4. Compliance requirements: Bone mineral densitometry

4.1. Radiation warning sign

4.1.1 A radiation warning sign complying with Schedule 6 of the Regulation **must** be displayed on the outside of the entry doors to any room in which a bone mineral density apparatus is installed.

4.2. Markings on X-ray generators and tube assemblies

4.2.1 X-ray generators and tube assemblies **must** be permanently marked in English and the markings **must** be clearly visible.

4.2.2 X-ray generators **must** bear either:

a. the name or trademark of the manufacturer,
b. the type or model number,
c. the serial number, OR
d. an EPA-generated number that links to (a), (b) and (c).

4.2.3 X-ray tube assemblies **must** bear either of the following markings in a visible position:

a. the name or trademark of the manufacturer of the X-ray tube housing,
b. the type or model number of the X-ray tube housing,
c. the serial number of the X-ray tube housing, OR
d. an EPA-generated number that links to (a), (b) and (c).

4.3. Quality assurance program

4.3.1 A quality assurance (QA) program **must** be instituted and maintained.

4.3.2 The program should ensure that consistent, optimum-quality images are produced so that the exposure of patients, staff and the public to radiation satisfies the ‘as low as reasonably achievable’ principle.

4.3.3 QA procedures **must** be standardised and documented in a QA manual.

4.3.4 The manufacturer’s recommended QC program should be followed. This program should include daily calibration of BMD before clinical use. CRE **must** examine the daily calibration results to determine whether the repeatability of BMD results is within the manufacturer’s limits.

4.3.5 The practice should have a control chart or data used for tracking BMD variations and an action plan to address variations.

4.3.6 Equipment should be maintained and serviced according to manufacturer’s recommendations. The service frequency should be at least annually.

5. Test protocols

5.1. Kilovoltage accuracy and reproducibility

Aim

- To determine how the measured kVp compares with the generator setting.
- To determine the variation in mean kVp over a number of exposures at the same generator setting.

Exposure factors

- kVp accuracy: Variable kVp, fixed mA and fixed time (e.g. 200 mA, 0.1s) or fixed mAs.
- kVp reproducibility: Fixed kVp, fixed mA and fixed time or fixed mAs.

Method

- Position the dosimeter at the distance recommended by the manufacturer.
- Collimate to the size of the dosimeter.
- Make a series of exposures across the clinically used kVp range and calculate the difference between the set and measured kVp.
- Make a minimum of three exposures at fixed kVp, mA and time (e.g. 70 kVp, 200 mA, 0.1s) and calculate the coefficient of variation from the quotient of the standard deviation (σ) and mean ($\bar{\mathbf{x}}$)

$$\textbf{Coefficient of variation} = \frac{\boldsymbol{\sigma}}{\bar{\mathbf{x}}}$$

Compliance requirement

See section 2.3.

Notes

- Do not use times below 0.1 seconds.
- Follow manufacturer recommendations regarding orientation of the dosimeter with respect to the anode-cathode axis of the X-ray tube.

5.2. Exposure timer accuracy and reproducibility

Aim

- To determine how the measured exposure time compares with the set time.
- To determine the variation in exposure time over a number of exposures at the same generator setting.

Exposure factors

- Exposure timer accuracy: Fixed kVp, fixed mA, (e.g. 70 kVp, 200 mA) variable time.
- Exposure time reproducibility: Fixed kVp, fixed mA and fixed time.

Method

- Position the dosimeter at the distance recommended by the manufacturer.
- Collimate to the size of the dosimeter.
- Make a series of exposures commencing at the clinically used shortest exposure time, then across the range of commonly used timer settings up to 0.5 seconds and calculate the difference in selected and measured time.
- Make a minimum of three exposures at fixed kVp, fixed mA and time (i.e. 70 kVp 200 mA, 0.1 s or similar) and the calculate the coefficient of variation.

Compliance requirement

See section 2.4.

Notes

This test is not required for apparatus where mAs is selected as a single component.

5.3. Radiation output reproducibility

Aim

To determine the variation in radiation output over a number of exposures at the same generator setting.

Exposure factors

70 kVp, 20 mAs or similar.

