

GE
Measurement & Control

Fast and accurate turbine blade inspection



Inspection Technologies: **blade|line**

Precise and fast 450 kV X-ray CT inspection and measurement system for complex and critical high pressure turbine blades.



GE imagination at work



blade|line: fast, precise and compact

The new GE blade|line X-ray CT inspection and measurement system enables fast, high quality imaging of complex, advanced technology engine components such as high pressure turbine blades.

As aircraft engine performance requirements become more stringent, turbine blade cooling schemes advance and require complex multi-wall castings that introduce new inspection challenges. The new inspection challenges require a shift from previous methods of measuring wall thicknesses and create a need for CT technology to measure the new multi-wall structures.

The new GE blade|line X-ray CT system answers a strong industry need, as it is specifically designed to inspect these ultra-complex, next generation aerospace turbine blade castings.

With fast inspection speeds and crisp image quality, the system builds on GE's extensive expertise and decades of experience in the aircraft engine business.

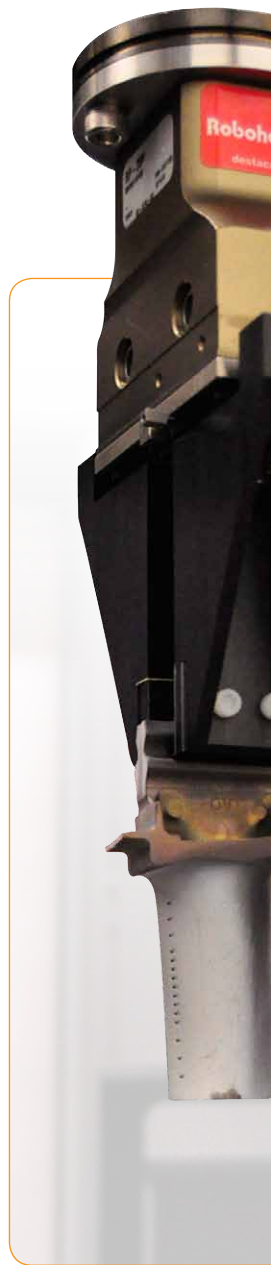
Key benefits:

- Fast & efficient - up to 30 parts/hour (while capturing up to 10 CT slices per part)
- Accurate & repeatable - compliance with MAI Affordable CT Guidelines, demonstrating measurement capability of $\pm 5\%$ or 0.001 inch
- Data integrity & security - DICONDE workflow and long-term data management
- Low cost of ownership - maintenance-free connectors and sealed X-ray tube versus open tube
- Increased productivity due to high throughput, low inspection time and costs per blade



GE's Jupiter Linear Detector Array (LDA)

The Jupiter LDA is specifically designed for high throughput, high precision fan beam imaging. The detector is exclusively offered by GE Inspection Technologies.

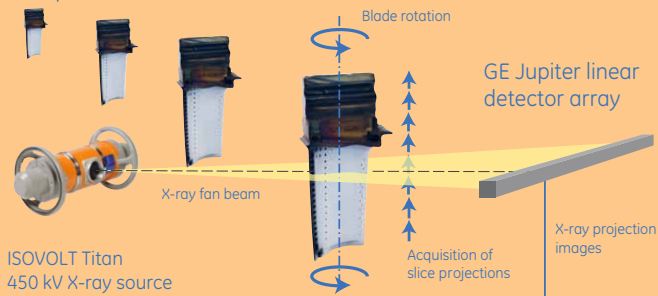


Extremely fast and accurate CT based inspection

When compared with conventional cone beam CT, highly collimated fan beam CT offers improved resolution, as well as, a higher quality CT slice result, due to the reduction of image artifacts caused by scattered radiation.

Robotic sample manipulation

Turbine blade



ISOVOLT Titan
450 kV X-ray source

Reconstruction of the CT slices

Wall Thickness Analysis

DICONDE data management

For each slice, a set of X-ray line profiles are acquired while continuously rotating the blade in the collimated X-ray fan beam. The line profiles acquired by GE's Jupiter linear detector array, featuring high resolution with extremely high read-out speeds, contain information on the position of the external and internal blade surfaces as well as internal casting flaws. This data is used to reconstruct the tomographic slice image.

By vertically shifting the sample through the fan beam, the required number of CT slices is compiled and analyzed at the GE Rhythm Review Workstation.

