JSP 425
Edition 6

EXAMINATION AND TESTING OF IONISING RADIATION DETECTION AND MONITORING EQUIPMENT (RDME)

Intentionally blank

Contents

List of Figures **Page**

List of Tables **Page**

Intentionally blank

Preface

1. This Joint Service Publication (JSP) details the minimum requirements for the examination and testing of Radiation Detection and Monitoring Equipment (RDME) and the minimum standards to be maintained by Ministry of Defence (MOD) Radiation Calibration Facilities to ensure that the employers' responsibilities under Regulation 19 of the Ionising Radiation Regulations 1999 are achieved.

2. The definition of terms and abbreviations used through out this publication are defined in Appendix 1 - Terms, Definitions and Abbreviations

3. Chapter 1 - The Examination and Testing of Radiation Detection and Monitoring Equipment details the testing policy to be adopted within the MOD for RDME. It details the categories of tests to be used, and emphasises the requirement for equipment to be tested by or under the direct supervision of a radiation calibration Qualified Person (QP). It introduces the procedures for an internal MOD audit program to ensure that the minimum MOD radiation calibration facility requirements and practices are being maintained. This includes the requirements for traceability and specifies the radiological quantities against which equipment shall be tested.

4. Chapter 2 - Radiological Standards, Traceability and Quantities details the specification and use of the associated radiological standards necessary for verification of the reference radiation fields.

5. For the purpose of this JSP a ‘test’ is defined as a procedure to evaluate an equipment performance in order to establish its suitability, or continued fitness, for a particular type or types of measurement. A test will involve elements of both examination and calibration. ‘Calibration’ is defined as the measurement of the response of the equipment to known radiation fields. ‘Examination’ is defined as an inspection of the mechanical and electrical state of the equipment. It is therefore important to recognise that the terms examination and calibration are not synonymous. See Appendix 1 for definitions of terms.

6. It shall be noted that within the MOD the ‘employer’ is the Commanding Officer (CO) who has a duty to the Secretary of State and a personal responsibility to protect the environment and to secure the health, safety and welfare of their staff at work. They are also required to protect persons not in MOD employment against risk to their health or safety arising from the MOD work activities (e.g. the general public). This includes ionising radiation safety. Their authority (but not responsibility) for ionising radiation safety management arrangements may be delegated to appropriate personnel such as a Radiation Safety Officer (RSO).

7. This JSP is sponsored by Joint Support Chain Support Chain Management (JSC SCM) a MOD organisation within Defence Equipment and Support (DE&S) responsible for Tri-Service test equipment calibration policy. The JSP is edited and published by the Chemical, Biological, Radiological and Nuclear Delivery Team (CBRN DT) within DE&S. CBRN DT is aided in the formulation of this JSP by the MOD Radiation Calibration Qualified Persons (MRCQP) Committee. Any comments or suggested amendments to this publication should be forwarded to the Secretary of the MRCQP.

Intentionally blank

Chapter 1 - The Examination and Testing of Radiation Detection and Monitoring Equipment

General Policy

0101. Regulation (19) of the Ionising Radiation Regulations 1999 (IRR99) requires employers who work with ionising radiations to monitor levels of ionising radiation in controlled and supervised areas, and to arrange that certain tests and examinations of the equipment used to carry out this monitoring are undertaken.

0102. This publication documents MOD policy for minimum standards to be maintained by Approved MOD Radiation Calibration Facilities and provides guidance on how to achieve those standards.

0103. The equipment sponsor is responsible for ensuring that suitable facilities for the testing and repair of RDME are available.

0104. The MOD Radiation Protection Instruments Committee (MOD RPIC) has been formed to provide guidance and assurance that the requirements of IRR99 Regulation (19) are being met and provides a central forum for the employers to state their monitoring requirements to central equipment support Delivery Teams (DTs) within the DE&S organisation.

0105. The MOD Radiation Calibration Qualified Persons Committee (MRCQP) committee has been formed to provide support and technical guidance to the MOD RPIC and equipment support Delivery Teams on all aspects of RDME examination and testing. The expert panel also recommends the minimum testing / calibration standards to be maintained by the radiation calibration facilities to ensure that the employers' responsibilities are achieved.

0106. The MRCQP committee is responsible for the management of the internal triennial radiation calibration facility audit scheme, on behalf of the MOD RPIC committee, a process designed to ensure that calibration facilities undertaking / calibration of MOD RDME meet the appropriate standard.

0107. Traceability is achieved through use of radiological standards offering provenance to National Metrology Institutions (NMI). Traceability requirements are detailed in Chapter 2 - Radiological Standards, Traceability and Quantities.

0108. A number of Good Practice Guidance (GPG) documents have been produced by the National Physical Laboratory (NPL) to provide best practice guidance on the examination and testing of RDME. Where applicable the MOD has used this guidance as a minimum standard and adapted the procedures to specifically meet MOD requirements.

0109. MOD policy dictates that best practice is implemented. The following policy stipulates the requirements covering all aspects of statutory RDME testing, including; test categories, Qualified Persons, calibration facilities, radiological standards traceability and specification, dosimetric indices, neutron monitor test arrangements, equipment test protocols and the Approved MOD / defence contractor Radiation Calibration Facility audit scheme.

Internal MOD Radiation Calibration Facility Audit Scheme

0110. An audit programme is undertaken to ensure Approved MOD Radiation Calibration Facilities meet the requirements of this JSP and are providing a service in accordance with MOD requirements. In addition the programme will engender a unified and structured adoption of best practice.

0111. The United Kingdom Accreditation Service (UKAS) currently provide ISO 17025 accreditation to a number of radiological calibration facilities. However, MOD approval relies upon conformance with the standards laid down in this document (and successful participation in the triennial audit program) and does NOT mandate the maintenance of UKAS accreditation. Facilities maintaining UKAS accreditation are not exempt from the MOD approvals process and approvals shall be specific to the tasks and equipments supported.

0112. In addition to the procedural audit, a practical assessment of the testing process will also be undertaken through comparison of results from standard equipment supplied by the equipment sponsor Delivery Team. As a minimum, one instrument appropriate to the facility capability and MOD contracted work will be tested by an independent facility and then forwarded to the calibration facility one month prior to the procedural audit. The results of the independent testing will be forwarded to the Audit team only and not the facility to be audited. The calibration facility shall then undertake testing of the supplied equipment and provide the auditors with the results of the test including calculation of sources terms and uncertainty budgets. The test instrument is to be retained by the facility for possible demonstration of process to aid comparison of results, during the actual audit visit.

0113. An audit report containing recommendations on the ability of the calibration facility to comply with MOD policy and actions required to maintain Approved MOD Radiation Calibration Facility status will be produced at the end of each audit. Recommendations which could be used to improve practice within the wider MOD 'approved' community will be discussed at the MRCQP committee. The audit team will allocate an agreed period of time (normally three months maximum) for receipt of confirmation that corrective actions have been taken.

0114. Calibration facilities achieving a satisfactory audit report will be accredited as an Approved MOD Radiation Calibration Facility; the list of Approved MOD Radiation Calibration Facilities will be maintained by the MRCQP committee. The list of Approved MOD Radiation Calibration Facilities is published in **Appendix 4 – List of Approved MOD Radiation Calibration Facilities**

0115. The Terms of Reference are given at **Annex 1A - Terms of Reference for the MOD Radiation Calibration Audit Team**.

