



Confidence in Quality Testing Components Utilizing Computed Tomography

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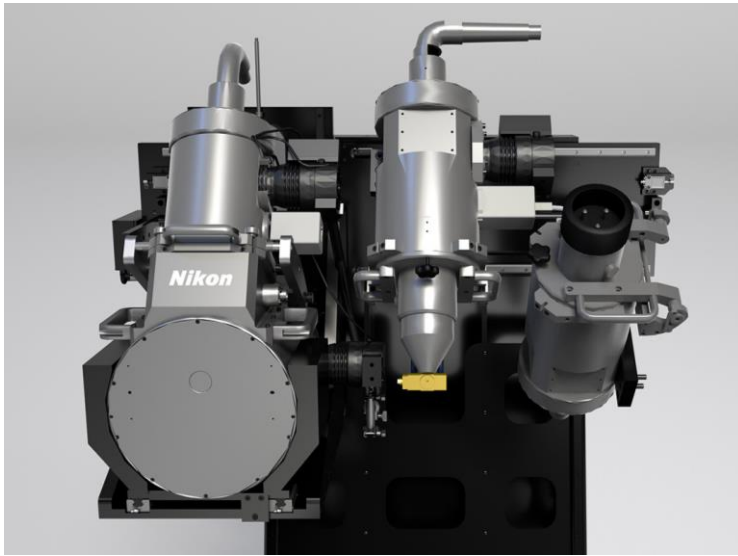
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What is Computed Tomography?

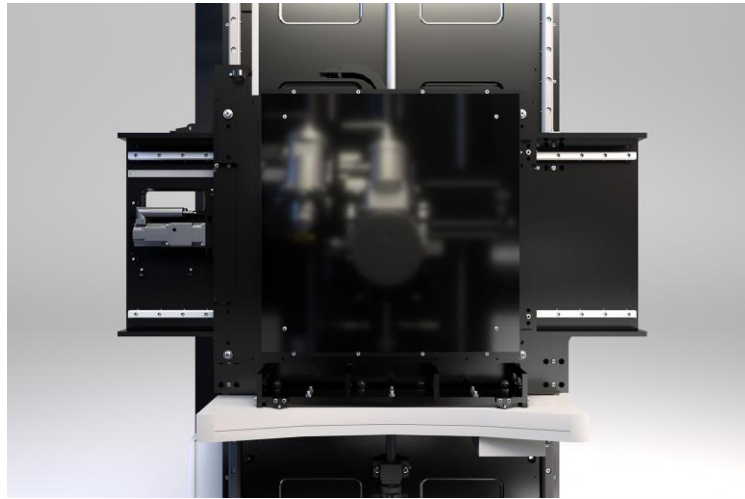
- A nondestructive testing method that uses X-rays to capture multiple images at different angles, which are then processed to create a 3D rendering of the object under test.
- Projections are captured at fractions of a degree intervals while part rotates 360 degrees.
- Software applies a Filtered Back Projection (FBP) algorithm for reconstruction of projections.
- System composed of 3 major systems.
 - X-Ray Tube Heads
 - Manipulator
 - Digital Detector Array (DDA)

