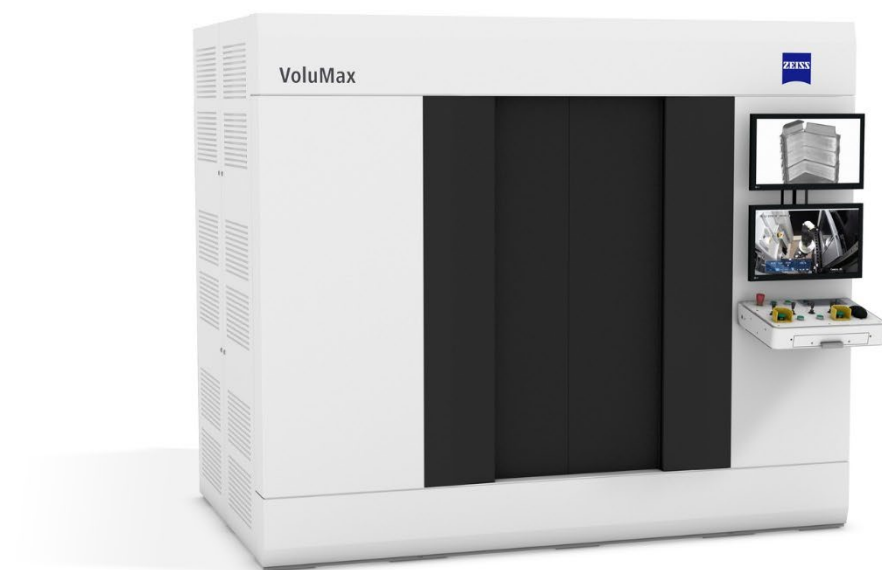




VOLUMAX 9 TITAN

Tomography system

Operating instructions

(Translation of original instructions)



To be read first!

- Please read these user instructions before commissioning the ZEISS product.
- For safety reasons, it is recommended to keep all relevant accompanying documentation on hand.

Disclosure or reproduction of this documentation, even partially, is not permitted without our previous explicit written authorization.
Failure of compliance with these provisions leads to compensation for damages.

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We reserve the right to make changes to this manual and technical modifications to the ZEISS product and its components.

All product names are registered trademarks or trademarks of their respective owners.

Contact

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ITALY

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Introduction

Information regarding these user instructions

These user instructions provide a description of the VOLUMAX 9 TITAN Radioscopy system. The user instructions contain important indications for safe operation and correct maintenance of the machine.

These instructions are intended for both the manager and the operator of the machine.

Structure of safety-related warnings

Safety warnings signal a hazard to health. They are distinguished in three levels: hazard, warning and caution. The three safety warnings are marked by the same warning symbol. The name of the safety warning is found at the side of the symbol. Below find the descriptions of the safety-related warnings used.

Structure of safety-related warnings

A safety-related warning can contain the following components:

- Warning symbol and name of the safety-related warning (signal word): hazard, warning or caution
- Source and cause of the hazard.
- Consequences for the operator if the safety-related warnings are not complied with.
- Necessary measures to be taken by the operator so that the possible consequences do not occur.
- A measure can have an intermediate result as a consequence.
- At the end of all the measures, there can be a final result.

Health hazard



HAZARD

»Hazard« indicates a serious risk of fatal injury and to health. Failure to comply with the safety-related warning when the hazard described occurs causes death or serious injury.
Example: electric shock hazard due to the high electric voltages.



⚠ WARNING

»Warning« indicates a possible risk of fatal injury and to health.

Failure to comply with the safety-related warning when the hazard described can cause death or serious injury.

Example: serious crushing hazard of the body caused by heavy loads.



⚠ CAUTION

»Caution« indicates a hazard to health. Failure to comply with the safety-related warning when the hazard described can cause slight to medium injury. *Example:* light crushing hazard of the limbs caused by light loads.

Hazard of material damage

If there is no hazard to health but a hazard regarding damage to the plant or its components, the following note is given:



The symbol at the side indicates possible damage to the plant.

Failure to comply with the safety-related warning when the event described occurs can cause damage to the plant or its components.

Example: collision of the piece with the X-ray tube.

Distinctive elements

The texts in this document are represented in various ways.
The examples and the meaning of the type of representation are given below:

Example	Meaning
<i>Not</i>	The words to be highlighted are represented <i>in italics</i> . The representation in italics is used sometimes to mark intermediate titles, e.g. <i>method of measurement</i> .
<i>Master switch</i>	When reference is made to control elements in the text, this is highlighted typographically.
Tolerance <i>Field</i>	Naming of partial ranges in the software windows.
Annul	Marking of the buttons
RETURN	The keyboard keys are represented in small capitals letters.
"InstallShield Wizard completed"	Software messages
File  Open	Representation of the menu items
Code	Source code
...\Calypso\opt\om\protform	File and directory
CALYPSO	Product name
ZEISS	Company name
CAUTION! The measurement table must be clean.	Safety-related warning incorporated in the text.
[1]	Representation of the position numbers in the texts

1

Preface

This chapter includes:

General definitions	1-2
Warranty.....	1-5

General definitions

Supply

The standard model of the VOLUMAX 9 TITAN Radioscopy plant is supplied with the following components:

- Tomography system
- Control
- User computer
- Control software
- Documentation
- Spare parts
- Sample for geometric calibration (if supplied)
- Sample for axial calibration (if supplied)
- Filter (if supplied)

CE Marking

CE Declaration of Conformity in accordance with the Machinery Directive 2006/42/EC pursuant to attachment II, part 1, section A.

With this document, we declare that as a result of its design or construction, as well as in the status in which it was placed on the market, the machine described below complies with the requirements of the 2006/42/EC Directive and the other EC Directives given below.

This declaration loses its validity in the case of modifications to the machine that are not agreed with the company.

Name of the machine:	Radioscopy system
Type of machine:	VOLUMAX 9 TITAN
Additional CE Directives:	(EMC) 2014/30/EC (LVD) 2014/35/EC
Harmonised Standards applied, in particular:	– EN ISO 12100:2010 – BS EN 60204-1:2006
National standards:	– DIN 54113 ■ DIN 54113-1 ■ DIN 54113-2 ■ DIN 54113-3

The product has the CE symbol on the identification plate.

Carl Zeiss X-ray Technologies Srl			
Via San Bernardo, 25/27			
21012 Cassano Magnago (VA) - Italy			
N° di Serie Serial nr.		Anno di costruzione Manufacture year	
Fasi Phases			
Peso totale Total weight			
  Manufactured in Italy			

Standards and prescriptions

The machine has been manufactured and inspected according to the following Standards and prescriptions:

Prescriptions

- DGUV prescription 3:
Accident-prevention Regulation – Electrical installations and equipment.

Standards

- DIN/VDE 0100:
Erection of power installations with rated voltages below 1000 V.
- IEC 61010-1:
Electrical equipment for measurement, control, and laboratory use.
- GB 4793.1:
Safety requirements for electrical equipment for measurement, control and laboratory use.
- IEC 60204-1:
Safety of machinery – Electrical equipment of machines.
- ISO 12100:
Safety of machinery – General principles for design – Risk assessment and risk reduction
- BS EN IEC 61326:
EMC – Immunity to interference, Table 2; emission of interference, class A.

- GB 4824:
Industrial, scientific and medical (ISM) radio frequency equipment
–Electromagnetic disturbance characteristics – Limits and methods.
- CAN/CSA-C22.2 n. 61010-1-04:
Safety requirements for Electrical Equipment for measurement, control and laboratory use.
- UL 61010-1, Second Edition:
Standard for Electrical Equipment for Laboratory use.
- DIN 54113-1:
Non-destructive testing - Radiation protection rules for the technical application of X-ray equipment up to 1MV - Part 1: Technical safety requirements and testing for the manufacture, installation and operation.
- EN (IEC) 61010-2-091:
Safety requirements for electrical equipment for measurement, control and laboratory use – Particular requirements for cabinet X-ray systems
- 21 CFR 1020.40:
Performance standards for Ionizing Radiation emitting products – Cabinet X-ray systems.
- GB 22448:
Protection rules for industrial X-ray radiographic equipment up to 500 kV.

Warranty

Notes

- Regarding translations into a foreign language, the indications and statements contained in the user instructions in Italian are predominant and binding.
- We reserve the right to make modifications to the model and content of the machine supply as well as its optionals, software packages and documentation attached.
- All rights reserved, in particular in the event of granting a patent or registration of a utility model.

The following are not covered by the warranty:

- Consumables
- Parts subject to wear.

Exclusion from the warranty

Right to assert the warranty is excluded in the following cases:

- if these user instructions are not complied with,
- if the plant we supply is modified,
- if maintenance is not performed by specially qualified staff at ZEISS,
- if the treatment interventions are not performed by the manager or operator in compliance with the indications provided,
- if original spare parts are not used for maintenance work,
- if the maintenance and care operations are not performed in compliance with the technical documentation and that stated in this manual.

All information regarding the treatment interventions, the consumables and parts subject to wear are contained in separate documents.

2

Safety

This chapter includes:

Use compliant with the purpose envisioned	2-2
Work in safety	2-3
Plant safety	2-11
Residual Risk Zones	2-16

Use compliant with the purpose envisioned

The machine is intended exclusively for non-destructive tests on non-living creatures. The test is performed using X-rays.

Use different or outside that described is to be considered non-compliant with the purpose envisioned.

The machine is built to the highest standards and in compliance with acknowledged safety technical regulations.

However, hazards to life and the integrity of the operator and third parties may occur during its use. Furthermore, damage may occur to the Radioscopy system and other assets.

The machine can only be used if it is in perfect working order. This means it must be regularly subjected to the maintenance operations envisioned. Any changes of the machine that can jeopardise safety must be eliminated immediately. The plant can only be used indoors.

Use compliant with the intended purpose also includes compliance with the user instructions.

Reasonably foreseeable incorrect use

The rules given in these users' instructions must not be disregarded.



⚠ WARNING

X-Rays.

Deadly radiation.

- Never test living creatures.

NOTE

Safe operation within the service life is only guaranteed if the machine is used in compliance with the warnings given in these user and maintenance instructions.

Liability

ZEISS does not assume any liability for damage to the machine and other assets or injury to persons due to non-compliance of the rules contained in these user and maintenance instructions.

Work in safety

Information regarding this chapter

Below are the rules to be complied with for safe operation of the machine.

- Read this paragraph carefully before starting the machine.
- Comply with all the indications given in order to guarantee safe operation.

General conditions

Relevant documentation

The following documents must be complied with for safe use of the machine:

- the complete documentation of the machine, e.g. user and maintenance instructions
- the accident-prevention regulations in the country of destination
- the acknowledged technical standards regarding safety and professionalism in the workplace.

Contract terms

Assembly operations, connection to the power supply, checks and commissioning are carried out according to that envisioned by the terms of the contract.

The warranty becomes null and void whenever construction modifications are made during the period of validity of the warranty, such as for example the transformation of the plant without approval from ZEISS.

Operator requirements

Requirements necessary for use of a radioscapy system

Special conditions are envisioned for use of a radioscapy system depending on the country. These conditions must be complied with. Normally this includes registration with the competent supervisory authority as well as inspection by a technical expert.

Definition of specialised staff

Specialised staff safely perform the work necessary and can recognise and avoid possible hazards.

The following conditions apply to the performance of a job:

- The specialised staff must be authorised by a person responsible for plant safety and perform the necessary jobs.
- The specialised staff must have suitable training and experience.
- The specialised staff must have been educated regarding use of the corresponding plant.
- The specialised staff must be aware of the standards, the provisions, the accident-prevention regulations in force and the operating conditions.

Tasks of specialised staff:

- Positioning the plant
- Maintenance work on the plant
- Work on electric plants e.g. control units
- Preparation of the measurement.

Requirements for safe use

In order to work safely with the plant, essential requirements must be met.

The following must be complied with:

- Respect the accident-prevention regulations and the general safety-related warnings.
- Only use the plant if all safety devices envisioned are present.
- Do not remove coverings, safety devices or warning signs.
- Only use cables and plugs that are in perfect operating conditions.
- The connection must consist of a fixed socket or a connector in compliance with the CEI EN 60309 Standard.
- Two attachments are necessary for protective conductors in perfect condition.
The second protective conductor is important due to the high leakage current.
- Respect the maximum weight of the piece allowed.

No warranty rights

The Manufacturer is not liable for damage deriving from unauthorized interventions on the X-ray system. In the case of unauthorized modifications, the warranty rights towards the manufacturer and supplier cannot be asserted and the CE declaration of Conformity is no longer valid.

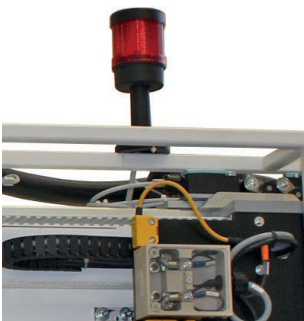
Documentation

Correct use of the plant is essential for safe operation. Knowledge of the content of the documentation supplied is assumed.

- Make sure that the plant user instructions always accompany the plant.
- Make sure that the appraisal always accompanies the plant.

Machine hazard point

Hazard point	Hazard	Measurement
Positioning system	Crushing hazard due to movement of the axes	There must be no parts of the body inside the radiation protection enclosure during movements. – During movements, never introduce the head or hands inside the enclosure.
	Crushing hazard during lifting and lowering movements	– Comply with the applicable national accident-prevention regulations. – Remain at a sufficient distance during the visual check. – If maintenance must be performed, disconnect the plant from the mains and prevent re-connection.
Turntable	Injury hazard with the support in movement	See »Support positioning system«
Electric control board	Hazard due to voltage	The plant must not be used with the electric control board open.
Command console	Hazard due to voltage	The plant must not be used with the command desk open.

Hazard point	Hazard	Measurement
Radiation protection enclosure  	Hazard due to X-rays	In the event of permanence in the radiation protection enclosure with the loading door closed, there is a risk of death due to the X-Rays. The accessible radiation protection enclosure has the following safety devices: – Warning LEDs: once the loading door has been closed, the orange warning light starts to flash. In this period of time the rays are deactivated. The red warning lights inside and the external one switch on as soon as the X-rays are activated. – Acoustic buzzer (if envisioned by the Directive of the respective country): once the loading door has been closed, the buzzer activates. The duration depends on the directives of the respective country. In this period of time the rays are deactivated. – EMERGENCY STOP: there are two <i>EMERGENCY STOP</i> buttons installed in the enclosure so you can save yourself. Another EMERGENCY STOP button is installed on the command desk. By pressing an <i>EMERGENCY STOP</i> button, the X-rays are blocked. The door drives and the movement unit are disconnected from the current. The loading door can be opened manually (even without the presence of current).

Essential safety recommendations

X-rays



⚠ WARNING

Risk of fatal injury due to X-rays in the radiation protection enclosure.

The X-rays are generated in the X-ray tube.

Life-threatening injuries with consequent death.

- Only use the plant if all safety devices are present.
- Deactivate the X-ray tube before opening the loading door.
- Do not make any modification to the program and do not install personal software in computers.
This can interfere with operation of the computers and the plant.
- Never enter the radiation protection enclosure when the X-rays have been activated.

Electric Voltage



⚠ WARNING

Risk of death from cables and electric components following electrocution.

Cardiac arrest burns and death.

Only specialised electricians can work on the control unit. The control unit cover can only be removed if the plant is decommissioned. Follow the operations below for decommissioning:

- Disconnect the drives and the control unit.
- Deactivate the master switch and prevent involuntary activation.
Warning: Even if the master switch is disconnected, just like the network filter, it continues to be live.
- Disconnect the power supply plug or disconnect the electric equipment from the power supply.

Note: There is not always a power supply plug present. Our plants are normally connected via a fixed connection.

Construction modifications



⚠ WARNING

Risk of death due to X-rays following construction modifications.

Any modifications can cause malfunctioning and can have life-threatening consequences. The performance of construction modifications can also have the annulment of the operating license as a consequence.

- Never dismantle or modify the plant.
- Never dismantle or modify any plant component.

High voltage in the X-ray tube



⚠ WARNING

Risk of fatal injury due to high voltage in the radiation protection enclosure.

Electric shock with consequent death.

- Never open the covers.



Smoke, odors and noises

⚠ WARNING

Risk of fatal injury due to possible damage to the plant if it emits smoke, unusual odors or strange noises.

It is extremely hazardous to continue to use the plant.

- Disconnect the plant immediately.
- Contact a ZEISS after-sales service technician.

Foreign substances



⚠ WARNING

Risk of fatal injury due to electric shocks and fire caused by foreign substances in the radiation protection enclosure or in the plant components.

The presence of foreign substances can cause operating anomalies and seriously damage the plant and consequently cause sudden hazards for the operator.

- Never use the plant if a foreign substance or liquid have penetrated into a component of the same.
- Contact a ZEISS after-sales service technician.

Damage of cables



⚠ WARNING

Risk of fatal injury due to electric shock or fire caused by damaged cables.

The cables may be live and cause an electric shock or burns in the event of contact. Furthermore, they may be the cause of fires.

- Always use power supply cables and other cables with great caution.
- Do not place any objects on the cables.
- Never stand on the cables.
- Never bend the cables.
- If the cables are damaged, it is essential to contact a ZEISS after-sales service technician.

Behavior in the event of a fire and after a fire



⚠ WARNING

Risk of fatal injury due to unexpected events caused by fire in the vicinity of the plant.

In the event of fire, safe operation cannot be guaranteed.

- Disconnect the entire plant immediately.



⚠ WARNING

Risk of fatal injury due to damage of the plant caused by a fire.

Safe operation cannot be guaranteed following a fire in the vicinity of the plant.

- Have the plant checked by a technician.
- Contact a ZEISS after-sales service technician.

Loading door



⚠ WARNING

Crushing risk when the loading door is closed.

Crushing of parts of the body, arms, hands and fingers.

- Before closing the loading door, make sure that it is impossible for anyone to introduce their hands into the door aperture or lean through the aperture into the radiation protection enclosure.

General prevention measures

Temperature of the electric control board



High temperatures inside the electric control board can cause operating anomalies.

In extreme cases, fires may occur.

- Make sure that the environmental conditions required are complied with.
- Make sure that the flow of fresh air to the fan is sufficient.

Temperature of the piece



Problems if the temperature difference between the piece and the radiation protection enclosure is too high.

Pieces that do not have the temperature present inside the radiation protection enclosure cannot be examined.

- Measure the temperature of the piece.

Cleanliness in the X-ray chamber



The inside of the radiation protection enclosure must be clean and dust-free.

For this purpose, the following rules must be followed:

- Do not leave the loading door open.
- Open the loading door only to organize the piece and/or for maintenance work.
- Only organize clean and dust-free pieces on the support.
- Clean the pieces outside the radiation protection enclosure.

Notes

High leakage current

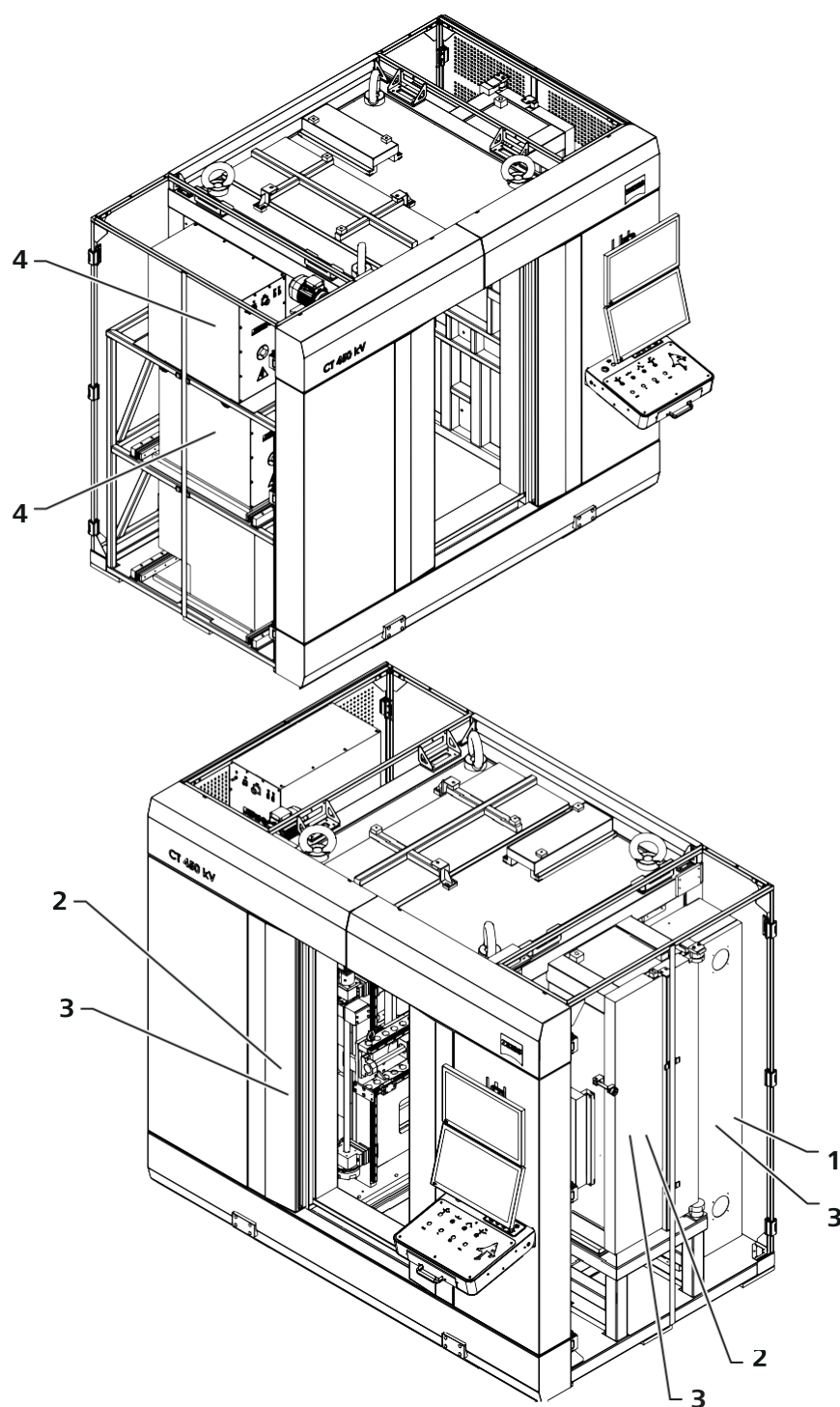
NOTE

In the presence of leakage current exceeding 10 mA, the plant must be fitted with a second earth cable.

