South African Health Products
Regulatory Authority
Building A
Loftus Park
Arcadia
Pretoria

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GUIDELINE FOR PATIENT DOSE MEASUREMENTS IN DIAGNOSTIC RADIOLOGY

The objective of this guideline is to provide a simple and standardize method to determine patient dose by implementing the entrance surface exposure.

Document History

Final Version	Reason for Amendment	Effective Date
0	First issue and published for implementation	October 2009
1	- Content structured on the latest SAHPRA Guideline Template - A unique document number SAHPGL-RDN-XR-21 allocated to this Guideline	September 2022

DR BOITUMELO SEMETE-MAKOKOTLELA

CHIEF EXECUTIVE OFFICER

Contents

Glossary

Abbreviation/ Term	Meaning
AAPM	American Association of Physicists in Medicine
AEC	Automatic Exposure Control
ALARA	As low as reasonably achievable
ANSI	American National Science Institute
CFP	Correction Factor for Phantom
DRL	Dose Reference Level
ESE	Entrance surface exposure
FAE	Free Air Exposure
FCD	Focus to Chamber Distance
FEBD	Focus to Erect Bucky Distance
FID	Focus to Image Distance
FSS	Film Screen Speed
FTD	Focus to table top Distance
ICRP	International Commission of Radiological Protection

1. INTRODUCTION

Two basic principles of radiological protection as recommended by the International Commission on Radiological Protection (ICRP) are justification of the practice and optimization of protection. Justification is the first step in radiological protection. It is accepted that diagnostic exposure is justifiable only when there is a valid clinical indication, no matter how good the imaging performance may be. Every examination must result in a net benefit to the patient.

Once a diagnostic examination has been clinically justified, the subsequent imaging process must be optimized to obtain the required diagnostic information for a patient dose that is as low as reasonably achievable. Because diagnostic medical procedures are usually for the direct benefit of the patient, somewhat less attention has been given to the optimization of protection in medical exposure than in other applications that use radiation source

In the area of optimization in diagnostic radiology there is considerable scope for reducing doses without loss of diagnostic information, but the extent to which the measures available are used varies widely. The optimization of protection in diagnostic radiology does not necessarily mean the reduction of doses to the patient — it is paramount that the image obtained contains the diagnostic information as intended.

In accordance with the recommendations of the ICRP, it is often helpful in the management of operations to establish values of measured quantities above which some specified action or decision should be taken. These values are generally called reference or guidance levels. Implementation of a procedure to measure Entrance Surface Exposure (ESE) is therefore long overdue. It was decided that a standardized simple, inexpensive, and versatile phantom, designed by the American National Science Institute (ANSI) instead of a patient would be used. This will ensure that measurements made under different conditions can be compared with international standards.

1.1 Purpose

To standardize the method of measuring patient dose and determining refence lever in diagnostic radiology by using the ANSI phantom.

1.2 Scope

The guideline covers patient dose measurements in diagnostic radiology that can be measured under different conditions ad be comparable to international standards.

2. LEGAL PROVISION

The guideline is implemented in promulgating the Hazardous Substances Act 15, 1973 (Act15 of 1973) the related Regulations R.1332.

3. ANSI PHANTOM

3.1 BENEFITS

- Optimization of the protection during medical exposures.
- Calculate national reference dose levels.
- Comparison of national dose levels with international dose levels.
- Perform trend analysis
- Identification of problem areas.
- Calculate the total collective population dose from medical exposures, and
- Apply ALARA

Drawings of the phantom compositions, which can be used for different diagnostic projections, are illustrated in *AAPM Report No. 31-1 - Standardized Methods for Measuring Diagnostic X-Ray Exposures (Fluke Biomedical)*. Available at www.aapm.org.

TABLE 1: PROJECTION FOR AIR KERMA MEASUREMENTS IN AIR WITHOUT BACKSCATTER.

Description	Thickness of body part in cm (P)	Correction factor for phantom (CFP)
CHEST (PA) Grid	23	0.75
ABDOMEN (AP) Grid	23	1.15
LUMBAR SPINE (AP) Grid	23	1.15
SKULL (LATERAL) Grid	15	1.10
FOOT - **Non-Grid**	8	

Average	71 kg and height of 174 cm	FEBD	Focus to Erect Bucky Distance
AEC	Automatic Exposure Control	FID	Focus to Image Distance
Chambe	Measuring chamber	Focus	Focal spot of X-ray tube
CFP	Correction factor for phantom	FSS	Film Screen Speed
ESE	Entrance Surface Exposure	FTD	Focus to Table-top Distance
FAE	Free in air exposure	P	Thickness of Body Part (see table 1)

FCD	Focus to Chamber Distance (Use measuring point of chamber)	FAECPT	*Average* Free in air exposure (instrument reading) multiply with correction factor for chamber and

NB. Temperature and pressure correction are applicable for ionisation chambers (not for solid state detectors) ESE measurements must only be performed on fixed installations, and NOT on mobiles.

4. MEASUREMENT PROCEDURE

4.1 Entrance Surface Dose Measurement - MANUAL MODE

4.1.1 Set the clinically used FID and record this value.

4.1.2 Measure and record the focus to tabletop or the focus to surface of the erect bucky distance (FTD or FEBD).

4.1.3 Position an appropriate patient-equivalent phantom (ANSI) (see AAPM-31-1 patient phantom) in the X ray field.

4.1.4 Place the chamber on a stand and the chamber shall be at least 23cm from the surface of the phantom to minimize backscatter.

4.1.5 Centre the chamber in the X-ray field. Measure and record the focal spot to the chamber distance (FCD).

4.1.6 Adjust the X-ray field area so that it is just bigger than the phantom. Remember the heel-effect!

4.1.7 Set the X-ray generator at the desired technique factors for an average person (use the technique factors as displayed on the technique chart).