The System

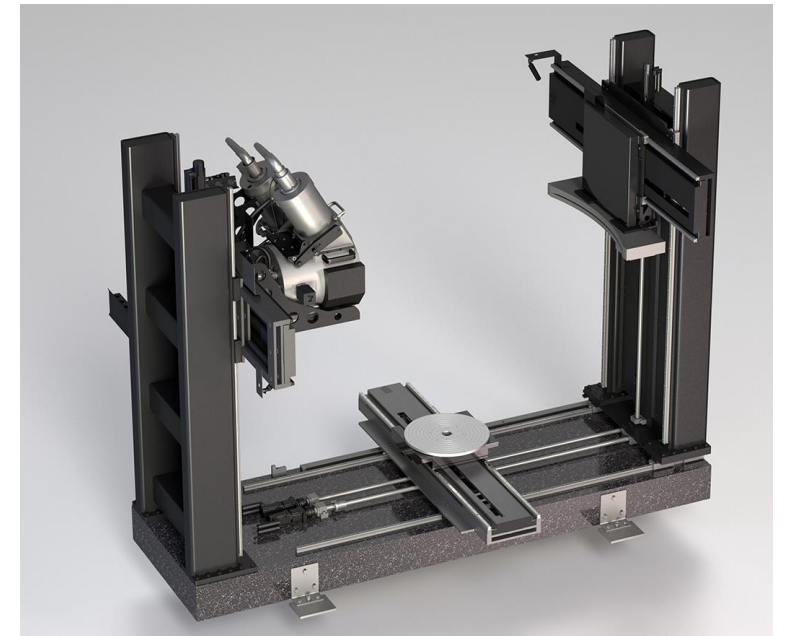
X-Ray Tubes



DDA/CLDA



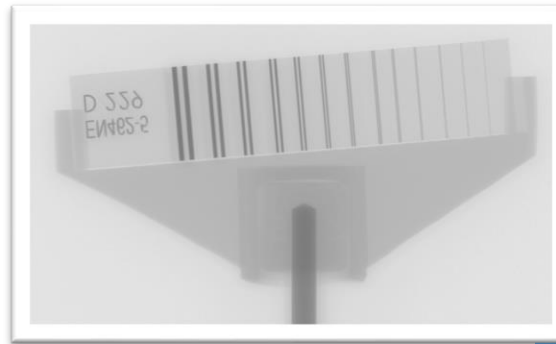
Manipulator



Detectability

- Many parameters can impact quality of a CT scan.
- Detectability can be simplified into four parameters to monitor.
 - **Resolution**
 - **Unsharpness**
 - **Contrast**
 - **Noise**