Plant safety

Safety symbols

There are several warning plates with explanatory pictograms in every zone that is a hazard for the operators and maintenance technicians.





VOLTAGE HAZARD

Plate positioned on electric/electronic components.

- **Do not perform operations with voltage connected. Risk of fatal injury.**



RADIATION HAZARD

Plate positioned on the enclosure door and on the door of the lead-lined box containing the X-ray emitter.

- **Do not enter the enclosure with the machine running. Risk of fatal injury.**



LIMBS CRUSHING HAZARD

Plate positioned in proximity of the piece support and on the doors that can be opened.

- **Pay attention when positioning the piece and during opening of the doors.**

**DANGER
HIGH VOLTAGE**

VOLTAGE HAZARD

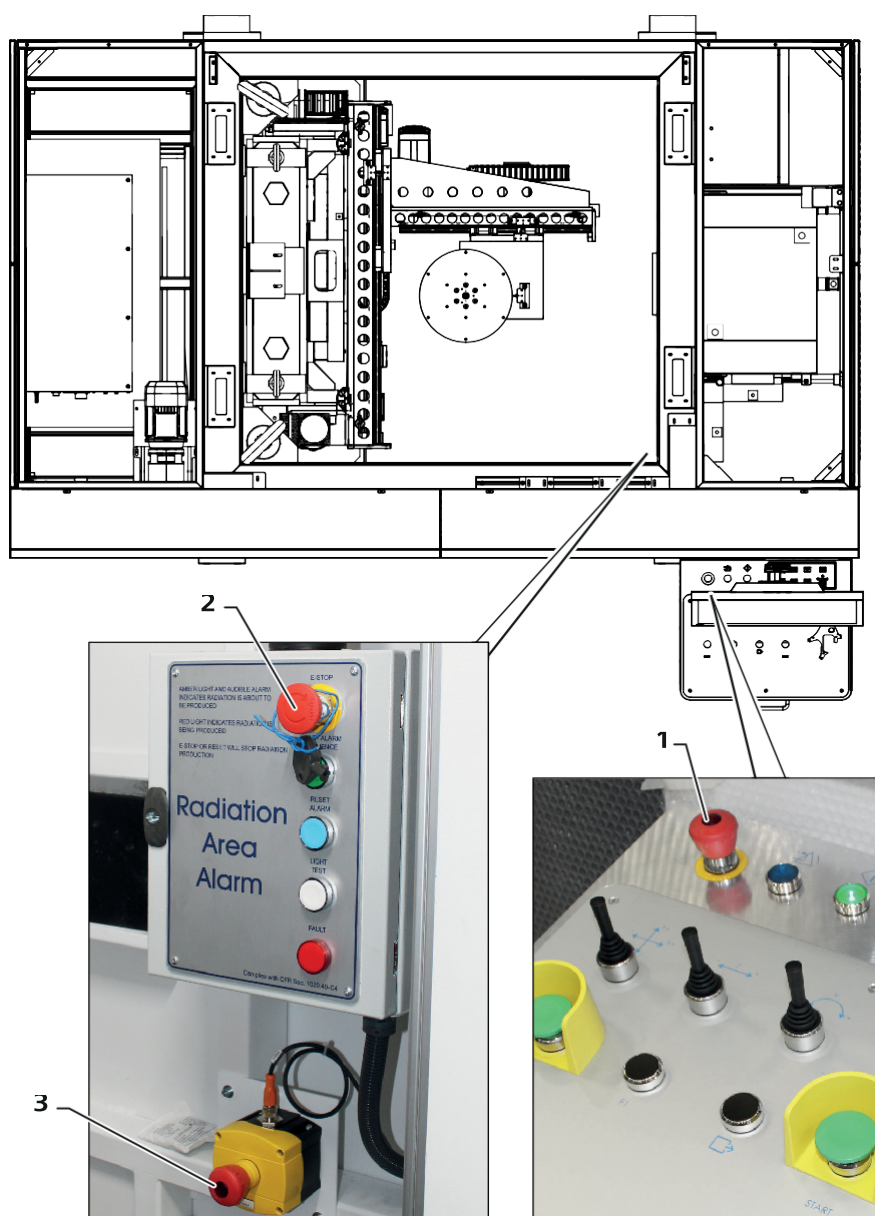
Plate positioned on the X-ray generators.

- **Do not perform operations with voltage connected. Risk of fatal injury.**

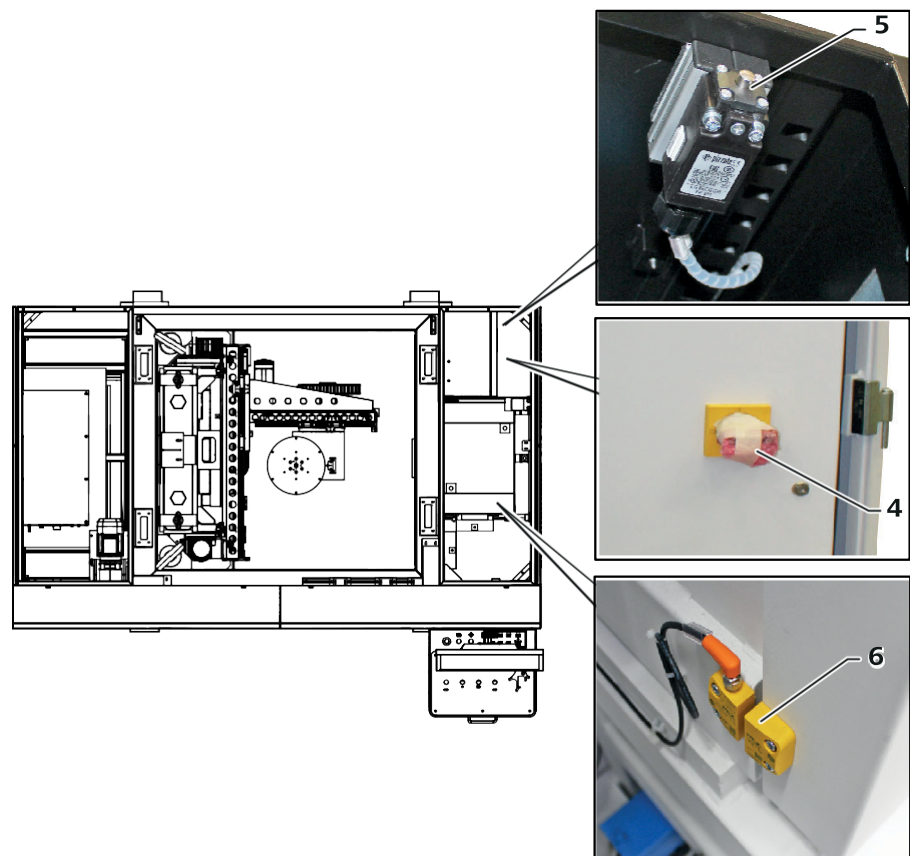
Safety devices

The following safety devices have been installed on the machine:

- [1] Emergency button for immediate shut down of the entire machine, positioned on the command desk.
- [2] Emergency button for immediate shut down of the entire machine, positioned inside the enclosure.
- [3] Emergency button for immediate shut down of the X-ray emitter, present on the control box positioned inside the enclosure.



- [4] Pad lockable master switch (with door lock device), present on the electric control board door.
- [5] Safety switch, present on the electric control board door.
- [6] Safety sensor, present on the door of the lead-lined box containing the X-ray emitter.



When an *EMERGENCY STOP button* is pressed, the following measures are started:

- the X-ray tube is switched off.
- the enabling of all movements is blocked.
- all drives are disconnected.



High stress on X-ray components by pressing the *EMERGENCY STOP button*.

The X-ray components are subjected to great wear.

- Only press the *EMERGENCY STOP button* in case of an emergency.
- Use control software to switch the X-ray tube off.

No warranty rights

The warranty rights become null and void in case of damage due to frequent and, above all, unnecessary activation of the *EMERGENCY STOP button*.

NOTE

Once an *EMERGENCY STOP button* is pressed, it is blocked. Turn it slightly to release it.

Drives OFF

The X-ray protection enclosure loading door movements are monitored. When the stress exceeds a determined value, the drives disconnect. The electric components continue to be live.

NOTE

The loading door and the positioning system cannot be moved. The drives must be re-connected to perform new movements. Incorrect movement of the door corresponds to pressing the *EMERGENCY STOP button*.

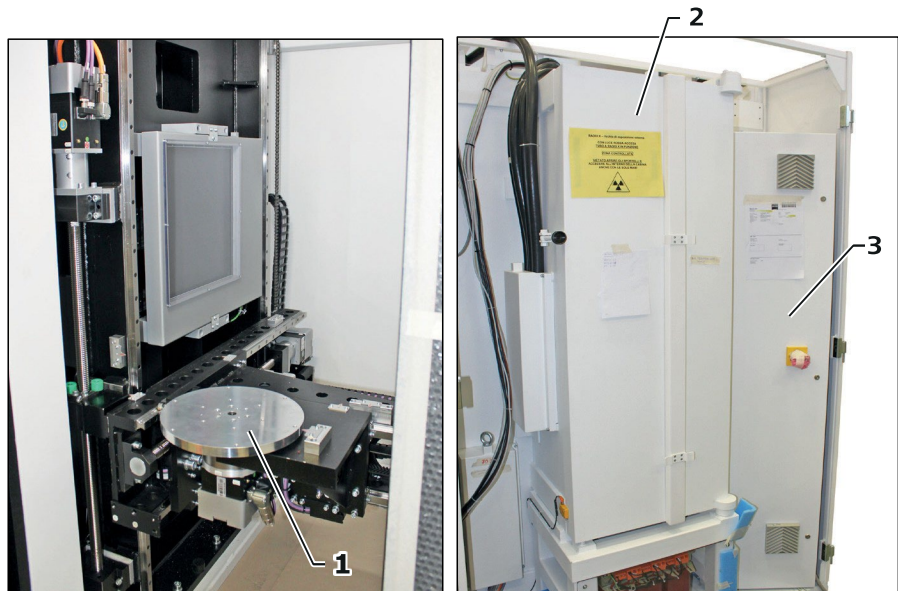
Residual Risk Zones

The zones with residual risk are those that cannot be protected due to the particular tasks they must perform. These zones are described successively.



LIMBS CRUSHING HAZARD

- [1] Support of the piece being checked; crushing hazard between the support and the piece (during the piece loading/unloading operations).
- [2] Door of the lead-lined box containing the X-ray emitter, crushing hazard during opening (during maintenance operations).
- [3] Electric control board door; crushing hazard during opening (during maintenance operations).



3

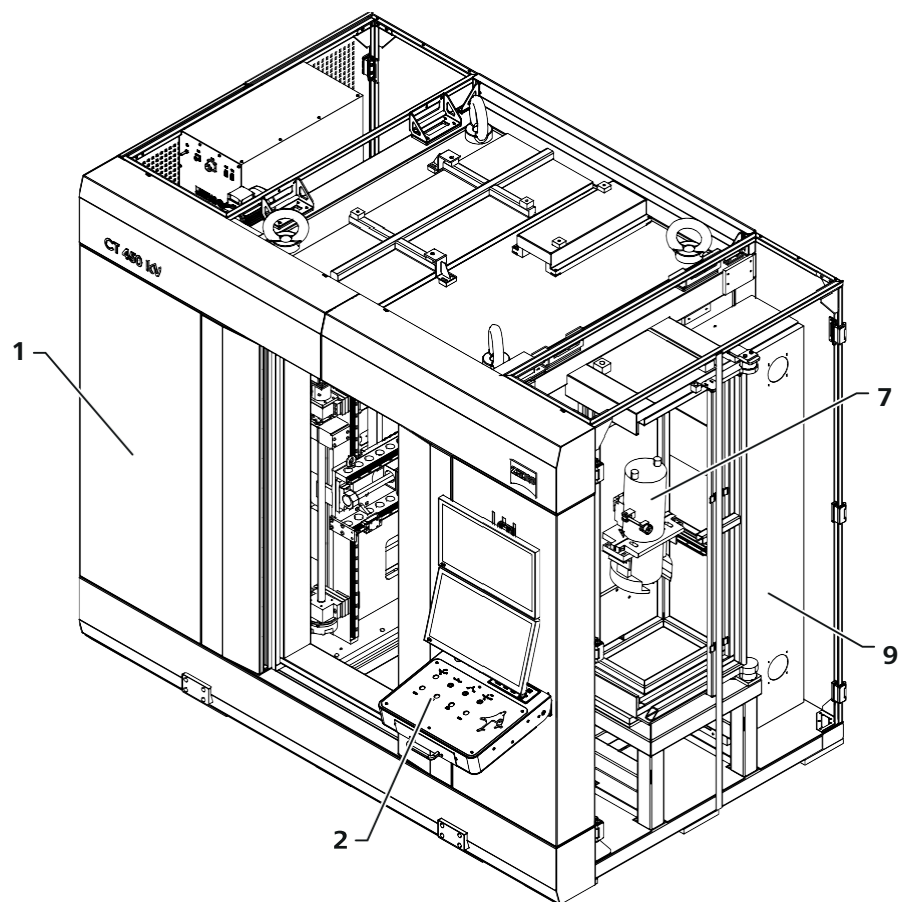
Description

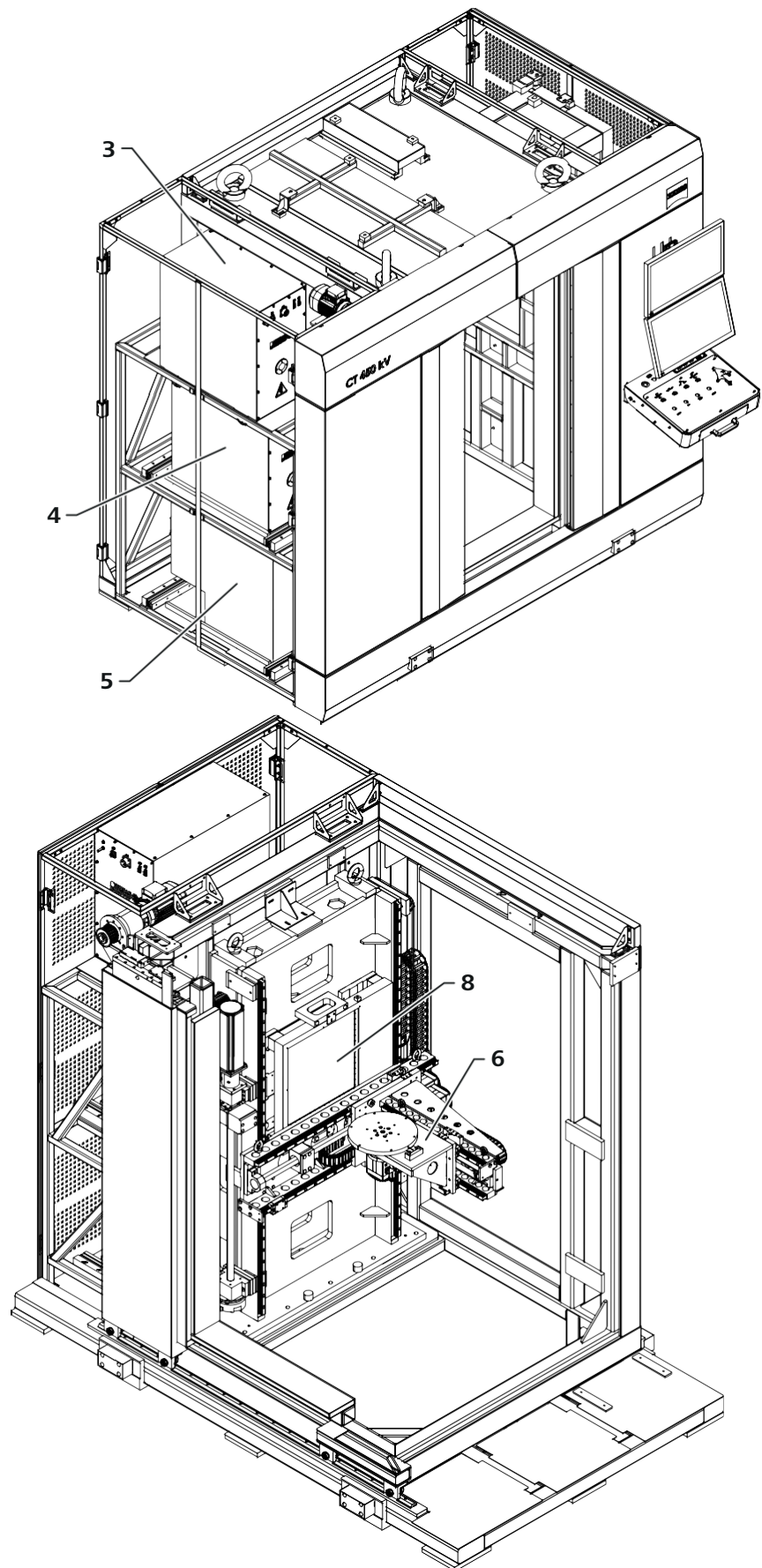
This chapter includes:

Structure of the plant	3-2
Components and functions	3-4
Command	3-9
Command Desk	3-10
X-ray emitter controls	3-12
Controls inside the Enclosure	3-13

Structure of the plant

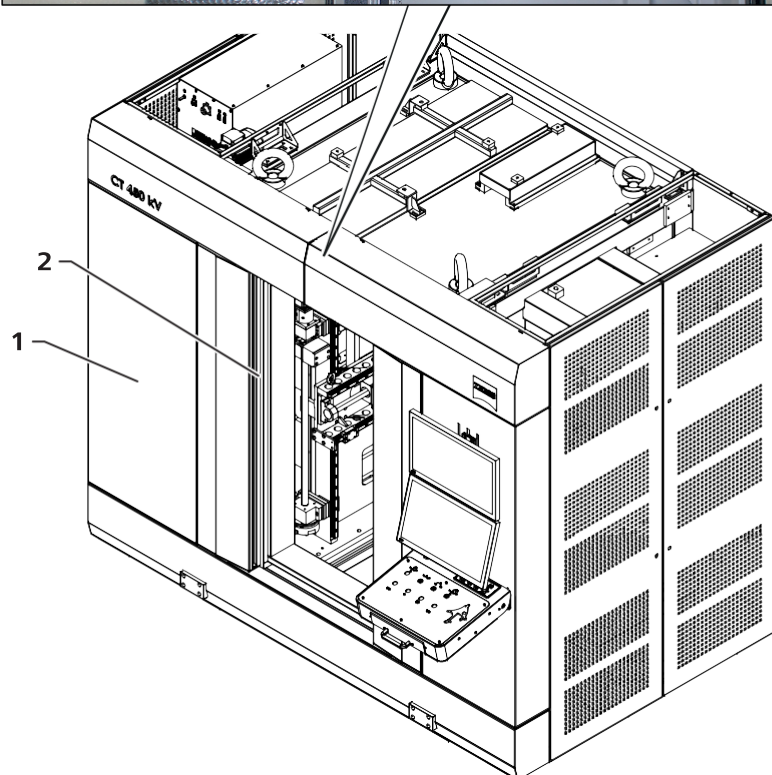
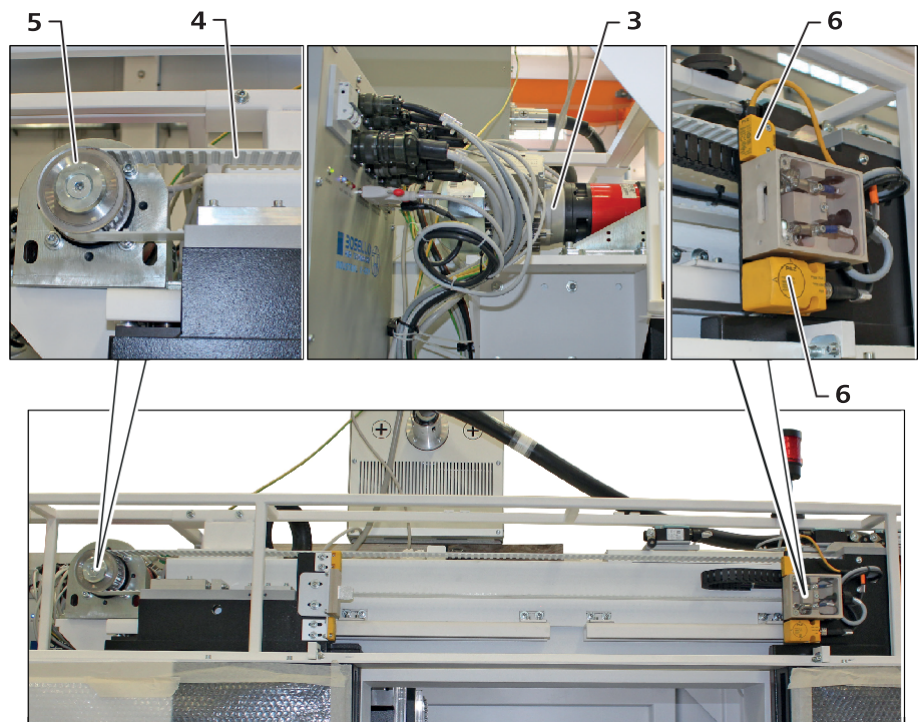
- [1] Lead-lined enclosure with access door.
- [2] Command desk with operator panel.
- [3] X-ray generator (positive).
- [4] X-ray generator (negative).
- [5] Cooling unit.
- [6] Support and handling system for piece being checked.
- [7] X-ray emitter.
- [8] X-ray images detector.
- [9] Electric control board.



