



# Insight into the Inside

Industrial X-ray and CT



Nikon  
100<sup>th</sup>  
anniversary

NIKON METROLOGY | VISION BEYOND PRECISION

# INSIGHT INTO THE INSIDE



**Get the inside picture of complex industrial parts, by looking into the internal structure. Use CT capability to qualify and quantify any inner or outer dimension in a smooth, non-destructive process.**

Industrial X-ray and CT systems bring high accuracy and the ability to measure internal and external dimensions simultaneously without destroying the part. Furthermore, they provide additional insight through the fourth dimension of material density and structure, rapidly making X-ray technology a must-have tool in the production toolbox.

## **A legacy of more than 30 years in X-ray and CT**

Nikon Metrology's X-ray and CT portfolio originates from the UK based, X-Tek Systems. With an experience of more than 30 years, X-Tek has an extensive installation base of thousands of X-ray and CT inspection systems worldwide. CT specialists in Tring, UK, design, develop and manufacture complete systems, incorporating proprietary microfocus X-ray sources, high-precision 5-axis fully programmable manipulators and fast acquisition and reconstruction software.

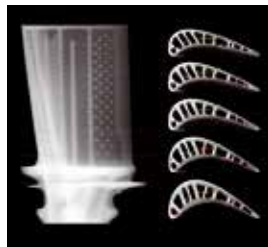
# A WIDE RANGE OF APPLICATIONS



Connector



Turbine housing



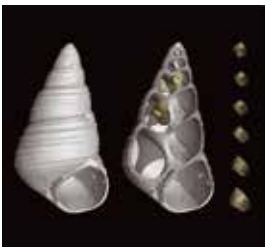
Turbine blade



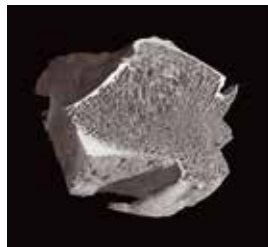
Shaving foam can



Connector



Snail fossil



Femur bone



Dragonfly



Fossilized canine tooth

Anywhere the internal structure matters, X-ray and CT technology serves as an efficient tool to provide valuable information. Detailed capture and measurement of internal features is often vital for quality control, failure analysis and material research across various industries.

- Fault detection and failure analysis
- Assembly inspection of complex mechanisms
- Dimensional measurement of internal components
- Part-to-CAD comparison
- Advanced material research
- Analysis of the biological structures
- Digital archiving of models

## Automotive

- Electrical connectors
- Injection nozzles
- Sensors (e.g. Lambda sensor)
- LED light pipes
- Small high-pressure die cast parts
- DPF (Diesel Particulate Filters)

## Aerospace

- Wax turbine blades
- Cast turbine blades
- Crack analysis in components
- Weld analysis

## Plastic injection molding

- Complex plastic components (e.g. fan)
- Soft, translucent materials where tactile or optical is no option
- Ultrasonic welding of plastic parts

## Pharmaceutical/medical

- Medicine dispensers
- Small instruments
- Small plastic or composite parts
- Bone structures

## Research

- Material verification and analysis (e.g. structure, porosity, defects)
- Paleontology (e.g. bones, skulls, fossils)
- Geology and soil science
- Archeology



# X-RAY SOURCES

## In-house design and build

Nikon Metrology X-ray sources are at the heart of our technology and have been designed and manufactured in-house from 1987 to this day; offering over 30 years of knowledge. Being at the heart of the image, control over the X-ray source technology allows Nikon Metrology to quickly move with the market and develop complete and innovative solutions to the application demand. All sources are open-tube giving a low cost of ownership and range from low (160) to medium (225) to high (450) kV, all with micron resolution.

### 450 kV static and high brilliance source

The unique 450 kV microfocus source gives industry leading performance for small high density or small to medium castings with unrivalled power and resolution.

Nikon's 450 kV high-brilliance source delivers 450 W continuous power, without any measurement time restriction, whilst maintaining a smaller spot size for faster CT scanning, collecting data up to 5x faster or with higher accuracy in a similar scan duration of the default 450 kV.



