Specific Accreditation Criteria
Calibration ISO/IEC 17025 Annex

Ionising radiation measurements

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Ionising radiation measurements

This document provides interpretative criteria and recommendations for the application of ISO/IEC 17025 for both applicant and accredited facilities conducting ionising radiation measurements.

Applicants and accredited facilities must also comply with ISO/IEC 17025 and the NATA ISO/IEC 17025 Standard Application Document (SAD) and the NATA Calibration ISO/IEC 17025 Appendix.
This appendix is divided into two sections; the first provides additional guidance and recognition of the general requirements that are applicable to all types of measurements in this discipline, while the latter provides additional guidance and recognition of the requirements that are specific to individual types of measuring equipment. For ease of use and to avoid fragmentation of the guidance, the clauses of ISO/IEC 17025 have not been applied.

General requirements

Personnel

The staff shall be conversant with the facility's operational and safety procedures in the handling and use of radioactive material and ionising radiation.

Accommodation and environmental conditions

The safety features and operational procedures of the facility shall comply with the relevant requirements of AS 2243.4 Safety in Laboratories - Ionising radiations and State regulatory authorities to assure adequate radiation protection. A radiation protection program shall be established and documented.

The facility's ambient conditions for temperature, relative humidity and where appropriate barometric pressure shall be monitored and records kept.

Measurement traceability

Note: The Chief Metrologist of Australia's National Measurement Institute (NMI) has issued authorisations to the Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) under the National Measurement Act 1960 (Cth) to maintain the necessary Australian primary and secondary standards of ionising radiation.

Responsibility for these Australian Standards for ionising radiation are distributed between ANSTO and ARPANSA as follows:

	Primary Standard	**Secondary Standard**
activity	ANSTO	ANSTO
exposure	ARPANSA	ANSTO, ARPANSA
absorbed dose	ARPANSA	ANSTO, ARPANSA
air kerma	ARPANSA	

Ambient dose equivalent ARPANSA

When measurements are for legal purposes in Australia and there is a necessity for them to have legal traceability, the measurements must be traceable to the standards maintained by either ANSTO or ARPANSA under their Authorisations from the NMI's Chief Metrologist or covered by a regulation 21 certificate. Traceability is only valid where the measurements are carried out using a technically valid procedure and calibrated measuring instruments or a calibrated radioactive standard, as appropriate. The determination of the uncertainty of the measurement is also part of the chain of traceability and shall include any uncertainty associated with the working radiation standard.

Specific requirements for types of measurement equipment

Alpha-particle Measuring Instrument Calibration

Test and calibration methods and method validation

The calibration procedure shall also describe the handling of the source. It shall ensure that the distance between the surface of the radiation detector and that of the alpha source is not greater than 3 mm and the source beam shall overlap the detector in all directions from their common axis.

Measurement traceability

The radionuclide shall be calibrated for alpha emission rate per unit area and shall be traceable to a primary standard.

Alpha radiation sources (planar or pseudo-planar) shall be used and their 2π surface emission rate (per unit area) shall be known.

^{230}Th and ^{241}Am are acceptable sources.

The radiation fields produced by the sources shall cover a range of at least three decades of alpha emission rates suitable for protection-level calibration.

Reporting the results

The calibration report shall include the identity of the radionuclide used, its traceability to the national standard, the emission rates at which the instrument was calibrated, the instrument detector response at each measurement point and a linearity check for each range.

Beta-particle for Contamination Monitoring Instrument Calibration

Accommodation and environmental conditions

The radiation room shall be such that scattered radiation, at the positions where the instruments are positioned for calibration, does not introduce significant errors in air kerma rate.

Test and calibration methods and method validation

The calibration procedure shall also describe the handling of the source. It shall ensure that the distance between the surface of the radiation detector and the beta source is not greater than 10 mm for low energy emissions and 50 mm for high energy emissions. The source beam shall overlap the detector in all directions from their common axis.

Measurement traceability

The radionuclide shall be calibrated for beta emission rate per unit area and shall be traceable to a primary standard.

Beta radiation sources for calibrating contamination survey instruments have low energy levels. ISO 8769 recommended radionuclides such as ^{14}C, ^{147}Pm, ^{204}Tl, ^{36}Cl, ^{90}Sr + ^{90}Y are acceptable sources.

