RaySafe X2

RaySafe X2 Solo

RaySafe™

Please consult the built-in help in your base unit
to ensure that you read a version corresponding to your specific instrument setup.

CONTENTS

GENERAL

ABOUT THE X2 SYSTEM

The RaySafe X2 is intended for measurements in medical X-ray imaging applications. The RaySafe X2 is not intended for use during patient examination.

The RaySafe X2 consists of a base unit, sensors and the RaySafe View computer software.

The sensor options are:

- **R/F**, for radiography and fluoroscopy measurements, with or without a phantom between the sensor and the X-ray source.
- **MAM**, for all kinds of mammography measurements.
- **DENT**, for dental X-ray measurements.
- **CT**, an ionization chamber for measurements on CT dose applications.
- **Light**, for illuminance measurements and luminance measurements on monitors and light boxes.
- **Survey**, a sensitive sensor for measuring leakage and scattered radiation, as well as other applications with low dose rate.
- **Volt**, for voltage measurements on X-ray equipment.
- **mAs**, an integrated tube current meter.

RaySafe View is a PC software for use with the X2 instruments. In RaySafe View, you can view measurements and waveforms on a larger display, store measurements, transfer data to Excel or other software and get software updates for the base unit.

When you want to measure, all you need to do is:

1. Turn on the base unit
2. Connect a sensor
3. Position the sensor
4. Expose

For more detailed information, see the help chapter for each sensor.

Note! The RaySafe X2 Solo is an X2 system with limited sensor functionality.

Note! If cleaning is needed, disconnect and power off the RaySafe X2 and wipe with a damp cloth.

NAVIGATE THE BASE UNIT

The base unit has a touch screen and three buttons.

Swipe up and down on the home screen to access your previously recorded measurements. Swipe right from the home screen to go to the setup screen, from which you can make settings and view information about the system. Tap on a parameter to get larger digits, one parameter at a time. You can also measure in this mode. From the single parameter screen, you can swipe right to view the measurement specifications, and left to see waveforms, if available.

The three buttons below the screen are:

- **Menu**, brings up a menu on the screen
- **Home**, takes you to the home screen
- **Back**, takes you back to the previous screen

On the back side of the base unit are:

- **Reset** switch, for forced reboot of the base unit
- **Charger/PC** connector, for charging or using with a PC with RaySafe View
- **mAs** connector, for tube current measurements
- Two **sensor** connectors
- **Ethernet** connector, for communication with a PC via TCP/IP
- **On/Off** switch. Press the button shortly to enter sleep mode. After a while in sleep mode, the base unit will turn off automatically. Press the button for 2 seconds to turn off the base unit immediately.

VIEW MEASUREMENT

Swipe up or down to scroll between measurements. Tap on a parameter to get larger digits. Swipe right to access the parameter information with measurement specifications. Swipe left to view a waveform, if available for the current parameter.

Press the menu button and select *Notes* to access more information about the measurement and to be able to add a note.

ACCESS ARCHIVED MEASUREMENTS

Measurements from previous sessions are automatically archived in the base unit. The memory allows about 10000 measurements. When the memory is full, the oldest measurements are automatically deleted.

The measurements are sorted by date and time.

Via base unit

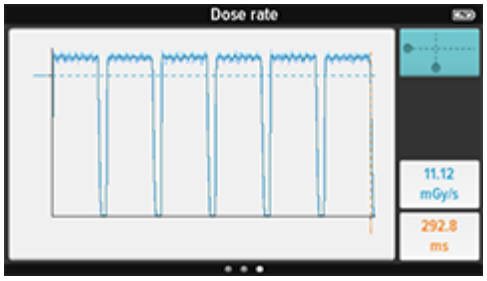
To access archived measurements, press the menu button and select *Measurement archive*. Select a session to see the individual measurements for that session. Swipe up or down to scroll between measurements.

Via RaySafe View

To access archived measurements via RaySafe View, connect the base unit to a computer running RaySafe View and select *Import from base unit* under the *File menu*.

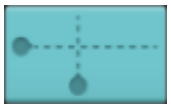
ANALYZE WAVEFORMS

View a single parameter by tapping on that parameter on the home screen. Swipe left to go to the waveform screen.

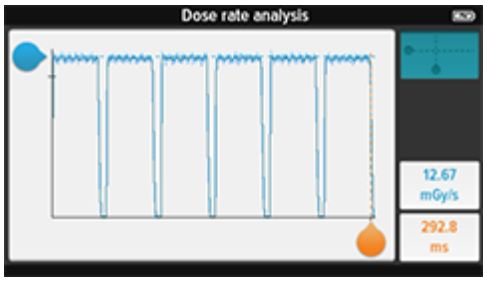


The dark line represents an average of the measured values. If there are more values than possible to show on the screen, the light blue pixles represent the range of these values.

The dashed lines indicate the measured parameter values, in this case average dose rate and time.



Tap on the button in the upper right corner to analyze the waveform.



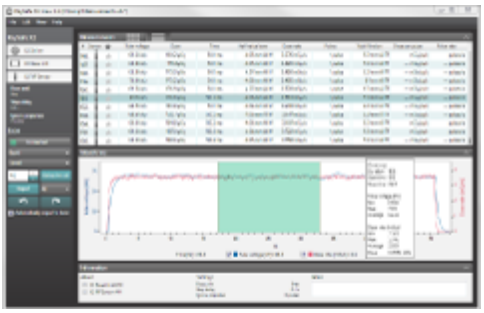
Slide the handles to view, for example, the peak dose rate of a pulse.

Pinch with two fingers to zoom in the waveform area.

Tap the button again to exit the analyze mode.

CONNECT THE BASE UNIT TO A COMPUTER

Connect the base unit to a computer running RaySafe View using a USB cable (recommended length: max 2 m). RaySafe View can be installed from the installation media that came with the system or be downloaded from raysafe.com.



If you measure, the results will automatically show up in RaySafe View.

You can also select *Import from Base Unit* in the *File* menu to import measurements stored in the base unit.

From RaySafe View, you can export measurements to Excel and other software. For more information, see the RaySafe View help, reached from the Help menu in RaySafe View.

CONNECT TO COMPUTER USING BLUETOOTH

Connect the Bluetooth adapter to a SENSOR port on the base unit. A gray Bluetooth status symbol appears in the upper right corner of the screen.

RaySafe View will automatically search for base units. The first time you connect, you will have to select your base unit from the Bluetooth menu in RaySafe View. The Bluetooth status symbol will turn white when connected.

When restarting RaySafe View, the base unit will automatically get connected.

UPGRADE THE BASE UNIT SOFTWARE

Connect the base unit to a computer running RaySafe View and make sure that the computer is connected to internet. If there are any updates available, the "Updates available" symbol will show up in RaySafe View. Click on that symbol and follow the instructions to upgrade the software.

CHARGE THE BATTERY

To charge the base unit, connect it to a wall socket with the included power supply. The charging time is approximately 4 hours.

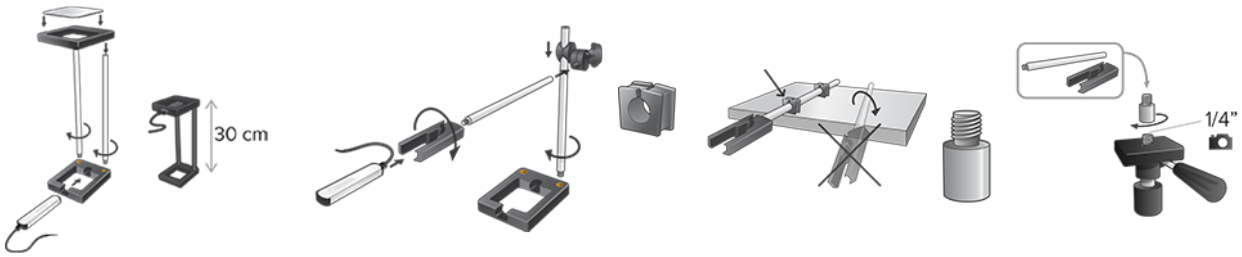
The battery lasts for about one day of extensive usage, which means that it is recommendable to start your working day with a fully charged unit.

The X2 system automatically enters power saving mode when idle for some minutes. If the system does not wake up by radiation or the buttons on the front, press the power button.

Tip! The base unit will maintain the energy level when connected to a computer.

USE THE FLEXI STAND

The flexi stand can be used in many different setups. Below are some examples.