$$CS_{4T}[\%] = [1 / C N R] * [MT_{IQI} / MT_{total}] * 100$$



$$U_g = (v - 1) * \phi$$

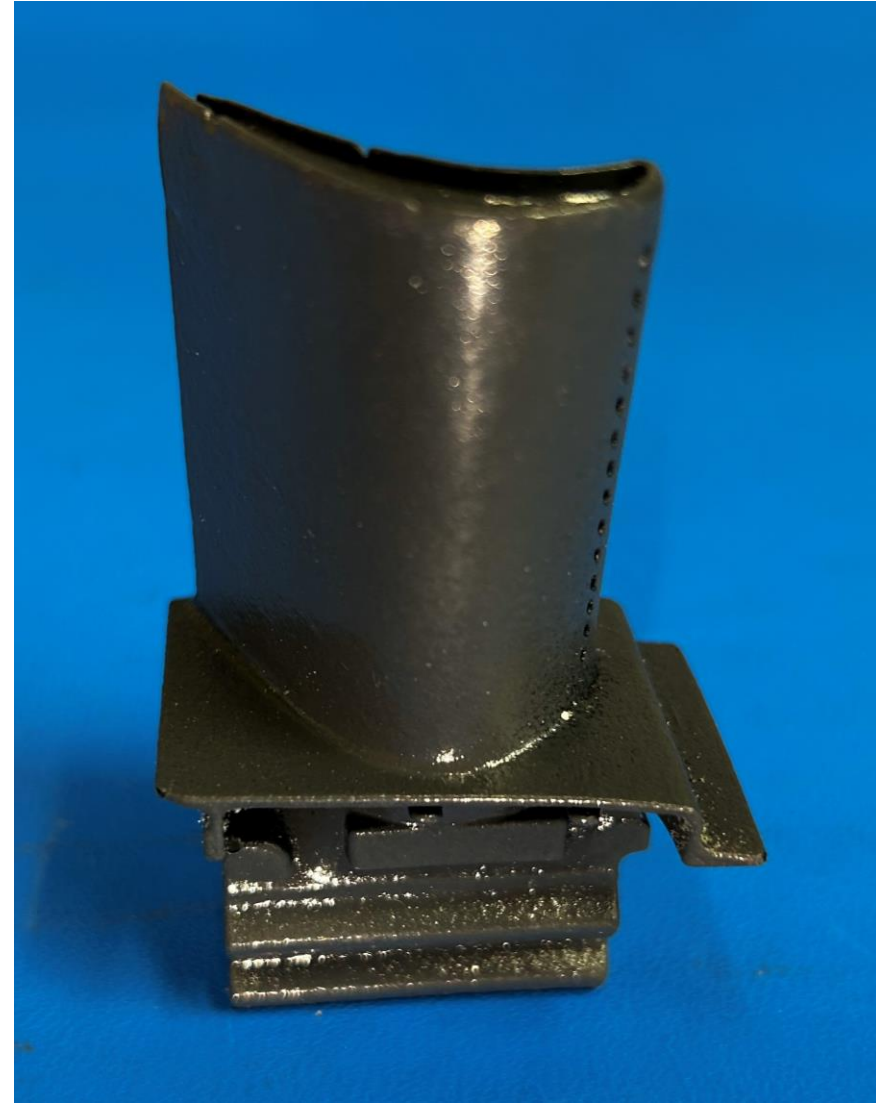


$$U_{Im} = \frac{1}{v} * \sqrt[3]{U_g^3 + (2.0 * SR_b^{detector})^3}$$

$$CNR = \frac{(PV_{median}[hole] - PV_{mean}[ROI \text{ surrounding hole}])}{Sigma[ROI \text{ surrounding hole}]}$$

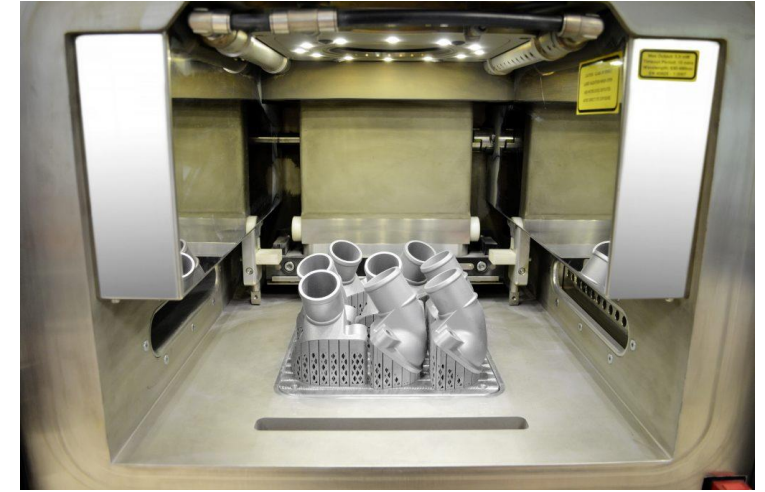
The Sample

- Turbine Blade
- Additively Manufactured
- Minimum Flaw Sizes
 - Pores and Cracks
- Manufacturing Tolerances
 - Nominal to Actual
- Clear Channels