Method

- Position the dosimeter at a fixed distance (75-100 cm) from the focal spot or at the distance specified by the manufacturer. Record the distance used.
- Place a lead sheet under the dosimeter to minimise backscatter (if applicable; note that some dosimeters are lead-backed).
- Collimate the beam to the size of the dosimeter.
- Make a minimum of three exposures and calculate the coefficient of variation.

Compliance requirement

See section 2.5.1.

Notes

If a unit fails output reproducibility other measurements may be meaningless.

5.4. Radiation output linearity with mA or mAs

Aim

To determine the linearity of the radiation output over a range of mA or mAs settings.

Exposure factors

70 kVp or similar, variable mA, 0.1 s or variable mAs.

Method

- Position the appropriate dosimeter at a fixed distance (75-100 cm) from the focal spot or at the distance specified by the manufacturer. Record the distance used.
- Place a lead sheet under the dosimeter to minimise backscatter (if applicable; note that some dosimeters are lead-backed).
- Collimate the beam to the size of the dosimeter. Make a series of exposures at as many mA or mAs settings as practicable, covering the clinically used range.
- Calculate μGy/mAs (X) by dividing output by the nominal mAs.
- Determine X_{max} and X_{min}
- Calculate the coefficient of linearity:

$$\text{Coefficient of linearity} = \frac{X_{max} - X_{min}}{X_{min} - X_{max}}$$

- The coefficient of linearity **must** not exceed 0.1.

Compliance requirement

See sections 2.5.2 and 2.5.3.

Notes

- kVp should be measured at each mA setting to assess kVp compensation.
- Linearity should be measured for both/all focal spot(s) sizes as μGy/mAs may vary.

5.5. Half-value layer

Aim

To assess the X-ray beam quality and determine the adequacy of filtration.

Exposure factors

Fixed kVp (i.e.70–100), fixed mAs (e.g 20 mAs).

Method

- Remove all optional or easily removable filtration.
- Position the dosimeter at a fixed distance (75-100 cm) from focal spot or at the distance specified by the manufacturer. Record the actual distance used.
- Place a lead sheet under the dosimeter to minimise backscatter (if applicable; note that some dosimeters are lead-backed).
- Collimate the X-ray beam to the size of the dosimeter.

If using direct meter reading

- Make an exposure and record the HVL from the dosimeter.

If using filters and air kerma measurements

- Make three exposures with no filters added (free in air), then calculate the mean air kerma.
- Position a 1 mm thick aluminium filter between the X-ray tube and dosimeter, make an exposure and record the air kerma.
- Repeat the exposures with additional aluminium filters until the measured air kerma falls to less than 50% of the unfiltered air kerma value.

- Plot air kerma against filter thickness using a semi-log scale.
- From the plot, determine the thickness of aluminium corresponding to half of the mean unfiltered air kerma.

Compliance requirement

See section 2.6.1.

Notes

- kVp should be checked before HVL assessment.
- Ensure the entire X-ray beam is intercepted by the filters.
- If the kVp selected for the HVL assessment is different from those listed in **Table 2**, use linear interpolation to estimate the minimum HVL required for compliance.
- If the measured HVL is compliant with this requirement at a single set tube voltage, it is assumed that it is compliant at all available tube voltages.

5.6. Dead-man exposure switch

Aim

To ensure that the exposure is terminated by removing pressure from the exposure switch.

Exposure factors

Low kV, mA, long exposure time (e.g. 0.5 seconds).

Method

- Position the dosimeter in the primary beam at 50 cm or similar from focus.
- Initiate an exposure and release the switch before the exposure terminates.
- Radiation emission **must** cease when the switch is released.
- The dosimeter will indicate the time taken for the exposure to terminate.

Compliance requirement

See section 2.8.

5.7. Backup/Guard timer

Aim

To ensure that the guard timer and/or backup timer are functioning, and the backup time or post exposure mAs do not exceed the specified tolerances.

Exposure factors

Low kVp (e.g. 40-50 kVp).

Method

- Cover the selected AEC sensor with the lead.
- Place the dosimeter in the beam.

- Make an exposure and record the displayed post exposure mAs and the measured exposure time.

Compliance requirement

See section 2.9.2.

Notes

- Use a low mA setting to test time cut off.
- Use a high mA setting to test for mAs cut-off.
- Some systems will activate the guard timer and an error message will be displayed indicating that the dose rate was insufficient to produce a clinical image.