X2 BASE UNIT: SPECIFICATIONS

Dimensions:	34 × 85 × 154 mm (1.3 × 3.3 × 6.1 in)
Weight:	521 g (18.4 oz)
Power source:	Rechargeable Li-ion battery
Battery time:	About 10 hours of intensive usage
Connector:	USB micro (5 V DC, 1.3 A), for PC communication and charging
Display:	4.3" LCD with capacitive touch
X2 Sensor connectors:	2 × USB Type A
Data storage:	About 10 000 stored measurements
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	55 – 110 kPa (5000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing

SETTING: SCREEN BRIGHTNESS

Adjust the screen brightness by sliding the bar.

Reduce the brightness to prolong the base unit battery time.

SETTING: SPEAKER VOLUME

0 % turns the speaker off and 100 % is max volume.

SETTING: TIME AND DATE

Set time and date according to your local time. Measurements are automatically stored in the base unit, sorted by time.

FINAL DISPOSAL OF THE SYSTEM

Final disposal is when the user disposes of the product in such a way that it can no longer be used for its intended purpose(s).

In the European Union (the WEEE directive), this label indicates that this product should not be disposed of with household waste.

This product should be disposed of at an appropriate facility to enable recovery and recycling.

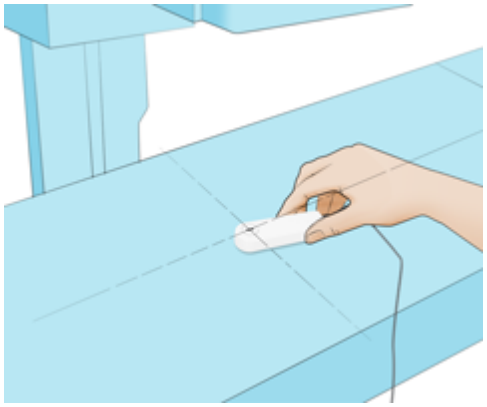
Unfors RaySafe supports users in:

- Recovering reusable parts.
- Recycling of useful materials by competent disposal companies.
- Safe and effective disposal of product.

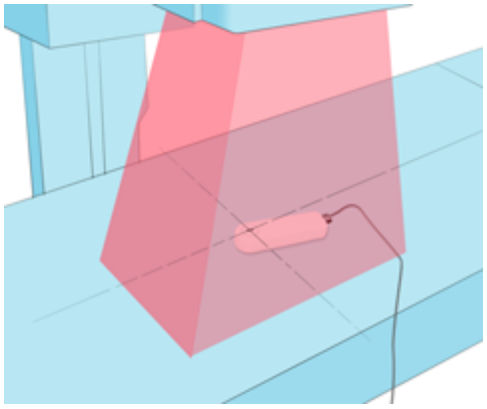
For advice and information, contact your Unfors RaySafe Service Organization first, or otherwise the manufacturer.

R/F

MEASURE WITH R/F SENSOR



Place the connected sensor centered in the field with the crosshair towards the X-ray source. The angle of the sensor in the horizontal plane has no impact on the measurement result.



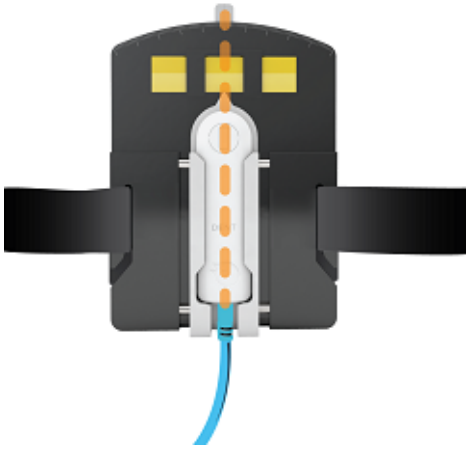
Expose.

Read the result.

Tip! Tap a parameter to get large digits, parameter information, and, if applicable, waveform. Switch between these by swiping sideways.

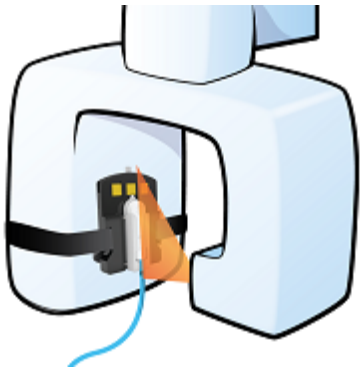
Note! The dark line centered in the circle represents the active area of the sensor. The lines on the side of the housing marks the vertical position.

MEASURE ON DENTAL PANORAMIC MACHINES



Position the panoramic holder with the X2 sensor centered, with the whole sensor rectangle inside the direct beam.

Adjust the position by exposing radiochromic or fluorescent film. You can also search for the highest dose value.



Expose.

Read the result.

Tip! You can also position the sensor centered in the direct beam without the holder, using for example tape.

R/F SENSOR: SPECIFICATIONS

Dimensions:	14 × 22 × 79 mm (0.5 × 0.9 × 3.1 in)
Weight:	42 g (1.5 oz)
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	70 – 110 kPa (3000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing
Reference point:	Center of upper sensor marking, depth indicated by line on the sensor side
Direction of incident radiation:	Orthogonal to the sensor marking surface
Minimum field of uniform radiation:	The thick solid line marked on the sensor
Angular deviation, dose:	< 1% within ± 10°
Backscatter:	Insensitive to scattered radiation outside ± 70°

The combined standard uncertainty for a dose or dose rate measurement is calculated according to the method described in IEC 61674:2012, annex A. The calculation considers, among others, the influence quantities repeatability, radiation quality, direction of incident radiation, pressure and temperature and is based on the calibration uncertainty of the RaySafe calibration lab as well as data from PTB type testing. The combined uncertainty is less than 5 %.

R/F SENSOR: MEASUREMENT PARAMETER DEFINITIONS

Dose and **HVL** are calculated from all recorded data.

Dose rate is the average dose rate, calculated as dose/time.

Time starts the first time the dose rate waveform reaches 50% of peak, and ends the last time it drops below 50%. Live readings are time since start trig.

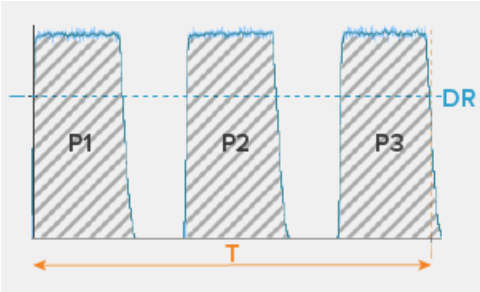
kVp and **total filtration** are calculated from an average of samples above 90 % of peak signal level.

Pulses are counted at every start trig with more than 4 ms since last end trig. With *AC pulse counting* set to *On*, pulses are counted each time the dose rate waveform rises above 50 % of peak.

Pulse rate and **dose per pulse** are moving averages.

For **measurements longer than 3 s**, the final readings of **dose rate, kVp, HVL** and **total filtration** are moving averages ending approximately 1–2 s before end trig. Live readings are moving averages.

Parameters in dose rate waveform



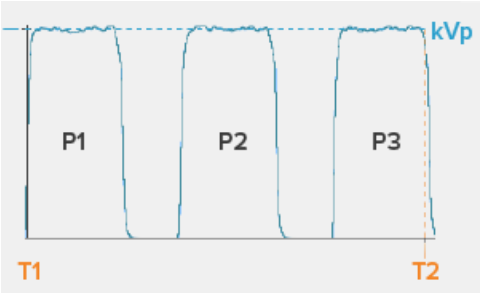
T: Time

P1, **P2**, **P3**: Pulses

DR: Dose rate

: Dose

Parameters in tube voltage waveform



T: Time

P1, **P2**, **P3**: Pulses

kVp: Peak tube voltage

Note! If measurements are made simultaneously with the R/F sensor and mAs cable, any shared parameter (*time, pulses* or *pulse rate*) will be taken from the R/F sensor.

SETTING: UNITS

Select displayed unit for dose and dose rate.

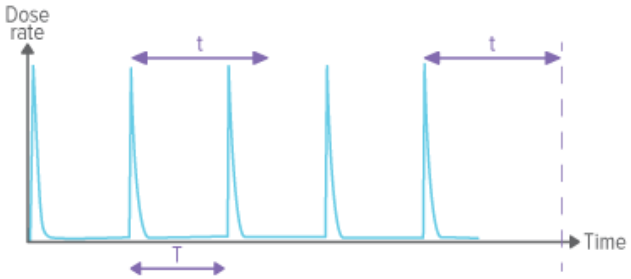
1 Gy = 114.1 R

Note! X2 systems subject to legal calibration (Eichung) in Germany or Austria do not have the possibility to change dose unit to Röntgen (R).