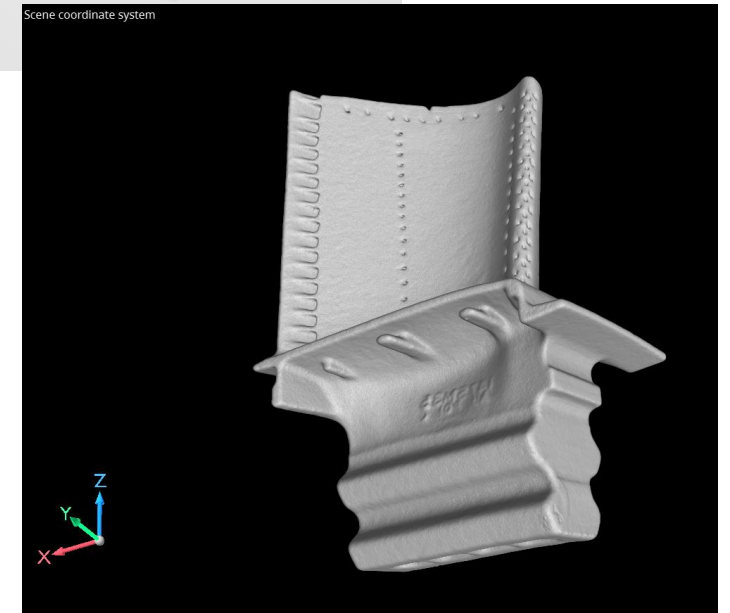
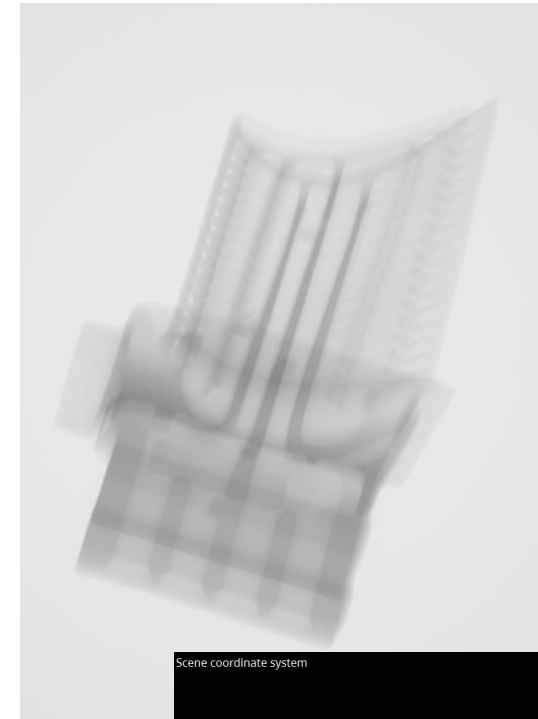
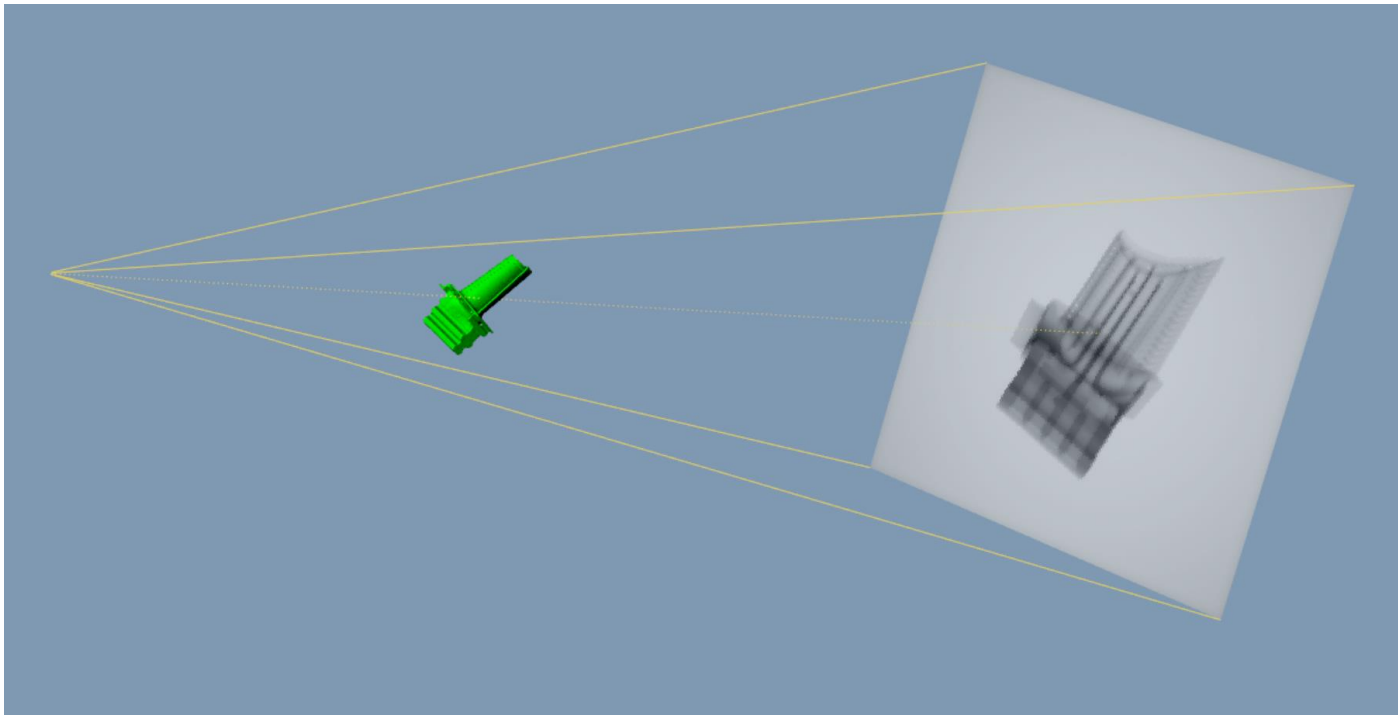
Representative Quality Indicator