5.8. Automatic Exposure Control reproducibility

Aim

- To assess the variation in radiation output and exposure time for a number of exposures of the same object under AEC.
- To assess the percentage difference in sensitivity of lateral AEC sensors.

Exposure factors

80 kVp, 200 mA or similar.

Method

- Place 1mm of copper or another appropriate absorber at the tube head.
- Place the dosimeter in the beam. If a lead backed dosimeter is used, ensure that the dosimeter is not situated directly in front of the selected AEC sensor.
- Set the SID and focal spot size to typical clinical conditions.
- Select the central AEC sensor and expose.
- Record the measured air kerma, post exposure mAs and displayed air kerma area product (KAP), if available.
- Repeat twice.
- Repeat for all other AEC sensors.
- Calculate the coefficient of variation for all recorded parameters for each AEC sensor.
- Calculate the percentage difference in either the post exposure mAs and measured air kerma of the lateral AEC sensors (Y_{left} and Y_{right}).

$$\text{Percentage difference (\%)} = \frac{|Y_{left} - Y_{right}|}{Y_{mean}} \times 100$$

Compliance requirements

See section 2.9.3 and 2.9.4.

Notes

- For CR, the dosimeter can be placed inside the Bucky next to the CR cassette.
- For DR, the dosimeter should be placed on the detector housing at the periphery of the beam to ensure it does not cover any of the AEC sensors. Ideally the grid should be removed

- At acceptance, any combinations of AEC sensors used clinically should be assessed.
- An estimation of the AEC detector air kerma (DAK) can be made by applying a distance correction and grid factor (if a grid is present) to the air Kerma measurement.
- Use identical technique factors when assessing difference in sensitivity of lateral sensors.
- If there are a total of five AEC chambers, the lateral sensors can be grouped into a left and right pair.

5.9. Automatic Exposure Control: kVp and thickness compensation

Aim

To ensure that the AEC device controls exposure such that the exposure index (EI) is within 20% of the mean EI when both kVp and patient thickness are varied.

Exposure factors

Variable kVp, AEC exposure.

Method

- Place an appropriate absorber at the patient position (10 or 15 cm water or PMMA phantom is recommended).
- Undertake an exposure at a clinically utilised kVp using the central AEC sensor and record the EI. Repeat the measurements by varying the kVp across the clinical tube potential range (e.g. 60, 70, 80 etc.).
- Repeat the measurements at 70 kVp by varying the attenuator thickness to mimic the range of attenuations found clinically (e.g. 5 cm, 10 cm, 15 cm & 20 cm of PMMA).
- Determine the mean EI across the kVp range and the mean EI across the range of attenuator thicknesses.
- Determine if the variation in each EI measurement is within 20% of the respective mean EI.

Compliance requirements

See section 2.9.5.

Notes

- Collimation **must** be fixed during the test as the EI may change with variations in collimation.
- The grid should be present in the beam.
- The relationship between the EI and DAK is not always linear. For non-linear systems, the relationship between the EI and DAK can be obtained simultaneously with the system STP in section 2.10.2. The inverse of this relationship can then be used to linearise the EI measurements to DAK_{EI} which will enable them to be used quantitatively (see Appendix 1). In this case, each DAK_{EI} value should be within 20% of the mean $DAK_{EI.}$

5.10. Digital image receptors: Signal transfer properties

Aim

To establish the relationship between DAK and mean pixel value (MPV) on digital detectors.

Exposure factors

70 kVp, various mAs.

Method

- Set the X-ray tube above the table top or floor and place the dosimeter in the centre of the X-ray beam at a minimum distance of 130 cm from the tube focus.
- Collimate the X-ray beam to the size of the dosimeter.
- Place an absorber (1 mm copper) at the collimator.
- Make a trial exposure and establish the mAs setting required to result in an air kerma of approximately 10 µGy. Measure the air kerma at a range of mAs settings (typically 1, 4, 10 and 20 µGy).
- Remove the dosimeter and position the detector at the same distance from the focus. The detector should ideally be placed onto a lead apron to minimise backscatter.
- Remove the copper or absorber used and open the collimator to fully cover the detector. Put the absorber back on the collimator.
- Select the acquisition protocol that produces images with minimal clinical processing (flat-field images).
- Expose the entire detector using the mAs pre-set estimated above to give a DAK of ~1 µGy. Draw a region of interest (ROI) of approximate size 2 cm x 2 cm in the centre of the image and record the MPV.
- Repeat the above procedure using the mAs presents required to give a range of DAK's of ~ 4, 10 & 20 µGy.
- Plot the relationship between DAK and MPV and obtain the detector's STP.