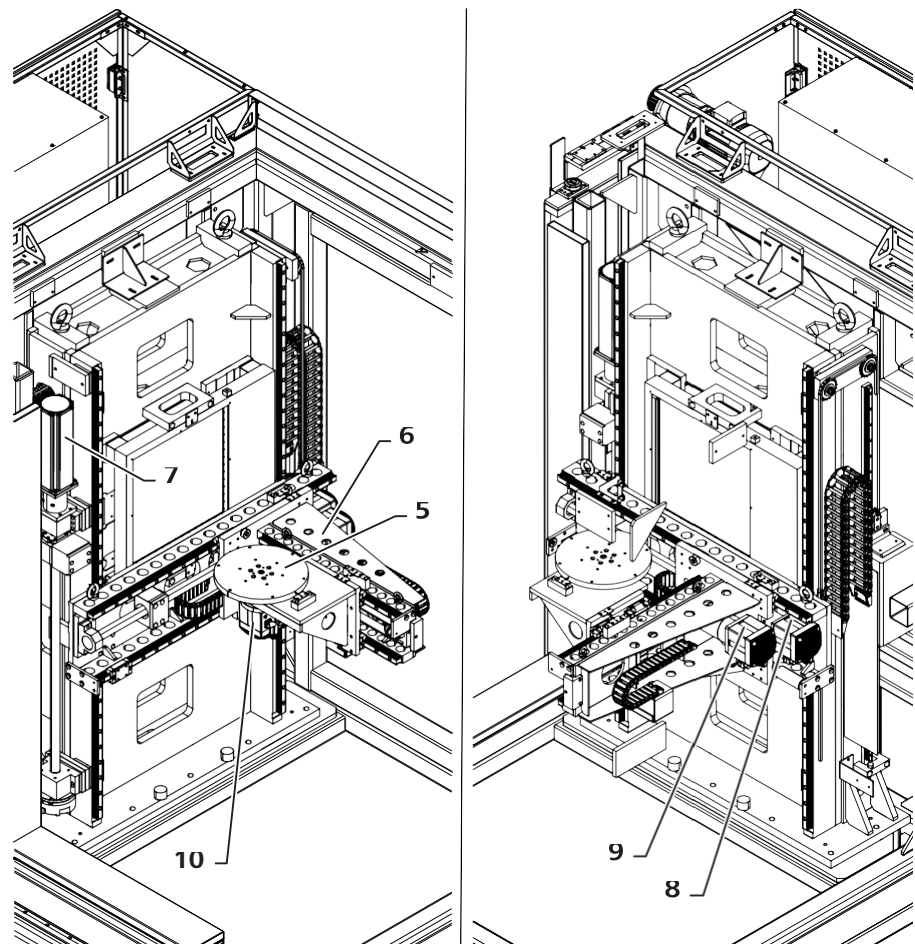


Components and functions

The machine is made up from a lead-lines enclosure [1], with an aperture and sliding access door [2], moved by a system made up from a motor [3], belt [4] and pulleys [5]. Travel of the access door is controlled by safety sensors [6].



The piece to be checked is positioned and fixed suitably to the turntable [5] by the operator. To allow the most suitable positioning in the verification phase, this support is installed on a motorized structure [6].

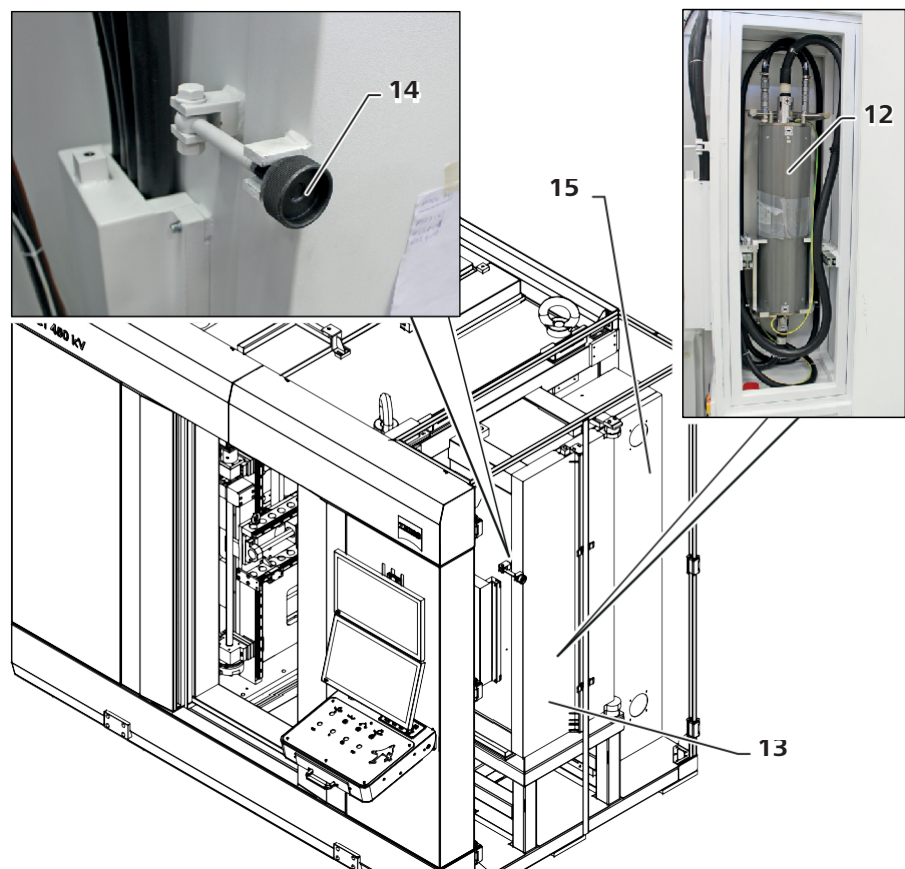


A first motor [7] allows up/down movement of the support ("Z" axis), a second motor [8] allows its forward/backward movement ("Y" axis), a third motor [9] allows its left/right movement ("X" axis), while a fourth motor [10] performs left/right rotation ("V" axis) of the support.

An X-ray image detector **[11]** is installed in the middle of the motorised structure.

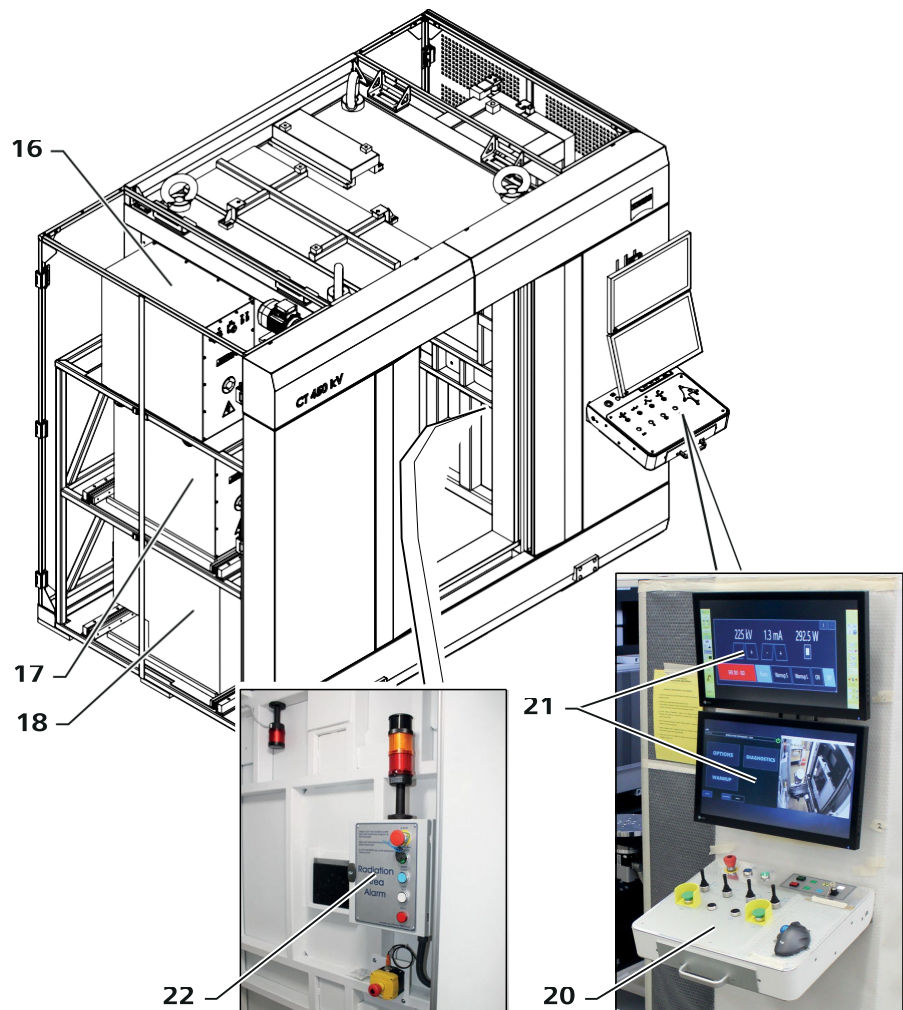


The X-ray emitter **[12]** is contained in a lead-lined box **[13]**, fitted with door closing device **[14]**.



At the side of the box is the electric control board **[15]**, in which the electrical equipment is enclosed.

The positive ray generator [16], the negative ray generator [17] and the cooling unit [18] are in the opposite side of the enclosure.



An environment camera [19] is present inside the enclosure in order to view the work process in real time.

An external command desk [20], complete with operator panel [21] and a box of internal commands [22] allow the machine to be controlled during the work process.



Support positioning system

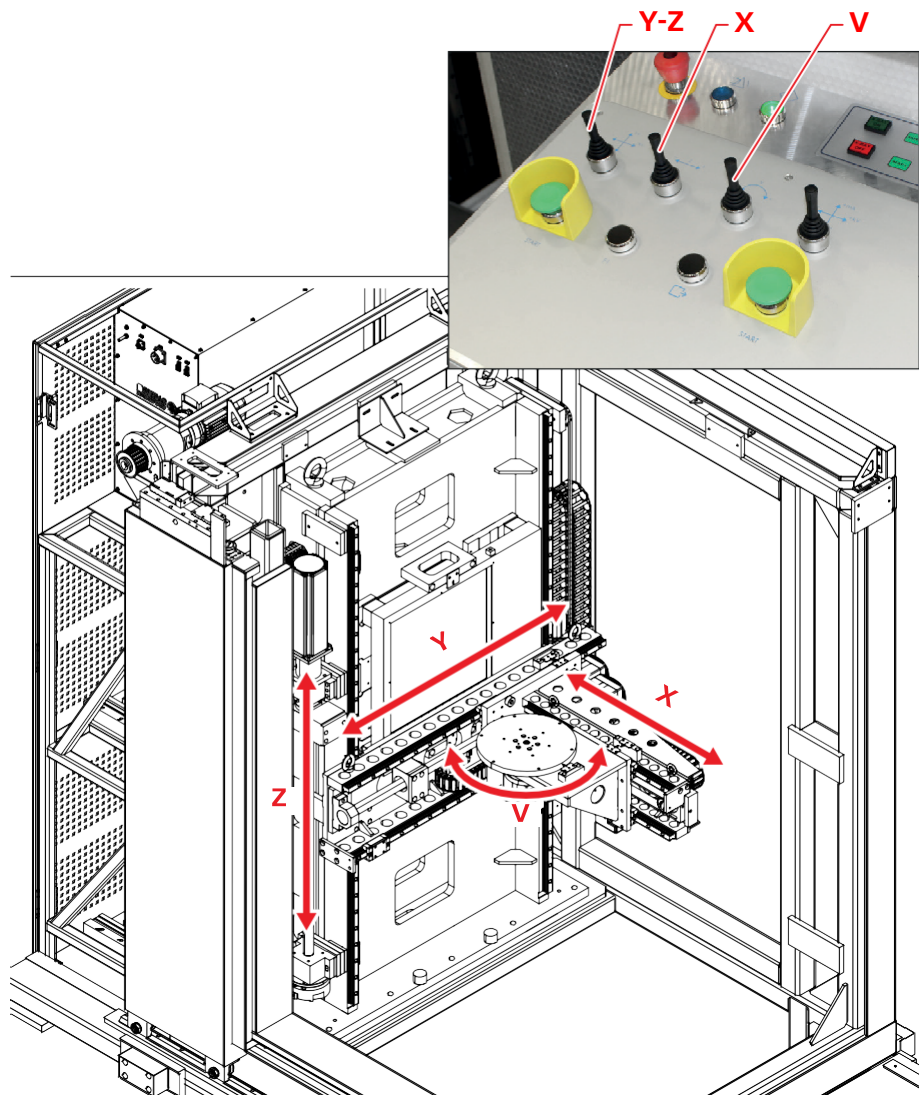
The positioning system is made up from several components on the following axes:

"Y" Axis = Piece support Forward / Backward movement

"Z" Axis = Piece support Up / Down movement

"X" Axis (ZOOM) = Piece support Left (ZOOM -) / Right (ZOOM +) movement

"V" Axis = Piece support Left / Right rotation



Command

Electric control board



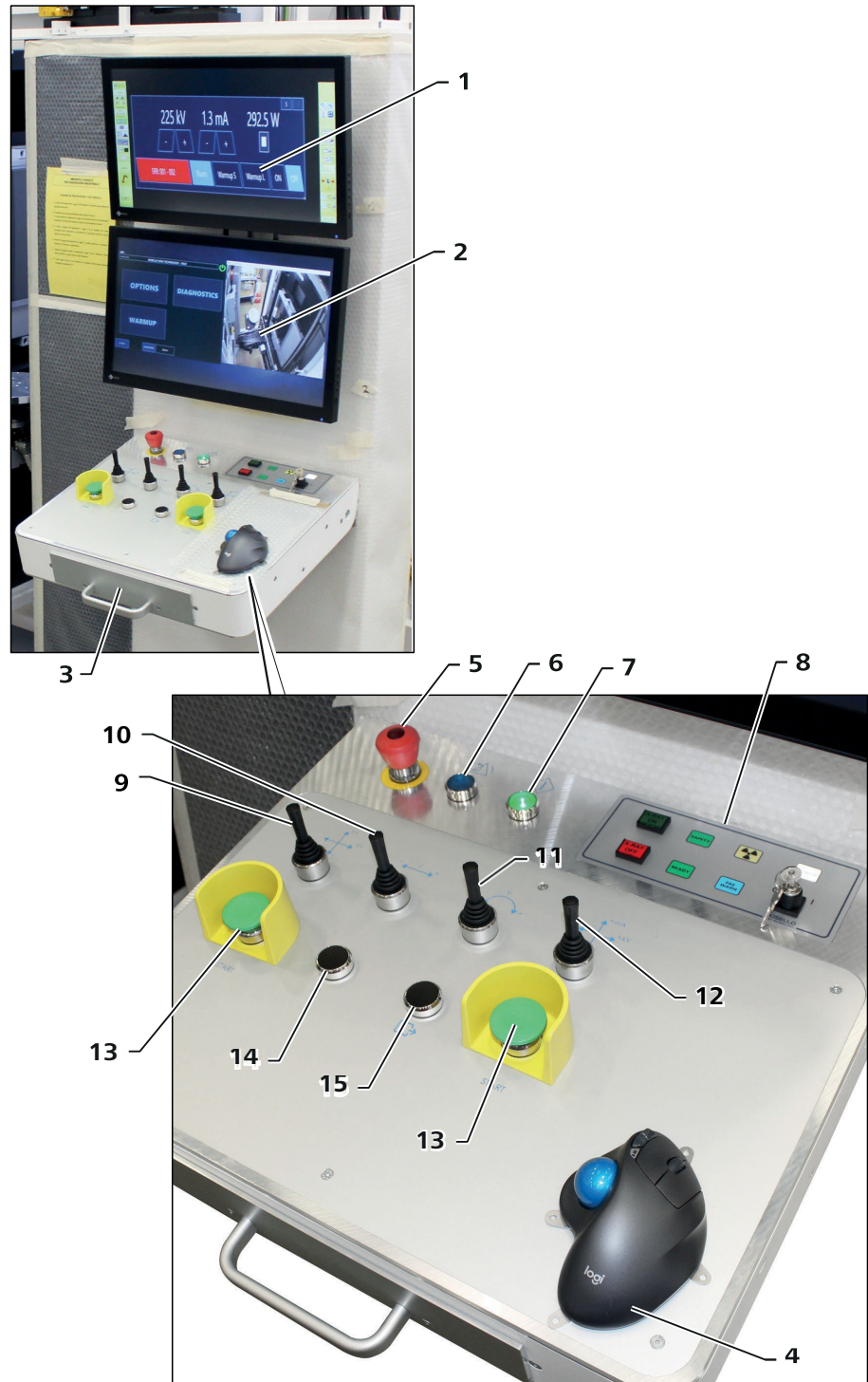
[1] Master switch

When it is turned to the "I/ON" position, the machine is on; when it is turned to "O/OFF", the machine is off.

NOTE

The voltage present warning symbol is found on the electric control board. The electric control board must only be opened by specialised electricians.

Command Desk



[1] Touch-screen operator panel

Operator panel for setting and managing machine working parameters.

[2] Monitor

Monitor for viewing the environment camera images.

[3] Alphanumeric keyboard compartment

Alphanumeric keyboard connected to the PC for operator panel management.

[4] Mouse “trackball”

Mouse connected to the PC for operator panel management.

[5] Red mushroom-head emergency button

Emergency stop button. When pressed, it immediately deactivates all the power circuits, interrupts the cycle and activates the safety module. Rotate it anticlockwise to reset.



Using it improperly could cause unexpected damaging situations.

[6] Luminous blue “RESET EMERGENCIES” button

Emergencies reset button. If it signals the emergency situation (emergency buttons pressed or other). To be pressed at every machine start-up and every time the emergency button is pressed and/or a safety device intervenes.

[7] Luminous green “CONTROLS CONNECTION” button

Button for connecting the machine circuits. If pressed, without emergency situations present, it controls the power supply of the power circuits, preparing the machine to run.

[8] Commands for controlling the X-ray emitter

For the description of the function of these controls, consult the next paragraph.

[9] “Y/Z” axes movement joystick

Joystick for the up/down and forward/backward movement of the support unit of the piece being checked.

[10] “X” axis (ZOOM) movement joystick

Joystick for the left (ZOOM -) / right (ZOOM +) movement of the support unit of the piece being checked.

[11] “V” axis movement joystick

Joystick for the left/right rotation of the support unit of the piece being checked.

[12] X-ray joystick

Joystick for setting the X-ray parameters (current and voltage).

[13] Green mushroom-head “START” buttons

Double controls for starting the machine. When pressed (simultaneously), they start the work cycle.

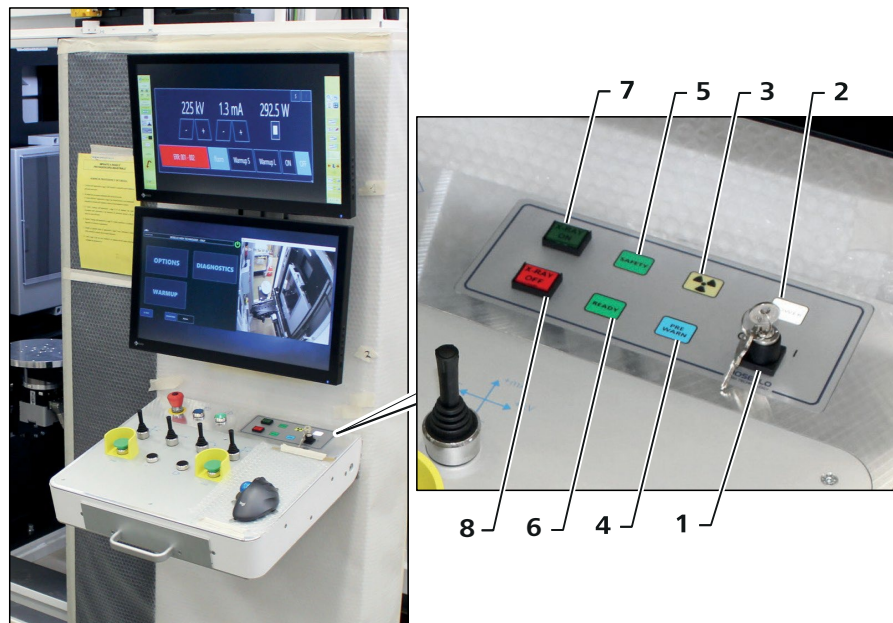
[14] Black “F1” button

Multi-function button set up for the assignment of a quick command by the machine software.

[15] Black “STOP” button

Work cycle stop button.

X-ray emitter controls



[1] Key selector

Selector turned to pos. *O* = X-ray emitter not powered.

Selector turned to middle pos. *stand-by* = X-ray emitter not powered.

Selector turned to pos. *I* = X-ray emitter powered.



The keys of this selector must be kept by the person in charge of the machine.

[2] White "POWER" LED

X-ray generator powered signal LED.

[3] Yellow "X-RAY" LED

X-rays activated signal LED.

[4] Blue "PRE-WARN" LED

X-ray source pre-heat active function signal LED.

[5] Green "SAFETY" LED

Safety devices enabled and operating signal LED. When it is on it indicates that the machine is ready for operation.

[6] Green "READY" LED

X-ray generator ready for operation signal LED.

[7] Green "X-RAY ON" button

Button for enabling operation of the X-rays.

[8] Red "X-RAY OFF" button

Button for disabling operation of X-rays.