0116. All calibration facilities seeking approval for the testing of MOD RDME will be subject to audit.

The Calibration Facility and Equipment

0117. Guidance on facility specification requirements is detailed in Paras 0118 thru 0129 below:

0118. The calibration facility must be of sufficient external construction and internal dimensions to provide a safe, secure and consistent environment. Source movement control, storage, interlocks etc must be consistent with As Low As Reasonably Practicable (ALARP) philosophy. Although not a direct function of the MRCQP audit team, any observation related to safety or the adoption of best practice will be noted. A formal assessment of the radiological safety of the facility should have been completed, and valid set of local rules specific to the facility is available. Prior to commencement of the audit the local rules shall be made available to the audit team.

0119. All MOD and defence contractors undertaking calibration of MOD RDME must have radiological calibration facilities offering traceability to national standards. Instruments used for the measurement of environmental conditions shall offer traceability to the national standard; the calibration should reflect the operational use of the equipment and should be capable of proving instrument linearity across the operational range encountered within the facility. A 1 point test does not provide sufficient information to determine serviceability or linearity. Environmental control or management operating procedures must be in place to maintain facility operation within the range 22° ± 5°C and 20% to 70% RH. Temperature, pressure and humidity shall be monitored and recorded using traceable instruments.

0120. The requirement to remain within the 20% to 70% relative humidity relates to the calibration of atmospherically vented ion chambers only, which can be affected by variations in ion pair mobility with changes in atmospheric humidity,[1] sealed detectors such as GM tubes, solid state detectors etc which are not unduly influenced by changes of humidity may be calibrated outside of the specified range. However, if an atmospherically vented ion chamber is being used as a transfer standard during the calibration, then the specified ranges will apply.

0121. Calibration facilities should have an appropriate collimated photon source exposure system interlinked with a reproducible equipment positioning facility. Uncollimated sources may be used but must be underpinned by substantial validation.

0122. The calibration facility should be able to demonstrate that they understand the background characteristics of their facility in order to appropriately meet the requirements of the calibration protocols being followed.

0123. The calibration facility must provide an acceptable scatter environment. The scattered photon characteristics of the facility at all equipment test distances shall meet the requirements of ISO 4037[2], i.e. the total dose equivalent rate from scattered photons shall not exceed 5% of that produced by the primary collimated photon beam at the equipment test position. However, where short source to equipment distances, less than

[1] Air KERMA Cavity Standards, L Büermann and D T Burns, 9 June 2008.

[2] ISO 4037 - X and γ reference radiations for calibrating dosemeters and dose ratemeters and for determining their response as a function of photon energy.

0.5m, for high dose rate or overload response testing is required, geometry related scatter effects greater than 5% are acceptable.

0124. The scatter characteristics of a neutron facility at all equipment test distances shall meet the requirements of ISO 8529-2, i.e. the total dose equivalent rate from scattered neutrons shall not exceed 40% of the direct neutron field at the equipment test position. At distances of less than 1m geometrical effects may need to be corrected. This process is also described in ISO 8529-2

0125. Where jigs are used to support testing within gamma exposure cells, the facility shall provide data relating to the scatter effects of the fixture.

0126. Calibration of alpha, beta and photon contamination monitors may be supported through the use of jigs or test fixtures to orientate the instrument to meet the requirements of the calibration protocol. Any jigs and test fixtures used must be demonstrated as fit for use for the intended application.

0127. Software used to support calibration operations i.e. positioning software, calculation spreadsheets etc, shall be validated and then configuration controlled in a systematic manner. The response quoted on the calibration certificate shall be obtained using the instrument primary display. Responses via a comm. link should not normally be used to determine instrument response.

0128. Original facility commissioning records and records of data derived within the facility shall provide sufficient information to demonstrate fitness for purpose, derive overall uncertainty estimations and establish an audit trail. The records shall provide evidence of conformance to criteria and include the identity of personnel responsible for tests and calibrations and results obtained.

0129. Testing in accordance with the MRCQP protocol of RDME must be the last step undertaken after any repair. Category 1 - Before First Use Testing shall be completed after any repair that may have affected the radiological properties of the RDME.

The Qualified Person

0130. The policy detailed below for the appointment of a QP applies to appointments after October 2008. It is not necessary to re-evaluate legacy appointments, unless specifically required by the RPA.

0131. The QP is defined as a person appointed by the employer having the necessary expertise, training and experience in instrumentation theory and practice to undertake or to directly supervise the examination and testing of RDME to meet the requirements of the IRR99.

0132. The QP must be competent in the use and the application of the following core framework areas:

Data and Error Analysis
Instrumentation Technology
Detector Principles
Principles of Radiation Decay
Quality Assurance Principles

Awareness of International Radiation Reference Standards
Instrumentation Applications / Uses

0133. The QP must be competent in the use and the application of the following as appropriate to the facility and QP's area(s) of responsibility:

Air KERMA Reference Standards
Alpha / Beta Contamination Standards
Neutron Reference Standards
Photon Reference Standards

0134. A QP employed to operate or supervise the operation of a radiation calibration facility is to be appointed in writing by a suitably senior, knowledgeable and accountable manager within the establishment in order to ensure that testing of RDME is carried out in accordance with the IRR99. The Chairman of the MRCQP is to be notified of any QP appointments.

0135. The suitability of qualifications, experience and status of persons prior to the appointment of a QP shall be evaluated by the employing organisation. Further advice can be obtained from chairman of the MRCQP.

0136. Newly appointed QPs must be able to provide a standard based evidence set reflecting relevant practical and academic activities to support the core framework.

0137. The following minimum must be contained within the evidence set:-
a. A minimum period of practical application after achieving vocational qualifications;
b. Peer review of competency;
c. Academic qualification, as a minimum to a level commensurate with the Nuclear Instrument Calibration Course (NICC) (or equivalent).

0138. QPs shall follow the agreed criteria / test procedures for MOD RDME testing detailed in the MRCQP Protocol Manual.

Staff Qualifications and Training

0139. Training and qualifications shall be commensurate to the position held. Definitive terms of reference for all staff are required as well as training records and planned training programmes.

0140. Where testing is being undertaken by staff not under the direct supervision of a QP, suitable supporting evidence reflecting the individual's competency portfolio shall be provided.

0141. The appointed QP must conform to the requirements specified in paragraph 0130 through 0138 of this document.

0142. A QP from each Approved MOD Radiation Calibration Facility shall be invited to attend or be represented on the MRCQP committee.

0143. An officer responsible for training shall be nominated and a means of measuring proficiency of trainees established. Records to demonstrate competence gained are to be retained for a minimum of 24 months following cessation of QP duties.

Facility Quality Management

0144. The management system adopted by the calibration facility shall ensure all requirements are met; these include the policy documented in this publication and contracted calibration facility customer requirements. These shall be documented and practised to ensure standards are maintained and equipments are correctly tested / calibrated with test procedures subsequently controlled in an effective manner.

Management System Review and Evaluation

0145. The management system established must be periodically and systematically reviewed by a suitable internal audit process to provide objective evidence of its continued effectiveness. The internal audit process shall be documented and define the conduct of the review, parameters to be examined, review periodicity, result reporting and corrective action procedures. All internal audit findings shall be reported, actioned and available for inspection.