Compliance requirements

See section 2.10.2.

Notes

- Some detectors are integrated into a Bucky/housing that may incorporate a fixed grid. The air kerma measurements will overestimate the DAK on these systems. However, this will not affect the methodology used to ascertain the STP of the detectors.
- ROI analysis can often be completed within the software on the acquisition workstation. However, detectors from certain vendors will require the images to be viewed and analysed on a reporting workstation.
- The exposure index may also be recorded following each exposure. This will enable the relationship between the DAK and EI to be established.

5.11. Digital image receptors: Uniformity and artefacts

Aim

- To quantify the uniformity of the recorded signal from a uniformly exposed digital detector.
- To visually inspect a uniform image for the presence of artefacts.

Method

- View the image obtained in Test 5.10 taken with a DAK of ~ 4 µGy on an appropriate reporting workstation.
- Visually inspect the image using 1:1 magnification and a narrow window width to identify any artefacts.

- Draw five ROI's of an approximate size of 2 cm x 2 cm, one in the centre of the image and one in the centre of each quadrant. Record the MPV in each ROI.
- Calculate the mean of the MPV's across the five ROI's.
- Calculate the percentage difference between each of the 5 ROI MPV's from the calculated mean MPV.

Compliance requirements

See section 2.10.3 and 2.10.4.

Notes

- If the detectors STP established in test protocol 5.10 is not linear, use the inverse of the STP equation to linearise pixel values to DAK_{MPV} (see Appendix 1).
- ROI analysis can often be completed within the software on the acquisition workstation. However, detectors from certain vendors will require the images to be viewed and analysed on a reporting workstation.

  To identify any areas of blurring, line defects or stitching artefacts, an image of a fine wire mesh can be obtained using a low kVp (50 kV, 2.5mAs, no copper in the beam) and viewed on a reporting monitor.

5.12. Digital image receptors: Exposure index

Aim

To ensure that the detector EI is repeatable.

Method

- Repeat the 4 µGy exposure in test protocol 5.10 three times and record the EI each time.
- Calculate the coefficient of variation in the EI measurements.

Compliance requirements

See section 2.10.5.

Notes

- For systems with a non-linear EI relationship with DAK, the displayed EI's will need to be linearised to DAK_{EI} prior to being used quantitatively.
- To determine the accuracy of the displayed EI, it is recommended that the manufacturer methodology (where available) is adopted.

5.13. Leakage radiation

Aim

To measure any leakage radiation through the X-ray tube assembly and beam limiting device.

Exposure factors

Maximum clinical kVp, with appropriate mAs (time should not exceed one second). Ensure tube rating is not exceeded.

Method

- The collimator should be fully closed or covered with ~ 3 mm of lead.
- Position the dosimeter at 1m from focal spot. Make a series of exposures to measure leakage at various positions, including the cathode, the anode and the front of tube assembly. Distances other than 1m may be used providing an inverse square law correction is applied.
- Calculate the time averaged leakage using the manufacturer recommended continuous mA rating at the kVp used for the measurement or alternatively, use tube cooling curve data.

Compliance requirements

See section 2.12.1 and 2.12.2.

Notes

- An incorrectly positioned X-ray tube insert or flaws in the lead shielding in a housing may give rise to narrow but intense beams of leakage radiation which fail to ionise the entire chamber and therefore appear not to exceed the specified limit; such beams are highly undesirable, and the cause should be remedied.
- Pinhole leaks or 'hotspots' can be detected by the use of a fluorescent screen or non-screen film wrapped around the X-ray tube assembly.

5.14. Collimation

Aim

- To ensure coincidence of the radiation field with the light field.
- To ensure the alignment of the centre of the light field with the centre of the imaged field.
- To ensure the alignment of the centre of the light field with the image receptor housing markings (when the centre of the image receptor is marked on the receptor housing).
- The X-ray field **must** not exceed the size of the image receptor at the image receptor plane by > 1% of the source to image distance (SID) (when there is provision for automatic adjustment of the collimator).

Exposure factors

60 kVp, 5 mAs or similar.