Controls inside the Enclosure – RAA

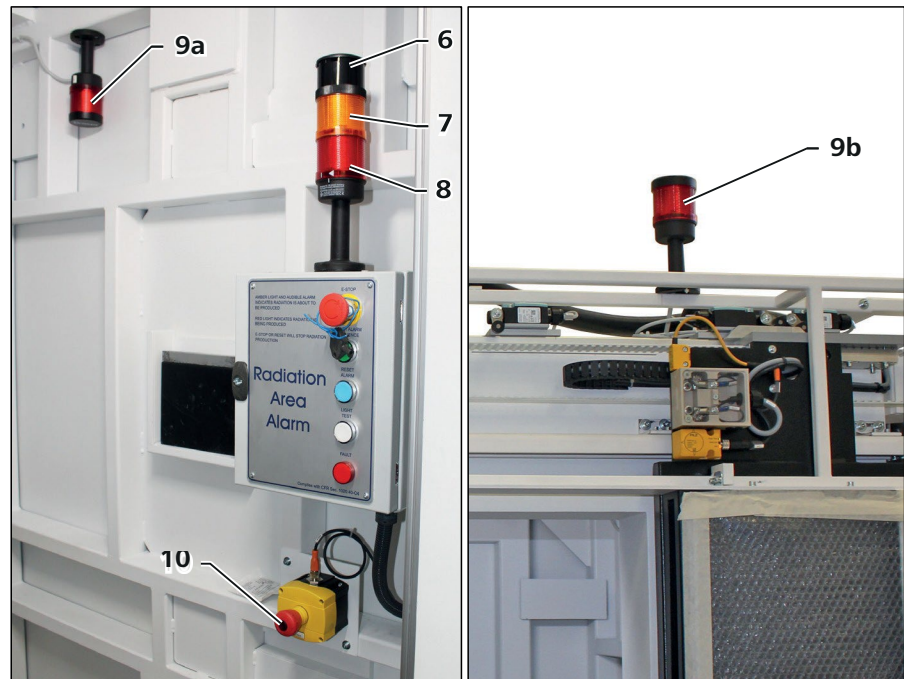
(Envisioned for the USA – it compliances with US regulation “21 CFR Part 1020.40”)



- [1] **Red mushroom-head emergency button**
X-ray emitter emergency stop button.
Rotate it anticlockwise to reset.
- [2] **Green “START ALARM SEQUENCE” button**
X-ray protection procedure start button.
- [3] **Blue “RESET” button**
X-ray emitter emergency reset button.
- [4] **White “LIGHT” button**
Lights (8 and 9) and “buzzer” [7] operating test button.
- [5] **“FAULT” LED**
X-ray emitter safety unit malfunctioning signal LED.

NOTE

Emitter malfunctioning is also signaled via an error message present on the operator panel.



[6] “Buzzer”

It activates to inform the operator that radiation is about to be generated.

[7] Yellow light

It turns on to inform the operator that radiation is about to be generated.

[8] Red light

It turns on to inform the operator that radiation is in progress.

[9a] Red light (inside the enclosure)

It turns on to inform the operator that the X-ray emitter is operating.

[9b] Red light (outside the enclosure)

It turns on to inform the operator that the X-ray emitter is operating.

[10] Red mushroom-head emergency button

Emergency stop button. When pressed, it immediately deactivates all the power circuits, interrupts the cycle and activates the safety module. Rotate it anticlockwise to reset.



Using it improperly could cause unexpected damaging situations.

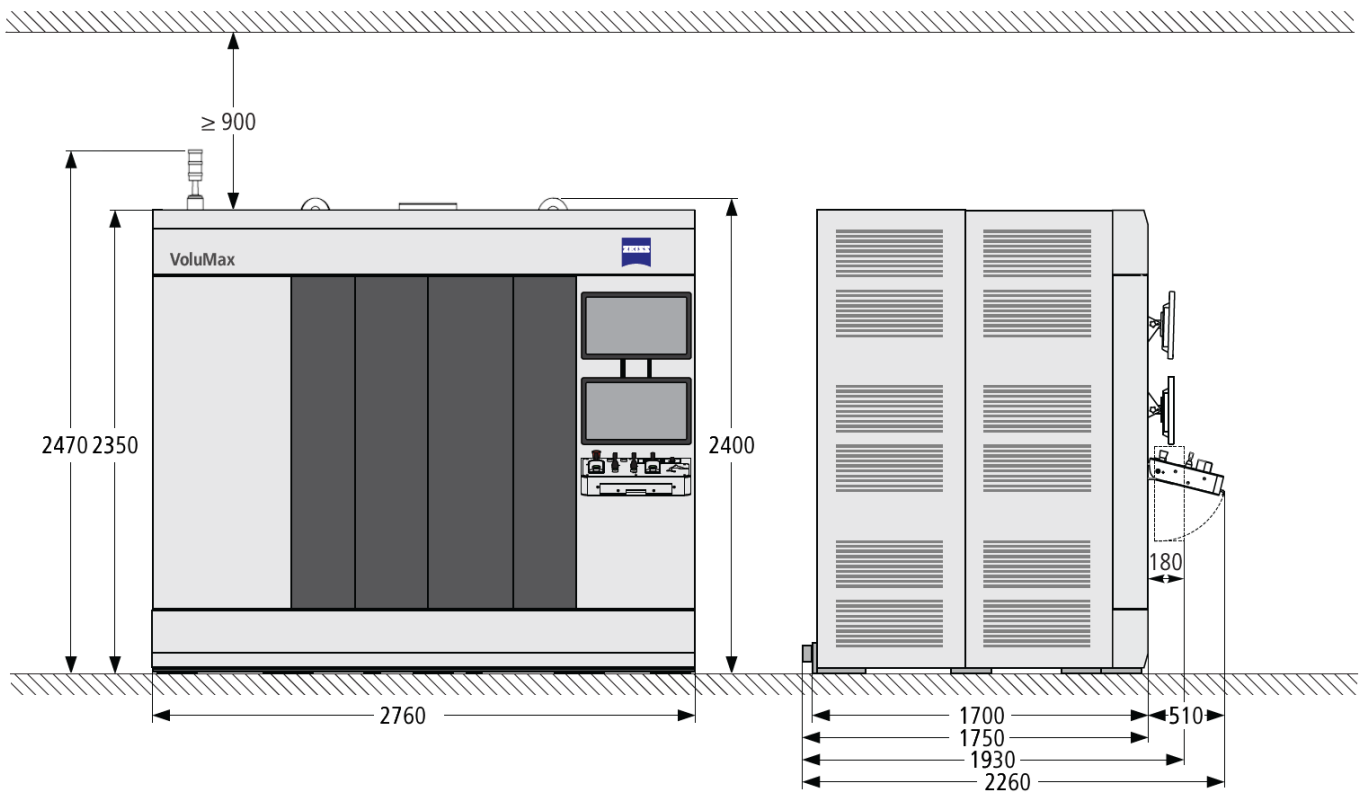
4

Technical data

This chapter includes:

Technical specifications	4-2
Electric data	4-3
Environmental conditions	4-3

Technical specifications



Width	[mm]	2760
Depth (including desk)	[mm]	2260
Height (including traffic light)	[mm]	2470

Electric data

Mains voltage	400 V~ ($\pm 10\%$)
	480 V~ ($\pm 10\%$)
Type of current	3+PE
Frequency	50-60 Hz ($\pm 3.5\%$)
Auxiliary circuits	24 Vdc
Power consumption, max.	9500 VA
Main fuse supply line	D16A

Environmental conditions

The following conditions must be met in order to guarantee perfect operation of the machine.

Environment temperature for operations	from +15°C to +40°C
Relative humidity	from 40% to 80%
Altitude a.s.l.	max. 2000 m

5

Transport and installation

This chapter includes:

Transport	5-2
Installation	5-4

Transport

To be observed on delivery

In the event of a plant made up of several units, the same are divided onto transport pallets.

The individual parts are supplied with insulating packaging. For shipping overseas, the individual parts are packaged in crates for transport.

Requirements of the lifting truck

A lifting truck with sufficient load-bearing force is necessary. The lifting truck must be suitable for the weight of the individual crates. To prevent the load tipping over, the forks must be positioned completely under the pallets or crates and the distance between the forks must be variable.

NOTE

The packaging must not be damaged. The packaging must only be removed at the place of installation by a ZEISS after-sales technician.

**Environmental
temperature from +5°C
to +40°C**

The machine and its components must remain in the packaging and be deposited in a covered place until installation.

The environment temperature in the place of deposit must be between +5°C and +40°C.

Transport conditions

The route from the place of deposit to the place of installation must be chosen carefully. It may be necessary to prepare it for the necessary conditions.

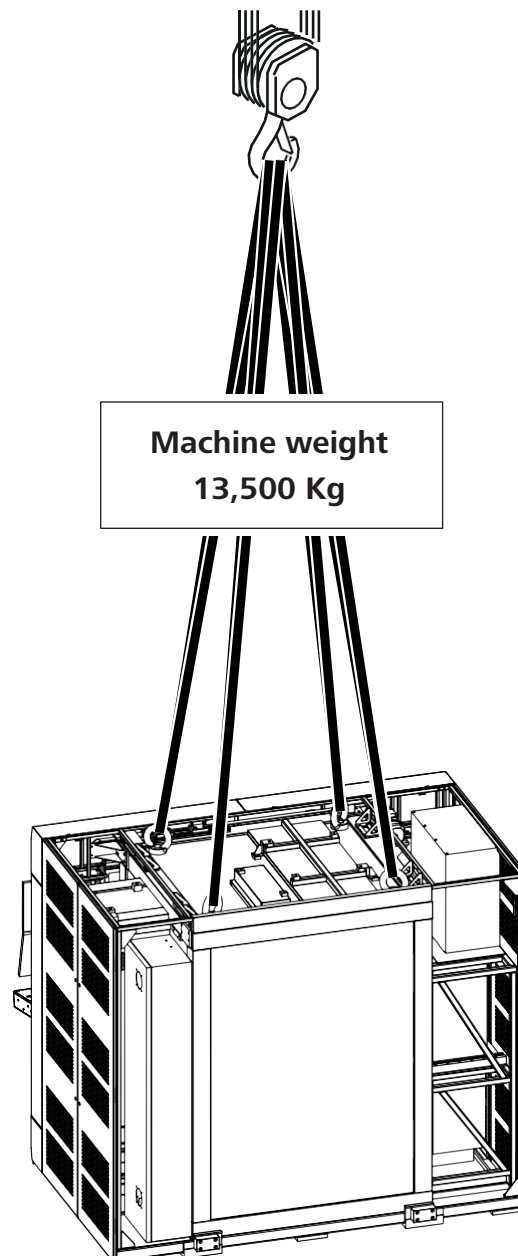
The following must be observed for transport:

- Weight: are the transport routes to the place of installation suitable for the weight of the crates and lifting truck, with reference to the loads allowed?
- Dimensions: are the height and width of the doors and transport routes sufficient for the crates and lifting truck?
- Lifting truck: does the lifting truck meet requirements?
- Overhead crane: does the overhead crane meet requirements?

Lifting the machine

The machine must be lifted using an overhead crane with suitable capacity, as stated below:

- Attach four chains or four steel ropes (suitably dimensioned on the basis of the machine weight) to the eyebolts.
- Lift the machine and position it in the final position; levelling it in a way that it is perfectly parallel.
- Connect the power supply and the accessory units to the machine following the layouts supplied.



Installation

Selecting the place of installation

The place of installation must meet determined requirements. It is good practice to clarify the following points:

- Is the height of the premises sufficient?
- Is the place available sufficient?
- Is the floor suitable for the weight of the machine and that of the lifting truck?
- What is the intensity of the vibrations on the place of installation? Disturbing vibrations can be caused by machines in adjacent rooms or building for example.
- Does the place of installation meet all environment conditions for perfect plant operation?
- Are there any large particles of dirt, e.g. glue dust, metal shavings, in the place of installation?
- Are there difficulties with the electric power supply?

Installation requirements

The following preliminary operations must be carried out before the machine is installed by a ZEISS after-sales technician.

All data necessary for the preliminary operations can be found in the »Installation warnings« document.

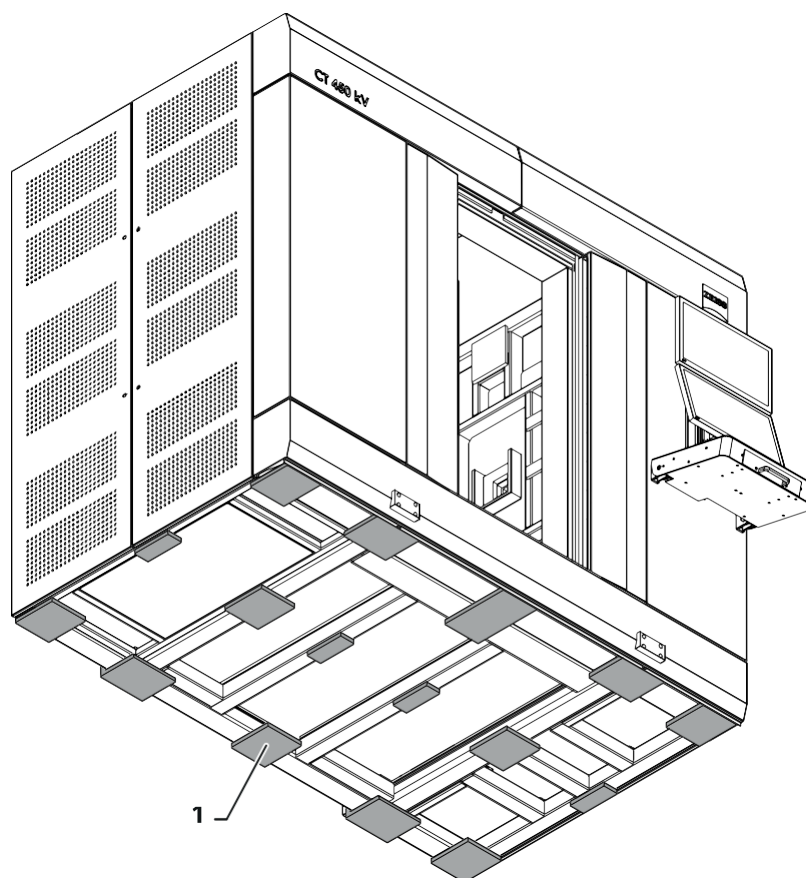
Positioning the machine

The floor where the machine will be positioned must be PERFECTLY levelled.

NOTE:

Failure to level the machine could negatively affect correct operation of the machine itself.

A series of support plates **[1]** are present under the base of the machine.



The machine must be positioned in its intended location, ensuring that there is the space around it necessary to operate in complete safety both during operation and during maintenance operations.

The minimum space necessary is given in the figure represented below.

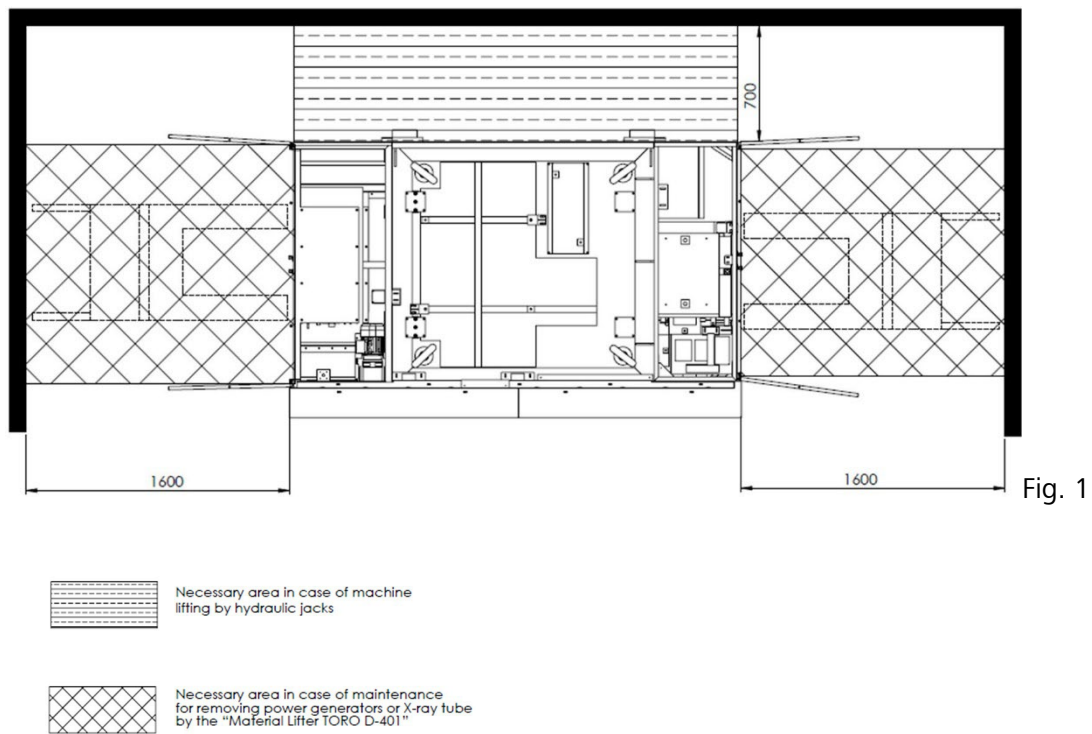


Figure 1: Minimum and suggested clearance distances around the system (mm).

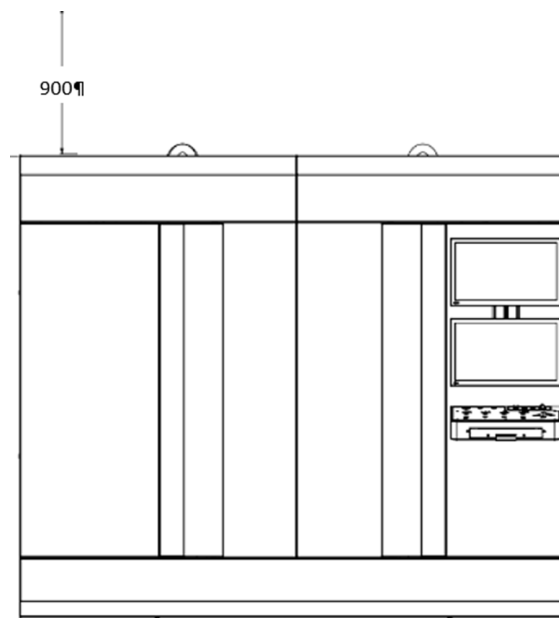


Figure 2: Minimum and suggested clearance distances on the upper side of the system (mm).

6

Preparation for commissioning

This chapter includes:

Preparation	6-2
Important information!	6-5

Preparation

Warnings

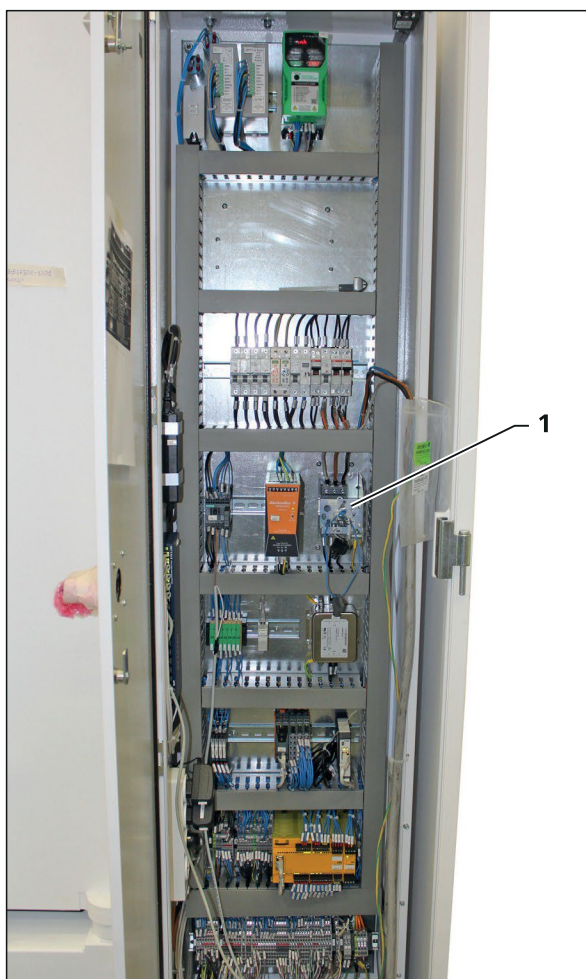
The preparation includes actions that do not have to be performed daily or weekly. The visual check is an exception.
It should be part of the daily operations on the plant.

Commissioning

Commissioning is carried out by a ZEISS after-sales technician. However, it is necessary to become familiar with the commissioning preparations as well as learn about and comply with the relevant safety warnings.
Comply also with the warnings given in the »Safety« chapter.

Connection to the electric power supply

In order to connect the electric power supply to the plant, the power supply must be in the immediate vicinity of the place of installation. This operation must be performed before installation of the plant. Comply with the electric data.



Connect the three phases (R, S, T) to the respective terminals of the master switch **[1]**.

Connect the earth cable to its terminal.

Visual check and check list

The visual check must be part of the routine jobs, also in the daily measurement operations. Before starting production, perform a visual check to make sure that the measurement system components have no visible damage.

If damage is identified, ...

In the event of damage, machine commissioning is not allowed.

- 1 In this case, prevent machine commissioning:
 - Turn the master switch off and padlock it in position.
 - Turn the operating mode key selector switch to «OFF» and remove the key.
- 2 Contact a ZEISS after-sales technician.

Coverings

The machine can only be commissioned if all coverings are mounted and all the doors have been closed.

- Mount all the coverings before performing any other operations.

Electric power supply cable

The cable must be in perfect condition. It must not be bent or damaged.

- Make sure there are no heavy objects on the cable.

Important information!

Notes

EMERGENCY STOP buttons

NOTE

All the *EMERGENCY STOP* buttons of the radiation protection enclosure must be released.

Duration of the heater filament

NOTE

After plant commissioning and after heating of the X-ray tube, during alignment of the heater filament an operating point is reached just a bit too high. This is due to the fact that the cathode is still cold. This does not have negative effects on the quality of the image or on the measurement result, but only on the duration of the heater filament.

- Align the heater filament after approx. 30 mins from commissioning. In this way, a new operating point is defined for the heater filament. This extends the duration of the heater filament.