Planning

0146. The facility shall set up a system to determine projected workload to enable suitable turnaround times in accordance with the customer requirements.

Units of Measurement

0147. RDME shall be tested using radiological Système International (SI) units and as a minimum, be tested with the nuclides and reference rates specified in the relevant equipment protocol. Non SI units RDME shall require approval for continued use by the relevant RPA.

0148. For further information on radiological quantities, standards and traceability, see Chapter 2 of this JSP.

Instrumentation Test Categories

0149. MOD RDME is to be tested to the following categories that relate to specific test requirements.

a. **Type Test**: For the employer, A ‘type test’ is used to ensure that the equipment is fit for purpose as defined within the User Requirement Document (URD), System Requirement Document (SRD) or Statement of Technical Requirement (SoTR), generated by the employer having received advice from their RPA and appropriate Subject Matter Experts (SMEs). The type test provides the required data to demonstrate that the equipment meets the capability requirement and also quantifies

and qualifies any radiation measurements that are subsequently made with the equipment.

Physical testing to confirm environmental specifications may be waived if sufficient documented evidence is available from recognised sources. Environmental testing is to be carried out with the equipment in a fully working condition and activated by an appropriate radiological source.

Type testing shall be carried out prior to the main purchase of equipment.

b. **Category One: Test Before First Use**. This test will be carried out by the equipment manufacturer or an Approved MOD / defence contractor Radiation Calibration Facility. The purpose of this test is to confirm that the equipment performance conforms to type test data. It must be undertaken before the equipment is brought into service or following a repair which may have altered the equipment's response.
When type test data is not available or considered insufficient then sufficient testing to establish a baseline for the equipment must be completed.

Testing of non-radiological parameters may be required to satisfy specific operational requirements; these are specified in the MRCQP Protocol Manual as appropriate.

c. **Category Two: Periodic or Annual Test.** This test shall be conducted at least annually or at a shorter period necessary to confirm that the performance of the equipment has not deteriorated. The tests necessary for a Category Two test may differ from those stipulated for Category One Tests. These are specified in the MRCQP Protocol Manual.

d. **Category Three: Check Before Operational Use.** The user shall carry out a check before operational use. The checks necessary for Category Three are as follows:

1. **Pre-radiation Tests, Electrical and Physical Examination.**
2. **Battery checks** - replace as necessary.
3. **Mechanical checks.** Check mechanical integrity of the equipment.
4. **Controls**. Check operation.
5. **Calibration Validity.** Check that the calibration seals are in place and that the calibration period has not expired.
6. **Check Source Response** using an instrument check source to produce a defined equipment response under specific conditions. This check provides user confirmation that the periodic / annual Category Two test results remain valid.

Documented Calibration/Test Procedures

0150. Calibration facilities shall have documented operational procedures available for reference and these shall be used as necessary for the testing of RDME. The facility must ensure that the latest issue of the procedure is used.

0151. The minimum test requirements are defined in the MRCQP protocol manual.

RDME Test Protocols

0152. The MRCQP protocol manual is edited by the MRCQP chairman. Protocols are developed by nominated calibration facilities and peer reviewed by the MRCQP committee. A systematic process controlled by the MRCQP Secretary is adopted to ensure a continual review of the manual. If an anomaly is identified in a protocol the QP has a duty to inform the MRCQP Secretary to enable investigation and possible amendment action to be taken at the earliest opportunity. An anomaly form and process map is contained in the MRCQP Protocol manual for this purpose.

0153. The MRCQP protocol manual contains detailed minimum test requirements for all approved RDME in use. If equipment submitted for calibration is not currently included in the protocol manual, the QP shall discuss with Secretary of the MRCQP committee and agree an interim test procedure until a ratified test protocol is published in the protocol manual. Where new equipment has insufficient type test data to produce a test protocol, then a representative sample of the equipment must be forwarded to an Approved MOD Radiation Calibration Facility for provision of the required type test data.

0154. The protocols consist of type test data for comparison, equipment illustration, Category Two annual test details and additional tests that are necessary following a repair that may have changed the performance characteristics of the RDME.

0155. Where equipment is unable to be tested fully in accordance with the relevant MRCQP protocol the equipment is to be identified as 'Limited Calibration'. The equipment is to be clearly identified as only receiving a 'Limited Calibration' and the limitations of the testing must be clearly identified on the calibration certificate.

Overall Test Uncertainty

0156. The overall calibration uncertainty, including radiological standard transfer is to be calculated and records maintained. Evidence that uncertainties are maintained as low as reasonably practical is to be provided. The uncertainty of measurement shall be stated on the calibration certificate.

0157. Guidance on the calculation of uncertainty budgets is detailed in NPL Measurement Good Practice Guide 49 - The assessment of uncertainty in radiological calibration and testing.

0158. Example spreadsheets are available from the MRCQP Secretary to aid calibration facilities in the development of their uncertainty budgets.

0159. MOD policy is to introduce best practice into radiation calibration facilities. Therefore in relation to uncertainty MOD has set an upper limit to the uncertainty that is required for its calibration facilities to achieve. This has been set at a maximum of ±20% at 95% confidence for tertiary laboratories.

0160. All laboratories are to show that the major components of the uncertainty budget have been considered for actions to reduce the impact on the overall budget.

Equipment Test Periodicity

0161. RDME must be tested annually to confirm that the performance of the equipment has not deteriorated, or after repairs that may have altered their radiological response. Test responses shall agree with type test data, within the tolerance band stipulated in the relevant equipment calibration protocol.

Calibration Certificates

0162. Certificates of calibration shall be issued by the calibration facility with all equipment tested. The certificate shall contain the following minimum information:

a. The description and unique identification of the item calibrated.
b. Equipment owner (i.e. who the test is for)
c. A statement of the actual range(s) and or calibration points tested (including indicated background).
d. Type of test (i.e. test before first use, periodic etc)
e. Reason for test, i.e. Pursuance of Regulations (19(2)) of IRR99 and JSP425.
f. The calibration results and associated uncertainties of measurement with declared confidence levels.
g. The result of the overall test (i.e. Pass, Fail)
h. Description of any test that was unable to be completed in accordance with the minimum requirements of the protocol. The equipment must be identified with a Limited Calibration Sticker.
i. Tabular presentation of results, e.g. Dose rate delivered vs. Equipment Response etc.
j. Traceability statement and reference standards used.
k. The indication produced by any relevant check source supplied with or associated with the equipment.
l. A statement of any relevant environmental conditions and any limiting functional conditions associated with the tests.
m. The date of issue of the certificate and the date of the calibration.
n. The identity of the issuing laboratory and authorisation of certificate by the authorised signatory.
o. A declaration of traceability of measurements.
p. A statement of any rectification work or adjustments made and where applicable the degree of adjustment made. A statement is to be made where no adjustments were required.

0163. An example of a typical γ calibration certificate is shown at Annex 1B - Example Calibration Certificate. General format is at the discretion of the individual calibration facility, but shall follow the guidance detailed above.

