Measurements with the RaySafe X2 R/F and X2 CT sensors on X-ray systems with AEC/ABC

INTRODUCTION

This application note describes how to use the RaySafe X2 R/F and RaySafe X2 CT sensors for dose measurements on X-ray systems with Automatic Exposure Control (AEC) or Automatic Brightness Control (ABC), with focus on:

- Sensor properties
- How to investigate if a sensor drives the AEC/ABC
- How to position sensors for measurements on systems with AEC/ABC

AEC and ABC are radiographic and fluoroscopic X-ray system features that help keep the signal to the image detector constant during a procedure. AEC is used for exposures and ABC for fluoroscopy and cine.

The purpose of the AEC/ABC functionality is to obtain a satisfactory image quality at X-ray procedures, regardless of *e.g.* patient size and focus-to-detector distance. If an object that attenuates X-rays is placed in the AEC/ABC area of the system, the signal is automatically regulated. For exposures (AEC), it is the dose or load that is regulated by changes in charge (mAs). For fluoroscopy and cine (ABC), it is the intensity that changes, by regulations of the tube current (mA) and tube voltage (kV).

Depending on make and model of the X-ray machine, the properties of the AEC/ABC area may vary in terms of size, position, shape and sensitivity (Figure 1). On some machines, the AEC/ABC area can be switched off or controlled. In other cases, for instance on older machines, the presence or properties of the AEC/ABC area may be unknown.

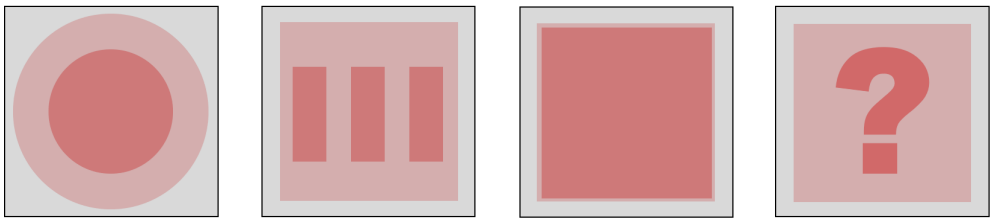

Figure 1: Top-down view from the X-ray source with examples of different AEC/ABC areas (dark red) on the total irradiated area (light red).

If a quality assurance (QA) meter is placed in the AEC/ABC area, it may attenuate X-rays, drive the AEC/ABC of the machine and influence the measurement results. To ensure correct and unbiased values, the properties of the AEC/ABC area as well as the QA meter need to be investigated prior to measurements.

PROPERTIES OF THE X2 R/F AND X2 CT SENSORS

The RaySafe X2 R/F sensor (X2 R/F) and the RaySafe X2 CT sensor (X2 CT) are both suitable for dose measurements on X-ray systems with AEC/ABC. However, the two sensors have different properties (Table 1) and radiological footprints (Figure 2) that need to be considered, in any measurement situation:

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.

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 skin dose measurements.

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

	X2 R/F	**X2 CT**
Technology	Silicon 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 Dose rate Time kVp Half-value Layer (HVL) Total filtration (TF)	Dose Dose rate Time Dose-length product

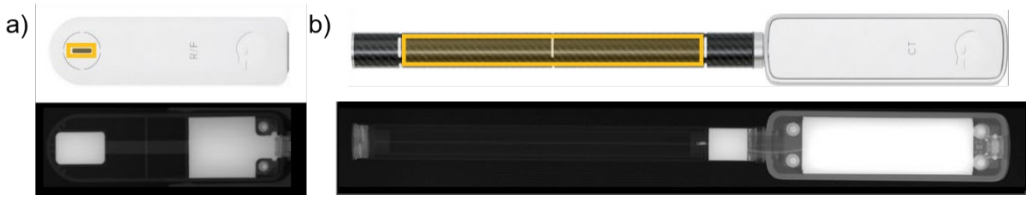

Figure 2: The active sensor areas and corresponding radiological footprints of the X2 R/F and the X2 CT. a) The X2 R/F has an active sensor area of 0.4 cm x 0.9 cm (yellow). The diodes and the electronics part of the sensor are shielded with tin (light areas in X-ray image). **b)** The X2 CT has an active 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).