7

Operator zones / Machine start up

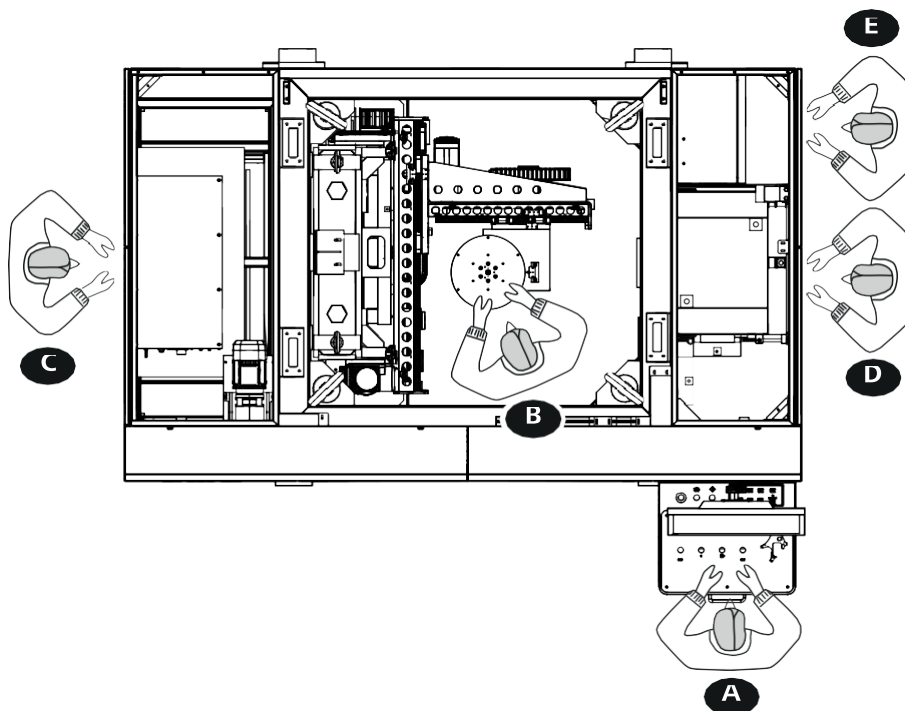
This chapter includes:

Operator zones	7-2
Adjustment of the piece and of the measurement	7-3
Machine start up	7-7
End the measurements	7-8

Operator zones

During machine operation, the operator is positioned:

- In front of the command desk (zone **[A]**) in a way to control machine via the relative controls.
- Inside the enclosure (zone **[B]**) to position the piece to process.



In order to perform any manual and maintenance operation, the operator can:

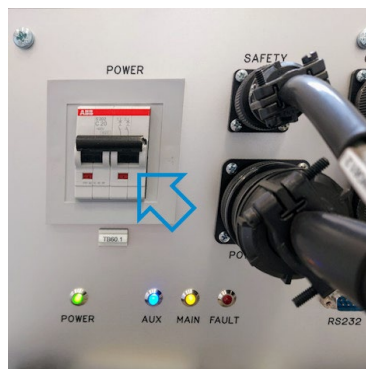
- Enter the enclosure (zone **[B]**).
- Be in proximity of the generators and the cooling system (zone **[C]**).
- Stand in front of the X-ray emitter (zone **[D]**).
- Stand in front of the electric control board (zone **[E]**).

Machine start up

- Before powering the electrical panel, ensure that the voltage is as indicated on the CE label and that the power cables are sized for the required power.
- Supply the electrical panel by turning the main line switch to the **I/ON** position.
- This powers the main frame of the machine and the control panel.
- Switch on the cooling unit using the appropriate switch.



- Switch on the **high-voltage generator** (refer to the specific HV generator manual).



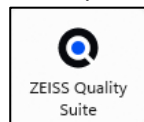
- Turn the *key selector* on the **X-ray control panel** to the centre *stand-by* position first, and then to position *I*.



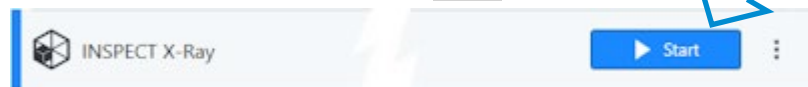
- Release the *EMERGENCY STOP pushbutton* [A].
- Press the **RESET** pushbutton [B].
- Press the **RUN** pushbutton [C], which should light up green.



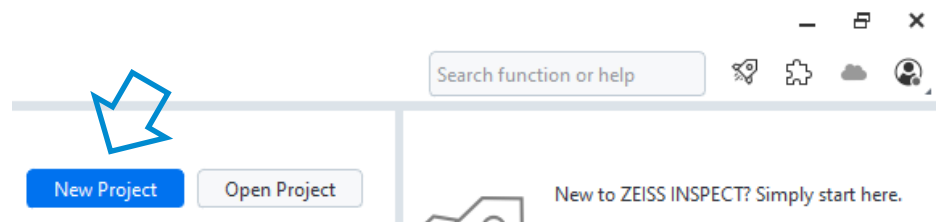
- The PC starts up automatically.
- Start **ZEISS Quality Suite** by double-clicking on the corresponding icon on the desktop.



- Start **INSPECT X-ray** by clicking **Start**.



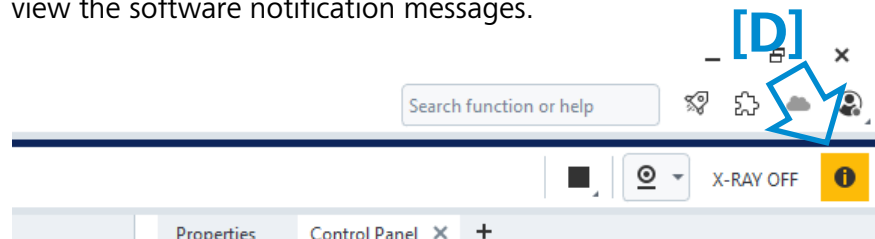
- Create a new project by clicking on **New Project**.



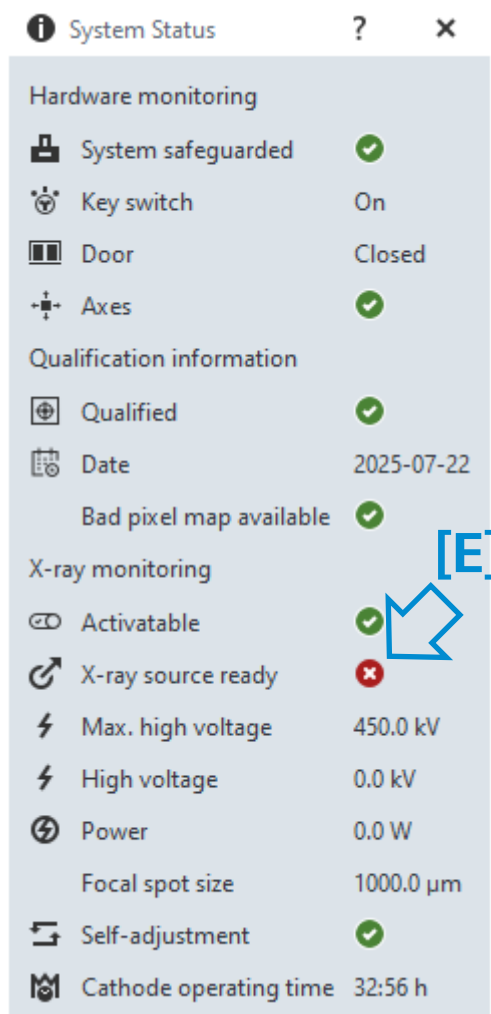
NOTE

Clicking on **New Project** automatically starts the system initialization process (which takes approximately 30 s).

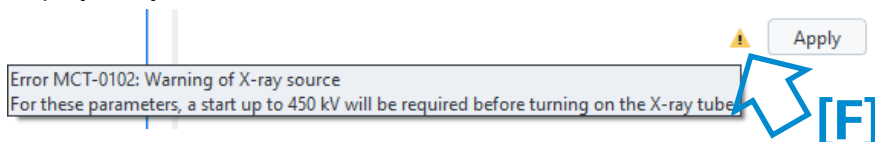
- In the main **INSPECT X-ray** window, click on the [D] icon to view the software notification messages.



- The dialog box opens, where the **[E]** icon highlights the problem to be solved.
In the case shown below, when the system starts up, you may be asked to launch the X-ray source *Warm-up*.

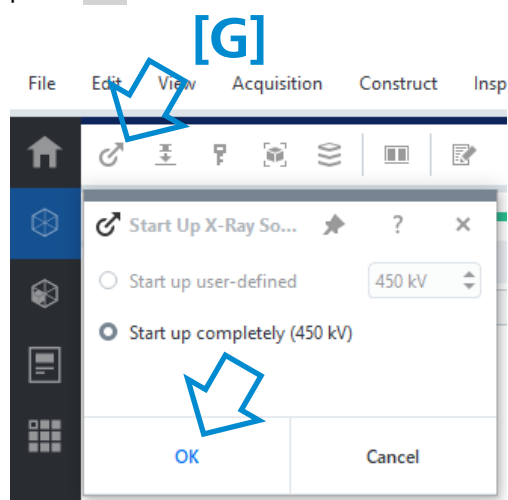


- In the main window of **INSPECT X-ray** another warning is displayed by the **[F]**, as shown below:



- As before, the warning relates to the system's request to perform the X-ray source *Warm-up*.

- To perform the X-ray source *Warm-up*, click on the **[G]** and press **OK**.



- At the end of the *Warm-up*, the system is ready to check the pieces.

NOTE

The system is provided with a touchscreen monitor that allows the operator to interact with the software. The operator can perform the relevant functions by pressing the keys directly onto the monitor.

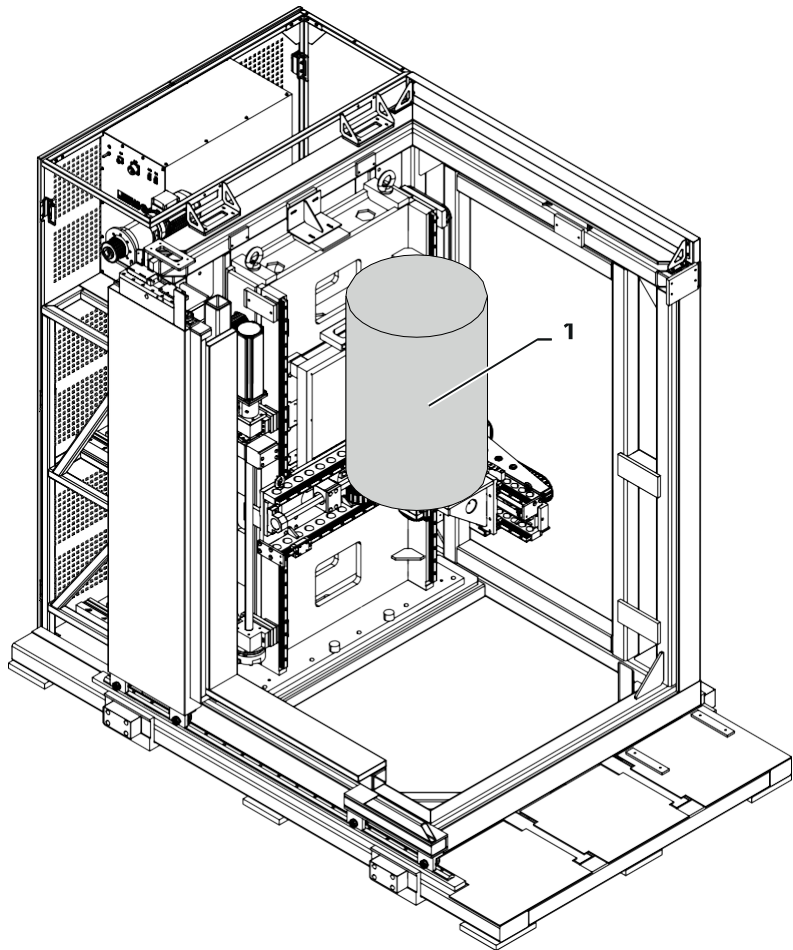
Adjustment of the piece and inspection parameters

Fixing the piece on the turntable

CAUTION



The fixing and stability of the piece **[1]** on the rotating support must be verified and guaranteed by the operator before starting the check. This is to prevent the piece falling accidentally with the consequent eventual injury of the operator and/or damage to the components of the machine itself.



Loading the part into the X-ray inspection cabin

To load the piece into the X-ray inspection cabin, press and hold the two green mushroom-shaped *START-cycle* buttons [A]:



The system will close the doors and the two **READY** and **SAFETY** [B] light on the **X-ray control panel** will turn green.

The system is now ready for X-ray startup.

Selecting voltage and current

Voltage

The high voltage in an X-ray tube accelerates the electrons onto a target (e.g. tungsten). The electrons are slowed down in the target and excite the nuclei of the atom, with the consequent generation of X-rays with different energy levels. The full spectrum of X photons generated is called the X-ray spectrum.

The X-ray spectrum with which the piece is recorded is defined by the voltage, the target material and the pre-filters selected.

The increase in voltage causes a highly energetic spectrum. Generally, photons are created with energies between 20 keV and the voltage created. For example, with an acceleration voltage of 180 keV, X photons with a maximum of 180 keV are generated. The higher the energy of an X photon, the better it can penetrate the piece. A spectrum with higher average energy is equivalent to "hard" X-rays.

The different penetration capacity of photons means that the transmission of rays through the object no longer has a linear correlation with the projected thickness. In the reconstruction this involves artefacts. Since the spectrum becomes increasingly harder after penetration of the objects, this effect is also called hardening of the beam.

Current

The current of the X-ray tube describes the amount of light generated and can be adjusted independently from the voltage.

The X-ray spectrum is defined by the voltage and pre-filter, while the current controls the intensity of the light. A higher current generally leads to a lighter image, meaning that a higher number of X photons contributes to the generation of the image. In this way it is possible to significantly reduce the noise in the reconstructed volume.

The increase of current however also leads to higher energy on the target. Therefore, the area hit by the electrons, the so-called source machine, must be increased to prevent the tungsten from melting. In this way, the maximum resolution that can be reached is worsened.

NOTE

In order to define a good measurement, initially concentrate on the adjustment of the spectrum and the position of the piece.

Within **INSPECT X-ray**, you can set the following parameter values:

- **High voltage** (kV) – [A].
- **Current** (mA) - [B].
- **Exposure time** (ms) - [C].
- **Resolution** (px) - [D].

Set Acquisition Parameters

User-defined

[A]	Focal spot	Power-dependent	Power-dependent
	High voltage	50 kV	0.0 kV
[B]	Power	10 W	0.0 W
	Current	200 μ A	0.0 μ A
[C]	Exposure time	33 ms	33.333 ms
	Resolution	952x952	952x952
[D]	Image averaging	1	1
	Prefilter		

Recommended max. power: 250 W

Apply

[E]

- Once you have set the desired values, click the [E] button.
- The X-rays will turn on.

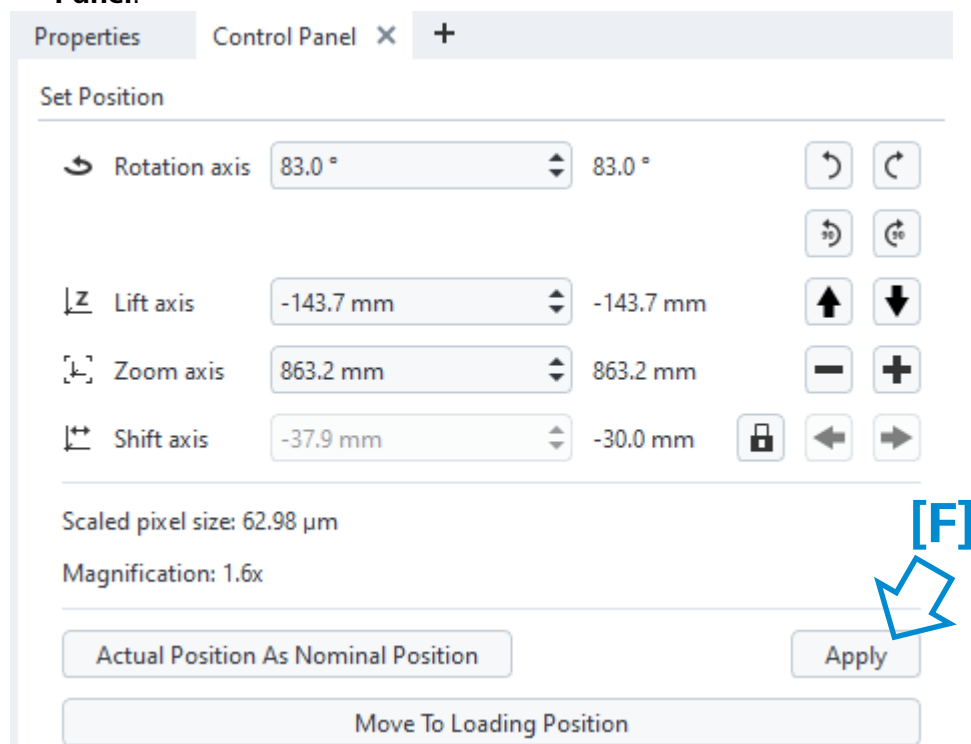
Adjusting the position of the piece

Checklist for positioning the piece

- Have the criteria for the piece been observed?
- Is the piece positioned as desired?
- Is the piece stable?

To optimize the position of the piece and center it in the detector panel view, it can be moved:

- Using the "Y" / "Z", "X" and "V" axis joysticks on the control panel.
- By setting the axis values from the **INSPECT X-ray** software **Control Panel**.



The screenshot shows the 'Control Panel' window with the 'Set Position' section. It contains four rows of axis settings, each with a joystick icon, a label, a value input field, a current value, and a set of control buttons.

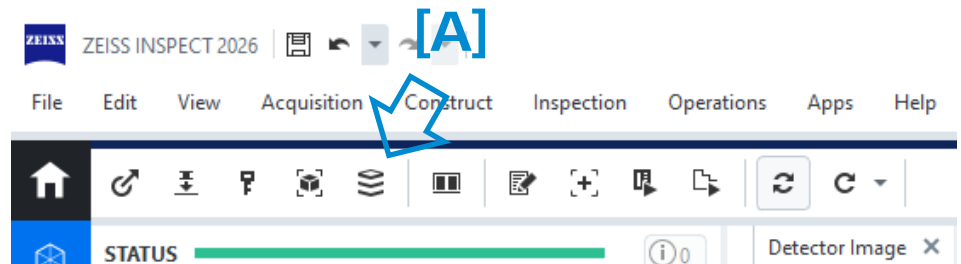
Axis	Value	Current Value	Buttons
Rotation axis	83.0 °	83.0 °	Reset, 90°, 360°
Lift axis	-143.7 mm	-143.7 mm	Up, Down
Zoom axis	863.2 mm	863.2 mm	Minus, Plus
Shift axis	-37.9 mm	-30.0 mm	Lock, Left, Right

Below the axes, it shows 'Scaled pixel size: 62.98 µm' and 'Magnification: 1.6x'. At the bottom, there are three buttons: 'Actual Position As Nominal Position', 'Apply' (highlighted with a blue arrow and '[F]'), and 'Move To Loading Position'.

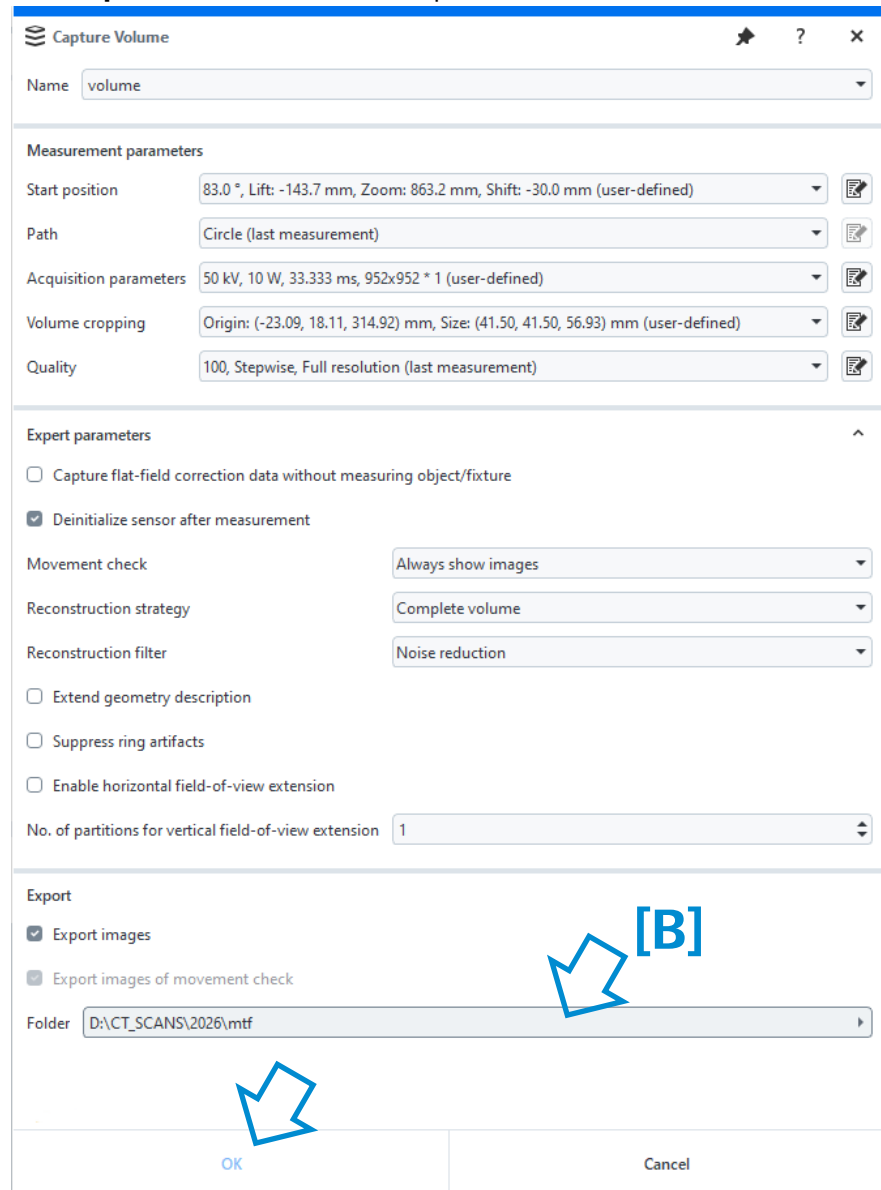
To confirm the set values and move the axes, press the **[F]** button.

