# ENTRANCE/SKIN DOSE MEASUREMENTS WITH THE RAYSAFE X2 R/F AND X2 CT SENSORS

## INTRODUCTION

Quality assurance of machines with Automatic Exposure Control/Automatic Brightness Control (AEC/ABC) typically includes measurements of the resulting **dose** or dose rate in the primary X-ray beam from the machine at a certain distance from the focal spot of the X-ray tube. For QA measurements of dose, it is the true output from the X-ray tube that should be investigated.

Another important measurement to control is the total absorbed radiation reaching a patient´s skin surface. The entrance/skin dose value also includes backscatter. Entrance/skin dose measurements can be done in several ways, but to get an accurate value, it is important to know how to utilize different devices for this purpose. This application note describes general principles, and how to successfully measure with either the RaySafe X2 R/F or CT sensor. Both can be used, but each sensor has its advantages depending on measurement requirements.

## SKIN DOSE MEASUREMENTS

**Entrance surface air kerma**, $K_e$. is the dose absorbed in the skin of the patient for a specific X-ray exposure. Unlike regular dose measurements, it includes dose from radiation backscattered to the meter, *e.g*. from the body of the patient (represented by a phantom), the examination table and detector. There are a number of ways to measure the total skin dose from direct and scattered radiation, for example:

1. By measuring with a meter that includes backscatter or
2. Make dose measurements with a meter that excludes backscatter, and then manually adjust for the theoretical extra dose contribution from backscatter, $K_e = B\ K_i$.

   *B= Backscatter correction factor. It depends on tube voltage, filtering, HVL value, exposed material and its size. More guidance can be found in IAEA Technical Report #457, Appendix 8.*
   *$K_i$=**Incident air kerma**, which corresponds to the radiation delivered to the surface of a patient´s body from the X-ray tube only (excluding backscatter).*

The properties of the QA meter therefore need to be considered to measure dose and entrance/skin dose correctly:

- A meter that excludes backscattered radiation underestimates the entrance/ skin dose, if the measurement is not compensated for backscatter. Typically, the total dose delivered to the body is 25-50% higher due to backscatter compared to the incoming dose contribution.
- Consequently, the entrance/skin dose will be overestimated if a theoretical backscatter factor is wrongly used for a meter that already includes backscatter.

In addition, the sensor should not affect the measurement itself.

## RAYSAFE SENSORS FOR ENTRANCE/SKIN DOSE MEASUREMENTS

The RaySafe X2 R/F sensor (X2 R/F) and the RaySafe X2 CT sensor (X2 CT) are both suitable for entrance/skin dose measurements.

However, the two sensors have different properties (Table 1) and radiological footprints (Figure 1) that need to be considered.

**Table 1: Selected properties of the X2 R/F and X2 CT sensors.**

| | **X2 R/F** | **X2 CT** |
|---|---|---|
| **Technology** | Silicon PIN diode | Ion chamber |
| **Minimum area to irradiate for dose measurements** | 0.4 cm x 0.9 cm | 10 cm x 1 cm |
| **Backscattered radiation** | Excluded | Included |
| **Measured parameters** | Dose<br>Dose rate<br>Time<br>kVp<br>Half-value Layer (HVL)<br>Total filtration (TF) | Dose<br>Dose rate<br>Time<br>Dose-length product |

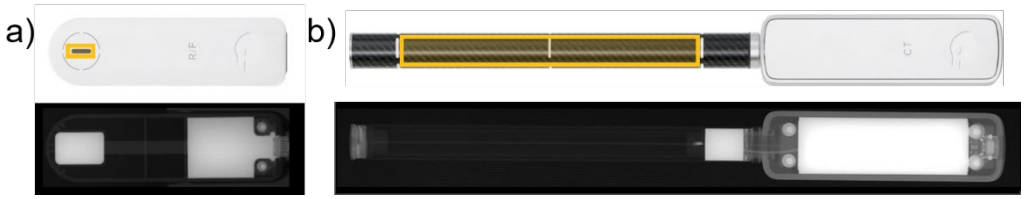



**Figure 1: The active sensor areas and corresponding radiological footprints of the X2 R/F and the X2 CT.**

a) The X2 R/F has an active sensor area of 0.4 cm x 0.9 cm (yellow). The diodes and the electronics part of the sensor are shielded with tin (light areas in X-ray image). Because of its limited size, the X2 R/F sensor does in most cases not significantly affect measurements.
b) The X2 CT has an active sensor area of 10 cm x 1 cm (yellow) that is virtually transparent to X-rays. The electronics part of the sensor is shielded with tin (light areas in X-ray image).

**The X2 R/F** is a silicon diode-based sensor. The diodes are situated inside a tin cage and are shielded from backscatter. Select the X2 R/F sensor when a small active sensor area is beneficial, and you want to measure kVp, and/or dose in the primary X-ray beam, without the contribution from backscattered radiation. Measurements of entrance/skin dose with the X2 R/F require usage of a theoretical factor to include backscattered radiation.