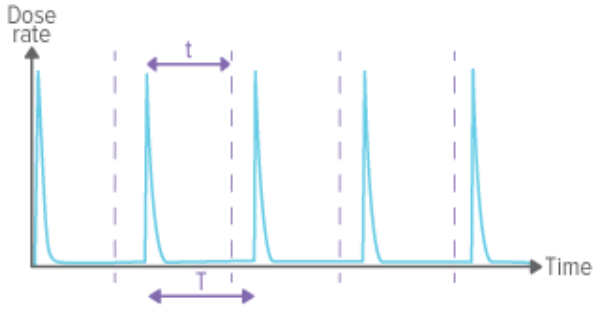
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for more radiation to include in the same measurement.

Use a longer stop delay when measuring on a pulsed fluoroscopy system or to get a prepulse recorded into the same measurement as the following ordinary exposure.



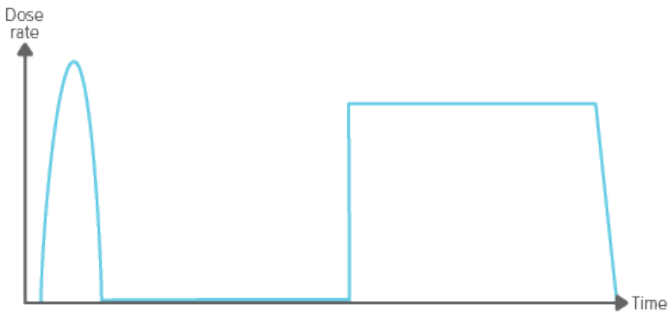
Stop delay setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



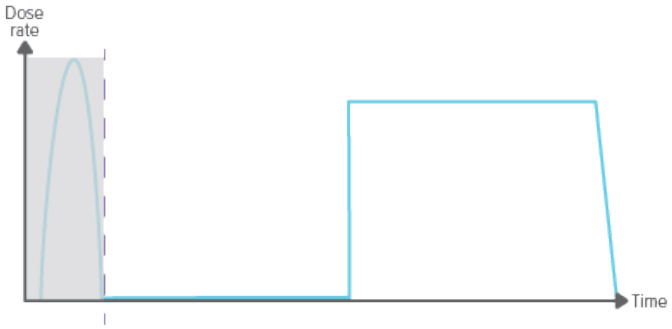
Stop delay setting shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

SETTING: IGNORE PREPULSES

Use the ignore prepulses setting to remove one or many unwanted prepulses from the measurement.



Ignore prepulses = 0, the whole exposure is captured.



Ignore prepulses = 1, the (first) prepulse is excluded from the measurement.

Note! This setting will affect all parameters, including the dose measurement.

SETTING: AC PULSE COUNTING

The AC pulse counting method can help in certain situations, but should normally be turned **Off**.

Exceptions:

To avoid counting pre-heat pulses on intra oral AC machines, select **On**.

To count individual pulses on full wave rectified single phase AC machines, select **On**.

Note! This setting affects **pulses**, **pulse rate** and **dose per pulse**.

SETTING: CORRECTION FACTOR

For some specific measurement setups, a correction factor is applicable. In all other cases, use **None**.

Siemens CT Straton

Some Siemens CT Somatom machines have a Straton tube. To get a correct kV value on such machines, select **Siemens CT Straton**. This setting affects only the kVp value.

GE CT 10.5°

When measuring kV on a GE CT machine with 10.5° anode angle, select **GE CT 10.5°** to use a correction factor specifically adapted for maximum kV accuracy on such machines. Measure without bow tie filter if possible. This setting affects only the kVp value and is intended for GE Field Service Engineers.

GE CT 7° Monopolar

When measuring kV on a GE CT machine with 7° anode angle and monopolar tube, select **GE CT 7° Monopolar** to use a correction factor specifically adapted for maximum kV accuracy on such machines. Measure without bow tie filter if possible. This setting affects only the kVp value and is intended for GE Field Service Engineers.

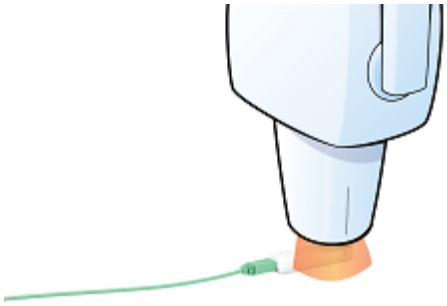
GE CT 7° Bipolar

When measuring kV on a GE CT machine with 7° anode angle and bipolar tube, select **GE CT 7° Bipolar** to use a correction factor specifically adapted for maximum kV accuracy on such machines. Measure without bow tie filter if possible. This setting affects only the kVp value and is intended for GE Field Service Engineers.

DENT

MEASURE WITH DENT SENSOR

Place the connected sensor centered in the field with the crosshair towards the X-ray source. Make sure that the whole sensor rectangle is inside the direct beam.



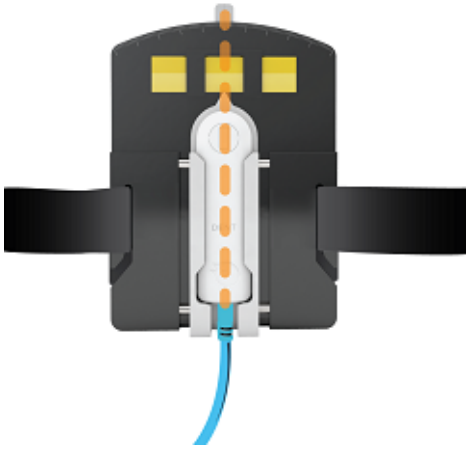
Expose.

Read the result.

Tip! Tap a parameter to get large digits, parameter information, and, if applicable, waveform. Switch between these by swiping sideways.

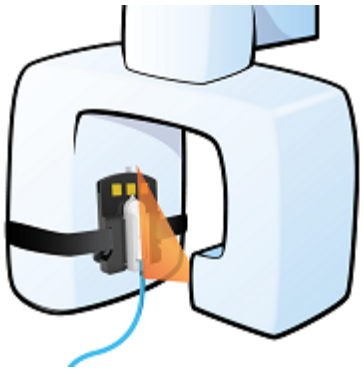
Note! The rectangle in the circle represents the active area of the sensor. The lines on the side of the housing marks the vertical position.

MEASURE ON DENTAL PANORAMIC MACHINES



Position the panoramic holder with the X2 sensor centered, with the whole sensor rectangle inside the direct beam.

Adjust the position by exposing radiochromic or fluorescent film. You can also search for the highest dose value.



Expose.

Read the result.

Tip! You can also position the sensor centered in the direct beam without the holder, using for example tape.

DENT SENSOR: SPECIFICATIONS

Dimensions:	14 × 22 × 79 mm (0.5 × 0.9 × 3.1 in)
Weight:	42 g (1.5 oz)
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	70 – 110 kPa (3000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing
Reference point:	Center of upper sensor marking, depth indicated by line on the sensor side
Direction of incident radiation:	Orthogonal to the sensor marking surface
Minimum field of uniform radiation:	The rectangle marked on the sensor
Angular deviation, dose:	< 1% within ± 10°
Backscatter:	Insensitive to scattered radiation outside ± 70°

The combined standard uncertainty for a dose or dose rate measurement is calculated according to the method described in IEC 61674:2012, annex A. The calculation considers, among others, the influence quantities repeatability, radiation quality, direction of incident radiation, pressure and temperature and is based on the calibration uncertainty of the RaySafe calibration lab as well as data from PTB type testing. The combined uncertainty is less than 5 %.

DENT SENSOR: MEASUREMENT PARAMETER DEFINITIONS

Dose and **HVL** are calculated from all recorded data.

Dose rate is the average dose rate, calculated as dose/time.

Time starts the first time the dose rate waveform reaches 50% of peak, and ends the last time it drops below 50%. Live readings are time since start trig.

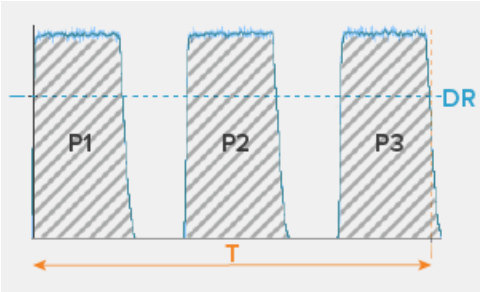
kVp and **total filtration** are calculated from an average of samples above 90 % of peak signal level.

Pulses are counted each time the dose rate waveform rises above 50 % of peak.

Pulse rate and **dose per pulse** are moving averages.

For **measurements longer than 3 s**, the final readings of **dose rate, kVp, HVL** and **total filtration** are moving averages ending approximately 1–2 s before end trig. Live readings are moving averages.