### 180 kV transmission target

Applicable for samples smaller than 10 mm, such as small rock cores or bone samples, the Transmission Target operates up to 180 kV to achieving a minimum spot size of 1  $\mu\text{m}$  leading to high resolution CT.



### 160/225 kV reflection target

With up to 225 kV and a minimum spot size of 3  $\mu\text{m}$ , the 225 kV microfocus source is the core of Nikon's XT H 225 range, devising flexibility to cope with a range of sample sizes and densities.



### 225 kV rotating target option

Nikon Metrology is the only company to produce an industrial 225 kV rotating target option. Using a rotating target, the electron beam falls on a moving instead of a fixed surface, which yields much more effective cooling. This offers the opportunity to measure objects faster, or denser objects with higher accuracy than using a conventional static 225 kV.



### 320 kV source

The 320 kV source is a unique microfocus source for samples too large or dense for 225 kV whilst still maintaining a small spot size. Ideal for rock cores and small castings, the source is an option in the XT H 320 cabinet.

# XT H 160 / 225

Detailed capture and measurement of internal component and assembly features is often vital for quality control, failure analysis and material research. The entry-level XT H 160 and the versatile XT H 225 systems offer a microfocus X-ray source, a large inspection volume, high image resolution and is ready for ultrafast CT reconstruction. They cover a wide range of applications, including the inspection of plastic parts, small castings and complex mechanisms as well as researching materials and natural specimens.



## Easy operation

Users are operational with the system within a few days of training. A CT wizard guides operators through the data acquisition process. Customizable macros automate the measurement workflow, and tight integration with industry-standard post-processing applications streamline the decision making process.

## Flexibility in CT

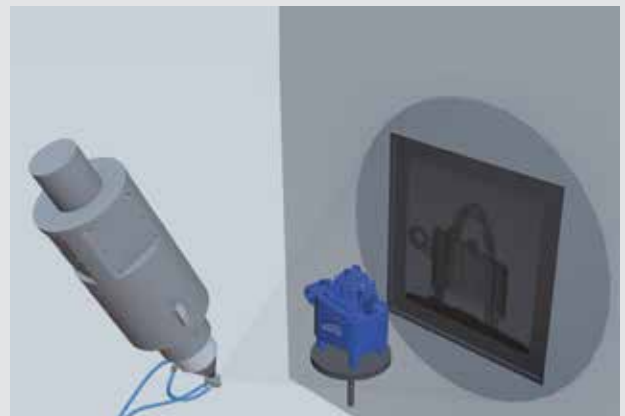
Specific applications require more detailed images or higher accuracy. The XT H 225 can be configured with different flat panels or source configuration (reflection/ transmission target) to adapt resolution to the specimen's needs: full part in coarse resolution and high resolution in a desired region of interest. A small spot size and a high-resolution flat panel create sharp images.

## Low cost of ownership

Regardless of the target of choice, the XT H 225 system uses an open-tube X-ray source that guarantees a lower cost-of-ownership. The open X-ray tube allows for local maintenance of internal tube components rather than whole tube replacements. The XT H 225 system is self-contained and quick to install. No special floor treatments are required.

## With all Nikon Metrology CT systems you can

- Verify complex internal structures
- Isolate and inspect included components
- Measure internal dimensions without sectioning the sample
- Automatically detect and measure internal voids/volumes
- Reveal internal and external surfaces with ease
- Reduce total inspection time
- Reduce number of iterations to fine-tune (pre-) production parameters



# XT H 225 ST

The XT H 225 ST is a Computed Tomography (CT) system ideally suited to a wide range of materials and sample sizes. The system has three interchangeable sources; the 225 kV reflection target, 180 kV transmission target and 225 kV rotating target. Combined with the wide range of flat panel detectors to choose from the ST system provides a flexible tool for quality laboratories, production facilities and research departments.



## Inspection volume

XT H 225 ST system is an extended version of the XT H 225 system. The large inspection envelope, tilt axis and choice of X-ray source from transmission target 180 kV to high flux rotating target 225 kV make the system a versatile tool for small and light to large and heavy samples in any industry.