0164. Surface contamination monitor calibration certificates must contain details of both the $cps.Bq.cm^{-2}$ and percentage 2π efficiency, quoting the P factor that has been used for the former. Results of linearity, light sensitivity and spatial response uniformity do not need to be quantified; a simple 'pass' statement will suffice. The background count rate and the instrument check source response, however, will be quoted.

Calibration Records

0165. The facility shall maintain records of all equipment tested. The records shall include the following:
   a. Description of the equipment.
   b. Unique identification i.e. serial number.
   c. Type of test performed
   d. Date on which the test was performed.
   e. Calibration interval.
   f. Calibration procedure used.
   g. Measurement results.
   h. Details of adjustments / repairs.
   i. Environmental conditions at the time of calibration.
   j. Measurement uncertainty.
   k. Limitations of calibration.
   l. A list of radiological standards used (including serial numbers) to establish traceability.
   m. Signature of the QP.

Calibration Labels

0166. All radiological standards / equipments calibrated by the facility must be labelled to indicate their calibration/test status. Any limitations of testing must be identified to the user by a suitable label attached to the equipment with limitations detailed on the calibration certificate.

0167. The following information, as a minimum, shall be indelibly inscribed on the label by the calibration facility:
   a. Equipment identification (serial number).
   b. Date of test (showing in order day month and year i.e. dd/mm/yyyy).
   c. Calibration certificate number.
   d. Space for the retest date (showing as a minimum in order month and year as local requirements dictate)
   e. Calibration facility name.

0168. Labels shall be situated such that they are visible whilst the RDME is in use and must not affect performance.

0169. The standardised series of MOD calibration labels are defined in JSP886 Volume 7 Part 8.17 and illustrated in MOD Form 1775. It is not mandated that these standardised labels are used; however the serviceable calibration label shall contain the information stated in paragraph 0167 above.

Integrity Seals

0170. Access to adjustable devices on standards and measuring equipment, which are fixed at the time of test and are not to be adjusted by the user shall be sealed or otherwise safeguarded to prevent tampering by unauthorised personnel. Seals shall be designed such that tampering will destroy them.

Invalidation of Calibration/Test

0171. The facility shall make provision for the immediate identification, removal from use and quarantine of any calibration standard or test facility support equipment that has failed in operation, is suspected of being outside its designated performance limits or shows evidence of physical damage which may affect its performance. Notification shall be made to the QP, following which a documented investigation, including corrective and preventative actions, shall be undertaken to determine any possible impact. Corrective and preventative actions highlighted by the investigation shall be actioned in a timely manner. Documented justification for non-action shall be recorded.

Out of Tolerance Reporting

0172. The facility shall make provision for the immediate identification, labelling, removal from use and quarantine or repair of any equipment found to be outside of protocol pass fail criteria. The test facility shall inform the customer / user when equipments have been tested and found to be outside designated performance limits. Documented procedures shall be maintained to detail and demonstrate compliance.

Storage and Handling

0173. The facility shall establish procedures for the control, issue, use, handling, storage, quarantine or return of all equipment, such that equipment status is maintained.

Sub-Contracting of MOD Calibration Work

0174. The prime contractor shall ensure that any test work sub-contracted shall be performed in a calibration facility, which operates a system meeting the minimum requirements of this JSP. Prior to sub contract the equipment sponsor is to be informed and documented evidence shall be available to detail and demonstrate compliance.

Intentionally Blank

Annex 1A - Terms of Reference for the MOD Radiation Calibration Audit Team

Title

1. The audit group shall be known as the MOD Radiation Calibration Audit Team.

Composition

2. The following shall be represented at all times: MRCQP Chairman, technical specialist or specialists appropriate to the type of facility being audited and administrative quality assurance (normally provided by DQAG FF).

Aims/purposes

3. To formally audit aspects of Approved MOD Radiation Calibration Facilities against the requirements of JSP 425, at the request of the sponsoring authority. To make appropriate recommendations to the calibration facility Management Organisation with regards to audit findings.

Scope

4. Specific audit parameters will be agreed with the sponsoring authority before audit but may include any area that relates to calibration work carried out on RDME used for MOD purposes.

Channel of Reporting

5. To the audit sponsoring authority and Calibration Facility Management Organisation.

Frequency

6. As per agreed program ideally every 3 years.

Categorisation of Audit Findings

7. All findings considered to reflect a non-adherence to this JSP, Customer requirement or current best practice will be identified as a Non-Conformance. These findings will require mandatory action to be taken to rectify the process / procedure. The mandatory action will require closure and evidence that the agreed action has been undertaken to rectify the finding and prevent recurrence of a similar finding shall be provided to the Lead Auditor within agreed timescales. This category of finding will be identified as an official 'Customer Complaint'.

8. Observations will cover findings that require clarification or review to assist in the introduction of best practice. Observations may also be made where a minor isolated non-adherence to this JSP, Customer requirement or current best practice has been found where it is clear that the departure from the requirement is not and will not become a systematic departure.

Intentionally blank

Annex 1B - Example Calibration Certificate

CERTIFICATE OF CALIBRATION
OF A GAMMA DOSE RATE MONITOR

PAGE 1 OF 3 PAGES

ISSUED BY: NOSUCH RADIOLOGICAL CALIBRATION FACILITY

SERIAL NUMBER: RM 0692/00002

CALIBRATION No 1234

No Such Rad Cal Fac
New Q Building
Leafy Lane Trading Estate
Burnt Field
AB1 QY2

Tel (0123) 456789 ext 1234/5678

NAME OF QUALIFIED PERSON:

Signature:

Operator (initials):

FOR:

INSTRUMENT TESTED: PDM1

Serial No: 820
Status: Routine Survey Monitor
Type: Periodic
Result: PASS
(see notes 6 and 7)

TEST: Date: 12-4-08

Certificate Date: 12-4-08

RESULTS:

Ambient Temperature: 20.0°C (see Note 3)
Pressure: 1024.2 mbar

Radiation Quality	Range	Ambient Dose Equivalent Rate, H* (10)	Observed Reading	Observed Fluctuation (μSv.h^{-1})
^{137}Cs	30 μSv.h^{-1}	2.5 μSv.h^{-1}	2.0 μSv.h^{-1}	1.5 - 2.5
^{137}Cs	30 μSv.h^{-1}	7.5 μSv.h^{-1}	7.0 μSv.h^{-1}	5.5 - 8.5
^{137}Cs	30 μSv.h^{-1}	15 μSv.h^{-1}	15.5 μSv.h^{-1}	14 - 17
^{137}Cs	300 μSv.h^{-1}	150 μSv.h^{-1}	155 μSv.h^{-1}	<10%
^{137}Cs	3 mSv.h^{-1}	1.5 mSv.h^{-1}	1.55 mSv.h^{-1}	<10%
^{137}Cs	30 mSv.h^{-1}	15 mSv.h^{-1}	14 mSv.h^{-1}	<10%
^{137}Cs	300 mSv.h^{-1}	150 mSv.h^{-1}	138 mSv.h^{-1}	<10%
^{241}Am	300 μSv.h^{-1}	300 μSv.h^{-1}	220 mSv.h^{-1}	195 - 245

1623A Check Source Response (see note. 9): 3 μSv.h^{-1}

Specimen Area Gamma Survey Monitor Calibration Certificate: Page 1

CERTIFICATE OF CALIBRATION
OF A GAMMA DOSE RATE MONITOR

PAGE 2 OF 3 PAGES

ISSUED BY: NOSUCH RADIOLOGICAL CALIBRATION FACILITY

SERIAL NUMBER: RM 0692/00002

CALIBRATION No 1234

No Such Rad Cal Fac
New Q Building
Leafy Lane Trading Estate
Burnt Field
AB1 QY2

Tel (0123) 456789 ext 1234/5678

NAME OF QUALIFIED PERSON:

Signature:

Operator (initials):

Radiation Quality	Range	Integrated Ambient Dose Equivalent, H* (10)	Observed Reading
^{137}Cs	30 μSv	20 μSv	18.5 μSv
^{137}Cs	300 μSv	200 μSv	185 μSv

An overload was carried out on each range (see note 5).