Parameters in dose rate waveform



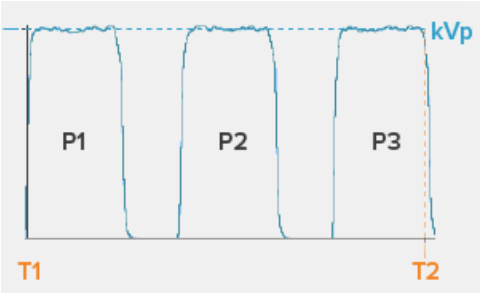
T: Time

P1, **P2**, **P3**: Pulses

DR: Dose rate

: Dose

Parameters in tube voltage waveform



T: Time

P1, **P2**, **P3**: Pulses

kVp: Peak tube voltage

Note! If measurements are made simultaneously with the DENT sensor and mAs cable, any shared parameter (*time, pulses* or *pulse rate*) will be taken from the DENT sensor.

SETTING: UNITS

Select displayed unit for dose and dose rate.

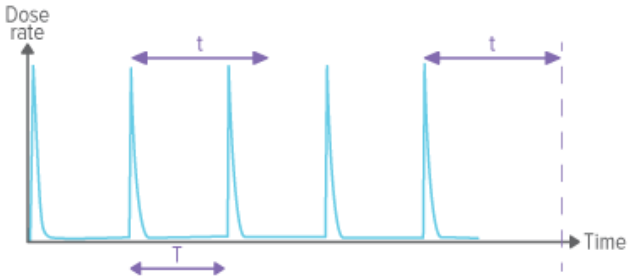
1 Gy = 114.1 R

Note! X2 systems subject to legal calibration (Eichung) in Germany or Austria do not have the possibility to change dose unit to Röntgen (R).

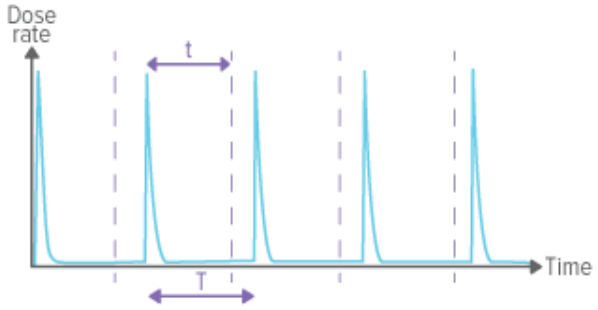
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for more radiation to include in the same measurement.

Use a longer stop delay when measuring on a pulsed fluoroscopy system or to get a prepulse recorded into the same measurement as the following ordinary exposure.



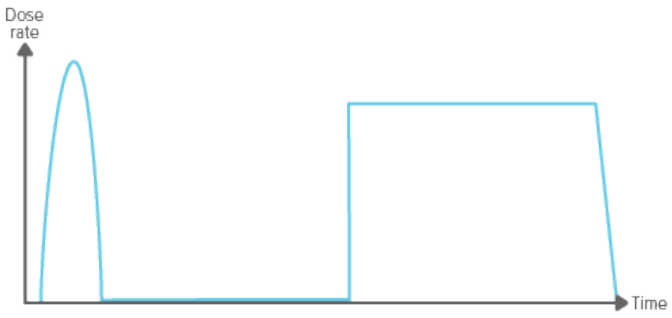
Stop delay setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



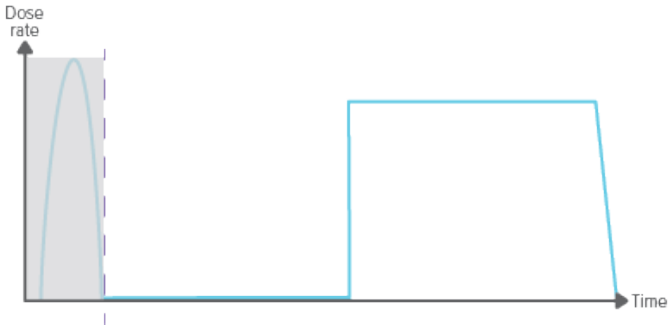
Stop delay setting shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

SETTING: IGNORE PREPULSES

Use the ignore prepulses setting to remove one or many unwanted prepulses from the measurement.



Ignore prepulses = 0, the whole exposure is captured.

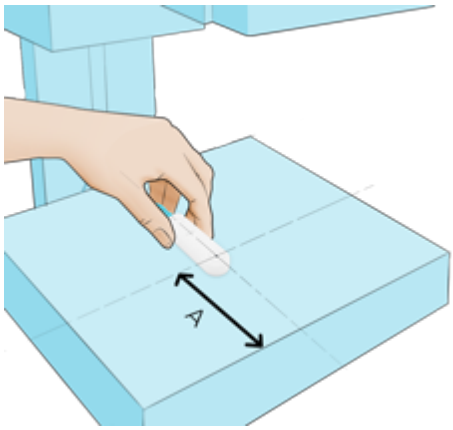


Ignore prepulses = 1, the (first) prepulse is excluded from the measurement.

Note! This setting will affect all parameters, including the dose measurement.

MAM

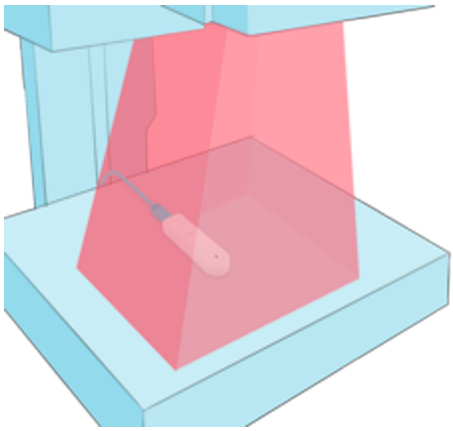
MEASURE WITH MAM SENSOR



The MAM sensor is ready to measure dose and HVL for all anode/filter combinations without changing any settings. Place the connected sensor centered in the field, with the crosshair 6 cm (4 cm in the US) from the examination table front edge (A). The angle in the horizontal plane has neglectable impact on the measurement result.

For kVp measurements, select your anode/filter combination in the sensor settings, or by swiping right from the home screen to access the quick settings.

Note! When measuring kV on Mo/Rh, use the included 2 mm Al filter. Follow the instructions printed on the filter.



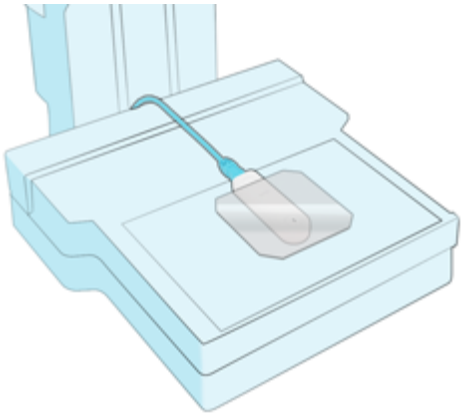
Expose.

Read the result.

Tip! Tap a parameter to get large digits, parameter information, and, if applicable, waveform. Switch between these by swiping sideways.

Note! The dark line centered in the circle represents the active area of the sensor. The lines on the side of the housing marks the vertical position.

MO/RH KV WITH MAM SENSOR



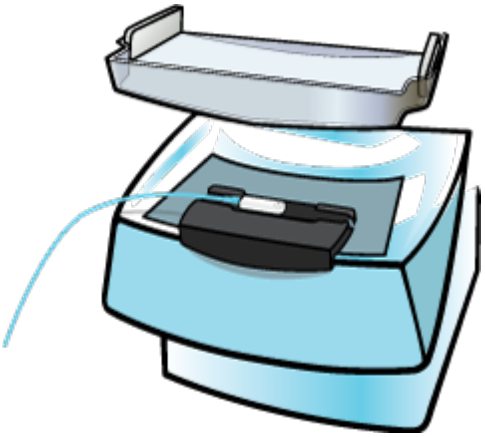
Place the sensor centered and 6 cm from the chest wall. Place the 2 mm Al filter on the sensor. Be sure to cover the active sensor area.

Recommended generator setting $\geq$ 100 mAs.

Select **Mo/Rh 2 mm Al** in the sensor settings.

W/AL SCANNING WITH MAM SENSOR

Mount the X2 MAM sensor in the holder.



Place the holder centered on the table, tight to the chest wall.

Settings:

Philips MicroDose: Stop delay: 2 s. W/Al Philips, if kVp is desired.

Fischer SenoScan: Stop delay: 2 s. W/Al, if kVp is desired.

Adani: Stop delay: 2 s. W/Al, if kVp is desired.

Always use the compression paddle, positioned as high as possible. Do not use the AEC functionality.

MAM SENSOR: MEASUREMENT PARAMETER DEFINITIONS

Dose and **HVL** are calculated from all recorded data.