4.1.8 Record the kV and mAs values.

4.1.9 Insert a loaded cassette into the bucky tray.

4.1.10 Expose phantom, detector and film.

4.1.11 Record the free-in-air exposure.

4.1.12 Develop the film.

4.1.13 Label this film with file number of the facility and machine number, description of examination, date, and processor if more than one is used.

4.1.14 Zero the densitometer and measure the density as close as possible to the centre of the Xray field (maximum reach of densitometer); NB - Not under the chamber. Record the density value.

4.1.15 Place the develop film in cassette and insert the loaded cassette into the bucky tray.

4.1.16 Perform 3 additional exposures at the above set-up and settings (insert a developed film in cassette for these exposures).

4.1.17 Calculate the average free-in-air exposure for the 4 exposures.

4.1.18 Calculate:

$$ESE = (FAECPT) \times \left[\frac{FCD}{FEBD - P}\right]^2 \qquad \textbf{OR} \qquad ESE = (FAECPT) \times \left[\frac{FCD}{FTD - P}\right]^2$$

and record this value.

4.1.19 Repeat steps 4.1.1 to 4.1.18 for other examinations listed in Table1

4.2 Entrance Surface Dose Measurement - AUTOMATIC EXPOSURE CONTROL MODE (AEC)

4.2.1 Set the clinically used FID and record this value.

4.2.2 Measure and record the focus to tabletop or the focus to the surface of the erect bucky distance (FTD or FEBD).

4.2.3 Position an appropriate patient-equivalent phantom (ANSI) (see AAPM-31-1 patient phantom) in the X-ray field between the focal spot and AEC detectors.

4.2.4 Adjust the X-ray field size so that it is just bigger than the phantom.

4.2.5 Place the chamber on a stand and the chamber shall be at least 23cm from the surface of the phantom to minimise backscatter. The chamber must be outside the sensory area of the active AEC detector(s), but sufficiently covered by the X-ray field. Remember the heel-effect! To minimise the heel effect, the measuring chamber should be as close as possible to the central axis.

4.2.6 Measure and record the distance from the focal spot to the chamber distance (FCD).

4.2.7 Set the X-ray generator at the desired technique factors for an average person (use the technique factors as displayed on the technique chart).

4.2.8 Insert a loaded cassette into the bucky tray.

4.2.9 Expose phantom, detector and film.

4.2.10 Record the average free-in-air exposure.

4.2.11 Record the kV and mAs values.

4.2.12 Develop the film.

4.2.13 Label this film with file number of the facility and machine, description of examination, date, and processor if more than one is used.

4.2.14 Zero the densitometer and measure the density in the centre of the X-ray field - NB - not under the chamber. Record the optical density

4.2.15 Perform 3 additional exposures at the above set-up and settings (insert a developed film in cassette for these exposures).

4.2.16 Calculate the average free-in-air exposure for the 4 exposures.

4.2.17 Calculate:

$$ESE = (FAECPT) \times \left[\frac{FCD}{FEBD - P}\right]^2 \times CFP \quad \textbf{OR} \quad ESE = (FAECPT) \times \left[\frac{FCD}{FTD - P}\right]^2 \times CFP$$

and record this value.

4.2.18 Repeat steps 4.2.1 to 4.2.17 for other examinations listed in Table1.

5. REFERENCES

The following related documents are referenced:

5.1 Standardized methods for measuring diagnostic x-ray exposures https://www.aapm.org/pubs/reports/rpt_31.pdf

5.2 ICRP Publication 34, Protection of the Patient in Diagnostic Radiology. Committee 3 of the International Commission on Radiological Protection, Pergamon Press, May, 1982.

5.3 NCRP Report #99, Quality Assurance for Diagnostic Imaging Equipment. NCRP, Bethesda, MD 1988.

5.4 Guideline for QC in Medical Diagnostic X-Ray Imaging Systems (SAHPGL-RDN-XR-01). https://www.sahpra.org.za/radiation-control-guidelines-and-codes-of-practice/

5.5 South Africa, 1973. Hazardous Substances Act, 1973 (Act of 15 of 1973). https://www.sahpra.org.za/radiation-control-acts-and-regulations/

5.6 South Africa, 1973. Regulations Concerning the Control of Electronic Products. Regulation Gazette No 3991. https://www.sahpra.org.za/radiation-control-acts-and-regulations/

6. VALIDITY

This guideline is valid for a period of 5 years from the effective date of revision and replaces the old guideline for Patient Dose Measurements in Diagnostic Radiology, revised October 2009. It will be reviewed on this timeframe or as and when required.

7. ANNEXURES

7.1 Annexure 1: Patient Dose Measurements in Diagnostic Radiology

Holder:												
Reference no			Licence no.					Machine no.				
DETAILS OF PERSON WHO PERFORMED THE MEASUREMENTS												
I, (PLEASE PRINT): …….. ……hereby declare that the results below is a true and accurate reflection of measurements performed on this x-ray unit.												
Cell no/☎			E-mail/Fax:					Date:				
Pressure	Temperature	Chamber correction factor	Chamber + detector info									
X-ray Generator							X-ray Tube					
Brand		Model:			Waveform		Total Filtration in mm Al		OR	Half Value Layer at 70 kV in mm Al		
Projection	FID (cm)	FTD / FEBD (cm)	FCD (cm)	kV	mAs	FAE µSv	ESE µSv	Film Density	FSS	Fine OR Broad	Grid YES/NO	AEC Chamber Position
CHEST (PA) Grid												
ABDOMEN (AP) Grid												
LUMBAR SPINE (AP) Grid												
SKULL (LATERAL) Grid												
FOOT Non-Grid												