

TR 18-02

CRITERIA FOR LABORATORY ACCREDITATION IN THE FIELD OF IONIZING RADIATION FOR RADIATION MONITORING EQUIPMENT

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1. Purpose and Scope

The purpose of this document is to define the specific technical requirements to be met by accredited laboratories in the field of Ionizing Radiation for radiation monitoring equipment. This document is applicable to South African National Accreditation System (SANAS) Accredited Laboratories in this field.

2. Abbreviations and Definitions

2.1 Definitions

2.1.1 ISO water phantom

The water phantom to represent the human torso with regard to backscattering of the incident radiation is the ISO water slab phantom of 30 cm × 30 cm × 15 cm depth. The front face of the water phantom consists of a 2.5 mm thick PMMA plate. The other phantom sides are 10 mm thick PMMA. [6]

2.1.2 **PMMA** is polymethyl methacrylate with a density of 1.19 g·cm⁻³ and a mass composition of 8.05% H, 59.99% C and 31.96% O. [6]

3. Environmental Requirements

- 3.1 An accredited laboratory in the field of Ionizing radiation performing measurements for radiation monitoring equipment measurement must be maintained at an ambient temperature of 20°C ± 5°C and any temperature fluctuations should occur at a rate not exceeding 1°C in any hour.
- 3.2 The laboratory shall be sited away from such sources of mechanical vibration, shock, electrical and radio frequency interference, and stray radiation fields as would be expected to affect the accuracy of measurement.
- 3.3 Relative humidity and atmospheric pressure shall be recorded when performing the calibration of any instrument which may be influenced by changes in humidity and atmospheric pressure.
- 3.4 If a laboratory cannot continuously operate within the specified requirements, it must produce documented evidence that it has made measurements under extreme conditions outside the prescribed requirements to determine that the measurement results are not invalidated. Should the results be adversely affected, the evidence must be produced to indicate that these influences are considered in the uncertainty budgets.
- 3.5 It may not be possible for a laboratory to produce extreme conditions at will to do the necessary test measurements. It can thus be accepted if a laboratory produces evidence that it has commenced such test measurements at a specific date, and will continue to record such results over a period of one year to have a full cycle of climatic effects on the laboratory environment. In the interim, it will still be required that the laboratory allow for the unknown component of the effects on the measurement results in the uncertainty of measurement calculations.

4. Traceability

- 4.1 The measuring standard of highest accuracy for each measuring capability in a laboratory establishes the basic measuring capability of that laboratory. In the case of radiation beams derived from sealed radioactive sources bearing reference numbers, the National Metrology Institute of South Africa (NMISA) may measure exposure and/or dose rates under specified geometric conditions with its own calibrated equipment. Such measured values shall provide the required traceability.

5. Technical Requirements

5.1 Reference Documents

- [1] Measurement Good Practice Guide No. 14: The examination, testing and calibration of Portable Radiation Protection Instruments of March 1999. NPL (UK) Ref. PDB:2286
- [2] IEC 60846-1 Ed 1.0 2009-04 : Radiation Protection Instrumentation – Ambient and/or directional dose equivalent (rate) meters and/or monitors of beta, X and gamma radiation - Portable workplace and environmental meters and monitors.
- [3] IEC 60325 Ed 3 (2002-06) : Radiation protection Instrumentation - Alpha, beta and alpha-beta contamination meters and monitors
- [4] IEC 61526 Ed 3.0 (2010-07) : Radiation protection instrumentation - Measurement of personal dose equivalents $H_p(10)$ and $H_p(0,07)$ for X, gamma and beta radiations - Direct reading personal dose equivalent meters.
- [5] ISO 4037-3 (1999) : X and gamma reference radiation for calibrating dosimeters and doserate meters and for determining their response as a function of photon energy - Part 3 : Calibration of area and personal dosimeters and the measurement of their response as a function of energy and angle of incidence.
- [6] IAEA Safety Reports Series No. 16 – Calibration of Radiation Protection Monitoring Instruments.

5.2 Technical requirements for the calibration of portable Radiation meters for the measurement of X and Gamma radiation.

The recommendations of reference [1] apply with the following specific conditions:

5.2.1 These requirements apply to:

Portable radiation instrument tests;

5.2.2 Units:

- a) Because large numbers of instruments, graduated in mR are still in use, they shall continue to be calibrated in terms of exposure.
- b) Instruments marked in Sv should be calibrated in Sv, and those marked in Roentgen the applicable conversion factor used:
 - i. If they are based on 1 Sv = 100R, they will be calibrated on that basis, ie. essentially in terms of exposure.
 - ii. For instruments specifically stated by the manufacturer to be designed to measure ambient dose equivalent, the calibration certificate should be in terms of ambient dose equivalent. The calibration will use using the conversion factors from air kerma to ambient dose equivalent given in Table 1. [6]

Table 1

Radionuclide	$H^*(10)/K_a$ S v.Gy ⁻¹
Am- 241	1.74
Cs-137	1.20
Co-60	1.16

One roentgen of air kerma deposits 0.00877 Gy.