The surface emission rate (i.e. number of particles of a given type above a given energy emerging from the face of the source or its window per unit time) shall be known to be better than ±10%.

Reporting the results

The calibration report shall include the identity of the radionuclide used, its traceability to the national standard, the emission rates at which the instrument was calibrated, the instrument detector response at each measurement point and a linearity check for each range.

Beta-particle Field Measuring Instrument Calibration

(Integrating dosimeters and dose-rate meters)

Accommodation and environmental conditions

The radiation room shall be of sufficient size such that scattered radiation, at the positions where the instruments are positioned for calibration, does not introduce significant errors in air kerma rate.

Test and calibration methods and method validation

The calibration procedure shall also describe the handling of the source and shall include the timing of the radiation beam used for calibration of fluence measuring instruments. It shall state that the beta-particle beam (field) size shall be large enough to accommodate the instrument being calibrated. The uniformity of the beta dose rate field shall be verified by measurement with a small area detector or film.

The beta radiation fields shall be characterised for absorbed dose rates and at each distance of irradiation from the source used.

There shall be no attenuation from the source self-absorption, containment or from beam flattening filters or air attenuation which may significantly change the beta spectrum. The same criteria for E_{res} listed below shall apply.

Measurement traceability

The radionuclides shall be characterised for dose rate at a given distance and this value shall be traceable to a primary standard.

Any radiation response measuring system used as a transfer standard for dose rate shall be traceable to appropriate national standards.

The radiation source shall provide a uniform field. This may be achieved by the use of a source small enough to be considered as a point source or by the use of beam flattening filters. However, distributed sources may be used where the instrument to be calibrated presents extreme measurement geometry.

ISO 6980 recommends suitable reference sources for beta radiation instrument calibration. Sources, such as ^{90}Sr + ^{90}Y, ^{204}Tl and ^{147}Pm, may be used with suitable beam flattening filters to produce a uniform dose rate over a large area at a specified distance.

Contamination by other radionuclides may change the beta or gamma radiation field emitted from a source. The beta spectral purity is considered to be adequate if the plot used to measure R_{res}, in an absorbing material, has a linear section, and the E_{res}, residual maximum energy, value meets the criteria below:

E_{max}	E_{res}/E_{max}
<100 keV	≥ 0.6
100 to 800 keV	≥ 0.7
>800 keV	≥ 0.8

Standards consisting of a thin-window fixed volume ionisation chamber or an extrapolation chamber shall be suitable for the range of beta energies, intensities and depth of dose measurement point being measured.

Reporting the results

The calibration report shall include the identity of the radionuclide (point source) and radiation field type (flat field) used, the reference dose rates and the dose rate (or dose) indicated by the instrument at each calibration point. The orientation of the instrument with respect to the radiation beam shall be described.

X-Ray Measuring Instrument Calibration

(Dosimeters and dose-rate meters)

Accommodation and environmental conditions

The radiation room shall be of sufficient size such that scattered radiation, at the positions where the instruments are positioned for calibration, does not introduce significant errors in air kerma rate.

Test and calibration methods and method validation

The X-ray field shall be characterised for ambient dose equivalent rate or exposure rate (air kerma) at the location of the detector of the instrument for calibration.

If the exposure delivered to the measuring instrument is controlled by a shutter operated by a timer, then any associated timing errors due to shutter transit times or high voltage ramping, shall be accounted for.

There shall be a system in place to check the radiation qualities and the output of the X-ray unit on a regular basis.

Measurement traceability

The kVp shall be measured with a high voltage divider and the measuring system should be calibrated and be traceable to an appropriate national standard.

If a high voltage divider is not used, then it must be demonstrated that the method is capable of determining the kVp to within a given percentage of its true value and this must be stated.

The X-ray beam produced shall be evaluated according to the provisions of ISO 4037.

Acceptable sources of radiation shall be as stated in ISO 4037.

Reporting the results

The calibration report shall include details of the X-ray beam, the reference value of the exposure (air kerma) rate or exposure (air kerma), the corresponding instrument reading and range setting.

The orientation of the instrument or detector shall be described.

Gamma-Ray Measuring Instrument Calibration

Accommodation and environmental conditions

The radiation room shall be of sufficient size such that scattered radiation, at the positions where the instruments are positioned for calibration, does not introduce significant errors in air kerma rate.