## Stunning images

Multi material or lower attenuating samples are better scanned with the Perkin Elmer flat panels due to the higher dynamic range offered by the panels. High resolution voxel data is achieved in CT scans by having high resolution flat panels with many pixels in the radiograph. The ST cabinet is configurable with higher resolution 4000 x 4000 pixel flat panels, offering a multiple of the resolution of the smaller XT H 160 and 225 systems.

## Motorized FID

As an option, the ST cabinet can have a motorized FID that allows to move the detector closer to the source. As the X-ray intensity drops with the distance, a shorter FID (Focal spot to Imager Distance) prevents that the X-ray flux decreases. This allows shorter imager exposure and results in faster scan times. Alternatively a shorter FID can give brighter images when using low energy X-rays. Both phenomena are advantageous when high magnification is not a limiting factor.

## MCT225: Absolute accuracy for Metrology CT

Dimensional inspection using industrial CT has many advantages as all internal dimensions are measured without destroying the part. Metrology CT is possible by - either calibrating scans by performing time consuming reference measurements - or by using a metrology grade system.

The MCT225 is pre-calibrated using accuracy standards by VDI/VDE 2630 guidelines for Computed Tomography in dimensional measurement. Several key metrology features provide enable an impressive absolute accuracy specification of  $9+L/50 \mu\text{m}$  combined with a long term stability.

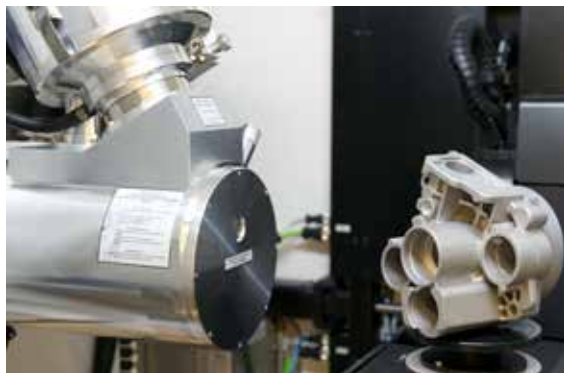


# XT H 320



The XT H 320 is a large cabinet system for the X-ray CT scanning and metrology of large components. The system consists of a 320 kV microfocus source delivering up to 320 W of power.

A high resolution flat panel is used to collect high quality images of the sample. The system is controlled by Inspect-X software which makes the collection of CT data and setting up of measurements simple and easy. The system can output volume data to industry standard volume viewing software.



## Powerful 320 kV microfocus

Most system suppliers only offer microfocus sources up to 225 kV, while more powerful sources in their offerings are minifocus. With larger samples, one often needs more penetration power and therefore Nikon Metrology offers a unique 320 kV microfocus X-ray source. As the X-ray spot size of these sources is orders of magnitude smaller compared to minifocus sources, end users benefit from superior resolution, accuracy and a wider array of measurable parts.

## Features

- Temperature controlled enclosure
- Liquid cooled X-ray source
- Finite element Analysis (FeA) optimized manipulator
- High precision linear guideways
- High resolution optical encoders

Extended information and specifications can be found in the MCT225 brochure or datasheet.

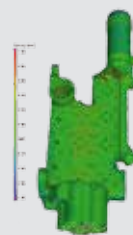
## Metrology CT process



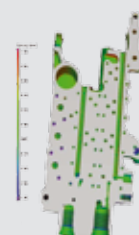
F1 car hydraulic manifold



CT volume reconstruction



Direct comparison to CAD model



Section of internal geometry



Dimensional report GD&T



# XT H 450



## Large capacity manipulator

Samples weights up to 100 kg

The XT H 450 system offers the necessary source power to penetrate through high density parts and generate a scatter-free CT volume with micron accuracy. At the core of this powerful equipment is a 450 kV microfocus source, providing superior resolution and accuracy up to 450 W power whilst offering sufficient

X-ray power to penetrate dense specimens.

The system is available with a flat panel (for 3D cone-beam CT) or a proprietary Curved Linear Diode Array (CLDA) (for 2D fan-beam CT) that optimizes the collection of the X-rays without capturing the undesired scattered X-rays.

