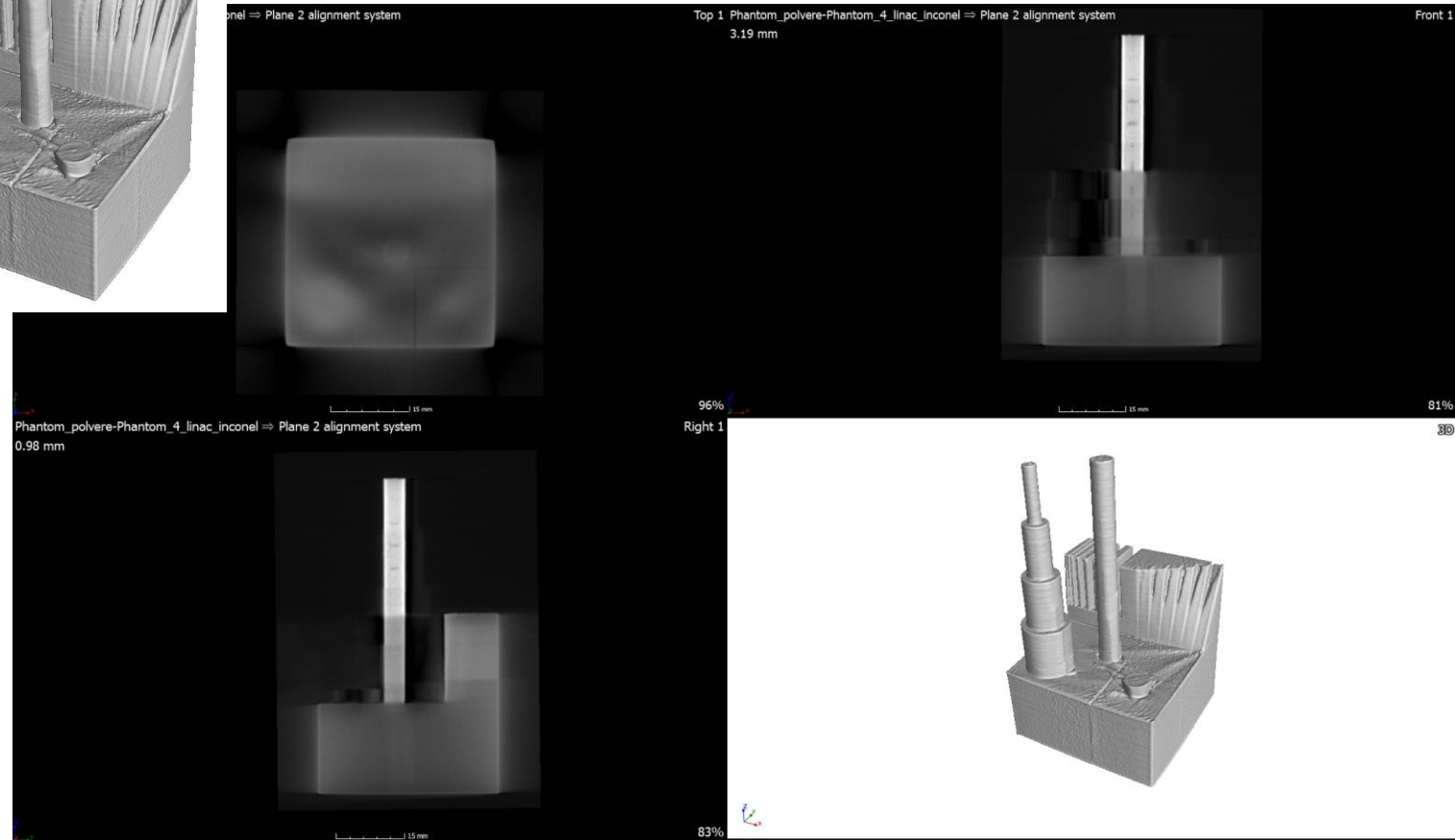
CASE STUDY 2: NI ALLOY RQI DESIGN



CT Scan:
X7500 System



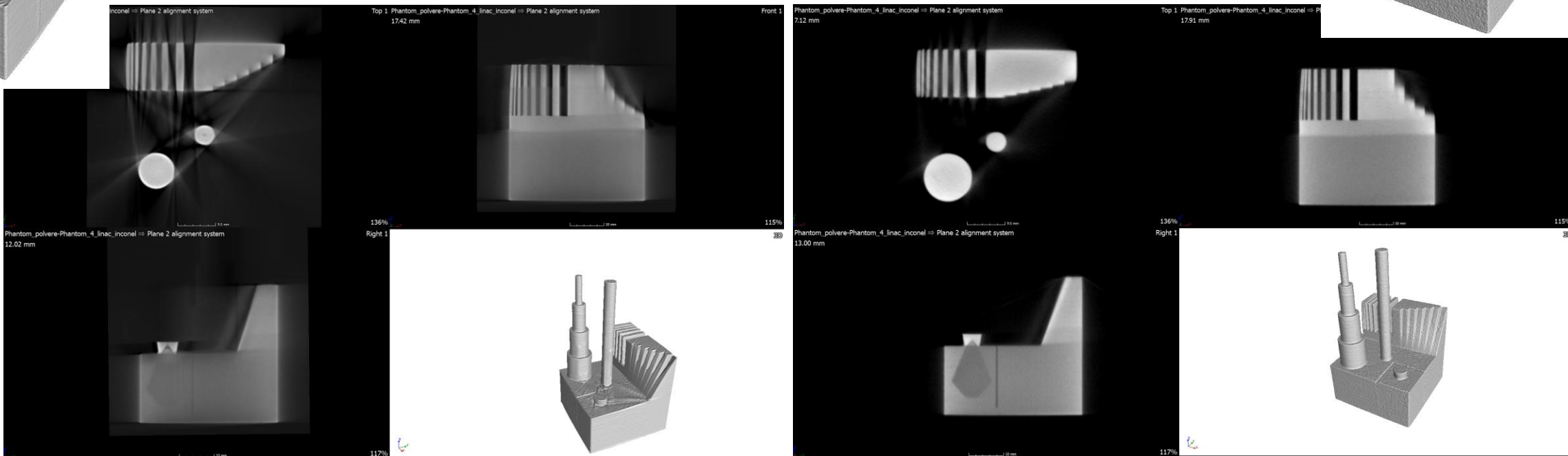
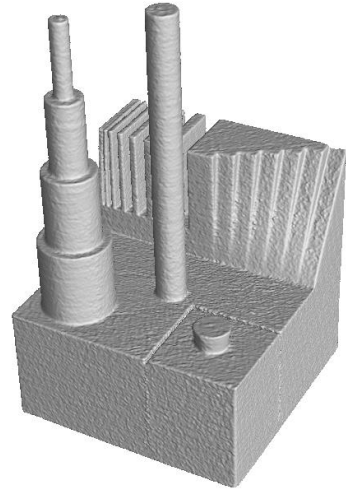
Scan performed on X7500 system.
High noise, non-rebuildable
surface.
Absence of features detectability