HOW TO INVESTIGATE IF A METER DRIVES THE AEC/ABC

At measurements on a machine with AEC/ABC functionality, it is good practice to investigate if the QA meter influences the measurement values.

If the AEC/ABC area of the X-ray machine is known:

1) Make an empty exposure, without the sensor in the X-ray field (Figure 3a). Expose until the values given by the X-ray machine (mAs, or mA and kV) are stable. Note the values.
2) Position the meter with the active sensor area in the middle of the AEC/ABC area (Figure 3b). Expose until the machine values are stable and compare with the empty exposure:
   a) **If the values are unchanged:** The meter does **not** drive the AEC/ABC and can be placed anywhere in the primary X-ray field at QA measurements.
   b) **If the values are elevated:** The meter drives the AEC/ABC and should be placed outside the AEC/ABC area (Figure 3c). If this is not possible, place the meter with only the active sensor area in the primary field of radiation (Figure 3d). Make another exposure and compare with the empty exposure to confirm that the values are not elevated.

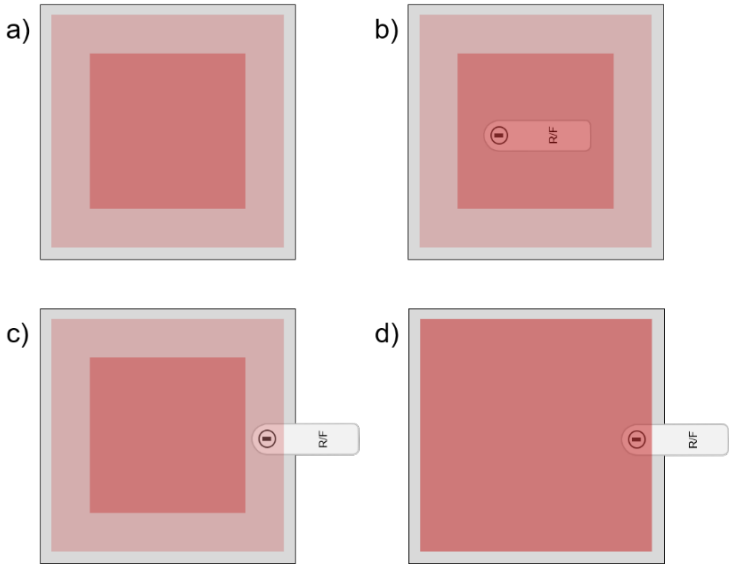

Figure 3: Illustrations of how to investigate if the sensor drives the AEC/ABC. Top-down view from the X-ray source with primary X-ray radiation in light red and AEC area of the machine in darker red. a) Empty exposure to acquire the unbiased machine values for kV/mA/mAs. **b)** The entire X2 R/F sensor placed in the AEC/ABC area. **c)** The X2 R/F sensor placed with the active sensor area in the primary field of radiation but outside the AEC area of the machine. **d)** The X2 R/F placed with only the active sensor area in the AEC area.

If the AEC/ABC area of the X-ray machine is unknown:

1) Make an empty exposure, without the meter in the X-ray field. Expose until the values given by the X-ray machine (mAs, or mA and kV) are stable. Note the values.
2) Position the meter with the active sensor area in the middle of the primary field of radiation. Expose until the machine values are stable and compare with the empty exposure:
   a) **If the values are unchanged:** The meter does **not** drive the AEC/ABC in this position and measurements can be performed as normal.
   b) **If the values are elevated:** The meter drives the AEC/ABC and should be moved. Place the meter with only the active sensor area in the primary field of radiation. Make another exposure to check the machine values and compare with the empty exposure. Repeat until you find a position where the meter does not drive the AEC/ABC. Note the position to save time in future measurements.

Note: The enlargement factor of the machine may change the sensitivity of the AEC/ABC area. Investigate all relevant enlargement factors for your measurements.

SENSOR POSITIONING FOR MEASUREMENTS ON SYSTEMS WITH AEC/ABC

It is not only the properties of the AEC/ABC area and the radiological properties of the sensor that matters. How the sensor is positioned in the AEC/AEC area at measurements also makes a difference.