Piece inspection

To start piece verification, press the **[A]** button in the **INSPECT X-ray** toolbar:



The **Capture Volume** window opens:



Pressing **OK**, the system starts volume capture, saving the images in the specified path **[B]**.

NOTE

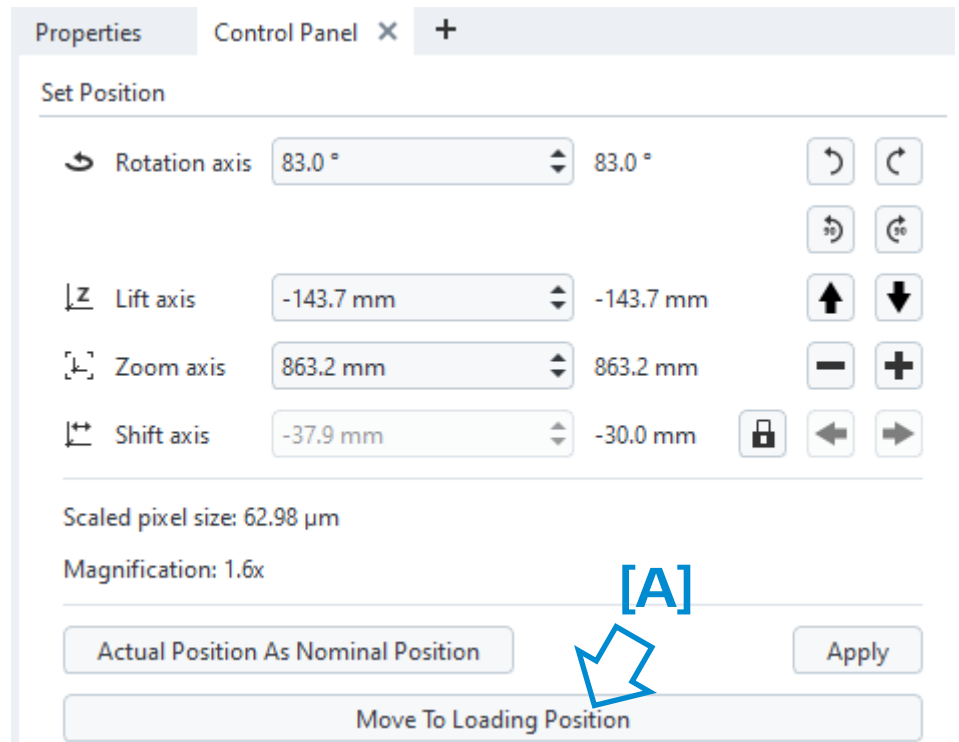
The characteristics of the parts to be checked must be within the limits allowed by the machine.

End of inspection and system shutdown

End of inspection

Once the volume has been captured, the system automatically turns off the X-rays.

At this point, to proceed with unloading the piece, press the **[A]** button in the **Control Panel** window:



- The system opens the doors.
- The turntable moves to the unloading position.
- Unload the inspected part.

System shutdown

- Press the two green mushroom pushbuttons *START-cycle* to close the doors.



- Turn the *key selector* on the **X-ray control panel** to the central *stand-by* position first, then to the *O* position (X-ray emitter not powered)



- Close **INSPECT X-ray**.
- Switch off the PC.
- Switch off the system by turning the main power switch to the **O/OFF** position.

8

Errors and anomalies

This chapter includes:

Errors before starting the measurement	8-2
Anomalies during measurement	8-3
Particular solutions	8-4
After-sales assistance	8-5

Errors before starting the measurement

If the plant cannot be commissioned, first check if all of the following errors can be excluded:

Error	Cause	Measurement	Control
Impossible to commission the plant	Sequence error during commissioning	– Respect the pre-defined order – Turn the plant on first and then the computer.	
Current supply	<i>Master switch</i> not connected	Connect the electric power supply: – Turn <i>the master switch</i> to position [1].	The position [1] must be visible.
Command	The control unit is not connected.	Connect the control unit: – Turn <i>the rotary switch</i> clockwise.	The rotary switch luminous LED must be on.
Drives	<i>The EMERGENCY STOP pushbutton</i> is blocked.	Release the button that has intervened: – Turn the <i>EMERGENCY STOP</i> pushbutton.	The button is pushed out by a few millimeters.
Operating mode	The operating mode is not introduced.	Set the operating mode.	
X-ray system	The X-ray system is not introduced. The X-ray system is in stand-by mode.	Introduce the X-ray system.	
Heating	The rated high voltage value is not reached.	See messages in the operator panel events window.	

- 1 If possible, exclude the errors indicated above, disconnect the plant and repeat commissioning.
- 2 If, despite the measures taken, it is still not possible to take a measurement, contact a ZEISS after-sales service technician or the telephone support service. See "After-sales assistance".

Anomalies during measurement

If anomalies occur during measurement, the following table helps to identify and eliminate them. An anomaly can have several causes. One or two solutions may be necessary to eliminate a determined cause. If two are indicated, it does not mean that both must be carried out to eliminate the anomaly.

Error	Cause	Measurement	Control
Movement impossible	The <i>Emergency stop</i> <i>BUTTON</i> is blocked	Release the <i>EMERGENCY STOP pushbutton</i> : – Turn the button slightly.	The button is pushed out by a few millimeters.
	Collision, e.g. piece with X-ray tube.	– Eliminate the cause of the collision. – Connect the drives again. – If necessary, initialise the X-ray tube again.	
	A measurement is in progress.	– Wait until the measurement has been completed.	
The voltage in the X-Ray tube cannot be increased.	The pause between the two measurements is too long.	– Perform heating.	
	No initialisation has been carried out.	– Perform complete initialisation.	

If, despite the measures taken, it is still not possible to take a measurement, contact a ZEISS after-sales service technician or the telephone support service. See "After-sales assistance".

Particular solutions

Measures after an EMERGENCY STOP

After having performed an EMERGENCY STOP, proceed as follows:

- 1 Release the *EMERGENCY STOP button*:
 - Turn the button slightly to release it.
The button lifts upwards. The button is released.
After release, press both loading door buttons (reset).
At this point the loading door can be opened.
- 2 Connect the drives again.
- 3 Close and re-boot the maintenance program.

After-sales assistance

Assistance

If it is not possible to eliminate an anomaly and the error continues to occur after re-commissioning, contact a ZEISS after-sales service technician or our telephone assistance at Cassano Magnago (ITALY). We can also be contacted via e-mail.

Contact information

Telephone	+39 0331 776109 Monday to Friday excluding Italian National Holidays
	8:00 - 12:00 and 13:30 - 17:30 GMT Rome.
E-mail	support.xray.iqs.it@zeiss.com

9

Maintenance

This chapter includes:

Maintenance.....	9-2
Care.....	9-23
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Maintenance

Purpose of maintenance

Maintenance is required:

- for safety during the measurement
- to prevent down times
- for measurement at maximum speed

In order to constantly meet these requirements, the plant must be subjected to regular maintenance.

NOTE

Only specialised staff can perform maintenance. The specialised staff must have specific training regarding the respective plant so as to be able to perform all maintenance work necessary.

Maintenance contract

It is recommended to stipulate a maintenance contract for safe operation. ZEISS offers maintenance contracts in order to facilitate maintenance.

- If you would like to stipulate a maintenance contract at a later date, contact our telephone after-sales service.
See "After-sales assistance".

Maintenance is distinguished in *maintenance of the X-ray system* and *large-scale maintenance*. Maintenance of the X-ray system is a preliminary condition for plant operation.

Maintenance intervals

The intervals between maintenance depend on the frequency of use and the X-ray components. See table.

NOTE

The maintenance intervals indicated are only valid if the environment conditions required are complied with.

Failure to comply with the maintenance intervals can cause damage to the plant. The manager assumes responsibility.

Maintenance intervals:

Frequency of use	Maintenance interval	
	Maintenance of the X-ray system	Large-scale maintenance - maintenance of the entire plant
Functioning with one working shift	6 months	Once a year
Functioning with two working shifts	6 months	Once a year
Functioning with three working shifts	6 months	Twice a year

Maintenance jobs**Maintenance of the X-ray system**

Sector	Maintenance operation	Possible consequence of no maintenance
Head of the tube	Check the cooling oil level.	Possible overheating of the head of the tube with consequent damage.
	Clean the head of the tube.	Inadequate measurement results.
High voltage components	Clean x-ray tube spot	Aberrations on the image, not uniformity.
	Maintenance of the high voltage cable	Increase of discharges. Reduction of the insulating effect in the connection outlets. Possible damage to the X-ray tube and the high voltage generator. The components should be replaced.

Sector	Maintenance operation	Possible consequence of no maintenance
X-ray system	Calibration	Necessary if the X-ray tube has been opened to reset the measurement accuracy.
	Checking measurement accuracy	

Large-scale maintenance

Maintenance jobs regard checking the following sectors:

Sector	Examples
Safety devices (supplied as per standard)	Drives control: anti-collision protection in serial measurement
Command	Command elements on the control board
Drive unit	Motor and transmission unit
X-ray system	Maintenance of the X-ray system

NOTE

If maintenance is required on optional devices, this must be stipulated in the maintenance contract.

Summary table of the interventions

NOTE

Before performing any of the following operations, remove the power supply to the machine by rotating the master switch to the "0/OFF" position.

Description	Frequency
MAINTENANCE AND CLEANING OF THE X-RAY ENCLOSURE The use of a suction device is recommended to clean the inside of the radioscopy enclosure. Do not use jets of compressed air.	WEEKLY
MAINTENANCE AND CLEANING OF THE ELECTRIC CONTROL BOARD Use a suction device to eliminate impurities, check for the presence of any condensate and eliminate it if necessary, check the correct connection of all parts of the control board and check the tightness of all screws and terminals.	MONTHLY
MAINTENANCE AND CLEANING OF THE COMMAND DESK Use a suction device to clean the areas that are not easy to access, check the correct operation of any fans and conditioners. Clean monitors and protective screens using a cloth dampened with anti-static liquid.	MONTHLY
MAINTENANCE OF X-RAY ACCESSORIES AND RELATIVE INTERFACE BOARD Check operation of all signal LEDs, the correct connections of the cables to the individual components and correct tightness of all screws and bolts.	MONTHLY
X-RAY GENERATORS <i>Consult the manufacturer's manuals attached.</i>	MONTHLY
COOLING UNIT Use a jet of compressed air to carefully clean the cooling fin of the equipment and check that the level of coolant is always at maximum. <i>Consult the manufacturer's manuals attached.</i>	MONTHLY
PROTECTION AND SAFETY PARTS AND CIRCUITS Check the correct functionality of the protection parts and control the efficiency of the safety circuits by simulating the emergency situation that they must control.	QUARTERLY
CHECK BELTS AND CHAIN Check the tensioning and the status of the drive belts and the support chain.	QUARTERLY

Maintenance

Description

Frequency

X-RAY PLANT MAINTENANCE

The connections between the X-ray tube and the X-ray plant generators must be made correctly, respecting the criteria, the materials and the procedures established by the Manufacturer.

EVERY SIX MONTH

Consult the manufacturer's manuals attached.

GREASING

Grease the runners, the "worm" screws, the supports and the support chain.

PERIODICALLY

COMPONENTS MAINTENANCE

X-RAY CONTROL UNIT MAINTENANCE AND CHECKS THE INTERFACE BOARD

Monthly

The X-Ray system control equipment does not substantially require any maintenance. However, it is recommended to check the functionality of the buttons, which could become jammed or damaged over time.

Even if non-functioning of the luminous LEDs does not jeopardise plant functionality, it is recommended (also for compliance with standards) to keep them in good working order. Check that the incandescent light bulbs present are not burned. If this is not the case, replace them using original spare parts supplied by the manufacturer.

Its main functions are: to distribute the power supply to the power and auxiliary circuits of the HV generator, supply the power of the circulation unit and cooling of oil, power the safety circuits and manage them in Hardware, command the luminous indicators relative to the X-ray system, interface the various signals between the generator and control equipment in Hardware.

Even if it does not require particular maintenance work, it is recommended to periodically verify tightness of the terminals and wear of the power relay contacts, which must be replaced using original spare parts if they should result oxidised or deteriorated.

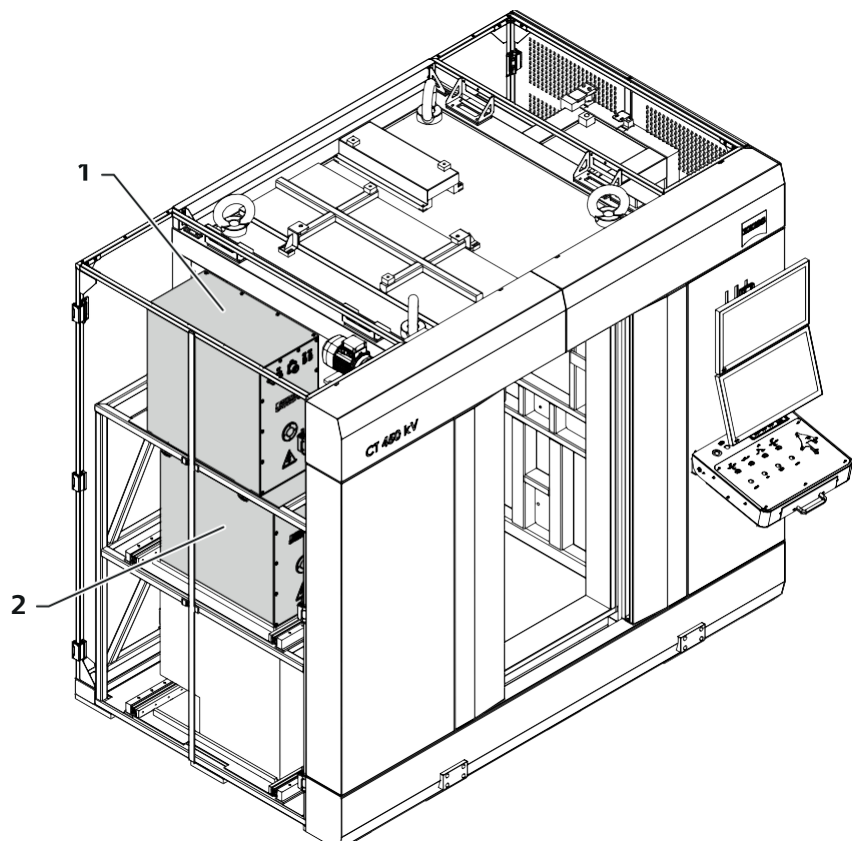
MAINTENANCE AND CLEANING OF THE X-RAY GENERATORS

Monthly

The generators do not require particular maintenance just monthly checks. It is particularly recommended to check correct operation of the circuit board cooling fans.

Remove the dust and dirt from the fans and check that the aluminum dissipaters are not covered or blocked by other objects and sufficiently ventilated.

The positive generator **[1]** can be reached from the upper part of the enclosure.



NOTE

In order to facilitate maintenance operations of the negative generator **[2]**, the same is installed on an extractable platform.

For a detailed description of the maintenance operations to perform on the X-ray generators, consult the Manufacturer's manual attached.

MAINTENANCE AND EFFICIENCY CHECKS OF THE COOLING UNIT AND CIRCULATION OF OIL

Monthly

This unit is used to guarantee the circulation of coolant inside the X-ray tube.

The oil circulates in one direction and cannot be reversed; therefore, if the pipes must be disconnected, make sure they are re-connected correctly.



The temperature of the oil leaving the cooler must not exceed 35°C and the flow of inlet oil must not be lower than 4 liters per minute.

Given the importance of keeping this equipment in perfect working order, it is recommended to perform the following operations and checks:

- Use a jet of compressed air to blow between the radiator fins to eliminate dust and impurities present. Occasionally carry out this operation also from the inside after having removed the lid.
- The level of the oil must be kept constantly between the min. and max. mark on the relevant lateral indicator. If insufficient, top-up the oil. If the plant must remain inactive for a long period of time where the temperature may drop under -15°C see table in specific manual.
- Check that there are no oil leaks from the fittings or inside the equipment.



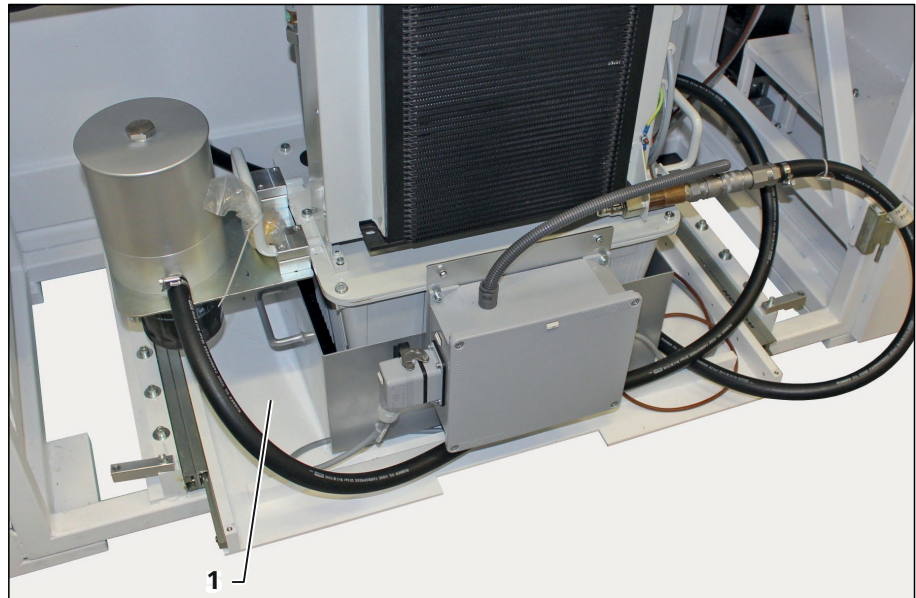
In the case of oil coolers, in order to maintain the dielectric value of the liquid, the filter salts must be replaced once a year (see cooler specific manual).

Before proceeding, turn the cooling unit off and place a clean bucket underneath the filter. Disconnect the pipe quickly coupling, unscrew the filter and empty it of oil and salt, replace the salts and restore the system.



The salts typically used are DRIERITE, defined with the following chemical formula: $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot n\text{H}_2\text{O}$ (Molecular Sieve type 4A). One of the producers of this material is ZEOCHEM (www.zeochem.ch); product code: Z4-01 / 2.5 – 5.0 mm.

Replace the second filter also (paper 10 micro) as indicated on the label.



NOTE

In order to facilitate maintenance operations of the cooling unit, the same is installed on an extractable platform **[1]**.

For a detailed description of the maintenance operations to perform on the cooling unit, consult the Manufacturer's manual attached.

CHECK SAFETY PARTS AND CIRCUITS

Quarterly

The plant is equipped with mechanical protection devices such as guards, cages, etc.... It may happen that these parts are removed to facilitate maintenance operations.

Check that they have been re-mounted correctly and entirely, since their removal could jeopardise safe operation of the plant, regarding the plant itself and the safety of people.

The plant is also fitted with several electric safety circuits (limit switch and emergency buttons):

- EMERGENCIES circuit; it is made up of 3 emergency buttons (mushroom-head), located on the command desk and inside the enclosure. The activation of these devices causes the immediate shut down of all moving plant parts and interrupts the emission of X-rays whenever they should be operating.
- "SAFETY 1" circuit is made up from a series of safety switches, located on the enclosure access door; opening the door prevents the emission of X-rays.
- "SAFETY 2" circuit is made up from a safety switch, located on the door of the box containing the X-ray emitter, and is also interlaces with the EMERGENCIES circuit.

It is recommended to periodically check the correct operation of all afore-mentioned parts, activating them manually or, regarding the limit switches of the "SAFETY" circuits, with the aid of the diagnostics program.



HAZARD

None of the devices that are part of the safety circuits can be by-passed or tampered with in any way whatsoever. If one of these devices is detected as being faulty or not functional, it must be replaced with the same or equivalent type.



The Manufacturer declines all liability regarding plant safety if one of the safety devices has been tampered with.

CHECK BELTS AND CHAIN

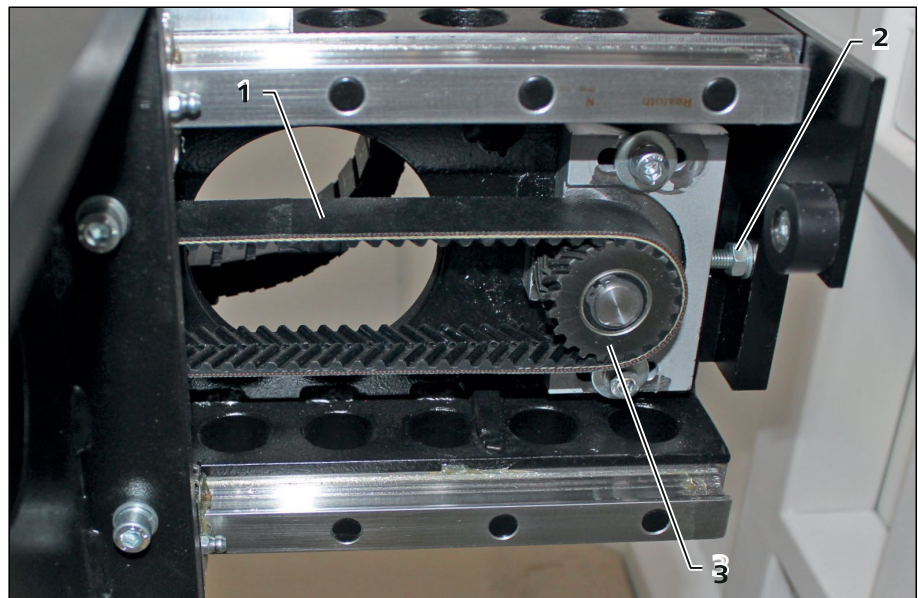
Quarterly

If one of the drive belts [1] loosens, operate on the relative tensioner [2] to restore correct tension.