The uncertainties are for a confidence probability of not less than 95%.

Specimen Area Gamma Survey Monitor Calibration Certificate: Page 2

CERTIFICATE OF CALIBRATION
OF A GAMMA DOSE RATE MONITOR

PAGE 3 OF 3 PAGES

ISSUED BY: NOSUCH RADIOLOGICAL CALIBRATION FACILITY

SERIAL NUMBER: RM 0692/00002

CALIBRATION No 1234

No Such Rad Cal Fac
New Q Building
Leafy Lane Trading Estate
Burnt Field
AB1 QY2

Tel (0123) 456789 ext 1234/5678

NAME OF QUALIFIED PERSON:

Signature:

Operator (initials):

NOTES:

1. Appropriate pre-radiation electrical and mechanical examination tests were undertaken.

2. The instrument was calibrated using the No. photon air KERMA facility. The overall uncertainty of the dose rates for Cs-137 is 5% and for Am-241 is 10%. The overall uncertainty was calculated at the 95% confidence level and propagated in accordance with the advice given in "The Expression of Uncertainties in Radiological Measurements" (NPL GPG49). Full details on the uncertainty treatment are available on request.

3. No ambient temperature and pressure standard conditions (temperature 20°C, pressure 1013 mbar) correction is undertaken for an open air ionisation chamber.

4. Conversion to ambient dose equivalent, H* (10), is performed using the factors 1.20 for Cs-137 and 1.74 for Am-241, as quoted in ISO 4037 Part 3 "Calibration of Area and Personnel Dose Meters".

5. The instrument linearity was tested on each range after an overload response test of 10 times the full-scale deflection for 30 seconds was carried out.

6. These tests were undertaken in pursuance of the Ionising Radiations Regulations 1999, regulation (19) and according to the guidance given in the JSP 425.

7. The response of this monitor required no adjustment to bring the linearity response to within ±20% of the dose rates to which it was exposed and the low energy response to within ±30% of the appropriate type test data.

8. The photon air KERMA and ambient dose equivalent rates used in this test were measured using tertiary standard electrometer serial No. XXXXXX and chamber Serial No. XXXXXX whose calibration is traceable to primary radiation standards held at the NPL.

9. A 1623A check source was positioned (with screw cap removed) directly in contact with the detector, the meter was allowed to stabilise for a period of 30 seconds and the mean of six independent readings were taken to establish the mean response quoted on page 1 of this certificate.

Specimen Area Gamma Survey Monitor Calibration Certificate: Page 3.

Intentionally blank

Chapter 2 - Radiological Standards, Traceability and Quantities

Introduction

0201. This Chapter details the concept of standards and traceability and the statutory obligation to demonstrate traceability of radiological measurement.

0202. Additionally, it specifies the radiological quantities (photon air KERMA and ambient dose equivalent, alpha and beta and photon surface emission rate, neutron fluence etc) against which equipment shall be tested. Details are given on the use and specification of the associated radiological standards necessary for realisation of the required radiation fields in the calibration facility.

0203. The Ionising Radiation Regulations 1999 and their associated Approved Codes of Practice specifies the requirement for traceability of all measurements made for the purpose of radiological protection.

0204. All radiological measurements shall be traceable. Traceability is defined in the International Vocabulary of Metrology as 'The ability to relate measurements to appropriate standards generally International or National through an unbroken chain of inter-comparisons'. In the United Kingdom, traceability is to primary radiation standards held by the NPL. It is emphasised that traceability must be underpinned by recognised approved and assessed measurement procedures.

0205. All radiological measurements made within the MOD, including HM forces, must be undertaken using RDME with calibration traceable to National Metrology Institutions (NMI) or Euromet governed European National Standards Laboratories, via tertiary and secondary standards.

Traceability Requirement

0206. The traceability requirement for the calibration of RDME and standard sources, dictates that the uncertainty of calibration can be determined by reference to National Radiation Primary Standards through a hierarchy of tertiary and secondary standards.

0207. The Atomic Weapons Establishment (AWE) has been contracted, via CBRN DT, to undertake calibration of MOD owned transfer standards. MOD departments purchasing transfer standards shall liaise with AWE to ensure the standards are suitable for recalibration by AWE.

0208. MOD departments and HM forces shall make provision for traceability of RDME calibration either through support agreements with the equipment sponsor or via direct contract with an Approved MOD Radiation Calibration Facility.

0209. MOD agents, consultants, contractors and sub-contractors using RDME and calibration sources in support of defence projects shall ensure calibration traceability to National Standards. Calibration facilities using calibration sources for MOD RDME which are supplied with non-UK national standards traceable calibration certificates must be capable of demonstrating that the sources used are traceable to UK national standards.

0210. The Bureau International des Poids et Mesures (BIPM) is tasked to ensure worldwide uniformity of measurements and their traceability to the International System of Units (SI). It does this with the authority of the 'Convention of the Metre', a diplomatic treaty between fifty-four nations since 1st Jan 2010, and it operates through a series of Consultative Committees, whose members are the national metrology laboratories of the member states of the convention, and through its own laboratory work. The BIPM web site **http://www.bipm.org/en/home/** provides assistance to the international comparison of standards.

Radiological Reference Standards

0211. Radiological standards are termed in this publication as reference sources, e.g. extended area emission rate standards or equipment based 'transfer standards' e.g. ion chamber and electrometer pairs.

0212. Details of the various radiological standards to be used by Approved MOD Radiation Calibration Facilities, to enable them to meet statutory RDME test requirements, are given in the following paragraphs.

0213. All radiological standards used for the calibration of MOD RDME must remain fit for purpose and undergo re-calibration as a minimum at the intervals given in Para 0217.

0214. Photon sources used for areal calibrations must be traceably calibrated in terms of their activity to support the generation of activity based response factors.

0215. Neutron sources used for the calibration of neutron survey meters shall be traceably calibrated in terms of emission rate and anisotropy of emission.

0216. Gamma exposure facilities shall realise rates in terms of air KERMA using a traceably calibrated standard transfer instrument, the instrument shall be appropriately sensitive and calibrated for the photon energies used within the facility.

0217. Radiological standards used within the calibration facility must be regularly re-calibrated. Re-calibration intervals are governed by radiological standard format, quality control measures and usage. However, the following re-calibration intervals shown below have been defined for Approved MOD Radiation Calibration Facilities.

a. electrometer and ion chambers for photon air KERMA measurement – three years (ref ISO 4037);

b. Alpha / beta emission rate and alpha / gamma activity standards – four years or two half lives, whichever is the sooner. Such standards where usage requires direct physical contact, i.e. working sources, shall be re-calibrated more frequently as justified to maintain traceability;

c. neutron fluence standard sources – ^{252}Cf every 30 months, ^{241}Am/Be every 5 years;

d. De Pangher long counters - every five years.

e. Other Neutron Transfer Standards – every year.