Figure 4 shows some general examples of how to position the **X2 R/F** at QA measurements on X-ray systems with AEC/ABC functionality, and what to avoid. Remember that the X2 R/F excludes backscattered radiation.

At measurements, the sensor should be positioned such that the entire active sensor area is irradiated but does not drive the AEC/ABC (Figure 4a-d). For exposures, the heel effect may cause measurable differences in dose across the exposed area. Place the sensor such that the influence of the heel effect is minimized. Avoid corners where the heel effect is prominent (Figure 4e-f).

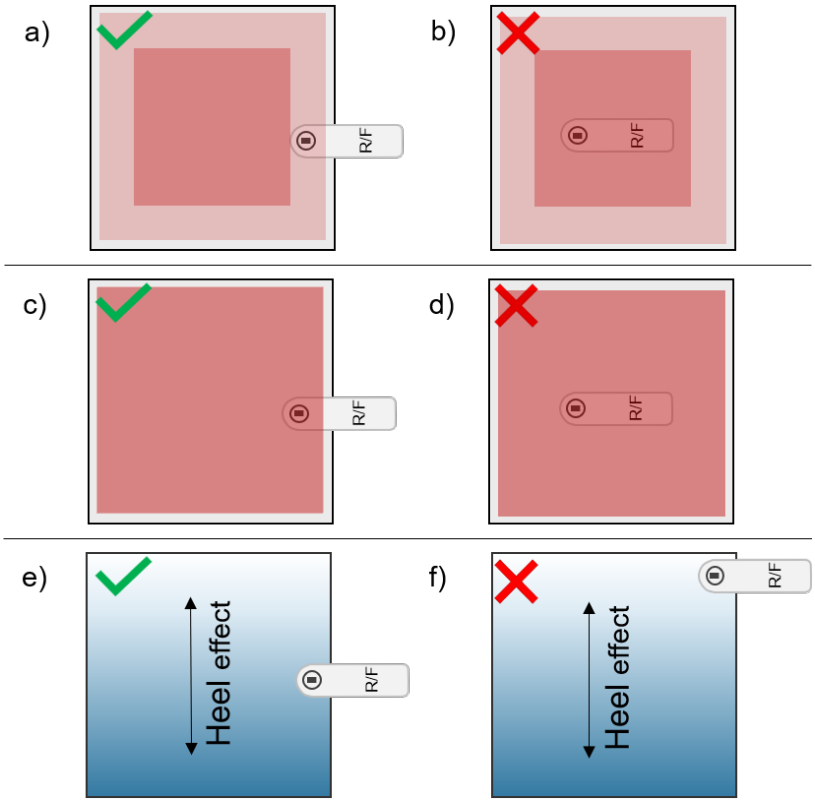

Figure 4: Positioning of the X2 R/F for measurements on X-ray systems with AEC/ABC. Top-down view from the X-ray source with primary X-ray radiation in light red and AEC area of the machine in darker red. Heel effect depicted in blue. a) Place the active sensor area outside of the AEC/ABC area, if possible. **b)** Avoid placing the electronics part of the sensor in the AEC/ABC area. **c)** If the X2 R/F sensor cannot be placed outside the AEC/ABC area, place only the active sensor area in the direct X-ray field. **d)** Avoid placing the radiation shielded, bottom part of the X2 R/F in the AEC/ABC area. **e)** Place the active sensor area in the middle of irradiated area, relative to the direction of the heel effect. **f)** Avoid placing the active sensor area in corners where the heel effect is prominent.

Figure 5 shows general examples of how to position the **X2 CT** at QA measurements on X-ray systems with AEC/ABC functionality, and what to avoid. Remember that the X2 CT includes backscatter.

At measurements, the sensor should be positioned such that the entire active sensor area is irradiated but does not drive the AEC/ABC (Figure 5a-d). For exposures, the heel effect may cause measurable differences in dose across the exposed area. Place the sensor perpendicular to the heel effect such that the influence is minimized. Avoid placing the X2 CT sensor along the heel effect (Figure 5e-f).