## 450 kV Microfocus

The proprietary 450 kV source is the world's only microfocus X-ray source at this energy, enabling the XT H 450 system to deliver 25 micron repeatability and accuracy. As this microfocus spot size is considerably smaller than existing mini-focus sources, the level of detail that it captures is beyond comparison. With the high-brilliance source the level of detail possible with 450 kV can now be collected up to 5x faster, or with higher accuracy in a similar scan duration, compared to the default 450 kV source.

## Unique CLDA technology

When X-rays hit an object, they are absorbed but also scattered, an undesired phenomenon that increases as the density of the object increases. Scatter coming from all points of the part reduces image contrast sensitivity, as is visible on flat panel images. Nikon Metrology has developed a proprietary CLDA that optimizes the collection of the X-rays travelling through the part, without capturing the undesired scattered X-rays. By avoiding image pollution and associated contrast reduction, the CLDA realizes stunning image sharpness and contrast. The linear array of diodes is curved to further enhance image quality by keeping the X-ray path length to diode receptors constant compared to straight arrays. This allows longer crystals to be used to enhance the X-ray sensitivity and hence boost the signal-to-noise ratio and reduce the scan time.

## Low cost of ownership

Serviceable open-tube source

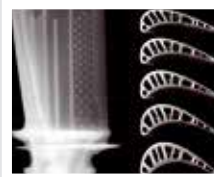
## Casting inspection



Microfocus sources at this energy are needed to run highly accurate inspection of dense industrial objects, such as large castings. The XT H 450 3D is a system designed to give industry leading performance in the scanning of large objects where scattering is not a limiting factor, e.g. large low density castings.

For higher density castings which exhibit scatter, the XT H 450 can build a 3D volume by combining CLDA 2D CT slices.