Radiation source storage containers shall provide sufficient shielding such that leakage radiation does not raise the background to a level where it contributes more than 10% of the measurement being made. The scattered radiation in the useful beam shall not exceed what is specified in ISO 4037 for the air kerma rate at any location where a detector is positioned for calibration. The approximate energy spectrum of the scattered radiation should be known.

An appropriate source shall be used as specified in ISO 4037.

The radiation fields produced, shall cover a range of air kerma rates covering the operating ranges of the instruments for calibration. The gamma beam shall be controlled from the source’s storage container and the central axis shall be defined. The standard ionisation chambers and electrometer shall be able to cover the energy and intensity ranges used.

Test and calibration methods and method validation

The calibration method shall also describe how the source is manipulated and positioned.

The gamma radiation field shall be characterised for air kerma rate as a function of distance from the source.

The intensity of the gamma beam shall not vary by more than 5% across the useful area of the beam or as specified in ISO 4037.

If the beam of radiation is controlled by a shutter operated by a timer, then any associated timing errors due to shutter transit times, shall be accounted for.

If an attenuator is used to reduce air kerma rate at any location in the beam field, its effect on the energy spectrum shall be specified or the effect of the altered spectrum on the accuracy of the calibration of each instrument type shall be specified.

Measurement traceability

The source shall be characterised for gamma air kerma rate and be traceable to the appropriate primary standard.

The radiation response measuring system shall be calibrated and shall be traceable to the appropriate national standards.

Reporting the results

The calibration report shall include the identity of the radionuclide used, the reference value of the air kerma rate or air kerma and the instrument detector response at each measurement point for each range of the instrument.

Neutron Measuring Instrument Calibration

The specific requirements for the calibration of portable instruments for measuring neutron ambient dose equivalent rate at radiation protection levels are described below.

Accommodation and environmental conditions

The radiation room shall be of sufficient size such that scattered radiation, at the positions where the instruments are positioned for calibration, does not introduce significant errors in the air kerma rate at the calibration position.

The neutron source shall preferably be used for calibration in a low-scatter environment, in an open area or at the centre of a large room (e.g. 10 m x 10 m with the source 4 m from both floor and ceiling). The room-scattered neutrons at the point of calibration should be less than 25% of the total instrument response and the appropriate corrections shall be made.

Test and calibration methods and method validation

The calibration method shall also describe the handling of the source capsule. The neutron radiation field shall be controlled and monitored when moving the source from a shielded to an exposed position. Appropriate timing control shall be used for the calibration of integrated ambient dose equivalent measuring instruments.

The radiation field shall be characterised for fluence rate (flux density) and for spectral composition at the point of calibration. The ambient dose equivalent rate shall be calculated on the basis of these characteristics as a means of setting calibration points for specific instrument types.

Correction for room scatter, air attenuation, air in-scatter and anisotropy of the calibration source shall be accounted for.

Measurement traceability

The radionuclides shall be characterised for neutron fluence rate (flux density) and be traceable to a primary standard. The fluence rate shall be converted to ambient dose equivalent rate based on conversion coefficients in ISO 8529. The source should be spherical or cylindrical and its anisotropy should be measured and accounted for.

The radiation response measuring system shall be calibrated and corrections shall be applied for any effects due to contamination of the neutron field by other types of radiation (e.g. photon or beta) if any.

The selection of a neutron source shall be such that the radiation field produced will provide an energy spectrum and ambient dose equivalent rates appropriate to the instrument being calibrated.

^{241}AmBe, ^{238}PuBe and ^{252}Cf or sources as recommended in ISO 8529 are acceptable sources.

Reporting the results

The calibration report shall include the identity of the radionuclide anisotropy of all sources used, and radiation field type (moderated or unmoderated), fluence rate, the scatter-corrected instrument reading at each calibration point and the conversion coefficient for calculating ambient dose equivalent rate from fluence rate. The orientation of the instrument with respect to the radiation field shall be described. The values of all corrections used shall be stated.

Personal Radiation Monitoring Devices

Personal radiation monitoring devices used to assess the radiation dose received by occupationally exposed persons include:

- film badge dosimeters;
- thermoluminescent dosimeters (TLD);
- track etch plastic plaque (CR39) dosimeters;
- quartz fibre electrometer dosimeters; and
- direct reading electronic dosimeters.