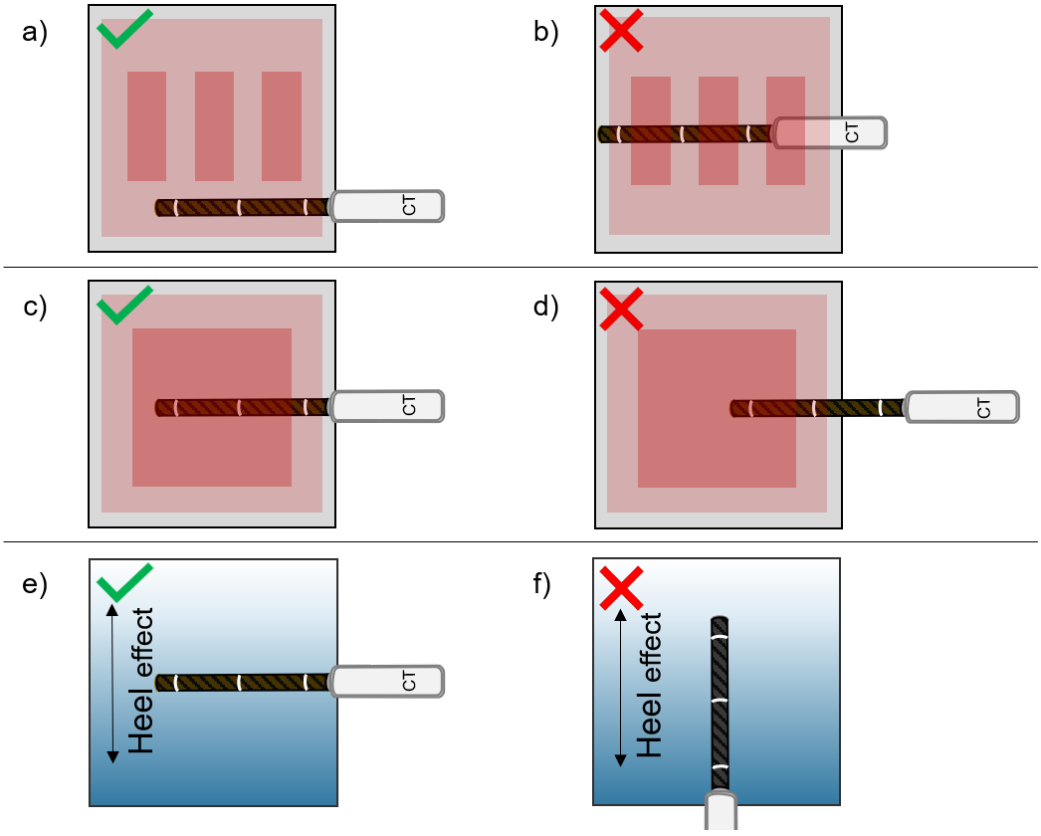

Figure 5: Positioning of the X2 CT for measurements on X-ray systems with AEC/ABC. Top-down view from the X-ray source with primary X-ray radiation in light red and AEC area of the machine in darker red. Heel effect depicted in blue. a) Place the active sensor area outside the AEC/ABC area, if possible. **b)** Avoid placing the radiation shielded (white handle) part of the X2 CT in the AEC/ABC area. **c)** Irradiate the entire active sensor area of the X2 CT. **d)** Avoid partial irradiation of the active sensor area. **e)** Place the active sensor area in the middle of irradiated area, perpendicular to the direction of the heel effect. **f)** Avoid placing the active sensor area along the direction of the heel effect.

SUMMARY

For measurements with the RaySafe X2 R/F and X2 CT sensors on X-ray systems with AEC/ABC functionality, consider the following:

- **Sensor properties:**
  - What is more beneficial for your measurements: The small active sensor area of the X2 R/F, or the larger, transparent sensor area of the X2 CT?
  - Would you like to include or exclude backscatter in your dose measurements?
  - Do you need to measure kVp?
- **Investigate if the sensor drives the AEC/ABC** of the X-ray machine and adjust the sensor position if needed. Remember to check all relevant enlargement factors.
- **Position the sensor correctly:**
  - Place the sensor outside the AEC/ABC area, if possible
  - Ensure that the entire active sensor area is irradiated
  - Adjust the sensor position to minimize the influence of the heel effect

CONTACT

Please visit www.raysafe.com for more information.