Method

- Align the X-ray tube to the centre of the detector and set the SID to 100 cm from the focus to the detector plane. The tube detents should be used for positioning when available.
- If the centre of the detector is marked on the housing, calculate the misalignment of the crosswire of the light field with the detector housing markings.
- Place the beam alignment test tool on the detector housing with its central axis aligned with the crosswire of the light field.
- Adjust the light field to alignment markers on test tool or collimate to approximately two-thirds of the detector size and use metal markers to delineate the four edges of the light field.
- Mark either the cathode or anode end of the tube for orientation purposes.
- Expose and process the image.
- Calculate the misalignment between the radiation field and light field for all edges.

- Measure the distance from the centre of the image of the test object to each of the four edges of the image. Calculate the misalignment between the centre of the light field and the centre of the imaged field.
- If the automatic adjustment of the collimator to the size of the detector is available, confirm that the light field does not exceed the detector at the detector plane by > 1% of the SID.

Compliance requirements

See section 2.14.3, 2.14.4 and 2.14.5.

Notes

- At acceptance and following the replacement of an X-ray tube, the above procedure should be completed using all available focal spot sizes.
- Apply an appropriate correction for magnification if a test tool or alignment markers are placed on the detector housing.
- X-ray assembly and collimator should be visually inspected to assess the perpendicularity before starting alignment test.
- If the alignment of the radiation field and light field is within tolerance, the light field can be used for the purposes of assessing compliance with clause 2.14.5 b.

5.15. Accuracy of air kerma area product meter

Aim

To ensure the accuracy of the KAP meter for patient dosimetry audits.

Exposure factors

Variable kVp (e.g. 60, 80 or 100), 10 mAs or similar.

Method

- Position the X-ray tube over a table and collimate to ~ 10x10 cm at a distance of 100 cm from the focus of X-ray tube.
- Place the dosimeter at the centre of the X-ray beam.
- Expose using 60 kVp and 10 mAs and record the measured air kerma and displayed KAP.
- Remove the dosimeter and position a CR cassette or portable digital detector at the centre of the X-ray beam without changing distance or collimation.
- Expose using a low level of radiation (direct exposure of digital detectors should be avoided).
- Process the image and measure the irradiated area.
- Multiply the measured air kerma by the measured irradiated area to calculate KAP.
- At acceptance, the above procedure should be repeated at another clinically utilised kVp and using a different collimated area.

Compliance requirements

See section 2.15.2.

Notes

- Be aware of the different KAP units and apply any necessary corrections when comparing the measured and displayed KAP.

- If the X-ray and light field alignment is already established, the exposed area may be inferred using the light field.
- Some systems will not display a KAP unless a digital image receptor has been directly exposed. If this is the case, lead should be used to cover the image receptor when measuring the air kerma using a lead backed dosimeter.

Schedule 1: Compliance requirements for medical radiography apparatus

The clauses contained in this Schedule are the requirements referred to in condition 4.1 of radiation management licence which the apparatus **must** meet for compliance.

Requirements or Condition	Clause(s)
Advice to person responsible	1.1.1, 1.1.3, 1.1.6, 1.1.8, 1.1.9,
Advice to CRE	1.2.1, 1.2.5
System Performance	2.1.1
Radiation warning sign	2.2.1, 2.2.2, 2.2.3
Accuracy of kilovoltage controls	2.3.1, 2.3.2
Accuracy of timer controls	2.4.1, 2.4.2
Exposure consistency and linearity	2.5.1, 2.5.2, 2.5.3
Filtration	2.6.1, 2.6.2, 2.6.3
Indicators of operation	2.7.1, 2.7.3
Exposure switch	2.8.1, 2.8.2, 2.8.3, 2.8.4
Automatic exposure control	2.9.1, 2.9.2, 2.9.3, 2.9.4,
Digital detectors	2.10.1, 2.10.2 2.10.3, 2.10.4, 2.10.5,
Control of multiple X-ray tubes	2.11.1
Leakage radiation	2.12.1, 2.12.2
Markings on X-ray generators etc.	2.13.1, 2.13.2, 2.13.3
Control of primary beam during radiography	2.14.1, 2.14.2, 2.14.3, 2.14.4, 2.14.5, 2.14.6,
Provision of an air kerma area product meter	2.15.2
Stability of X-ray tube assembly	2.16.1
Stability of mobile apparatus	2.17.1
Capacitor discharge apparatus	2.18.1, 2.18.2, 2.18.3, 2.18.4, 2.18.5, 2.18.6
Quality assurance program	3.1.1, 3.1.3
Wet film processing	3.5.3

Schedule 2: Compliance requirements for bone mineral densitometry apparatus

The clauses contained in this Schedule are the requirements referred to in condition 4.1 of radiation management licence which the apparatus **must** meet for compliance.