A facility which issues film badge dosimeters, TLDs or plastic plaque dosimeters shall have available calibration facilities which may be used to expose reference personal dosimeters to known doses of beta, X-, gamma or neutron radiation, as appropriate. In the case of film badge dosimeters these facilities allow the production of calibration curves (optical density versus radiation dose) to be produced, from film badges exposed to known radiation doses, to enable the optical density of the wearers' film badge dosimeters to be interpreted in terms of the radiation dose received. For personal monitoring systems using TLDs as the sensing element, these facilities allow the production of similar calibration data (relating TLD light output to radiation dose) as a function of radiation type and energy.

Quartz fibre dosimeters and direct reading electronic dosimeters shall be calibrated in a manner similar to that for other ionising measuring instruments. (See Sections 'X-Ray Measuring Instrument Calibration' and 'Gamma-Ray Measuring Instrument Calibration'.)

Test and calibration methods and method validation

ISO 4071 should also be consulted.

The calibration method shall provide details of:

- the method of calibration of the radiation output from each radiation source used in the calibration process and details of its traceability to the appropriate national standard;
- each 'secondary standard' instrument (e.g. ionisation chamber and electrometer) used to calibrate the radiation sources/fields of the calibration facility and of its calibration traceability;
- the phantom used and the positioning of the dosimeter.

The intensity of X- and gamma radiation fields should not vary by more than 5% across the useful beam at the position of the personal dosimeter being calibrated. Corrections for lack of field uniformity shall be applied if the variation exceeds 5%.

Appropriate timing control shall be used for the calibration of the personal dosimeters.

If an attenuator is used to reduce the air kerma rate at any location in the radiation beam its effect on the energy spectrum must be specified or the effect of the altered spectrum on the accuracy of the calibration of the personal radiation monitoring device shall be known.

Dosimeters shall be calibrated in terms of Hp(10), i.e. personal dose equivalent and Hp(0.07) directional dose equivalent using the conversion coefficients in ICRP74.

Measurement traceability

The X- and gamma radiation fields used for calibration shall be characterised in terms of air kerma rate and shall be traceable to an appropriate national standards.

The beta radiation fields used for calibration shall be characterised in terms of absorbed dose to tissue or air (at a depth in tissue of 7 mg/cm^2) at a given position or distance from the source and shall be traceable to appropriate national standards.

The neutron radiation field used for calibration shall be characterised in terms of the fluence rate (flux density) and spectral composition at the point of calibration and shall be traceable to an appropriate national standards.

The calibration of the standard ionisation chamber(s) and electrometers used in the calibration facility shall be traceable to an appropriate national standard.

Appropriate neutron energies are specified in ISO 8529.

Radioactive sources used for calibration shall be stored in a manner such that any leakage radiation from them does not raise the background, in the calibrating area, to a level which contributes more than 1% of the dose rate used for each calibration.

The radiation sources used for calibration shall be such that each reference film badge dosimeter and reference TLD can be exposed to X- and gamma radiation doses in the range 50 to 20,000 microsievert.

The standard ionisation chamber(s) and electrometer used in the calibration facility shall be able to cover the energy and intensity ranges used.

A phantom that represents a body should be used when calibrating personal radiation dosimeters. A suitable phantom is a 30 cm x 30 cm x 15 cm poly methyl methacrylate.

Reporting the results

The calibration report shall include details of the radionuclides and X-ray machines used, details of their traceability to the relevant national standards, the dose to which each reference film badge or TLD was exposed, the conversion coefficients used to determine $H_p(0.07)$ and $H_p(10)$ and reference to ICRP74.

Measurement of Radionuclide Activity

(used in medicine, pharmaceutical industry and research)

Test and calibration methods and method validation

The test method shall also describe the handling of the radionuclide. There shall be a test procedure for checking the measuring system to monitor the validity of the test data.

Examples of derivation of uncertainties of measurement of radioactivity covering the required ranges shall be documented.

Measurement traceability

The measuring system shall be capable of measuring the range of activity for the radionuclides to be characterised. There shall be a means of recording of the time and date.

Radionuclide standards traceable to an appropriate national standard shall be used to calibrate the measurement system.

Differences in geometry between the source under test and the reference standard shall be accounted for.

Consideration shall be given to the effects of shielding, impurities and background.

The measuring system shall be calibrated for the range of radionuclides to be tested. The calibration shall be traceable to the appropriate primary standard of activity for specific radionuclides. In-house checks on the measuring system shall be carried out daily for linearity and at three-monthly intervals for stability.