0218. Sufficient interim quality assurance checks should be in place to ensure standards adhere to relevant decay constant. If working standards may be suspected to be vulnerable to significant variation within the accepted calibration period, the frequency of calibration should be increased or evidence provided to counter the suspicion.

Radiological Standards and Associated Equipment

0219. The test facility must possess a suitable inventory of radiological standards to perform the tests detailed in the protocols for the equipment calibrated by the facility.

0220. The test facility must possess a suitable inventory of and maintain records for jigs and support equipment to perform the tests detailed in the protocols for the equipment calibrated by the facility.

0221. The records shall include at least the following:

a. Description of the equipment.
b. Unique identification i.e. serial number.
c. Date on which the test was performed – acceptance and QA interval.
d. Calibration interval.
e. Calibration procedure used.
f. Measurement results.
g. Details of adjustments / repairs.
h. Environmental conditions at the time of calibration.
i. Measurement uncertainty (if applicable).
j. Limitations of calibration.
k. A list of standards used (including serial numbers) to establish traceability.

Radiological Quantities

0222. This section specifies the radiological quantities (photon air KERMA and ambient dose equivalent, alpha and beta and photon surface emission rate, neutron fluence etc) against which equipment shall be tested. Details are given on the use and specification of the associated radiological standards necessary for realisation of the required radiation fields in the calibration facility.

0223. Radiological quantities stated in this publication are the accepted operational quantities for calibration of radiological standards. Radiological standards are the 'physical devices' within the calibration facility that enable the realisation of traceable radiation fields in terms of the relevant radiological quantity.

0224. Conversion of air KERMA (Ka) expressed in Gray (Gy) to operational units such as ambient dose equivalent (H*(10)) expressed in Sieverts (Sv) shall be achieved using conversion coefficients published in the ISO 4037 series.

0225. Neutron dose equivalent rate monitors must be tested for linearity, overload and energy response in terms of ambient dose equivalent (H*(10)), using fluence to dose equivalent conversion coefficients ($pSv.cm^2$) as published in the ISO 8529 Series documents.

0226. RDME shall be adjusted to scale correctly in terms of (H*(10)) wherever possible. Where the scaling of RDME is not designed for ambient dose equivalent (H*(10)) Sievert units the equipment shall be calibrated in terms of their designed scale units.

0227. Details of the radiological units used for testing are specified in the associated protocol and shall be clearly indicated on the supporting calibration certificate.

Dose Equivalent Quantities

0228. The quantity used for environmental (area) monitoring of strongly penetrating photon radiation is known as Ambient Dose Equivalent (H*(d)) measured in Sieverts, where the value *d* is equivalent to 10 mm. Details of conversion coefficients for the realisation of calibration fields in units of ambient dose equivalent (Sv) from air KERMA (Gy) are documented in ISO 4037 parts 1 to 3.

0229. H*(d) is defined by the International Commission on Radiation Units and Measurements (ICRU) as the dose equivalent that would be produced by the corresponding aligned and expanded field in the ICRU sphere at depth *d* on the radius opposing the direction of the aligned field.

0230. The quantity used to provide an indication of the dose equivalent below a specific point on the body at an appropriate depth is known as Personal Dose Equivalent H_p (*d*); any statement of personal dose equivalent should include a specification of depth *d*, expressed in millimetres. For weakly penetrating radiation, a depth of 0.07 mm (H_p (0.07) is employed to represent to dose to skin. For strongly penetrating radiation, a depth of 10 mm (H_p (10) is employed. The quantities are derived (for normal photon incidence) using conversion factors specified in ISO 4037 which incorporates a backscatter component (simulating the body of the wearer). Personal dosimeters are designed to be worn on the truck of the body and should ideally be calibrated using a suitable phantom assembly (specifications for phantom assemblies are provided in the ISO 4037 series documentation). Where dosimeters are calibrated (or used) 'free in air' without a supporting phantom, additional correction factors (dosimeter type specific) are required to compensate for the reduction in backscatter.

Alpha and Beta Emission Rate Standards

0231. All alpha, beta and wide area reference standards used for the calibration of contamination monitoring equipment must be traceably calibrated in terms of their surface emission rate i.e. alpha, beta emissions in the forward 2π solid angle. The minimum standard of legacy sources used shall be equivalent to class 2 reference standards as defined in ISO 8769 parts 1 & 2. The minimum standard of new sources introduced in to Approved MOD Radiation Calibration Facilities after Aug 2012 shall be equivalent to class 2 reference standards as defined in ISO 8769-2010.

0232. Regulatory documents refer to surface contamination in terms of activity per unit area. The reported response of RDME relates directly to the radiation emitted from the surface rather than the activity contained upon or within it, therefore, the required radiological quantity for testing of surface contamination monitors is alpha or beta emission rate.

Chapter 3 - The Generation of Traceably Calibrated Radiation Fields for Use in the Calibration Facility provides guidance on how to inter-convert between 2π efficiency and activity responses expressed in terms of cps per $Bq.cm^{-2}$ and their derivation from measurement using extended area emission rate standards.

0233. Recommendations are made on the nuclides required for alpha and beta contamination monitor testing in the relevant calibration protocol. It must, however, be noted that specific nuclides relative to the application of the equipment should be selected to confirm that the equipment is fit for purpose for the specific application.

0234. For non-standard monitoring applications (novel radionuclides) a fit for purpose assessment resulting in a special application calibration protocol must be undertaken. Approval for digression from the published protocol must be sought from and approved by the RPA and DE&S equipment sponsor prior to submitting equipment for testing.

0235. Recommended product specifications for suitable standards are given in Table 2.1 - MOD Recommended Alpha and Beta Emission Rate Standards. Specific standards applicable to the various type of RDME are given in the relevant RDME Protocol.

Specification of Small Area Standards

0236. Planar, non-recessed, small area emission rate standards are required for linearity and spatial uniformity tests of surface contamination monitors.

0237. The nuclides selected do not have to be the same as those utilised for contamination response factor derivation. However, type test data and test protocols are available for ^{241}Am (alpha contamination monitors) and, $^{90}Sr/Y$ (beta and beta/gamma monitors). Recommended product specifications for suitable standards are given in Table 2.1 - MOD Recommended Alpha and Beta Emission Rate Standards. Specific standards applicable to the various type of RDME are given in the relevant RDME Protocol.

Photon or Electron Capture Nuclide Emission Rate Standards

0238. Extended area photon emission rate standards are required for calibration of photon surface contamination monitors. The recommended nuclides to be used depend on the photon energies emitted by the work place fields.

Recommended large area emission rate standards shall meet ISO 8769-2 and are detailed in Table 2.2 - MOD Recommended Electron Capture Nuclide Photon Emission Rate Standards and Filters

Photon Air KERMA/exposure Standard Transfer Instruments

0239. Photon or gamma electromagnetic radiation interacts with a medium through which it is passing by a variety of processes to produce energy deposition or transfer via ionisation. The magnitude of this energy transfer (KERMA), under conditions of secondary electron equilibrium is equal to the absorbed dose Gray (Gy) ($1\ Gy = 1\ J.kg^{-1}$).