Requirements or Condition	Clause(s)
Advice to person responsible	1.1.1, 1.1.3, 1.1.6, 1.1.8, 1.1.9, 1.1.10
Advice to CRE	1.2.1, 1.2.5,
Radiation warning sign	4.1.1
Markings	4.2.1, 4.2.2, 4.2.3
Quality assurance program	4.3.1, 4.3.3, 4.3.4

Appendix 1

(a) Digital detectors: Signal Transfer Property

In order to obtain meaningful quantitative measurements, a digital detector system **must** have a linearisable relationship between detector air kerma (DAK) and mean pixel value (MPV). This relationship defines the signal transfer property (STP) of the detector. A simple STP relationship (linear, logarithmic or power) should be obtained as specified in compliance test 2.10.2. The equations for these STP relationships and their respective inverses are shown below, where a, b and c are constants, and DAK_{MPV} is the MPV linearised with DAK.

Linear: $MPV = a + bDAK \rightarrow DAK_{MPV} = \left(\frac{MPV-a}{b}\right)$ [A1.1]

Logarithmic: $MPV = a\mathbf{ln}(DAK) + b \rightarrow DAK_{MPV} = exp\left(\frac{MPV-b}{a}\right)$ [A1.2]

Power: $MPV = aDA\mathrm{K}^{\mathrm{b}} + c \rightarrow DAK_{MPV} = \left(\frac{(MPV-c)}{a}\right)^{\frac{1}{b}}$ [A1.3]

The inverse STP equations above can be used to obtain the linearised DAK_{MPV} values required for compliance tests 2.10.2 and 2.10.3.

(b) Digital Image Receptors - Exposure Index

Compliance test 2.10.5 requires the repeatability of the exposure index (EI) to be assessed by calculating the coefficient of variation in the EI from a series of exposures. If the detector has a non-linear relationship between DAK and EI, the EI **must** be linearised with DAK.

The EI can simply be interchanged for the MPV in the appropriate equation (A1.1, A1.2 or A1.3) to obtain a linearised EI (DAK_{EI}). The EI measurements can be completed simultaneously using the exposures taken during compliance test 2.10.2.

(c) Automatic Exposure Control - Exposure Index

Compliance test 2.9.6 requires that the EI is recorded and used to check the consistency of the automatic exposure control (AEC) function when varying both tube potential and water/PMMA thickness placed at the patient position. The EI values for all exposures should not vary by more than 20% from the mean EI. This quantitative analysis requires a linear relationship between DAK and EI.

If the detector has a non-linear relationship between DAK and EI, the EI **must** be linearised with DAK. The relationship between DAK and EI established in compliance test 2.10.5 can be used to infer DAK_{EI} from the measured EI values when operating under AEC with the absorber placed at the patient position.

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Definitions

In this standard:

Absorbed dose means energy delivered from radiation per unit mass of absorbing material, measured in Gray (Gy) or mGy. One Gray equals one joule per kilogram.

Act means the *Radiation Control Act 1990*.

AEC means automatic exposure device.

Air kerma means *kerma* measured in a mass of air.

Added filtration means quantity indicating the filtration affected by added filters in the useful beam but excluding inherent filtration.

Authority means NSW Environment Protection Authority.

Barrier means a protective wall of radiation attenuation material(s) used to reduce the dose equivalent on the side beyond the radiation source.

Coefficient of variation means the standard deviation divided by the mean of a set of numbers.

Coefficient of linearity = $(X_{max.} - X_{min})/(X_{min.} + X_{max})$

Council means the Radiation Advisory Council.

CRE means Consulting Radiation Expert.

Detector air kerma (DAK) is the kerma measured in a mass of air at the position of the radiographic detector.

