Application Note

Quality Control of automatic exposure control systems

This application note describes how to evaluate AEC-systems using the PMX III and oRTIgo.

General description

This application note will apply to the three-field AEC device only.

The automatic exposure control - AEC - systems are designed such that the film obtained from any given radiological examinations would be exposed to yield an adequate density for proper diagnosis. This design criteria indicates that the AEC devices should be capable of producing an acceptable film density, consistently, regardless of

1) the radiation field size
2) the kVp
3) the thickness of the object.

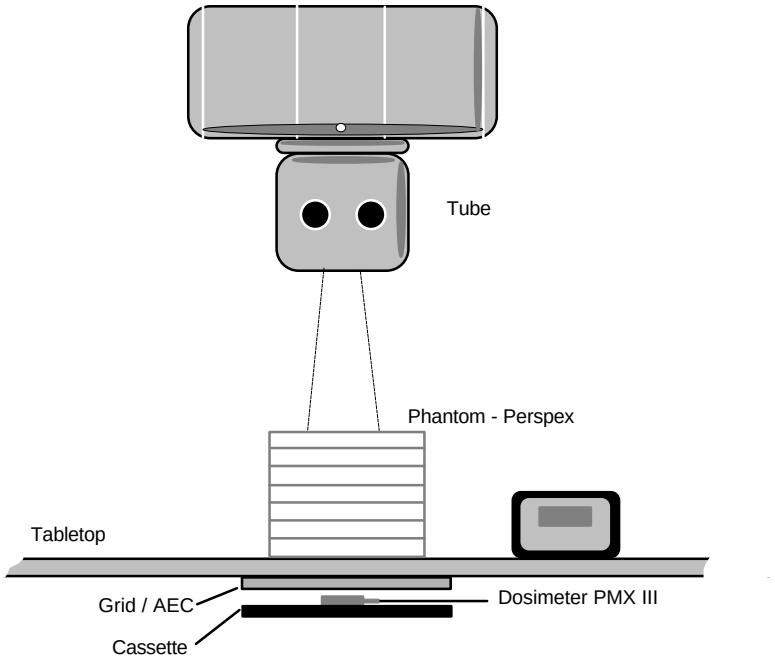

Fig. 1 The set-up for AEC tests

The AEC device

A chest stand or the table Bucky tray is normally equipped with a three-field AEC device. During an exposure, the ion-chambers work as a current source. The ion-chamber amplifier then produces a voltage signal proportional to the induced charge. The signal is fed into a comparator unit and is compared with a pre-set voltage determined by the density control.

When the ion-chamber voltage reaches the pre-set voltage, the exposure will be automatically terminated.

The previously mentioned pre-set, density control voltage is influenced by several factors:

1) The chamber selector
2) The patient thickness correction
3) The kVp-dependence compensation
4) The radiation field size correction
5) The density correction selector
6) The screen-film combination selector

Some of the above mentioned factors are therefore useful quality control check points.

Acceptance test

Most manufacturers perform their calibration of the AEC at 80 or 90 kVp with a given thickness of phantom and phantom material. It is usually 1 or 2 mm Cu or 20 mm Al. The performance level is determined by the film dose obtained. Prior to any dose measurement, one should make sure that the optical density of the film is correct.

Quality Control using the PMX-III + oRTIgo equipment

Equipment needed:

1. PMX III + oRTIgo + computer
2. R100 detector
3. Perspex phantom (5 pcs of 25 x 25 x 5 cm)
4. Lead

When doing measurements using the Perspex, make sure that the radiation field does not exceed the top area of the phantom. Adjust the field size at the empty table ensuring that the chamber/chambers of interest is/are covered. (See fig. 1).

kVp check

Prior to any quality control on the AEC, the kVp must be checked. This is done in the usual manner with the AEC disabled. (bild 1, AEC 0)

Chamber position

Firstly the position of the chambers must be checked. This is done by selecting the different chambers individually and then covering the selected chamber with lead. The position is usually indicated by the light-field.

1. Use settings 80 kVp and AEC.
2. Choose a chamber and cover it with lead.
3. Make an exposure.

The resulting exposure time and mAs-value should be comparably large.

4. Proceed with the other chambers.

The most common error is that the left and right chambers are shifted.

Please observe that the chamber positions can be shifted in those cases where investigations are made on the patient's backside.