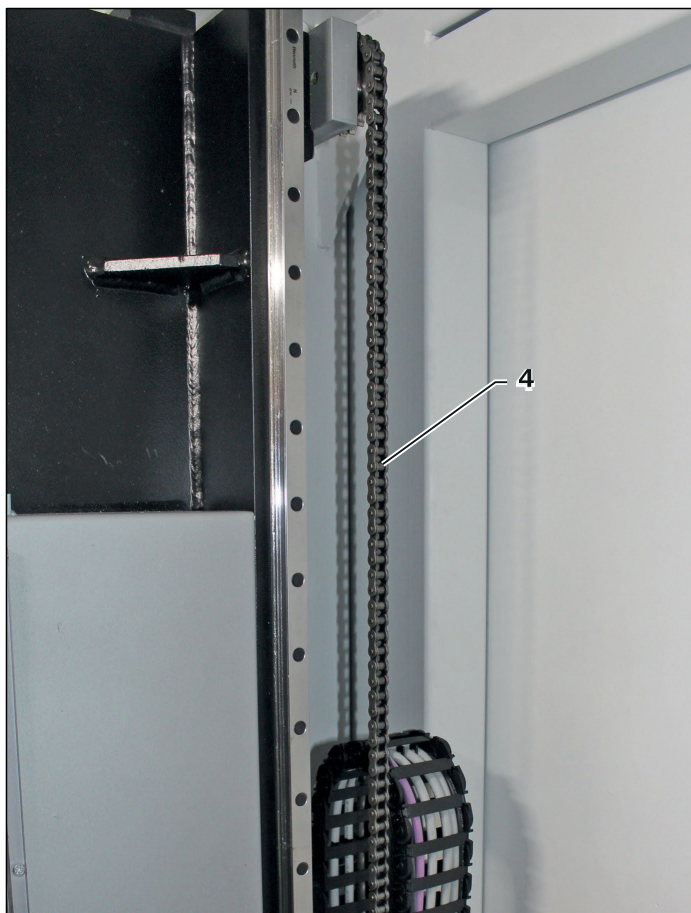
It must be replaced on the basis of wear.

Loosen the tensioner [2] and move the pulley [3] until the belt is released.

When the belt has been replaced, operate on the tensioner [2] to restore the correct tension.



Check the tensioning and status of the support chain [4].



X-RAY PLANT MAINTENANCE

Every six months



Any intervention to be carried out on the X-ray system must be carried out **ONLY** by **QUALIFIED STAFF** and specifically regarding the instructions given by the manufacturer, which declines all liability in the event of tampering or unauthorised modifications.

Maintenance and greasing the "HV" cable

NOTE

The systems with tube integrated into the generator are excluded.

The HV (high voltage) cable is one of the most delicate parts of the plant and must be handled with extreme care. It is used to power the X-ray tube with a voltage that can reach up to 450 KV, i.e. 450,000 Volt.

It is of extreme importance to periodically check its integrity. It must be ascertained that it is not damaged or cut, that there is no possibility of coming into contact with moving parts of the robot along its pathway, and that any bends are not too tight.

The connection of the two terminals must be made with well-determined criteria in order to ensure the best electric contacts and guarantee a suitable level of insulation at the same time.

These connections must be verified periodically, because the climatic excursions (temperature, humidity) could cause dilation or narrowing of materials and alterations to the efficiency of the silicone grease used to optimise coupling of the insulating materials. It is recommended to make this connection again approx. every 6 months and clean the insulating terminals and consequently grease them.



⚠ WARNING

If there are doubts regarding the procedure, contact the Manufacturer's after-sales service. In all cases, before proceeding, make sure that the generator power supply has been disconnected, that the key has been extracted from the control panel and wait for approx. 5 minutes.

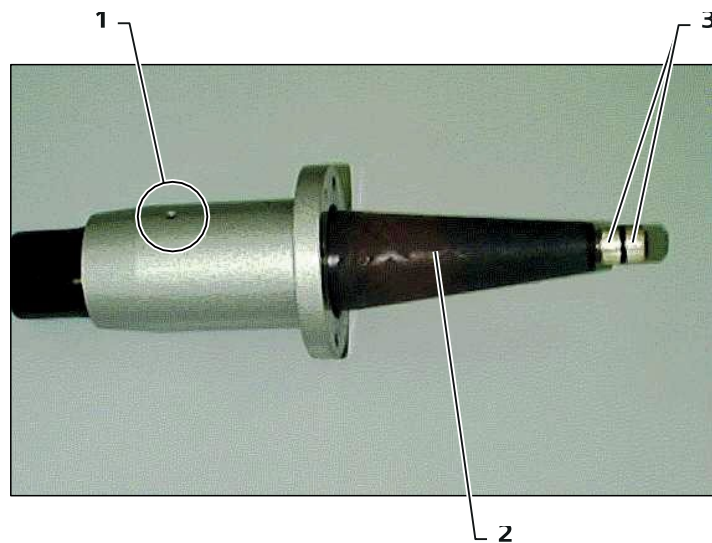
Proceed as described below; if both terminals are to be greased, it is advised to start with that on the generator side.



⚠ WARNING

Due to the capacitive effect, the cable may be electrically charged even without power supply.

Before any operation, for safety reasons take the connector ring contacts into contact with an earth point in order to discharge any energy accumulated by the cable.



[1] Flange stop screw.

[2] Insulating cone.

[3] Ring contacts.

Paying attention not to leave any residues, use paper or a clean cloth to carefully remove all of the grease from the insulating cone of the connector; **do not use alcohol or solvents.**

Clean the inside of the receptacle on the generator in the same way, being as thorough as possible, but avoiding touching the contacts on the bottom.

After having performed cleaning, loosen the connector flange stop screw and make the flange rotate anticlockwise for a pair of turns and then introduce the connector fully home without pushing excessively.

Rotate the flange until an equal distance from the support surface is obtained on the entire circumference and then block it by tightening the previously loosened stop screw.

To evaluate the distance to be kept before blocking the cables, consult the table below.

Gap required for standard cable Used Standard cable (installed more than 3 months ago)	4.5 mm
Gap required for standard cable New	5.5 - 6 mm
Gap required for Spring-Loaded cable	6 ÷ 7 mm

NOTE

For new plants with voltage exceeding 160 kV, revamping of the joints is recommended one month after the start of use. The spring-loaded connections must be re-adapted after six months and then at least once a year.



Space too small

Correct interval

Space too large

For spring-loaded cables, check through the flange window that the correct pressure has been reached: 2 rings must be visible as in the image in the middle above. If only one ring is visible (image on the left) or three are visible (image on the right), remove the high voltage cable and repeat the connection completely from the start, adjusting the space on the basis of the previous result.

After having verified that the ring contact terminals are clean and free from grease deposits, introduce the connector again, paying attention to introduce it without the contacts coming into contact with the parts dirty with grease.

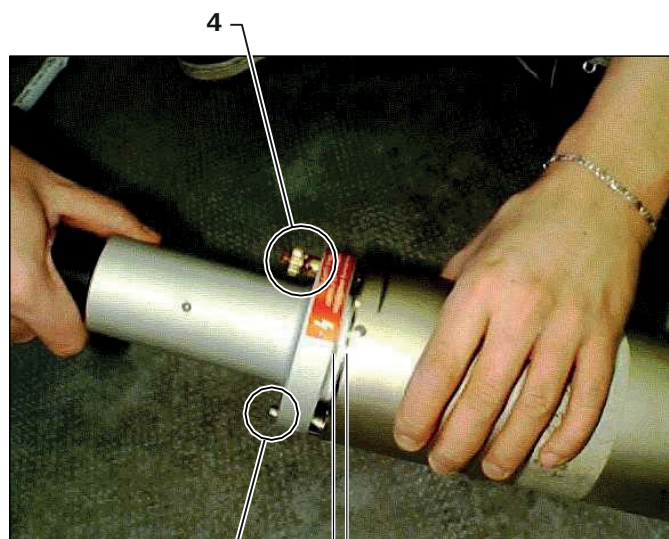
Introduce the flange screws and tighten them gradually in a crosswise manner, while trying to maintain an equal distance between the flange and the receptacle support surface until closed completely.

Proceed in the same way for connection of the X-ray tube, paying particular attention to the quick couplings of the cooling oil pipes and the connection of the earth cable.



NOTE

For the 130 kV plants (RTW), the X-ray tube has just one HV connection and therefore the connection must be made on the generator side, since the cable is integrated onto the X-ray tube.



5

For this measurement, consult the table given above.



Oil may escape from the fittings. In this case, prevent it entering inside the tube receptacle.

[4] Earth connection.

[5] Oil connections.

Maintenance and checks of the X-ray tube

It is recommended to verify the efficiency of the quick couplings of the cooling oil pipes periodically and make sure there are no oil leaks or excessive condensate.

Remove any "SHUTTER" or "FILTER CHANGER" device (if present) and clean it with a jet of compressed air. Clean the tube window in the same way.



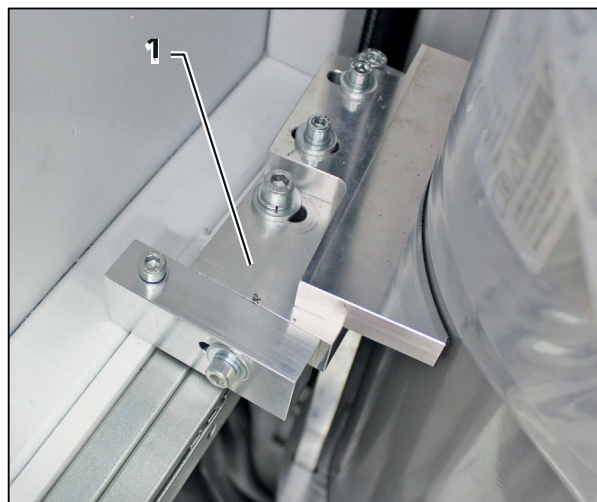
HAZARD

The window of the tube in beryllium **MUST NOT BE TOUCHED** for any reason whatsoever.



NOTE

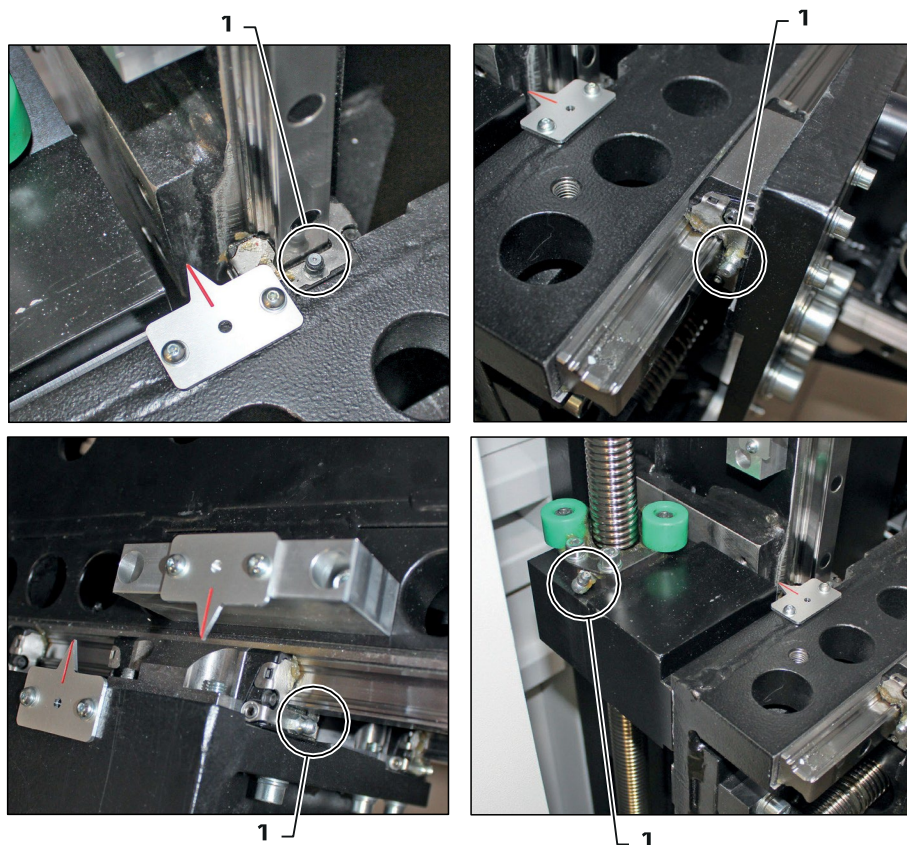
To facilitate maintenance operations on the X-ray tube, it is installed on sliding supports **[1]** and has handles **[2]**.



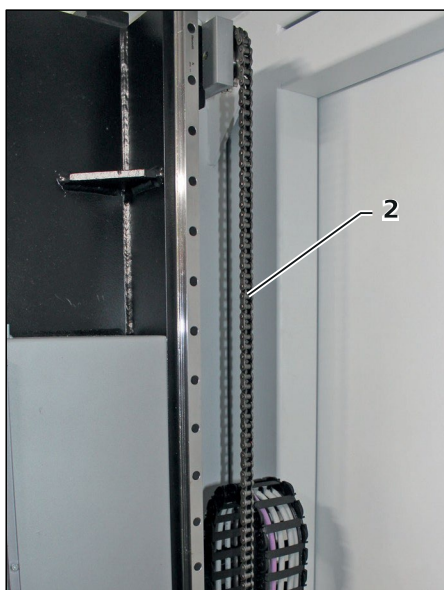
GREASING

Periodically

Using the relative greasers [1], grease the runners and "worm" screws.



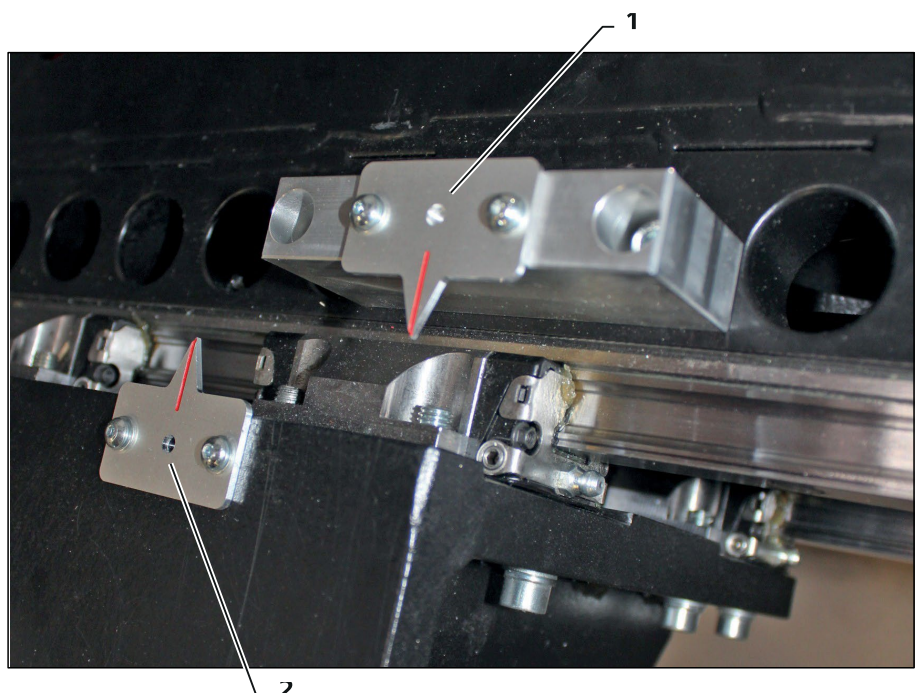
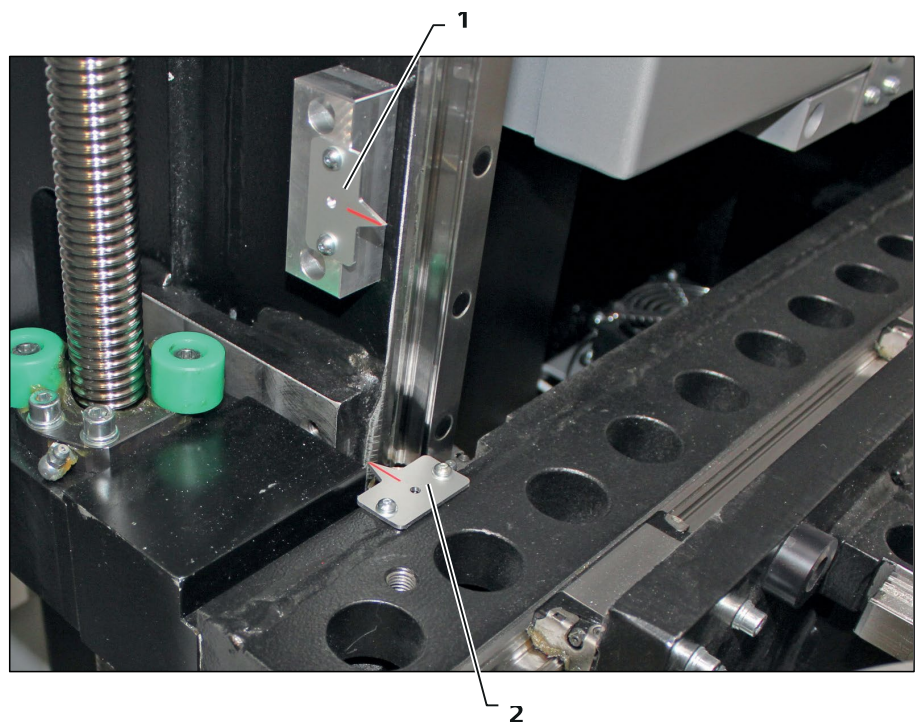
Grease the support chain [2].



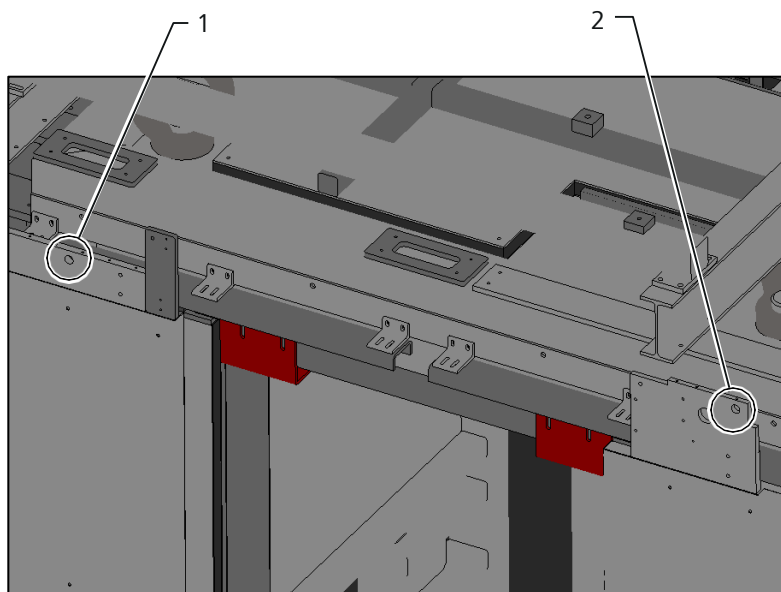
MOTOR REPLACEMENT REFERENCES

In correspondence with the motorised structure axes there are references [1] and relative markers [2], with "0" (zero) point function.

If the motors must be replaced, these references must be used in order to obtain correct setting of the movement axes.



REMOVAL OF ACCESS DOORS

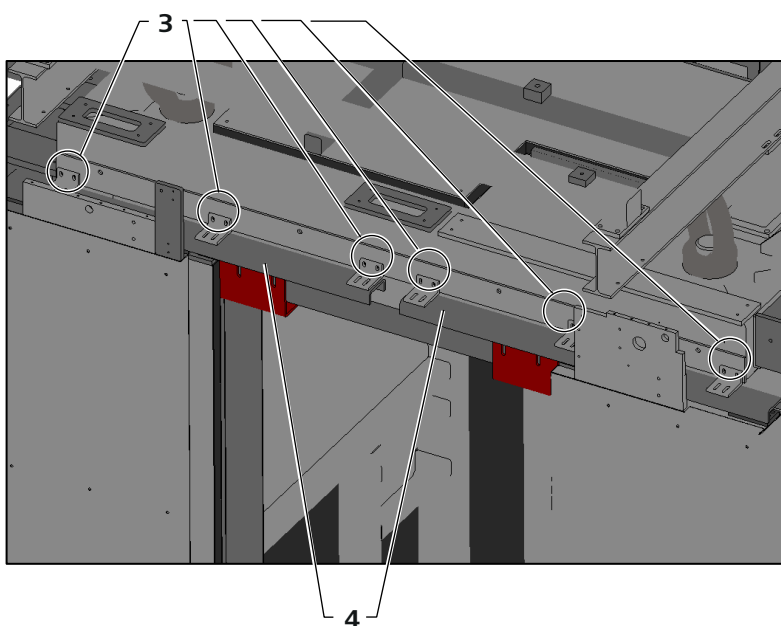


If the access door must be removed for maintenance reasons, proceed as described below:

**HAZARD**

The presence of at least 2 operators is required for removal and handling of the door. Pay maximum attention during these operations.
CRUSHING RISK

- Locate the two holes ([1], [2]) present in the two plates joined to the structure of the doors.





HAZARD

CRUSHING RISK

- Unscrew all the six plates **[3]** from the carpentry.
- Leave the six plates **[3]** fixed to the guides **[4]**.
- Remove the two guides **[4]** and the six plates **[3]** jointed to them.
- At this point, with the door released, lift it.