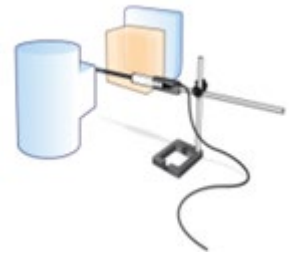
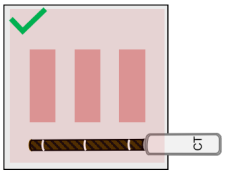
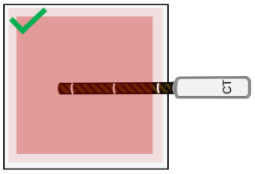
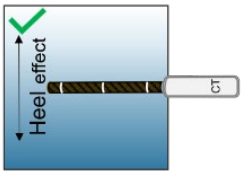
**The X2 CT** is an ion chamber-based sensor without shielding in the sensor area. Select X2 CT if a completely transparent sensor area is needed, and if you want to include backscattered radiation, for instance for entrance/skin dose measurements. Without any compensation!

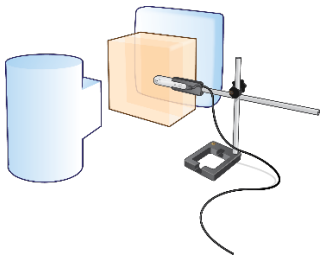
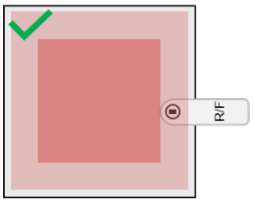
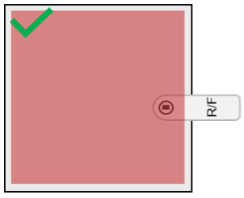
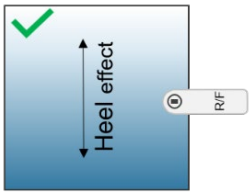
Note! It is important to irradiate the whole active sensor length (100 mm).

## SENSOR SPECIFIC MEASUREMENT CONSIDERATIONS

### Entrance/skin dose measurements, $k_e$ (incoming radiation, including backscatter)

Use a phantom to simulate a patient when measuring the total absorbed radiation dose at the skin surface. To facilitate measurements, place the sensor in its specific holder which can be conveniently fitted to the X2 Flexi Stand and adjusted to a suitable height.

<table>
<tr><th colspan="4">X2 CT Sensor</th></tr>
<tr><td rowspan="2">  </td><td colspan="3">FOR MEASUREMENTS ON X-RAY SYSTEMS WITH AUTOMATIC EXPOSURE CONTROL/AUTOMATIC BRIGHTNESS CONTROL (AEC/ABC)*</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Backscatter is included in the measurement. No correction factor needed.</td><td>If possible, place the active sensor area outside the AEC/ABC area (darker pink in image above).</td><td>Irradiate the entire active sensor area of the X2 CT<br>Just make sure to keep the shielded “non-transparent” parts of the sensor outside the AEC/ABC area (darker pink in image above).</td><td>Place the active sensor area in the middle of the irradiated area, perpendicular to the direction of the heel effect.<br>Especially avoid corners of the radiated area where the heel effect has the greatest impact on measurements.</td></tr>
</table>

| **X2 R/F Sensor** | | |
|---|---|---|
|  | FOR MEASUREMENTS ON X-RAY SYSTEMS WITH AUTOMATIC EXPOSURE CONTROL/AUTOMATIC BRIGHTNESS CONTROL (AEC/ABC)* | |
| |  |  |
| |  | |
| **Backscatter is not included in the measurement. You need to compensate for this using a correction factor $K_e = B K_i$.** | **Place the active sensor area outside of the AEC/ABC area.**<br>If not possible, place only the active sensor area in the direct X-ray field. | **Place the active sensor area in the middle of the irradiated area.**<br>Especially avoid corners of the radiated area where the heel effect has the greatest impact on measurements. The X2 R/F sensor does not have to be perpendicular to the direction of the heel effect as often is the case with sensors of other brands. |

**For further guidance on how to place the sensor and measure correctly on systems with AEC/ABC, please see the "Measurements with the RaySafe X2 R/F and X2 CT sensors on X-ray systems with AEC/ABC" application note.*

## SUMMARY

RaySafe X2 R/F and X2 CT are both suitable for entrance/skin dose measurements:

- To measure total skin dose (backscatter included), choose the X2 CT if the geometry allows to have the whole active length of the sensor in the X-ray field
- If you use the X2 R/F, compensate for backscatter using a correction factor

# CONTACT

Please visit www.raysafe.com for more information.



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