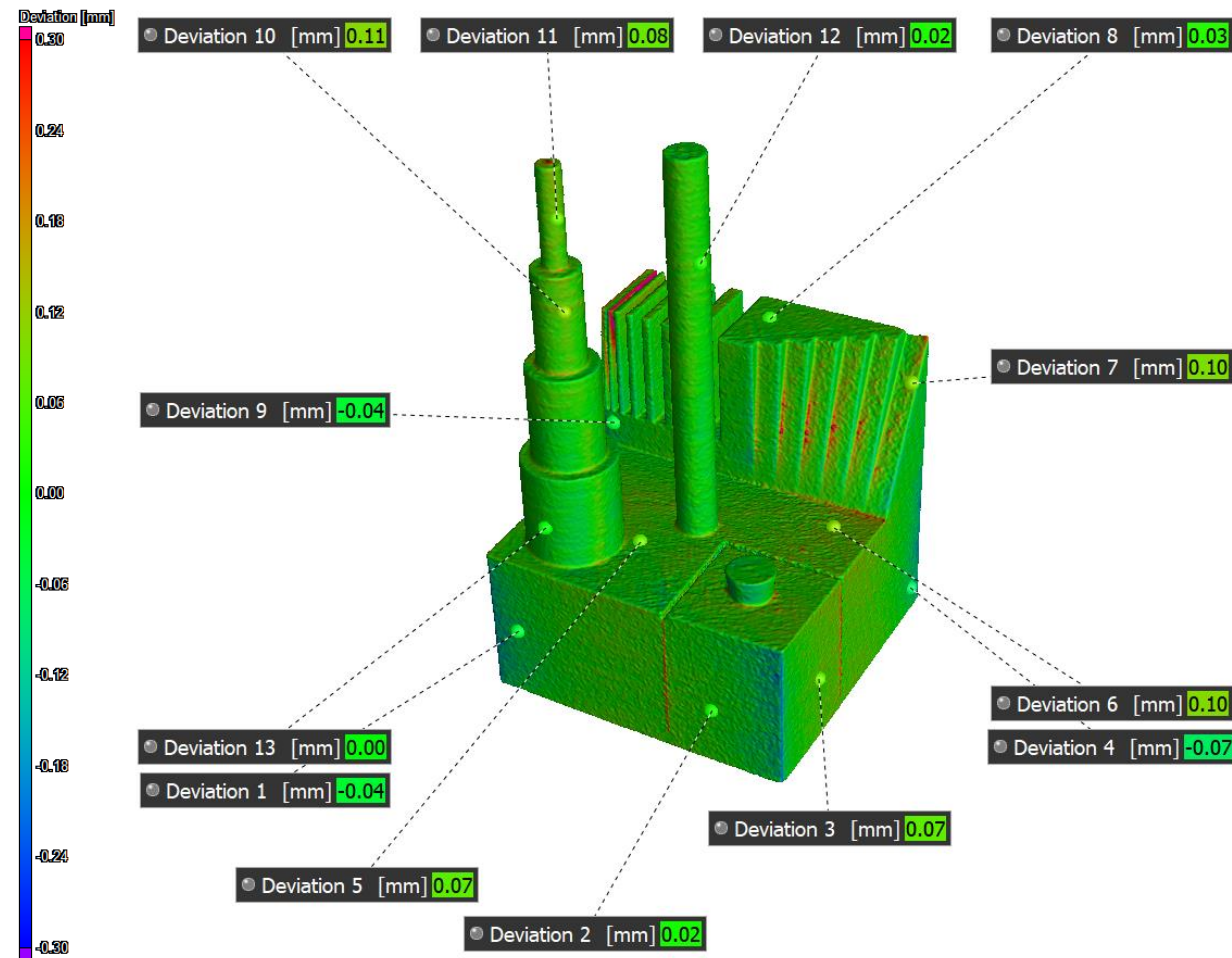
CASE STUDY 2: X7500 VS LINAC

Surface Reconstruction
Identifying internal features
Better result by using LINAC than a high-powered system





CASE STUDY 2: NI ALLOY RQI CAD COMPARISON LINAC





CONCLUSIONS

- CT technology currently has far fewer reference standards than other non-destructive techniques
- The validation of tomographic systems is mostly done through best practices and scans of components with known or artificial discontinuities.
- Additive technology, with the possibility to engineer artificial discontinuities represents a paradigm shift in the validation of tomographic systems, which until now depended on unrepresentative RQI or EDM holes that do not represent real discontinuities
- The implementation of more and more precise reference standards, combined with additive technology, will allow the CT to fill, in the short term, the current regulatory gap compared to other techniques





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