Dose rate is the average dose rate, calculated as dose/time.

Time starts the first time the dose rate waveform reaches 50% of peak, and ends the last time it drops below 50%. Live readings are time since start trig.

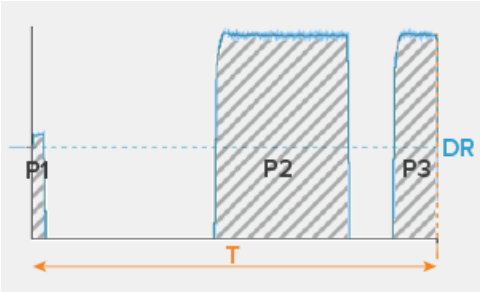
kVp is calculated from an average of samples above 33 % of peak signal level.

Pulses are counted at every start trig with more than 4 ms since last end trig.

Pulse rate and **dose per pulse** are averages from the last 6 pulses.

Live readings of **dose rate, kVp** and **HVL** are moving averages. Final readings are based on the whole measurement.

Parameters in dose rate waveform



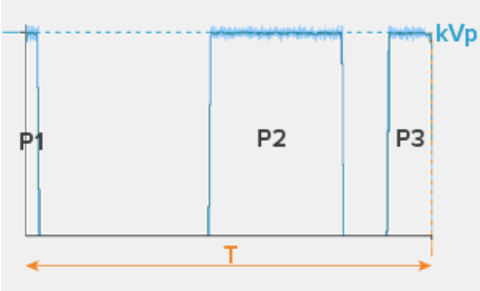
T: Time

P1, **P2**, **P3**: Pulses

DR: Dose rate

: Dose

Parameters in tube voltage waveform



T: Time

P1, **P2**, **P3**: Pulses

kVp: Peak tube voltage

Note! If measurements are made simultaneously with the MAM sensor and mAs cable, any shared parameter (*time*, *pulses* or *pulse rate*) will be taken from the MAM sensor.

MAM SENSOR: SPECIFICATIONS

Dimensions:	14 × 22 × 79 mm (0.5 × 0.9 × 3.1 in)
Weight:	42 g (1.5 oz)
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	70 – 110 kPa (3000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing
Reference point:	Center of upper sensor marking, depth indicated by line on the sensor side
Direction of incident radiation:	Orthogonal to the sensor marking surface
Minimum field of uniform radiation:	The solid line marked on the sensor
Angular deviation, dose:	< 1% within ± 10°
Backscatter:	Insensitive to scattered radiation outside ± 45°

The combined standard uncertainty for a dose or dose rate measurement is calculated according to the method described in IEC 61674:2012, annex A. The calculation considers, among others, the influence quantities repeatability, radiation quality, direction of incident radiation, pressure and temperature and is based on the calibration uncertainty of the RaySafe calibration lab as well as data from PTB type testing. The combined uncertainty is less than 5 %.

SETTING: KVP MODE

The MAM sensor is ready to measure dose and HVL for all beam qualities without any settings. However, to get a kVp reading you have to select a beam quality.

If your beam quality is not in the list, you have to change your anode/filter combination to one of the listed. Expose, and you will get a kVp reading which is applicable to all anode/filter combinations for the mammography machine (since the high voltage generator will behave identically regardless of selected anode/filter combination).

Note! This setting will only affect the kVp measurement.

SETTING: UNITS

Select displayed unit for dose and dose rate.

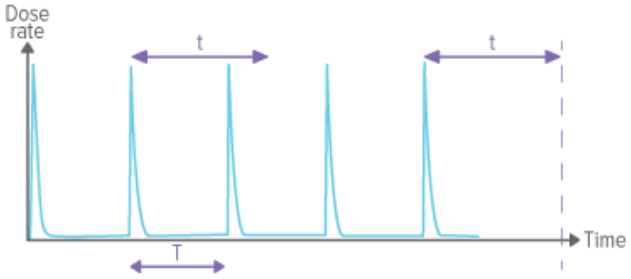
1 Gy = 114.1 R

Note! X2 systems subject to legal calibration (Eichung) in Germany or Austria do not have the possibility to change dose unit to Röntgen (R).

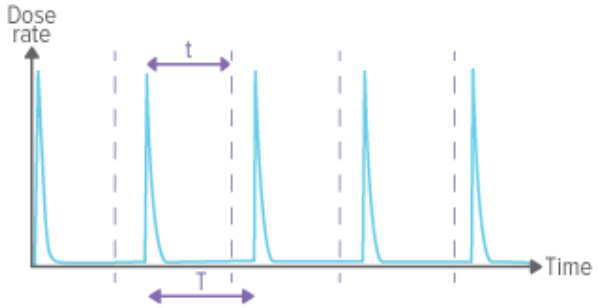
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for more radiation to include in the same measurement.

Use a longer stop delay when measuring on a pulsed fluoroscopy system or to get a prepulse recorded into the same measurement as the following ordinary exposure.



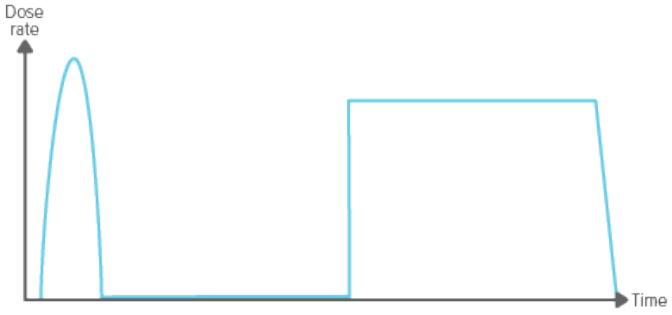
Stop delay setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



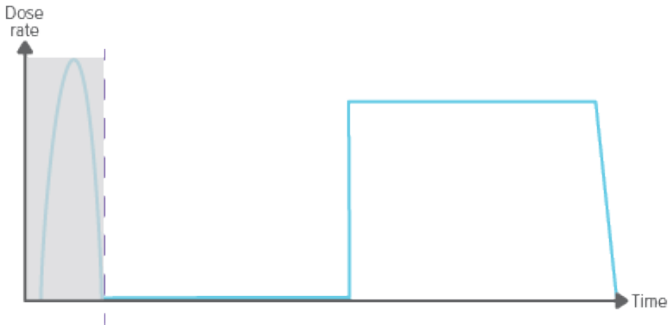
Stop delay setting shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

SETTING: IGNORE PREPULSES

Use the ignore prepulses setting to remove one or many unwanted prepulses from the measurement.



Ignore prepulses = 0, the whole exposure is captured.

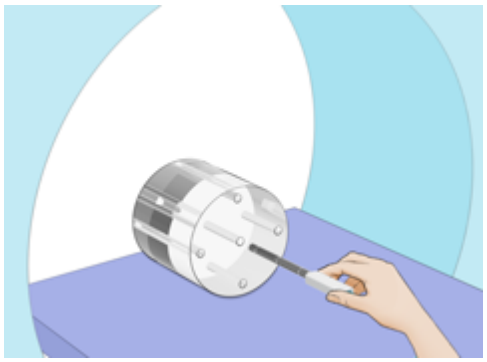


Ignore prepulses = 1, the (first) prepulse is excluded from the measurement.

Note! This setting will affect all parameters, including the dose measurement.

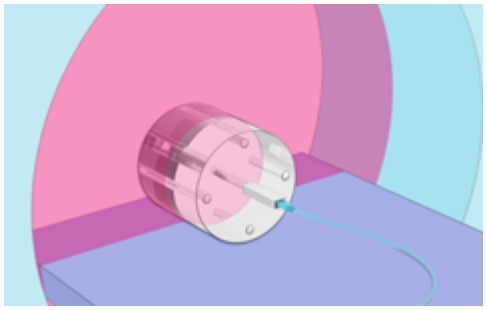
CT

MEASURE WITH CT SENSOR



Push the connected sensor tight into the phantom ...

... or use the flexi stand for positioning free in air.



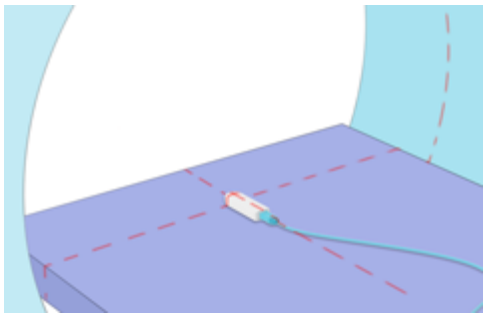
Expose.

Read the result.

Note! The effective length of the CT sensor is 100 mm, and is marked with center and edge lines on the tube.

Tip! Tap a parameter to get large digits, parameter information, and, if applicable, waveform. Switch between these by swiping sideways.