Reporting the results

The certificate of measurement (can be called characterisation) of the radionuclide activity shall include the calibration time and date associated with the measured radioactivity, life time and a statement of the uncertainty of measurement accompanied by a confidence level or coverage factor.

Glossary for Ionising Radiation Measurements

absorbed dose

The quotient of dE by dm, where dE is the mean energy imparted by ionising radiation to matter of mass dm. The unit of absorbed dose is joule per kilogram ($J.kg^{-1}$) with the special name gray (Gy).

air kerma

When the material referred to in the definition of ‘kerma’ (see below) is air.

attenuator

Absorbing material intentionally placed in the path of a radiation beam to reduce its intensity.

beam flattening filter

A specially shaped attenuator used to modify a radiation beam profile so that the beam profile perpendicular to the beam direction is flat in accordance with a specified tolerance.

calibration

The set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system, or values represented by a material measure, and the corresponding known values of a measurand.

conversion coefficient

Coefficient used to convert air kerma free-in-air or exposure to ambient dose equivalent for the radiation beam under investigation.

Emax

The maximum beta particle energy emitted by an unattenuated source of beta radiation.

Eres

The residual maximum beta energy after the beta spectrum is modified by absorption and scattering in the source material itself, the source holder, the source encapsulation and other media between the source and the calibration position.

extrapolation chamber

A parallel plate ionisation chamber in which the distance between the plates can be varied, thereby enabling a series of measurements with decreasing separation, so that the measured ion current per unit volume can be extrapolated to the case of infinitesimal volume.

flux density

The number of neutrons, which, per unit time, enter a sphere of cross sectional area; it is expressed in neutrons.$m^{-2}.s^{-1}$.

free-air facility

A calibration facility in which the radiation emitted by the source reaches the instrument under calibration with minimal scatter from nearby structures.

kerma

The kinetic energy released in material by ionising radiation. Kerma is determined as the quotient of dE_{tr} by dm, where dE_{tr} is the sum of all the kinetic energies of all the charged ionising particles in a material of mass dm. The unit of kerma is joule per kilogram ($J.kg^{-1}$) with the special name gray (Gy).

leakage radiation

All ionising radiation coming from the source except the useful beam.

measurand

A specific quantity subject to measurement.

neutron fluence

The time integral of neutron flux density.

neutron fluence rate

The number of neutrons per unit cross-sectional area per unit time.

point source

A radiation source the maximum dimension of which is small compared to the source-to-detector distance used for the irradiation of an instrument or dosimeter.

Rres

The residual maximum beta range in an absorbing material of a beta spectrum of residual maximum energy E_{res}.

reference personal dosimeter

A personal dosimeter which is exposed to a known dose of ionising radiation and used to provide calibration information for measuring the dose received by personal dosimeters worn by customers of a personal radiation monitoring service.

scattered radiation

Radiation that, as a result of interaction with matter, has had its direction changed and, in some cases, its energy also changed.

References

This section lists publications referenced in this document. The year of publication is not included as it is expected that only current versions of the references shall be used.

Standards and other references

AS 1000 *The International System of Units (SI) and its application*

Ionising Radiation Measurements

AS 2243.4	*Safety in Laboratories - ionising radiations*
ICRP74	*Conversion coefficients for use in radiological protection against external radiation*
ISO 4037	*X- and gamma reference radiations for calibrating dosimeters and dose ratemeters and for determining their response as a function of beta radiation energy*
ISO 6980	*Reference beta radiations for calibrating dosimeters and dose ratemeters and for determining their response as a function of beta radiation energy*
ISO 8529	*Neutron reference sources for calibrating neutron-measuring devices used for radiation protection purposes and for determining their response as a function of neutron energy*
ISO 8769	*Reference sources for the calibration of surface contamination monitors. Beta emitters (maximum beta energy greater than 0.15 MeV) and alpha emitters*
ISO 4071	*Exposure Meters and Dosimeters – General methods for Testing*

Amendment Table

The table below provides a summary of changes made to the document with this issue.

AMENDMENT TABLE	
Section or Clause	**Amendment**
New document	This document represents a direct adoption of the former Calibration Application Document Appendix G. The document has been reviewed and updated to reflect the new accreditation criteria documentation structure.