4.2.3 Range of calibration:

Instruments shall be calibrated up to the maximum range of the instrument or the maximum air kerma rate for which the laboratory is accredited, whichever is the smaller, for Cs-137; plus a minimum of one point with an Am-241 source.

4.2.4 Minimum number of points to be measured:

- a) 3 points, evenly distributed over the scale, for each range in the case of linear scales;
- b) 3 points per decade (as far as practically possible) in the case of logarithmic scales;
- c) 3 points per decade (as far as practically possible) in the case of auto-ranging instruments.
- d) The lowest point must be smaller than or equal to 20 % of full scale deflection and the highest point must be greater than or equal to 80 % of full scale deflection.
- e) For integrating (dose) assemblies: 3 points per decade with no less than 2 significant digits (in terms of the resolution of the instrument)

4.2.5 Linearity of response :

The instrument shall conform to the following requirements:

- i. The average absolute relative intrinsic error shall not exceed 15 %
- ii. The relative intrinsic error of no single reading shall exceed ± 25 %
- iii. The relative intrinsic error is defined as:

$$\frac{\text{Instrument reading} - \text{Actual value}}{\text{Actual value}} \times 100\%$$

4.2.6 Energy Dependence :

For Am-241, the following statement regarding instrument reading too low or too high shall appear:

“For Am-241, the instrument reads low/high by a factor of ** and is not suitable for measuring X-or gamma radiation of energies below 60 keV.”

4.2.7 Re-calibration interval:

As defined by regulatory authorities and after repair.

5.3 Technical Requirements for the Calibration of Contamination Monitors.

The recommendations of reference [1] apply with the following specific conditions:

5.3.1 Radionuclides to be used:

- a) Instruments which detect beta radiation : C-14, Cl-36, Sr-90/Y-90.
When it is known that C-14 response will be negligible, this must be stated on the calibration report.
- b) Instruments which detect alpha radiation: Am-241 or Pu-239.

5.3.2 Detector position:

Detector shall be positioned with the outer face of the probe, 4 mm from the surface of the source. This shall be stated on the calibration report.

5.3.3 Re-calibration interval:

As defined by regulatory authorities and after repair.

5.4 Technical Requirements for the Calibration of Direct Reading Dose Equivalent and/or Dose Equivalent Rate Dosimeters

The requirements of reference [4] and [5] apply with the following specific conditions for routine calibrations:

5.4.1 Reference point

The reference point (point of test) of the unit under test shall be stated on the certificate of calibration.

5.4.2 Calibration factor

No calibration factor shall be calculated. The results shall be summarized in a table.

5.4.3 Units of calibration

The instrument shall be calibrated for $H_p(10)$ on a slab water phantom or water phantom using the conversion factors given in Table 2. Instruments shall not be calibrated for $H_p(0,07)$ and this shall be clearly stated on the certificate of calibration.

Table 2

Radionuclide	$H_p(10)/K_a$ Sv.Gy ⁻¹ (ISO 4037-3 Table 33)
Am- 241	1.89
Cs-137	1.21

1 roentgen of air kerma deposits 0.00877 Gy.

5.4.4 Linearity

The linearity of the instrument shall be determined using Cs-137 according to one of the following methods :

Method A : The linearity of response of the dosimeter shall be measured in air. The instrument response on the phantom need only be done at one dose. A typical instrument response can be applied using history (data shall be kept). The method and results shall be reported clearly.

Method B : The linearity of response of the dosimeter shall be measured in terms of $H_p(10)$ on the phantom. The results shall be reported in $H_p(10)$.

5.4.5 Range of calibration

Instruments shall be calibrated for the dose and doserate function (if applicable) and for the full range of the instrument. Where this is not required or not possible, a partial calibration shall be performed. Instruments shall be calibrated for a minimum of 3 points per decade from at least 1 μ Sv to at least 1 mSv (where applicable).

5.4.6 Limits

Instruments shall conform to the following requirements:

- i. The average absolute relative intrinsic error shall not exceed 15 % for the dose function
- ii. The average absolute relative intrinsic error shall not exceed 20 % for the doserate function
- iii. The relative intrinsic error of no single reading shall exceed ± 25 %
- iv. The relative intrinsic error is defined as:

$$\frac{\text{Instrument reading} - \text{Actual value}}{\text{Actual value}} \times 100\%$$

5.4.7 Energy Dependence :

For Am-241, one point (corresponding to one point done with Cs-137) shall be performed.

The following statement regarding instrument reading too low or too high shall appear:

“For Am-241, the instrument reads low/high by a factor of ** and is not suitable for measuring X-or gamma radiation of energies below 60 keV.”