- Representative Quality Indicator (RQI) – a real part, or a fabrication of similar geometry in radiologically similar material to a real part, that has features of known characteristics that represent those features of interest for which the parts to be purchased are being examined (E1817).
- The idea of an RQI is to take a known good part and create defects of the size that are of concern and introduce them into areas that would be most problematic.
- It is also good practice to place these defects in areas that are most difficult to image due to density and scatter.




Simulation

- Digital Twin Software to simulate the inspection.
- Ability to imbed flaws of known sizes
- Analysis of signal-to-noise ratio and contrast-to-noise ratio.



Scan Data



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CT Inspection Technique

Customer Name	Part Number/Description	Drawing #
	Turbine Blade	

Equipment			
System	Tube Type	Tube SN	Fixture
	RRT		Foam 45 degree

Geometry					
SDD - Actual (mm)	SDD - Software (mm)	SOD - Actual (mm)	SOD - Software (mm)	Magnification	Effective Pixel Size (µm)
1140		337		3.37	59.19

X-Ray Parameters			
Voltage (kV)	Current (µA)	Power (W)	Focal Spot Size (µm)
120	625	75	28

Filter		
Material	Thickness	Location

Detector			
Model	SN	Pixel Pitch	Analog Gain
1621		200	18
Digital Gain	Integration Time	FPS	Binning
	250ms	4	