Internal wall thickness measurements on a simulated turbine blade





Precision manipulation
blade|line 4-axis SCARA robot enables high reproducibility of inspection and measurement results



GE Isovolt X-ray tube
450 kV supplied by the maintenance-free high-power ISOVOLT tube



The Power of Rhythm / DICONDE

All the 2D and CT slice images acquired by the blade|line system are automatically created in the non-proprietary and reliable DICONDE (Digital Imaging and Communication in NDE) format. DICONDE incorporates many features that are NDE-focused describing all of the necessary syntax, attributes and data elements. Users can evaluate, archive, transmit and receive acquired data. The GE blade|line CT system uses the well-established GE Rhythm Software platform for image analysis and data management.

Rhythm Review software

DICONDE compliant software for image analysis, quality control and automatic archiving of the resultant images for a pre-programmed number of years.

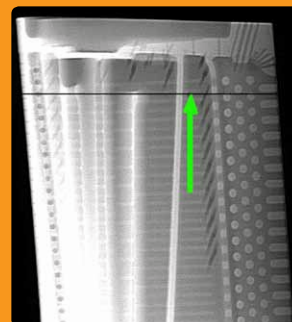
Rhythm CT blade|line module

This GE Rhythm-based CT blade|line software module offers advanced functionality, such as wall thickness measurements of various turbine blade walls within each CT slice. The software module also allows the system to produce a 2D digital X-ray image of an entire turbine blade and then the operator can manually select regions of interest (ROIs) to perform subsequent 3D CT slice evaluations. For example, if the operator detected something of concern within the 2D image, such as an overdrill or an internal casting defect, a region-specific CT slice can be captured to verify, or further quantify, the initial detection.

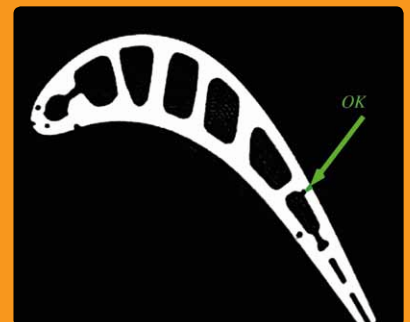
2D with 3D spot check CT

The GE blade|line combines 2D and 3D inspection needs into one system. The extremely fast GE Jupiter linear detector array quickly generates radiographic 2D images that allow for easy and fast identification of critical internal structures in specific areas of interest for further verification by CT.

The CT slice measurement mode allows more detailed evaluations (wall thickness measurements and defect analysis) of internal casting components.



The 2D radiographic imaging capability reveals a potential over drill location.



Example turbine blade CT slice.

GE blade|line Technical Specifications

Source

Tube type and max voltage	Maintenance-free closed high-power 450 kV GE ISOVOLT minifocus X-ray tube, collimated for fan beam CT with minimized scattered radiation artifacts
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Sample

Sample Ø x H	Max. 3D scanning cylinder up to 150 mm Ø x 190 mm (5.90" x 7.48")
	Max. sample size up to 190 mm (7.48") x 200 mm (7.87") with limited travel range
Max. sample weight	Up to 2 kg (4.4 lbs.)

Detector & System Performance

Min. scan speed	20 s. at 50 Hz / 10 s. at 100 Hz per slice plane (1,000 projections). Total data acquisition time for 5 slice planes 125 s. at 50 Hz / 65 s. at 100 Hz (each 1,000 projections incl. move time between planes)
Measurement accuracy	Up to ± 5% or 0.001 inch

Software

GE VISTAPLUS acquisition and volume reconstruction software.

DICONDE data export to GE Rhythm Review and data management software (Additional Rhythm Review Workstation on request)

GE Rhythm CT module blade|line including wall thickness measurement tool for turbine blades

System

Cabinet	Small footprint protection cabinet with manual sliding door and lead glass window
Dimensions basic cabinet W x D x H	2,250 mm x 1,550 mm x 2,600 mm (88.6" x 61" x 103")
System weight (without ext. components)	Appr. 5,500 kg (12,127 lb)
Radiation protection	The radiation safety cabinet is a full protective installation without type approval according to the German RöV. It complies with French NFC 74 100 and the US Performance Standard 21 CFR Subchapter J. For operation, other official licenses may be necessary

Key features:

- 450 kV fan beam Computed Tomography (CT) inspection to support throughputs of up to 30 turbine blades per hour with appr. 75 measurement locations distributed over 10 axial positions
- Optimized speed, performance and precision robot based component manipulation
- Unique GE Jupiter linear detector array with up to 100 fps scan speed
- Robust design with small footprint for 24/7 operation
- Integration of GE Rhythm Review software for image viewing, enhancing and archiving based on the standardized DICONDE file format and communication protocol

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