At photon energies above 2 MeV a small correction is required for loss of kinetic energy transferred to secondary electrons (KERMA) through radiative losses due to bremsstrahlung production. This correction is nominal for isotope sources used within calibration facilities and air KERMA is an accurate measure of absorbed dose to air, under the conditions specified.

0240. Standard transfer instruments used for the measurement of absorbed dose to air (expressed in terms of air KERMA (Gy)) consist of ion chambers of appropriate volume (matching the radiation field intensity) connected to a sensitive electrometer assembly (to measure the ionisation current). Additional build-up caps are used to ensure electronic equilibrium.

0241. The sensitivity of the ion chamber ($Gy.C^{-1}$) varies with photon energy and calibration factors are supplied by AWE or appropriate standards laboratory (in the relevant calibration certificate) for conversion of specific chamber responses into units of air KERMA (Gy).

Neutron Fluence Standards

0242. The method of characterizing the neutron fluence for neutron reference standards at any given facility is a direct measurement of the source emission rate and the anisotropy factor for the sources encapsulation undertaken by the National Standard Laboratory. This enables the use of a mathematical method to calculate the neutron fluence at a given point using various correction factors. This process is described in detail in ISO 8529-2.

0243. Any calibration must be performed using a well characterised source. This can be achieved either measurements performed at a national standards laboratory as stated above or through the use of a transfer standard.

0244. The required reference sources for production of appropriate dose equivalent rates and recommended conversion coefficients from neutron fluence to ambient dose equivalent H*(10) are detailed in ISO 8529-1.

0245. Facility scatter shall be determined by at least two independent techniques, such as: shadow cone, Monte Carlo simulation or a least squares technique such as that developed by Eisenhauer. Details of these procedures can be found in ISO 8529-2. Once understood the scatter characteristics shall be factored in to the calibration, details of how this is implemented shall be available.

Table 2.1 - MOD Recommended Alpha and Beta Emission Rate Standards

Format (Active Area)	Function
10 x 15 cm	Contamination response for Standard Probes
16 mm disc	Linearity / Spatial Uniformity
50 mm disc	Contamination response for Drawer / Castle Assemblies
NOTE – Specific source requirements are detailed in the relevant equipment calibration protocol	

Table 2.2 - MOD Recommended Electron Capture Nuclide Photon Emission Rate Standards and Filters

Approximate Mean Photon Energy (1) (keV)	Half Life (Years) (± 1%)	Radionuclide and Filter (2)
5.9	2.7	^{55}Fe (None)
16	87.7	^{238}Pu 32.5 mg.cm^{-2} Zirconium
32	1.57 x 10^7	^{129}I 81 mg.cm^{-2} Aluminium
60	432	^{241}Am 200 mg.cm^{-2} Stainless Steel
124	0.74	^{57}Co 200 mg.cm^{-2}
600	30.2	^{137}Cs 800 mg.cm^{-2} Stainless Steel
1200	5.27	^{60}Co 81 mg.cm^{-2} Aluminium
NOTE – It must be noted that these are sources of photon or electrons of a particular energy range and not sources of a particular radionuclide.		
(1) The approximate mean photon energy is equal to $(\Sigma n_i.E_i)/\Sigma n_i$ where n_I is the number of photons emitted from the source with energy E_i. (2) Stainless Steel is that which has the composition 72% Fe, 18% Cr, and 10% Ni.		

Intentionally Blank

Chapter 3 - The Generation of Traceably Calibrated Radiation Fields for Use in the Calibration Facility

Introduction

0301. For routine testing of RDME traceable radiation fields have to be generated or 'realised' within the calibration facility in terms of the appropriate radiological quantities using the radiological standard instruments and sources specified in Chapter 2 - Radiological Standards, Traceability and Quantities.

0302. Manufacturer's Type Test data for contamination monitors is invariably expressed in terms of 2π counting efficiency. Historically, MOD calibration facilities have compared the measured counting efficiency with well established data to determine if the unit continues to operate to 'type'.

0303. Guidance is given on the conversion of emission rate responses of surface contamination monitors to the required monitoring quantity cps per $Bq.cm^{-2}$. For gamma dose equivalent rate monitor testing, the secondary standard transfer instrument is supplied with Air KERMA calibration factors.

0304. Guidance is also given on the characterisation of gamma irradiation facilities in terms of beam profile and analysis of inverse square law data.

0305. The calibration of a neutron area survey monitor is described at para 0344 onwards.

Alpha, Beta and Beta / Gamma Surface Contamination Monitors: Emission Rate Fields

0306. The radiological performance of alpha, beta and photon surface contamination monitors is derived using certified, wide area emission standards. In practice the sources should offer a semi-infinite plane geometry such that their surface area is equal to or larger in area than the sensitive portion of the probe under test.

0307. All alpha, beta and photon wide area reference standards used for the calibration of contamination monitoring equipment must be traceably calibrated in terms of their surface emission rate i.e. alpha, beta or photon emissions in the forward 2π solid angle.

0308. Standard jigs are available to ensure that in service monitors are positioned at a standard distances, jig references are provided in the relevant calibration protocol.

Derivation of Surface Contamination Response (cps per $Bq.cm^{-2}$) or Efficiency (2π) from Use of Emission Rate Standards

0309. The certified alpha, beta or photon surface emission rate from the reference source shall be used to derive the contamination response of a monitor, either in terms of cps per $Bq.cm^{-2}$, cps per $em.cm^{-2}$ or 2π efficiency (Note: 2π efficiency has been maintained as some legacy equipments are supported by type test data reporting performance in 2π). Worked examples are provided for each case later in the chapter.

0310. The common approach for determining the activity response of alpha and beta contamination monitors utilises a P factor. Current best practise (GPG 14) recommends a P-Factor of 2 for α and β calibration reference sources (i.e. 1 emission per second

equates to 2 Bq.). The value of P used in the test shall be recorded on the calibration certificate.

0311. If the operational user requires contamination response calibrations that reflect operational self-absorption, i.e. for real life rather than test measurements, then a different P factor from that used in the test may be applicable for routine monitoring. Guidance shall be sought from the RPA for the utilisation of P-Factors other than 2 to ensure the activity response calculated is appropriate to the monitoring task and situation.

0312. P-Factors will not be used with photon surface contamination standards and all responses will be quoted as a function of surface emission (*cps per emission* $s^{-1}.cm^{-2}$).

Surface Emission Rate Derivation (Emissions s^{-1} per cm^{-2})

0313. Calculate the emission rate per second per cm^2, *E*, from the emission rate standard on the basis of the certified alpha or beta emission rate, *S*, and active area, *A:*

$$E = \frac{S}{A}$$

Emission Response Derivation (cps per Em.cm^{-2})

0314. Using the standard jig and appropriate large area emission rate standard, record the net monitor response, *M*, in cps, at the fixed geometry simulating a semi-infinite plane.