MEASURE KVP ON CT



For kVp measurements, use an R/F sensor. Position it flat on the table and expose without rotation, using scout, tomogram or topogram mode. Use no or slowest table movement.

CT SENSOR: MEASUREMENT PARAMETER DEFINITIONS

Dose length product and **dose** are calculated from all recorded data.

Time starts the first time the dose rate waveform reaches 50 % of peak, and ends the last time it drops below 50 %. Intermediate readings are time since start trig.

Dose rate is the average dose rate, calculated as dose/time. For measurements longer than 3 s, intermediate readings are moving averages.

Note! X2 systems subject to legal calibration (Eichung) in Germany or Austria do not show dose or dose rate on the base unit display.

Note! Dose and dose length product readings are automatically corrected for temperature and pressure by multiplying with a factor $k = T/T_{std} \cdot P_{std}/P$. Here, T is the measured temperature,

P is the measured pressure, T_{std} = 293.15 K (20 °C) and P_{std} = 101.325 kPa.

Tip! The temperature and pressure sensors are located inside the CT sensor. Their measured values can be viewed by importing the measurement session to RaySafe View and exporting to Excel.

CT SENSOR: SPECIFICATIONS

Dimensions:	14 × 22 × 219 mm (0.5 × 0.9 × 8.6 in)
Diameter:	12.5 mm (0.5 in)
Weight:	86 g (3.0 oz)
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	55 – 110 kPa (5000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing
Effective length:	100 mm (3.94 in), indicated by the two white lines on the sensor
Direction of incident radiation:	± 180°

The combined standard uncertainty for a dose or dose rate measurement is calculated according to the method described in IEC 61674:2012, annex A. The calculation considers, among others, the influence quantities repeatability, radiation quality, direction of incident radiation, pressure and temperature and is based on the calibration uncertainty of the RaySafe calibration lab as well as data from PTB type testing. The combined uncertainty is less than 5 %.

SETTING: UNITS

Select displayed unit for dose and dose rate.

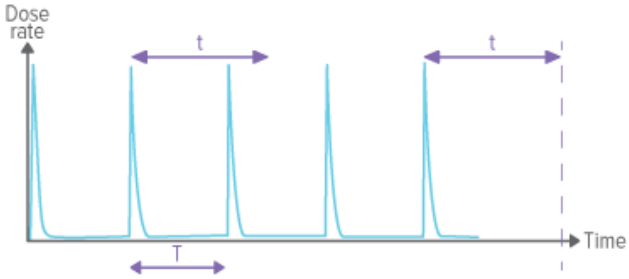
1 Gy = 114.1 R

Note! X2 systems subject to legal calibration (Eichung) in Germany or Austria do not have the possibility to change dose unit to Röntgen (R).

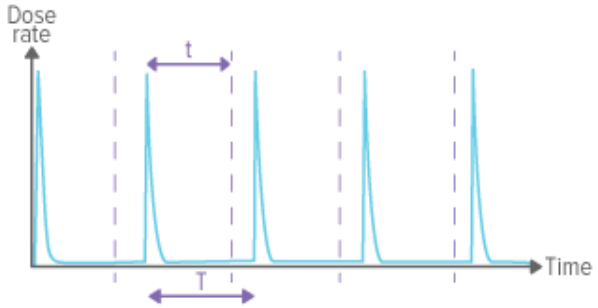
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for more radiation to include in the same measurement.

Use a longer stop delay when using a phantom and a slow rotation rate, to prevent that an axial scan will be cut into two measurements.



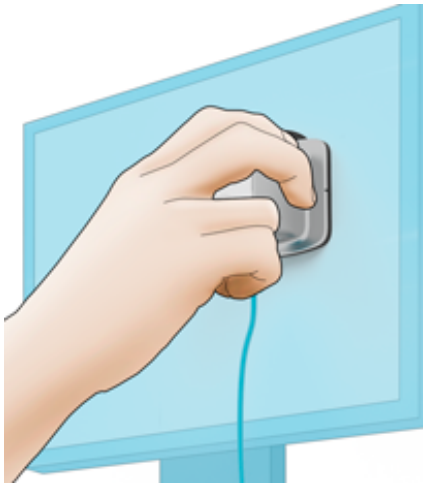
Stop delay (t) setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



Stop delay setting (t) shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

LIGHT

MEASURE WITH LIGHT SENSOR



Luminance: Place the connected sensor with the aperture centered on the area you want to measure, and with luminance selected on the sensor wheel.

Illuminance: Place the connected sensor with the diffuser in the direction you want to measure, and with illuminance selected on the sensor wheel.

The sensor is constantly measuring. If you want to store a value, press the button once the reading is stable. The measurement will continue below the stored value.

Tip! Tap a parameter to get large digits and parameter information. Switch between these by swiping sideways.

Zero adjust: If prompted to make a zero adjust, select zero adjust (0) on the sensor wheel. The zero adjust will take approximately 10 s.

Note! Store the sensor with the sensor wheel in a closed position (0 or illuminance), to prevent dust in the optics.

LIGHT SENSOR: MEASUREMENT PARAMETER DEFINITIONS

Illuminance is the amount of light incident on a surface.

Luminance is the amount of light emitted from a surface.

LIGHT SENSOR: SPECIFICATIONS

Dimensions:	48 × 60 × 68 mm (1.9 × 2.4 × 2.7 in)
Weight:	136 g (4.8 oz)
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	70 – 110 kPa
Operating humidity:	< 80 % relative humidity, non-condensing

SETTING: UNITS

Select between

- cd/m^2 and lux, **or**
- fL and fc

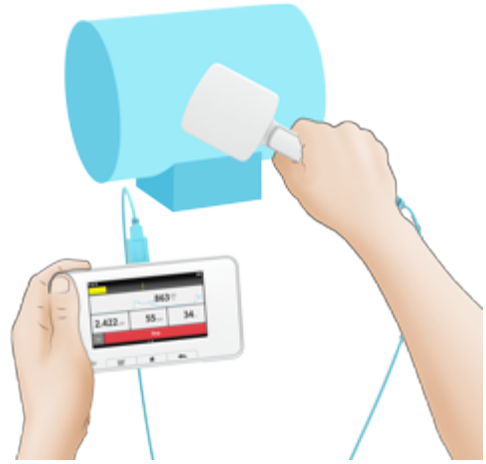
1 cd/m^2 = 0.2919 fL (luminance)

1 lux = 0.09290 fc (illuminance)

SURVEY

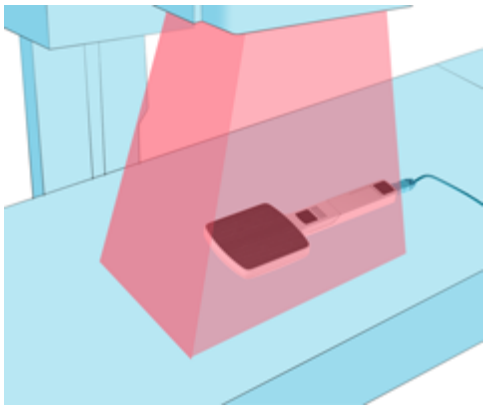
MEASURE WITH SURVEY SENSOR

Position the sensor with the dark side towards the radiation source.



If you measure in manual trig mode, press *Start* or *Stop* whenever you want to begin or end measuring.

If you measure in auto trig mode, measurement is triggered by radiation.



You can also use the sensor for low dose rate measurements, positioned centered in the X-ray field, with the dark side towards the radiation source.

Note! Dose rate readings may need some time to return to zero after high radiation levels, due to afterglow in the scintillators.

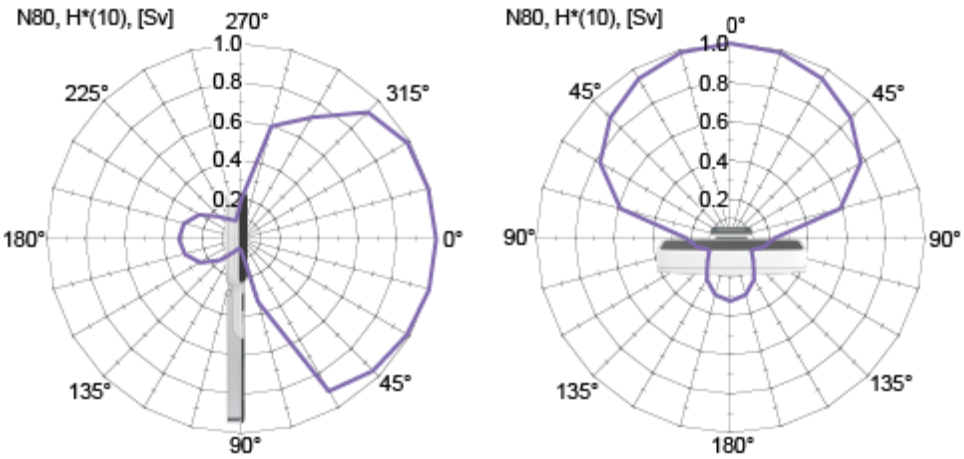
Tip! Tap a parameter to get large digits, parameter information, and, if applicable, waveform. Switch between these by swiping sideways.