## Turbine blade inspection

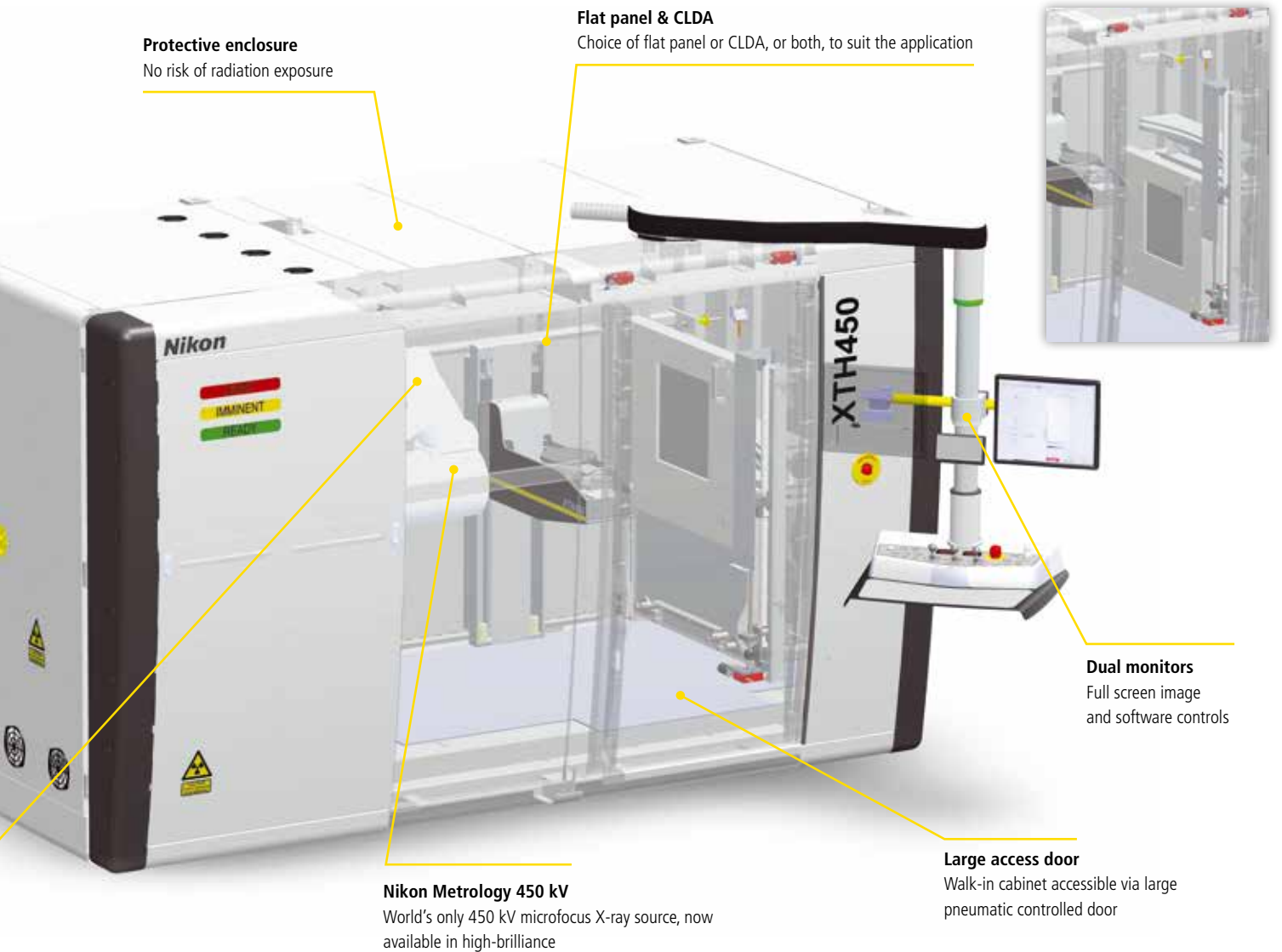


A 450 kV source in combination with a CLDA is ideal for radiographic and CT inspection as well as metrology of small to medium metal alloy turbine blades. Such an X-ray system offers sufficient source power to penetrate through the part and generate a scatter-free CT volume.

In a production environment, the system runs automatic data acquisition, high-speed CT reconstruction and inspection, generating pass/fail status for each inspected part. Blade manufacturers can run detailed CT metrology inspection of turbine blades (e.g. wall thickness) to optimize the fuel economy of jet engines.



# HIGH VOLTAGE MICROFOCUS CT



## CT versatility with configurable systems



When there is no standard X-ray and CT system available that suits your organization's specific requirements, Nikon Metrology can provide a configurable CT system that can be built into (existing) cabinets or walk-in rooms. These modular systems support multiple sources, multiple detectors, specific manipulators and can be custom-configured to fit a variety of applications.



# INTELLIGENT SOFTWARE

**Interactive and user-friendly software is essential in evaluating the complex internal structure of samples and performing accurate inspection. Inspect-X helps you acquire the X-ray images and reconstruct the CT volumes most efficiently. Developed to streamline the process of CT measurement, it runs internal inspections in minutes, instead of hours or days.**

## EASE-OF-USE

- 'CT Wizard'/'Guided Workflow' for easy learning curve and simplified CT process
- Single button to re-scan a previously scanned sample
- Macro-based automation requires no programming skills
- Workflow based GUI

## REAL TIME X-RAY INSPECTION

- Intuitive joystick control for interactive part positioning
- Ultra-fast acquisition of X-ray scans
- Measure on screen and annotate data
- C.Clear real-time image enhancement



## MAXIMUM PRODUCTIVITY

- Batch CT for measuring an array of samples
- X.Tend scanning of tall parts by moving the sample up through the X-ray cone-beam as the sample rotates
- Time delay CT allows to define optional delays between scans, to analyze changes over time in organic materials or to monitor the effects of applying varying pressures to a certain sample
- Inter Process Communications (IPC) for customized system control and complex task automation including Volume Graphics macros



## POWERFUL PROCESSING

- World's fastest industrial single PC reconstruction algorithm
- Automatic single material beam hardening calculation
- Automated CT reconstruction
- Macro-based automation of data analysis

## DATA MANAGEMENT

- Archive CT profile to internal library for quick scan loading
- Various volume formats and TIFF stacks
- Meta-data (Information Tagging) association with CT profile
- Reporting tool and output in HTML and CSV



# FOCUSING ON PRODUCTIVITY

## IMAGE ANALYSIS / ENHANCEMENT

- Precise reconstruction into 3D volume dataset using off-the-shelf PC hardware
- Fast full part reconstruction for general analysis
- Detailed reconstruction for analysis of specific regions of interest
- On-the-spot creation of 2D slices