Reproducibility check - AEC 1

To make sure that you can trust the measurement values you are about to convey it is important that the reproducibility of the AEC is checked. If the X-ray unit fails at this stage, it is virtually useless to carry on. If the system passes however, you don't have to make more than one measurement on every setting.

1. Choose the Middle chamber and 80/81 kVp.
2. Insert a cassette if necessary and make 5 exposures in a row. No phantom material is necessary for this test.
The dose values obtained should not result in a variation coefficient of more then 10 %.

bild 2, AEC 1

Relative chamber response - AEC 2

It is absolutely essential that the different chambers and their combined response is correct to ensure a correct optical density and minimise the retake frequency. The relative chamber response test can also sometimes resolve a faulty grid or a non-aligned tube. By using 20 cm of Perspex and then consecutively choose the different chambers and combinations in order. Any deviation larger than approx. +/- 28 % from the middle chamber is not acceptable. Please note than some manufacturers deliberately sets the L and R chamber to a lower sensitivity, i.e. a higher dose value in order to compensate for the divergence of the field and the usually higher density material obscuring the middle chamber. This offset can be as high as the maximum deviation acceptable. On some equipment it is not possible to choose L + R without inserting a 35 x 35 cm cassette and it is generally a good idea to choose this format from the very beginning and use it throughout the test.

bild 3, AEC 2

Thickness correction - AEC 3

1. The dose value is obtained for 80/81 kVp with increments of 0 through 25 cm with increments of 5 cm.
2. The dose value thus obtained from the measurement on 15 cm is regarded as a reference (or whichever one prefers). This value is keyed in manually in the template to obtain the calculated deviation resulting from different thickness.

Most systems have difficulties in keeping the dose level at appropriate values for thin patients. Acceptable dose deviation is approx. +/- 28 % which equals one step in the mAs-scale discernible for the eye observing an X-ray film.

bild 4, AEC 3

Density correction - AEC 4

The density correction function can be used in those cases the picture contrast should not be altered. (The contrast is kVp dependent). It is also used to compensate for unlinear AEC systems where especially thin patients may cause a problem. Every full step equals one step in the mAs-scale, i.e. it affects only the optical density and nothing else. On some modern equipment there can be halfsteps *and* fullsteps ranging from -4 to +4. It is an impossible task to verify all these and consequently only the clinically relevant settings should be chosen.

The measurement is carried out by using 20 cm Perspex, 80/81 kVp and chamber M Insert a cassette if necessary.

1. Use oRTIgo as usual and move the cursor in the AEC-4 template to the row indicating a zero correction.
2. Make an exposure.
3. Type in the value at the "mAs set" to set the reference dose. Continue with the other density correction steps. Every full step should deviate yet another 28 % from the reference.

Bild 5, AEC 4

Patient thickness correction - AEC 5

On some equipment it is possible to correct manually for the patient thickness. There are usually three or five levels of thickness. When choosing a thickness deviating from normal, the generator automatically changes the kVp settings. This is pre-programmed and has to be evaluated practically. The same acceptance criteria are valid as for the thickness correction.

1. The dose value is obtained for different thickness with increments of 5 through 25 cm with increments of 5 cm (or 10 if there are three levels).
2. The dose value thus obtained from the measurement on 15 cm is regarded as a reference (or whichever one prefer).
3. This value is keyed in manually in the template to obtain the calculated deviation resulting from different patient thickness correction. Any deviation larger than approx. +/- 28 % from the reference value is not acceptable.

Bild 6, AEC 5

Screen combination correction - AEC 6

This type of correction resembles the density correction but is specialised for the type of screen used. The speed of the screen is inverted proportional to the dose needed to achieve the optical density 1.00, i.e. a "400" screen (fast) needs less dose than a "250" (medium).

The measurement is carried out by using 20 cm Perspex, 80/81 kVp and chamber M Insert a cassette if necessary.

1. Use oRTIgo as usual and move the cursor in the AEC-6 template to the row indicating the reference screen, i.e. most used screen.
2. Make an exposure.
3.Type in the value at the "mAs set" to set the reference dose. Continue with the other screens. Compare "speed" values to the values given by the manufacturer.
The most common error is that there only exist one screen correction regardless of how many choices there are. When there is only one screen type available, the unused buttons should then be disabled to avoid confusion.

Bild 7 - AEC 6