Note! The dark entrance window represents the active area of the sensor. The lines on the side of the housing marks the vertical position.

SURVEY SENSOR: SPECIFICATIONS

Dimensions:	14 × 66 × 192 mm (0.5 × 2.6 × 7.6 in)
Weight:	140 g (4.9 oz)
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	70 – 110 kPa (3000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing
Reference point:	Center of entrance window, at a depth indicated by lines at the sides of the sensor
Direction of incident radiation:	Orthogonal to the entrance window
Minimum field of uniform radiation:	Size of entrance window; 67 × 73 mm (2.6 × 2.9 in)
Angular deviation, dose:	< 1% within ± 10°
Backscatter:	Back side of sensor protected
Sound:	Tick frequency proportional to the measured dose rate

Angular deviation, dose:



SETTING: TRIG MODE

The trig mode setting affects both how a measurement is triggered and which parameters are displayed.

Auto

When in auto trig mode, start of measurement is triggered by radiation, with trig level (N80) 20 µSv/h or 10 µGy/h (1.2 mR/h). The sensor is in this mode useful as a sensitive dose rate meter, placed in the primary X-ray field.

Parameter displayed are:

- accumulated dose,
- time,
- instantaneous dose rate (final reading: average dose rate),
- mean energy.

Manual

In manual trig mode, you can start and stop the measurement from the base unit. This mode is suitable for measuring leakage or scattered radiation from X-ray equipment and γ-emitting isotopes.

Parameters displayed are:

- accumulated dose,
- time,
- instantaneous dose rate (final reading: peak dose rate),
- mean energy.

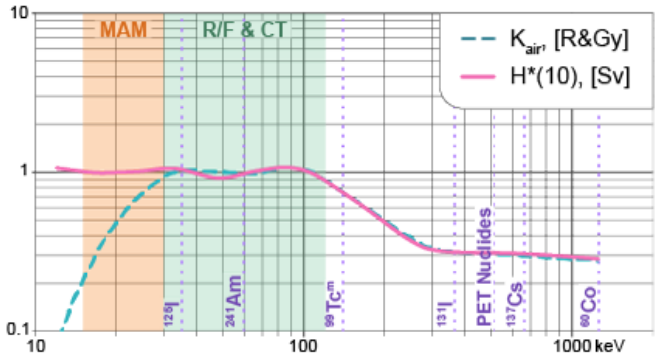
SETTING: UNITS

Select displayed unit for dose and dose rate.

Air kerma, K_{air}, is measured in Gy or R, where 1 Gy = 114.1 R.

Ambient dose equivalent, $H^*(10)$, is measured in Sv.

Typical response:

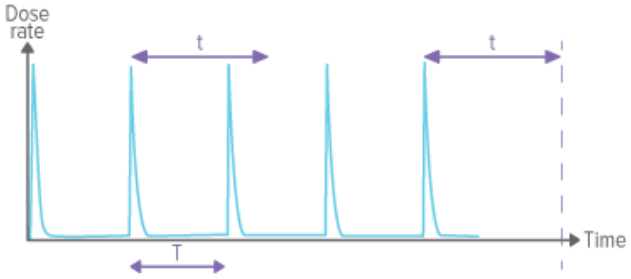


Note! X2 systems approved by PTB do not have the possibility to change dose unit to Röntgen (R).

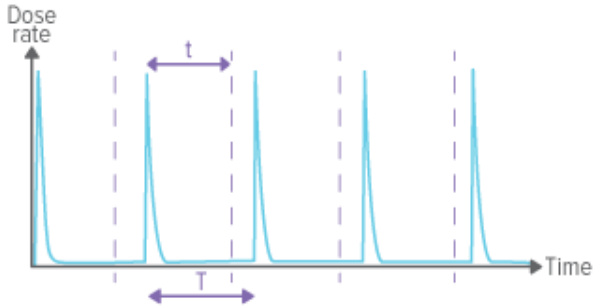
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for more radiation to include in the same measurement.

Use a longer stop delay when measuring on a pulsed fluoroscopy system or to get a prepulse recorded into the same measurement as the following ordinary exposure.



Stop delay setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



Stop delay setting shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

Note! This setting will only affect measurements in auto trig mode.

VOLT

MEASURE WITH VOLT SENSOR

Connect the Volt sensor to the device using the Volt cable.

A live value is displayed in the lower left corner of the screen. The live value is the average voltage, recalculated and updated four times per second.

Note! To ensure functionality and safety, only use Volt cables provided by RaySafe.

To get other measurement parameters, in addition to voltage (V) and time (s), select an applicable conversion factor. Swipe right from the home screen to access the quick settings with the conversion factors.

A conversion to kV will add a calculated tube voltage (kV) value to the measurement.

A conversion to mA will add calculated tube current (mA) and tube charge (mAs) values to the measurement.

Press the home button to go back to the home screen.

Press Activate to make the instrument ready for measurements.

The instrument will automatically perform a zero adjustment, which means that a new zero level is set, based on the voltage measured during activation. The voltage must be stable during the activation.

When the home screen returns, the instrument is ready for measurements.

Expose.

Read the result.

After the last measurement, press Deactivate. This prevents the instrument to trig during cable

disconnection.

Caution! Connection of the RaySafe X2 Volt directly to test points on generators shall only be done by personnel authorized in calibration and repair of X-ray equipment. The user may be exposed to electrical hazards if the equipment is damaged or improperly connected, or if the input voltage to the Volt sensor is more than the specified maximum of ± 16 V.

Tip! Tap a parameter to get large digits, parameter information, and, if applicable, waveform. Switch between these by swiping sideways.

VOLT SENSOR: SPECIFICATIONS

Dimensions:	17 × 23 × 93 mm (0.7 × 0.9 × 3.7 in)
Weight:	55 g (1.9 oz)
Input terminal:	BNC connector
Input voltage:	±16 V
Storage temperature:	-25 – +70 °C (-13 – +158 °F)
Storage humidity:	Non-condensing
Operating temperature:	15 – 35 °C (59 – 95 °F)
Operating atmospheric pressure:	55 – 110 kPa (5000 m above sea level)
Operating humidity:	< 80 % relative humidity, non-condensing

VOLT SENSOR: MEASUREMENT PARAMETER DEFINITIONS

Voltage is calculated as an average of all samples from the first time the signal reaches 50 % of peak until the last time it drops below 50 %.

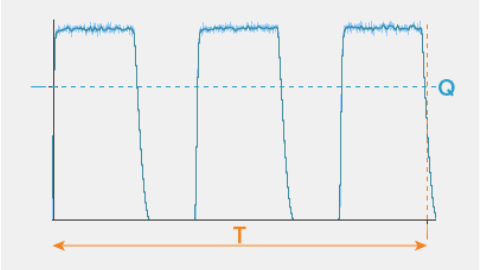
Time starts the first time the signal reaches 50 % of peak, and ends the last time it drops below 50 %. Live readings are time since start trig.

mA and **kV** are calculated from voltage using the selected conversion factor.

mAs is calculated as mA × time. Live readings are based on all samples since start trig.

Live readings of voltage, mA and kV are averages from the last second.

Parameters in waveform



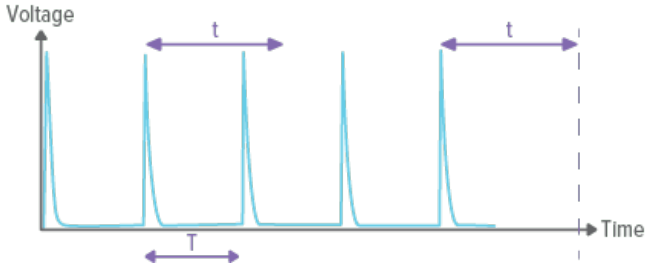
T: Time

Q: Voltage (V), Tube voltage (kV) or Tube current (mA)

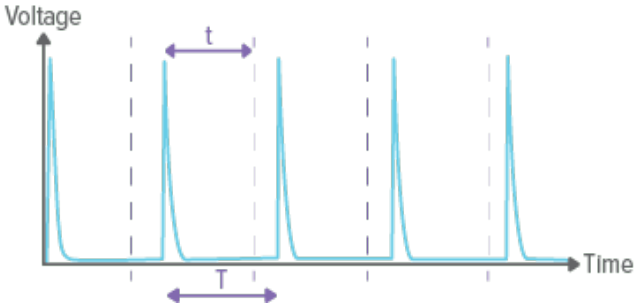
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for signal to include in the same measurement.