Deviation Index is a parameter which quantifies the deviation of an actual exposure index from the appropriate exposure index (called target exposure index) as defined in IEC 62494-1. $D = 10.\log \{EI/EI_T\}$ where D is the deviation index, EI is the actual exposure index and EI_T is the target exposure index.

EPA means NSW Environment Protection Authority.

Exposure Index is a number which is a measure of the detector response to radiation in the relevant region of an image acquired with a digital X-ray imaging system.

Filtration means modification of the spectral distribution of an X-ray beam as it passes through matter by the differential absorption of poly-energetic photons.

Focal spot means the area of the *target* from which X-rays are emitted.

Half-value layer (HVL) means the thickness of a specified material that reduces the absorbed dose in air of a given X-ray beam to half its original value.

Inherent filtration means the *filtration* affected by the irremovable materials of an *X-ray tube assembly* (i.e. glass, oil and port seal), through which the radiation beam passes before emerging from the X-ray tube assembly. It is expressed in terms of thickness of a reference material that, at a specified potential difference and waveform, gives the same radiation quality in terms of *half-value layer*.

Kerma (K) means kinetic energy released in a material by ionising radiation and is determined as the quotient of dE_{tr} by dm, where dE_{tr} is the sum of the initial kinetic energies of all the charged

ionising particles liberated by uncharged ionising particles in a material of mass dm ($K = dE_{tr}/dm$). The unit of kerma is the Gray (Gy), or joule per kilogram.

KAP means air kerma-area product i.e. air kerma multiplied by radiation area. The KAP value may be displayed on the operator's console, or on a separate kerma-area product meter. The units of KAP are typically $Gy.cm^2$, or similar e.g. $mGy.cm^2$, $cGy.cm^2$, $\mu Gy.m^2$. It is important to make a note of the units when conducting a patient dosimetry audit.

Kerma rate means kerma per unit time and is determined as the quotient of dK by dt, where dK is the increment of kerma in the time interval dt. Variants include incident air kerma rate (does not include backscattered radiation) and entrance surface air kerma rate (includes backscattered radiation).

Lead equivalent means the thickness of lead causing the same attenuation of a beam of a specified radiation quality as the material under consideration.

New installation means a completely new build or modifications to barriers in an existing room.

Optical density (OD) means the degree of film blackening produced during development, where optical density is the log of the reciprocal of the fraction of light transmitted through the blackened film.

Operator means a person licensed under section 7 of the Act to use ionising radiation apparatus.

Person responsible means as defined in section 6 of the Act.

Phantom means a test object that simulates the average composition of various structures.

Primary beam means all ionising radiation that emerges through the specified aperture of the protective shielding of the X-ray tube and the collimating device.

Radiographic apparatus means ionising radiation apparatus, which emits ionising radiation, used for the purpose of radiography.

Radiation leakage means ionising radiation transmitted through the protective shielding of a radiation source other than the primary beam.

Radiation quality refers to the penetrating ability of a beam of X-rays. It is determined by the energy distribution of the photons in the beam, which in turn depends on the kV waveform and peak voltage across the tube, and on the filtration through which the beam has already been transmitted. The quality of an X-ray beam is described by the HVL of the beam and is measured in terms of mm of aluminium in the diagnostic range.

Regulation means the Radiation Control Regulation 2013.

Scattered radiation means ionising radiation produced from the interaction of electromagnetic ionising radiation with matter. It has a lower energy than, or a different direction from, that of the original incident ionising radiation.

SID means source-to-image receptor distance.

Target means the area of the anode that is struck by the electrons from the cathode.

Target Exposure Index means the expected value of exposure index when the detector is appropriately exposed.

Total filtration means the sum of inherent filtration and added filtration between the radiation source and the patient or other defined plane.

X-ray tube assembly means the *X-ray tube housing* with an *X-ray tube insert*, but not including a collimating device.

X-ray tube housing means a container in which an X-ray tube is mounted for normal use, providing protection against electric shock and against ionising radiation except for an aperture for the useful beam. It may contain other components.

X-ray tube insert means a highly evacuated vessel for the production of X-radiation by the bombardment of a *target*, usually contained in an anode, with a beam of electrons accelerated by a potential difference.

X-ray tube potential difference means the peak value of the potential difference applied to the X-ray tube, expressed as kilovolts peak (kVpkVp).

Unless otherwise defined, all words in this standard have the same meaning as in the Act and the Regulation.