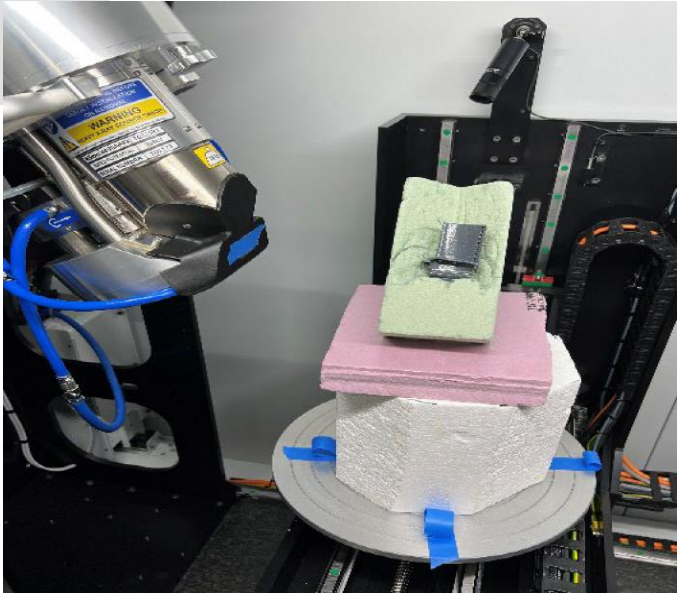
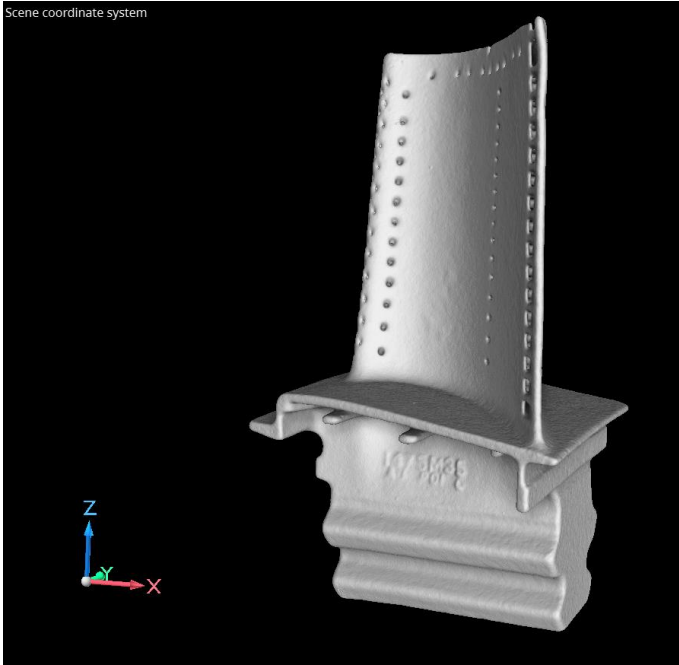
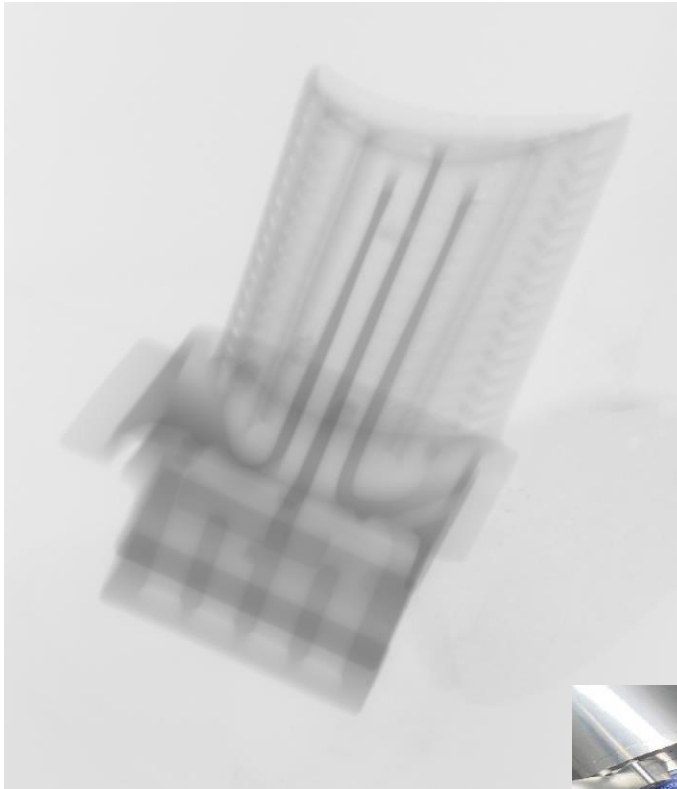
CT Parameters		
Scan Type	Projections	Frame Averaging
	1800	4
Continuous/Step Scan	Scan Time	
step	45 min	

Shading Corrections		
Number of Images	White Target	Frames to Average
4	60000	800