Use a longer stop delay when measuring on a pulsed fluoroscopy system or to get a prepulse recorded into the same measurement as the following ordinary exposure.



Stop delay setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



Stop delay setting shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

SETTING: CONVERSION FACTOR

Select a conversion factor suitable for your application. With a conversion factor selected, the instrument will automatically calculate values, based on the measured voltage, for tube current (mA) and charge (mAs), or tube voltage (kV), depending on the selected factor.

In other cases, use **Conversion off**.

SETTING: TRIG LEVEL

Select the trig level suitable for your application.

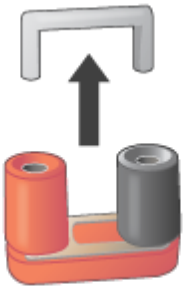
50 mV is usable in most situations. Handles short pulses.

Use **2 mV** when the signal is too low to trig a new measurement otherwise. Bandwith is reduced from 10 kHz to 1.5 kHz. Recommended for measurements with the *PROVA 15 Current probe.*

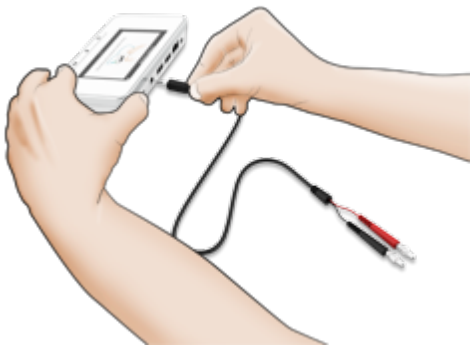
MAS

MEASURE MAS

Switch off the X-ray generator.



Remove the jumper.



Connect the mAs cable to the base unit and to the generator.

Switch on the X-ray generator.

Make an exposure and read the result.

Note! Users of RaySafe X2 mAs must be aware of the potential damage to generators and of electrical human hazards in case of improper connection or damaged equipment. RaySafe X2 mAs is intended for use only by personnel authorized in performing calibration and repair of X-ray equipment.

Tip! You can measure with the R/F, DENT or MAM Sensor and the mAs cable both connected to get radiation and generator current values at the same time.

Tip! Tap a parameter for large digits, to get information about that specific parameter, and, if applicable, see a waveform.

MAS: MEASUREMENT PARAMETER DEFINITIONS

mAs is calculated from all recorded data.

mA is calculated as an average of all samples above 50% of peak. Rush currents are automatically removed. Live readings are based on samples since last reading. For long measurements, the final reading is recorded approximately 1–2 s before end trig.

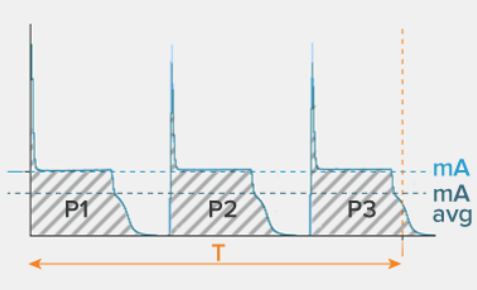
mA avg (average) is calculated as mAs / time. For measurements longer than 3 s, the final reading is a moving average ending approximately 1–2 s before end trig. Live readings are based on a 1 s moving average. (Change *mA mode* to *mA avg* to measure according to this definition.)

Time starts the first time the current reaches 50% of the calculated mA and ends the last time it drops below 50%. Live readings are time since start trig.

Pulses are counted every time the signal reaches trig.

Pulse rate and **mAs per pulse** are averages for the last 6 pulses.

Parameters in mA waveform



T: Time

P1, **P2**, **P3**: Pulses

mA: mA

mA avg: mA value if the setting **mA mode** is **mA avg**

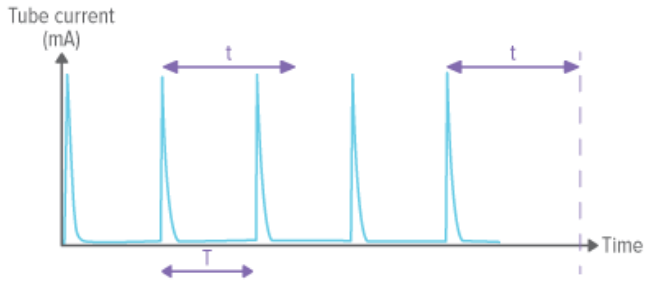
: Displayed mAs value.

Note! If measurements are made simultaneously with a sensor and mAs cable, any shared parameter (*time, pulses* or *pulse rate*) will be taken from the sensor.

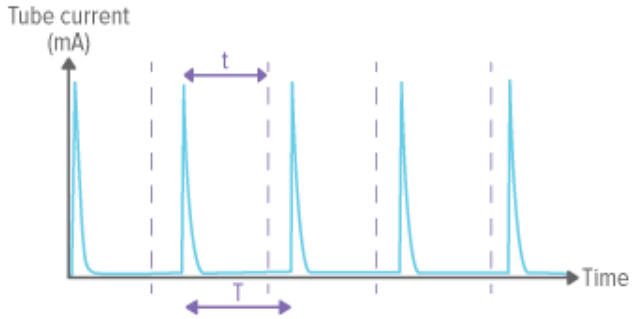
SETTING: STOP DELAY

The stop delay setting defines for how long the instrument will wait for more radiation to include in the same measurement.

Use a longer stop delay when measuring on a pulsed fluoroscopy system or to get a prepulse recorded into the same measurement as the following ordinary exposure.



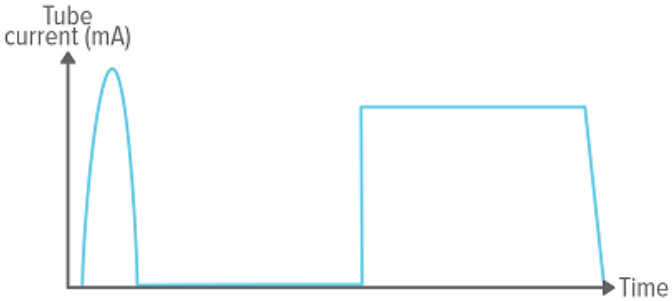
Stop delay setting longer than the time between pulses (t>T), will result in one long measurement. Note that you have to wait as long as the stop delay setting (t) after the last exposure before the measurement ends and values will be displayed.



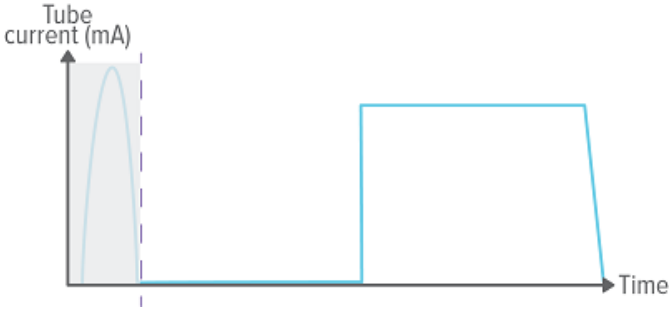
Stop delay setting shorter than the time between pulses (t<T), will result in many short measurements (one for each pulse).

SETTING: IGNORE PREPULSES

Use the ignore prepulses setting to remove one or many unwanted prepulses from the measurement.



Ignore prepulses = 0, the whole exposure is captured.

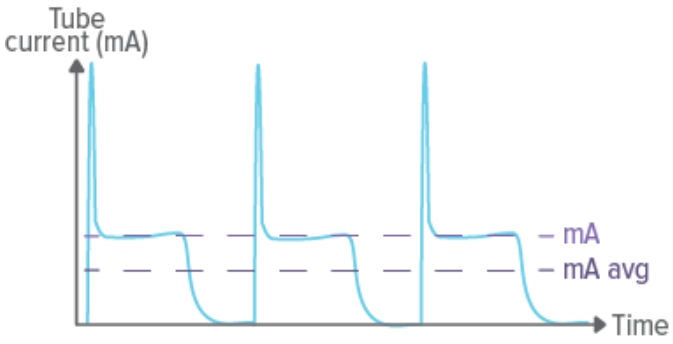


Ignore prepulses = 1, the (first) prepulse is excluded from the measurement.

Note! This setting will affect all parameters, including the dose measurement.

SETTING: MA MODE

Select **mA avg** when you want to measure the average tube current on a pulsed exposure. Otherwise, use **mA**.



Example of the difference between **mA** and **mA avg**.