## OFFLINE CT ANALYSIS

- Off-line analysis on dedicated visualization station
- CAD-comparison of external and internal surfaces (optional)
- Geometric shape fitting in internal 3D features (optional)



# SPECIFICATIONS

Microfocus source	Max. kV	Max. power	Focal spot size		XT H 160	XT H 225	XT H 225 ST	MCT 225	XT H 320	XT H 450	Custom cabinet
160 kV Reflection target	160 kV	225 W	3 µm up to 7 W	225 µm at 225 W	○						○
180 kV Transmission target	180 kV	20 W	1 µm up to 3 W	10 µm at 10 W		○	○				○
225 kV Reflection target	225 kV	225 W	3 µm up to 7 W	225 µm at 225 W		●	●	●	●		○
225 kV Rotating target option	225 kV	450 W	10 µm up to 30 W	160 µm at 450 W			○		○		○
320 kV Reflection target	320 kV	320 W	30 µm up to 30 W	320 µm at 320 W					●		○
450 kV Reflection target	450 kV	450 W	80 µm up to 50 W	320 µm at 450 W						●	○
450 kV High brilliance source	450 kV	450 W	80 µm up to 100 W	113 µm at 450 W						○	○

Detectors	# Bits	Active pixels	Pixel Size	Max. frame rate at 1x1 binning	Max. frame rate at 2x2 binning							
Varian 1313DX	16-bit	1000 x 1000	127 μm	30 fps	60 fps	○						○
Varian 2520DX	16-bit	1900 x 1500	127 μm	12.5 fps	30 fps	○	○					○
Varian 4030	14-bit	2300 x 3200	127 μm	3 fps	7 fps		○	○				○
PerkinElmer 0820	16-bit	1000 x 1000	200 μm	7.5 fps	15 fps	○	○					○
PerkinElmer 1611	16-bit	4000 x 4000	100 μm	3.75 fps	7.5 fps			○		○	○	○
PerkinElmer 1620	16-bit	2000 x 2000	200 μm	3.75 fps	7.5 fps			○	●	○	○	○
PerkinElmer 1621 EHS	16-bit	2000 x 2000	200 μm	15 fps	30 fps			○		○	○	○
Nikon Metrology CLDA	16-bit	2000	415 μm	50 fps							○	○
Combination PE162x & CLDA		Configuration with both Flat panel and Curved Linear Diode Array detector									○	○

● Basic configuration ○ Alternative configuration

	XT H 160	XT H 225	XT H 225 ST	MCT 225	XT H 320	XT H 450
<b>Manipulator</b>						
# Axes	5	5	5	4	4 (optional 5 <sup>th</sup> axis)	4
Axes travel (Typical values - Exact values depend on system configuration)	(X) 185 mm (Y) 250 mm (Z) 625 mm (Tilt) +/- 30° (Rotate) n*360°	(X) 185 mm (Y) 250 mm (Z) 625 mm (Tilt) +/- 30° (Rotate) n*360°	(X) 450 mm (Y) 350 mm (Z) 725 mm (Tilt) +/- 30° (Rotate) n*360°	(X) 400 mm (Y) 300 mm (Z) 720 mm (Tilt) +/- 30° (Rotate) n*360°	(X) 500 mm (Y) 610 mm (Z) 800 mm (Rotate) n*360°	(X) 400 mm (Y) 600 mm (Z) 600 mm (Rotate) n*360°
Max. sample weight	15 kg	15 kg	50 kg	50 kg / 5 kg (for metrology)	100 kg	100 kg
<b>General specifications</b>						
Cabinet dimensions (LxWxH)	1,830 mm x 875 mm x 1,987 mm	1,830 mm x 875 mm x 1,987 mm	2,414 mm x 1,275 mm x 2,202 mm	2,414 mm x 1,275 mm x 2,202 mm	2,695 mm x 1,828 mm x 2,249 mm	3,613 mm x 1,828 mm x 2,249 mm
Weight (approx.)	2,400 kg	2,400 kg	4,200 kg	4,200 kg	8,500 kg	14,000 kg
Safety	All systems are manufactured to IRR99					
Control software	All systems are controlled by Nikon Metrology's in-house Inspect-X software					



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