Document Name
FRM - CT Inspection Technique

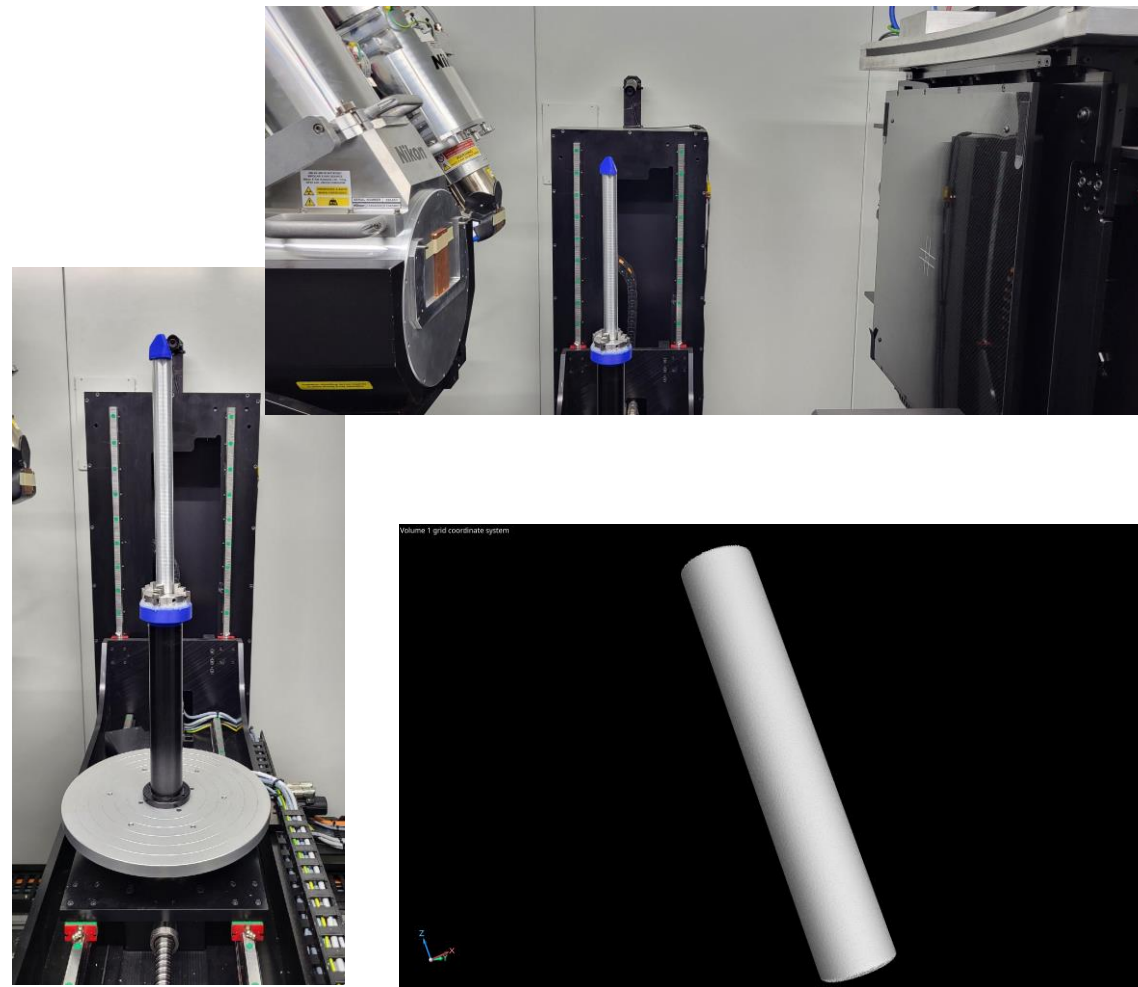
Revision
20240222KDS

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Stability Monitoring

- Cylinder Phantom that is a right circular cylinder of uniform material.
- Should take up at least 80% of the detector height.
- Results Given
 - Modulation Transfer Function (MTF)
 - Contrast Discrimination Function (CDF)



Questions?

Nikon



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