To re-mount the access door, proceed in reverse order.

Care

Important information!

The plant must be cleaned regularly. In particular, there must be no dirt particles or metal parts inside the X-ray protection enclosure.

NOTE

Only care operations that can be performed from the outside are permitted. Never enter the X-ray protection enclosure.

- If there are foreign substances inside the x-ray protection enclosure, contact a ZEISS after-sales service technician.

Cleaning and control

Regular cleaning and checks lie within the care operations of some components. The following are necessary for cleaning:

- Non-abrasive detergent
The detergent must be able to dissolve greases and not be corrosive.
- Lint-free cloth, e.g. linen
- Suction device

The following substances must not be used:

- Chlorinated hydrocarbons such as tetrachlorethylene or trichlorethylene
- Inflammable, volatile or caustic liquids



CAUTION

Injury hazard due to involuntary movements.

Crushing of parts of the body and eye injuries.

- Disconnect the drives in order to carry out the care operations safely.



Damage caused by dust particles that swirl due to the compressed air.

Dust particles can compromise the operation of the guides and other plant components.

- Never use compressed air to clean the plant.

NOTE

Preventive maintenance also means that the pieces to be checked are clean. There must be no working residues or dust on the pieces (e.g. metal shavings, oil).

- Clean the pieces before organizing them on the support.

Overview

The components that require care are given below. The data relative to frequency assume that the place of installation meets the requirements envisioned.

Measures of care

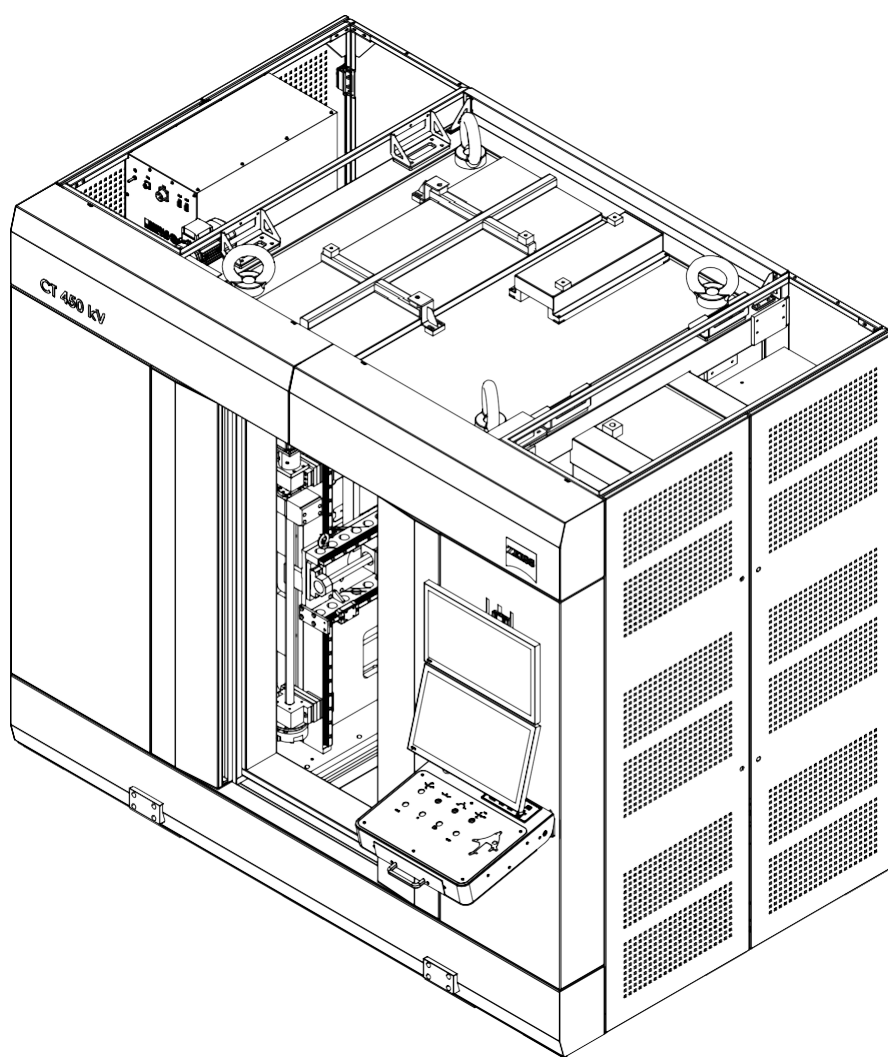
Object	Frequency	Type of care
Clean inside of enclosure	Every week	Suction device
Electric control board	Every month	Suction device
Command console	Every month	Suction device
Piece support	Every month	Suction device, detergent
Threaded holes at the turntable	Every month	Suction device
Coverings	Every month	Normal non-abrasive detergent

Cleaning components

Clean inside of enclosure

Weekly

The inside of the enclosure **must be cleaned weekly**. With the enclosure opened and the power disconnected, use an industrial suction device to remove the metal residues detached from the castings and deposited on the surfaces of the components contained within the enclosure.



Cleaning the electric control board

Monthly



HAZARD

Before carrying out any of the following operations, make sure that the power supply voltage has been disconnected via the line master switch ("0/OFF"). Pay attention to the release coil control circuit, which could remain powered; the components of this circuit, if present, are protected and signaled by hazard indications.

Great attention is recommended regarding the ventilation and conditioning parts.

- Clean the lateral conditioner filters with a jet of compressed air approx. once a month and replace them annually. Furthermore, once a year remove the lid of the conditioner and remove as much dust as possible that has deposited inside using a jet of compressed air; paying attention to keep the electric control board closed during this operation.
- Check that there is no condensate (water) inside the electric control board; the condensate must only be drained from the relevant hole in the lower external part of the conditioner.
- Check that the internal temperature of the electric control board does not exceed 35 degrees centigrade (the temperature must be measured while the machine is operating and in the upper part of the electric control board in proximity of the CNC rack or the PLC). If this is not the case, contact the manufacturer.
- Since the electric control board is sealed, only a small amount of dust will be deposited; in all cases, it is recommended to remove it periodically.
- Remove the dust from inside the electric control board using a suction device and not compressed air since the water that is almost always present in the air circuit could deposit on the components or contacts that normally live.
- Periodically check that all connection terminals are tightened well, since with time they could become loose due to heat dilation and any vibrations, making the electric connections precarious; just tighten them one by one using a screwdriver.

Cleaning the command desk

Monthly



HAZARD

Before carrying out any of the following operations, make sure that the power supply voltage has been disconnected using the master switch ("0/OFF").

- Check that there is no condensate (water) inside the desk; the condensate must only be drained from the relevant hole in the lower external part of the conditioner.
- Check that the internal temperature of the desk does not exceed 35°C (the temperature must be measured while the machine is operating and in the upper part of the electric control board in proximity to the monitors). If this is not the case, contact the manufacturer.
- In the CNC machines, check the correct operation of the small fan integrated into the computer power supply unit. In the case of malfunctioning, contact the manufacturer to replace the power supply unit, if necessary.
- Clean the monitor weekly using a soft cloth and anti-static liquid.

Control measures

Checking the coolant

A cooling device is available to cool the X-ray tube. The cooling device is on the control board. In order to guarantee operation of the cooling device, there must be a determined amount of coolant in the cooling device. The level of coolant must be checked monthly.

10

Decommissioning and disposal

This chapter includes:

Decommissioning	10-2
Disposal	10-3

Decommissioning

If the plant is to be decommissioned for a rather long period of time, the machine must be disconnected from the electric power supply. It is also recommended to protect the plant from dust during storage.

- 1** Close all plant doors.
- 2** Disconnect the plant from the electric power supply.
- 3** Cover the plant, e.g. with a tarpaulin.

Disposal

Packaging

Disposal of the packaging is subject to the regulations of the country in which the machine is installed.

General information

Why does disposal have to comply with regulations?

Correct disposal of the product contributes to protecting health and the environment.

Re-sale

If the machine and its peripherals are to be sold, the purchaser must be informed of the obligation to dispose of the products in compliance with the law.

Marking for electronic components

Some machine components have the symbol below. This symbol indicates that the piece contains electronic components and that they must not be disposed of with household waste.

Validity for EU-28 countries



Within the EU-28 countries, the components marked with this symbol must be disposed of appropriately and correctly according to that envisioned by the 2012/19/EU Directive or respective national law. This symbol is valid only in the European Union.

Category 9 (WEEE)

Information regarding WEEE and RoHS

All ZEISS products, including commercial goods they distribute belong to category 9 of the appendix to the WEEE Directive.

All ZEISS products meet the Directive, provided they are not subject to derogation.

According to the provision of the definitions pursuant to the EC/EU 2011/65/EU Directive (article 3), the ZEISS machines correspond to large fixed industrial tools and therefore lie within a derogating provision concerning RoHS compliance.

- The machines are formed from different components, which can satisfy the function assigned only if combined together.
- The machines are installed and commissioned by experts.
- The machines are used and commissioned in an industrial production plant or research and development plant.

Withdrawal according to general contract terms

Rules

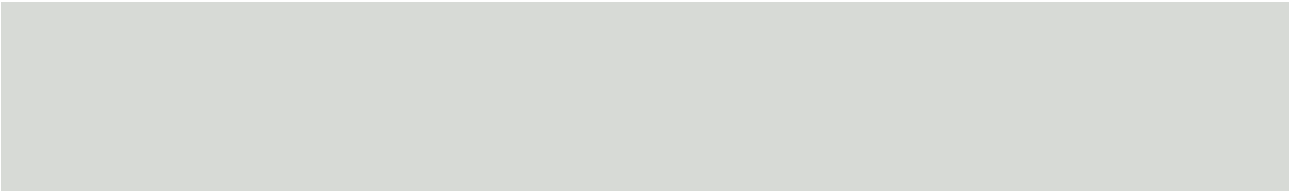
The machine and its peripherals can be returned to ZEISS for disposal. Withdrawal of the machine is subject to general contract terms.

For customers part of the European Union:

For the disposal of electric and electronic equipment, please contact the dealer or supplier.

Outside the European Union:

Regarding disposal of electric and electronic equipment, follow the respective legal provisions and rules in force in the country in question.



Appendix

This chapter includes:

Information regarding computed tomography Appendix 2

Information regarding computed tomography

Image generation

Data collection

Computed tomography consists in a data acquisition and reconstruction process.

X-rays are generated in the X-ray tube. The conical beam radiation passes through a diaphragm and spreads in the direction of the X-ray detector. The rays first hit the piece and then the surface of the detector.

Grayscale image

The rays are weakened depending on the geometry and absorption properties of the piece. The detector generates a two-dimensional grayscale image.

The piece is rotated progressively by 360° on the rotation axis. In this way, a large number of images of the piece are obtained.

Volume data

3D image via volume reconstruction

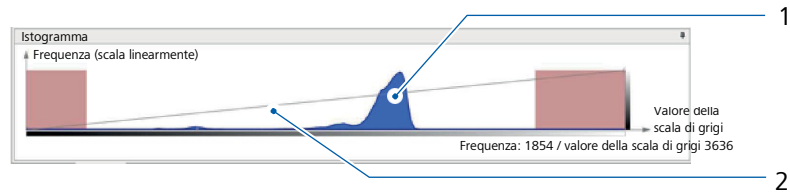
During computed tomography, 3D data volumes are generated starting from the projections acquired (voxel model).

The reconstruction data volume corresponds to the product of the number of voxels and the memory requirements of one voxel. One voxel requires two bytes in the «uint16» format. The number of voxels results from the volume defined by the reconstruction box. The volume is calculated according to $H \times W \times D$, where H is height, W is width and D is the depth of the volume of reconstruction in pixel.

The reconstruction time depends on various influencing factors. The most important influencing factors are the dimensions of the reconstruction box in voxels and the number of projections.

Histogram

The histogram is a graphical representation showing how frequently grayscale values occur. This is valid for all types of images, e.g. correct and incorrect detector images.



Histogram

[1] Grayscale values of the background

[2] Grayscale values of the piece

The background is always uneven in the incorrect images and is always represented by a peak on the right of the histogram.

The piece shows a high variance of grayscale values. In the histogram, the piece is represented via the surface on the left of the background peak. Due to the reduced height of individual values, it is often difficult to recognise them.

From pixel to voxel

Voxel

The voxel is a three-dimensional pixel to which a determined grayscale value is assigned. The natural dimension of the voxel can be defined via the resolution of the detector and magnification.

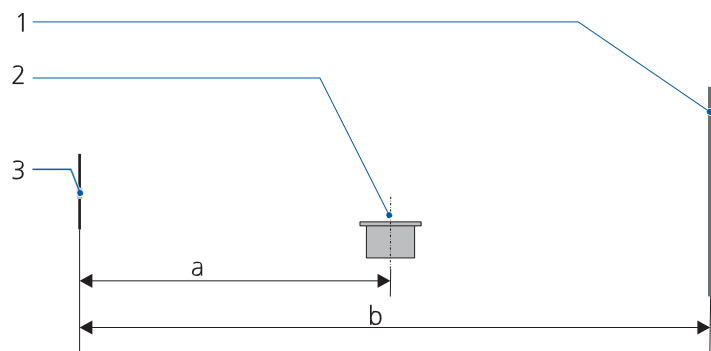
Generally, any size of the voxel can be reconstructed. Usually, the appropriate voxel size is its natural size, i.e. the dimension of the detector pixel reduced according to the current magnification.

Effect of voxel size:

- If reconstruction is performed with voxel size smaller than the natural size, »empty resolution« is obtained. The data volume of the reconstruction increases without new details appearing in the piece.
- If reconstruction is performed with voxel size greater than the natural size, the details of the piece that would be still visible in the detector are suppressed.
This is useful if rapid results are required and if an approximate reconstruction is sufficient.

Normally:

Dimension of the voxel	= dimension of the pixel / magnification
Magnification	M factor with which the piece is projected onto the detector. $M = b / a$ Specifically: distance between X-ray source and detector / distance between X-ray source and piece.



Factors for enlarging

- [1] Detector
- [2] Turntable axis
- [3] X-ray source

Focus point (focal spot)

When there is high voltage in the X-ray tube between cathode and anode and current is running, the electrons are accelerated in the direction of the anode.

The electrons hit the anode at high speed. The point of impact is called the focal spot. In this point, the kinetic energy of the electrons is transformed into X-rays.

The focus point represents the minimum diameter of the electron beam inside the X-ray tube. When the electron beam is focused, the focus point is on the surface of the target.

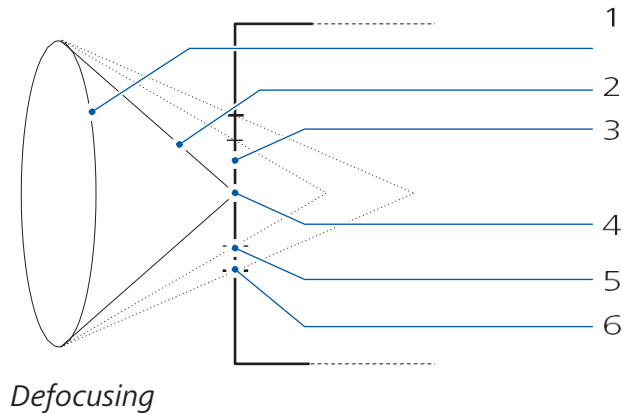
NOTE

The terms focus point and focal spot are used as synonyms. In reality, this is only valid if the focus point lies on the same plane as the focal spot.

With higher power defocusing, this condition is no longer met. The focus point is moved and consequently the focal spot enlarges. See image below.

Defocusing

When the intensity of the radiation must be increased, the focal spot must be enlarged to prevent the target material from melting. The focal spot is enlarged, defocusing the electron beam. Consequently, the focus no longer lies on the surface of the target.



[1] Focusing unit

[2] Electron beam

[3] Target

[4] Focus with 10 W; the focus is exactly on the surface of the target

[5] Limit of the focal spot with focus shifted at average power, e.g. 100 W

[6] Limit of the focal spot with focus shifted at high power, e.g. 200 W

NOTE

Defocusing starts at a power of 10 W. On increasing the power, the focal spot must be enlarged by approx. 1 μm per watt in order to prevent the target from melting.

Dimension of the focal spot

The dimensions of the focal spot depend on the power and lie within the order of the μm . The dimensions of the focal spot are inversely proportional to the blurring of the X-ray image. The smaller the focal spot, the sharper the image.

Target material

The physical load capacity of the target material affects the dimensions of the focal spot. For this reason, tungsten is used for the anode. Tungsten is the metal with the highest melting point and it has a high atomic number.

Effect of larger pieces

High radiation is needed to radiate larger pieces.

Consequently, the focal spot enlarges and blurring increases. However, given that the larger pieces are only represented reduced enlargement, blurring is not so marked.

NOTE

In order to prevent an increase of blurring of the voxel matrix due to the enlargement of the focal spot, the dimensions of the focal spot must be correlated with the dimensions of the voxels before measurement. The focal spot must be smaller than the size of the voxel.

Blurring

Geometric blurring

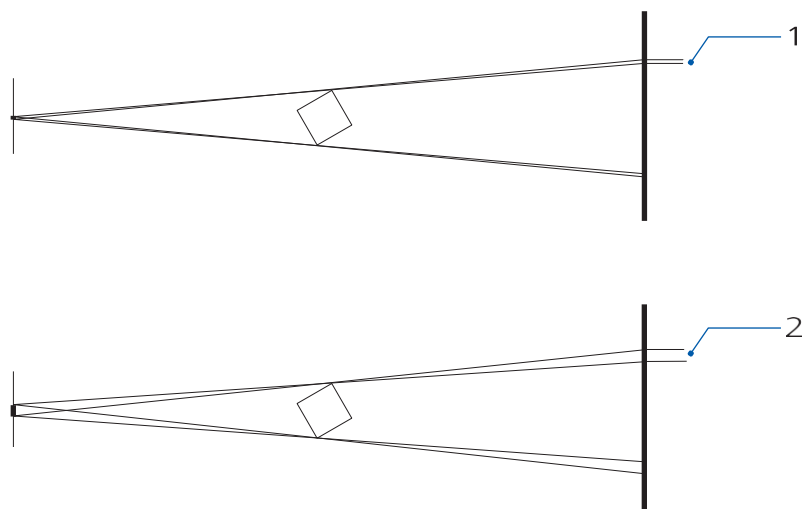
Geometric blurring U_G can be defined using the following formula:

$$U_G = f(M-1),$$

where: f = diameter of the focal spot M = geometric enlargement.

Factors that affect blurring

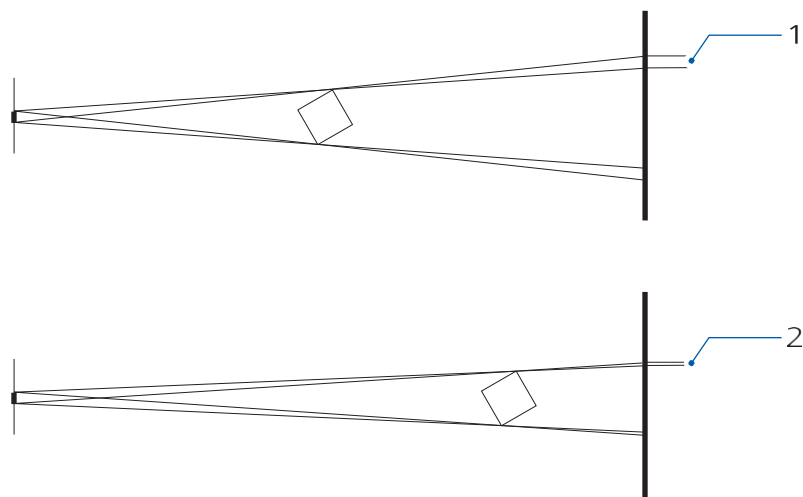
Geometric enlargement is determined by the dimensions of the focal spot and by the distance between the X-ray source and the piece.



Effect of the dimensions of the focal spot-on blurring

[1] Blurring limited with small focal spot

[2] Blurring accentuated with large focal spot

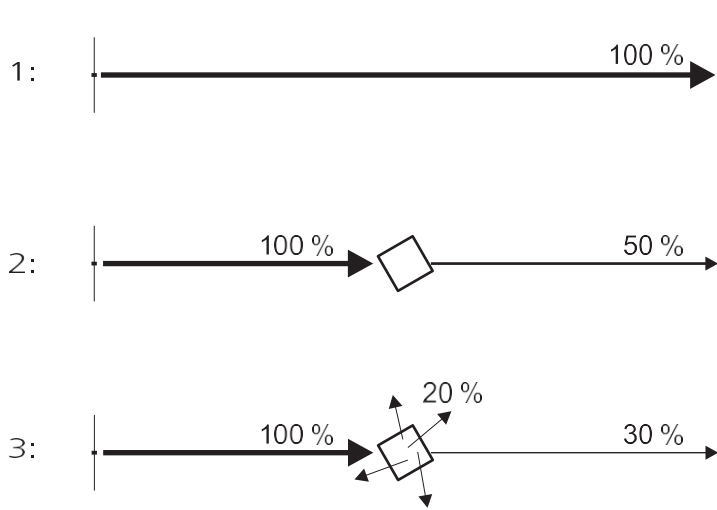


Effect of the distance between the X-ray source and the piece on blurring

- [1] Blurring accentuated with X-ray source at a short distance from the piece
- [2] Blurring limited with X-ray source at a long distance from the piece

Scattered radiation

The attenuation of the X-rays is always the result of the double process of absorption and deflection.



- [1] No absorption: 100% of the X-rays hit the detector
- [2] Absorption: 50% of the X-rays are absorbed by the piece; the remaining 50% hit the detector.
- [3] Absorption and deflection: 50% of the X-rays are absorbed by the piece; 20% of the X-rays are deflected and move in several directions; the remaining 30% hit the detector.

NOTE

The scattered radiation originating in the piece or in the detector is without direction. When it is detected, it causes a worsening of the contrast. The percentage scattered radiation increases with the increase of the energy of the X-rays (keV).