5.4.8 Re-calibration interval:

As defined by regulatory authorities and after repair.

Appendix 1 – Example of Accreditation Schedule

SCHEDULE OF ACCREDITATION

IONIZING RADIATION

Facility Number: 1199

Permanent Address of Laboratory: Radioactivity Laboratory Lab 202 Joshua Road Pretoria		Technical Signatories: Ms A Radiation Mr B Protection		
Postal Address: P.O. Box 1234 Pretoria Outer 0099 Tel: (012) 899-1234 Fax: (012) 899-5678 E-mail: aradiation@radlab.co.za		Nominated Representative: Ms L Botham Issue No.: 01 Date of Issue: 25 July 2019 Expiry Date: 25 July 2024		
ITEM	MEASURED QUANTITY OR TYPE OF GAUGE OR INSTRUMENT	NUCLIDE	RANGE OF MEASURED QUANTITY	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm)
1	Absorbed dose to water • Therapy level dose meter	Co-60	0,5 Gy to 9 Gy	4 %
2	Absorbed dose to tissue • TLD'S	Sr-90/Y-90 Kr-85	0,750 mGy to 120 mGy 8,30 μ Gy to 24,0 mGy	9,5 % 9,5 %
3	Air kerma • Therapy level dose meter	Co-60	0,40 Gy to 9,0 Gy	1,5 %
		x-ray	0,40 Gy to 9,0 Gy	1,5 %
	• Protection level dose meter	Co-60	0,15 μ Gy to 5,00 mGy	3,0 %
		Cs-137 Am-241	0,007 μ Gy to 131 mGy 0,250 μ Gy to 11,4 mGy	3,0 % 5,0 %
• TLD'S	Co-60	0,012 μ Gy to 1,5 mGy	5,0 %	
		Cs-137	0,50 μ Gy to 45,0 mGy	5,0 %
		Am-241	1,8 μ Gy to 0,18 mGy	6,0 %
4	Air kerma rate • Protection level survey meter	Co-60 Cs-137 Am-241	5 μ Gy/hr to 11 mGy/hr 0,438 μ Gy/hr to 0,2 Gy/hr 13 μ Gy/hr to 11,4 mGy/hr	5 % 4 % 5 %
5	Ambient dose equivalent rate • Protection level survey meter	Co-60 Cs-137 Am-241	6,0 μ Sv/hr to 12,0 mSv/hr 0,55 μ Sv/hr to 0,25 Sv/hr 22,0 μ Sv/hr to 19,0 mSv/hr	9 % 9 % 9 %

Original Date of Accreditation: 25 July 2019

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Date of Issue: 25 July 2019

Expiry Date: 25 July 2024

ITEM	MEASURED QUANTITY OR TYPE OF GAUGE OR INSTRUMENT	NUCLIDE	RANGE OF MEASURED QUANTITY	CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm)
6	Exposure • Personal dosimeter	Cs-137 Am-241	0,12 mR to 6,50 R 0,12 mR to 22,0 mR	9 % 9 %
7	Exposure Rate • Protection level survey meter	Co-60 Cs-137 Am-241	0,60 mR/hr to 1,20 R/hr 0,10 μ R/hr to 24 R/hr 1,5 mR/hr to 1,5 R/hr	10 % 10 % 12 %
8	Personal dose equivalent • Personal dosimeter	Cs-137 Am-241	5 μ Sv to 10 mSv 5 μ Sv to 2 mSv	8 % 10 %
9	2π Efficiency • Contamination monitor	Am-241 Sr-90/Y-90 Cł-36 C-14	0 to 100 %	5 % 6 % 8 % 4 %
10	Surface activity response • Contamination monitor	Am-241 Sr-90/Y-90 Cł-36 C-14	Up to 500 cps/(Bq/cm ²)	10 % 10 % 10 % 10 %

Original Date of Accreditation: 25 July 2019

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The CMC, expressed as an expanded uncertainty of measurement, is stated as the standard uncertainty of measurement multiplied by a coverage factor $k = 2$, corresponding to a confidence level of approximately 95%

Addendum 1: Amendment Record

Proposed By:	Section	Change
STC	Title Page	'Radiation Dosimetry' changed to 'Ionizing Radiation'
STC	Definitions	Added Definitions 'ISO Water Slab phantom' and 'PPMA'
STC	Section 3.3	Requirement amended - recording of humidity and atmospheric pressure
STC	Section 4.1	NML changed to NMISA
STC	Section 5.1	Updated references to latest editions
STC	Section 5.1	Added IAEA Document Safety Report Series No 16
STC	Section 5.2.2	Remove reference to NAMAS
STC	Section 5.4.3	Added water phantom
STC	Appendix 1	Draft Schedule of accreditation added