0315. Calculate the monitor emission rate response, E_r:

E_r = cps per emission $s^{-1}.cm^{-2}$

$$E_r = \frac{M}{E} \quad (cps\ per\ emission\ s^{-1}.cm^{-2})$$

Contamination Response Derivation (cps per Bq.cm^{-2})

0316. Using the standard jig and appropriate large area emission rate standard, record the net monitor response, *M*, in cps, at the fixed geometry simulating a semi-infinite plane.

0317. Calculate the monitor emission rate response, E_r using the method defined in Para 0315.

0318. The required contamination response in terms of activity, A_r (cps per Bq.cm^{-2}) is then simply calculated from:

$$A_r = \frac{E_r}{P}$$

Where *P* = ratio of surface activity (Bq) to surface emission rate.

A value of $P = 2$ should be used in association with the recommended emission rate standards.

Efficiency Response Derivation (2π)

0319. The determination of 2π counting efficiency is realised using two methods:
   a. The first method is used when the source area is greater than that of the detector and offers 'semi-infinite plane' geometry to the detector. In these circumstances, the net monitor response (cps) is divided by a (decay corrected) 2π particulate emission rate that has been normalised to the area of the probe i.e. the effective source area has been mathematically corrected such that it is identical to the detector area.
   b. The second method is used when the source area is less than or equal to that of the detector and offers 'point source' geometry to the detector. In these circumstances, the emission rate does NOT require normalisation and the net monitor response (cps) is divided by the gross (decay corrected) 2π particulate emission rate.

0320. Manufacturer's Type Test data for contamination monitors is invariably expressed in terms of 2π counting efficiency, i.e. the recorded monitor net counts per second, divided by the normalised to area particulate emission rate from a reference source of given area, placed under the monitor at a specified distance.

0321. Using the standard jig and appropriate large area emission rate standard, record the net monitor response, *M*, in cps, at the fixed geometry simulating a semi-infinite plane.

0322. Calculate the source emission rate, *E*, using the method defined in Para 0313.

0323. The required 2π efficiency response is then simply calculated from:

$$2\pi \text{ eff} = \frac{M}{E \times Pa}$$

Where *Pa* = Probe Area in cm^2.

Multiply the result by 100 to produce a percentage performance figure.

0324. Historically, MOD calibration facilities have tested satisfactory monitor response in terms of efficiency, efficiency may be used as a pass fail criteria but sufficient data for determination of activity shall be provided.

Worked Example for an Alpha Surface Contamination Monitor

0325. A probe with an effective area, *Pa*, of 20 cm^2 was used to monitor an ^{241}Am emission rate standard offering active dimensions of 10 cm x 15 cm (150 cm^2 active area, *A*) with total surface emission rate 1830 alphas per second, *S*, in a standard jig, and a source to detector separation of 3 mm, the net monitor response was 50 cps, *M*:

$E = S/A \quad 1830/150 = 12.2$ alphas $s^{-1}.cm^{-2}$

$E_r = M/E \quad 50/12.2 = 4.098$ cps per emission $s^{-1}.cm^{-2}$

$A_r = E_r/P \quad 4.098/2 = 2.05$ cps per $Bq.cm^{-2}$ (for $P = 2$)

$$2\pi \text{ eff} = \frac{M}{E \times Pa} \quad (50/ (12.2 \times 20)) \times 100 = 20.5\ \%$$

Linearity Response Derivation Using Small Area Standards

0326. The linearity of alpha, beta and photon surface contamination monitors is derived using a series of certified small area emission standards. In practice the set of linearity sources should offer a range of emission rates (reflecting the operational range of the instrument), each source within the set should be of identical nuclide and construction and offer an emission rate unique to the set.

0327. Small area alpha, beta and photon reference standards used for linearity testing must be traceably calibrated in terms of their surface emission rate i.e. alpha, beta or photon emissions in the forward 2π solid angle.

X-ray/Photon Wide Area Monitors: Areal Ground Contamination

0328. The testing of wide area 'areal' X / Gamma surface contamination monitors requires the reproduction of large area photon emission rate.

0329. Several in service X-ray ground surface contamination monitors, e.g. the XP110, XP120 and the IS610 have semi-infinite plane detection geometries of approximately 2 m^2.

0330. Large area standards of the relevant nuclide ('A' grade Pu) are not available at these dimensions and specialist point source integration techniques have been developed. The techniques employ small ^{241}Am activity standards spaced radially from the detector centre point to derive contamination responses for these equipments.

0331. Test protocols derived from those techniques are detailed in the MRCQP Protocol Manual for equipments of this type.

Realisation of Photon Air KERMA / Exposure Fields: Measurement of Source Terms and Beam Profiles

0332. Prior to measurement of source terms beam profiles must be completed to determine specific beam characteristics for operational use.

0333. Beam profiles shall be produced by taking a series of relative measurements at incremental points across the Y and Z axes of the associated positioning system. These measurements shall be taken with the smallest volume ionisation chamber that is consistent with accurate measurement of the ion current produced by the source of interest. Profiles are generally taken at 1, 2, 3 and 4 metres to enable calculation of the collimator half angle and to determine air attenuation and scatter effects along the beam. The associated data obtained from the beam characterisation process shall be documented for review by the audit team.

0334. Beam profile measurements shall be presented graphically and normalised to the unity point (the central axis of the radiation beam). If the maximum is offset from the expected position it is indicative of 'beam clipping' by the collimator or inaccuracies in the

geometry of the positioning system. A typical beam profile for a 12^{o} full angle collimator is shown in Figure 3.1 - Typical Beam Profile. Beam widths at the required uniformity for equipment testing shall be quantified; this is usually at the 95% uniformity region for routine equipment testing.

Analysis of Source Term Variation with Distance

0335. The track system shall be normalised along the uniformity axis of the beam and definitive source terms shall now be realised. Measurements shall be taken with the air KERMA standard at distances of 1 m intervals commencing at 1 m to the maximum distance utilised in calibration of equipments. Measurements shall be repeated sufficient times at each measurement point to minimise random uncertainty (<5% at 95% confidence level). Additional 0.5 m measurements may be of use, if significant scatter is indicated in the analysis below;

0336. The measured air KERMA rate shall be corrected to the specified ambient temperature and pressure conditions detailed in the secondary standard transfer instrument calibration certificate. The corrected measurements, at 1 m to 4 m, shall then be analysed using the following technique.

0337. Using the value of air KERMA rate measured at 1 m, calculate the theoretical value expected at the measurement points, on the basis of the inverse square law, i.e.:

$$\textit{Dose Rate at } x \textit{ (m)} \quad = \quad \textit{Dose Rate at 1 m} \times \frac{1}{x^2}$$

0338. Compare the measured values with the theoretical values calculated above. If there is no air attenuation (approx. 1.5% m^{-1} at ^{137}Cs photon energy) and no scatter from the facility, the ratio of measured dose rate / predicted dose rate would be 1.000 (i.e. perfect inverse square law observance).

0339. The ratio calculated above shall be presented in graphical form; examples are given for Mainance ^{137}Cs and ^{241}Am units respectively in Figure 3.2 and Figure 3.3.
The ^{137}Cs plot is a good example of what will be observed if there is an insignificant facility photon scatter returned to the calibration beam. In this case the ratio of measured over calculated air KERMA rate is not unity but falls from this value at approximately $1\%m^{-1}$, i.e. the value is 0.99 at 2 m to 0.97 at 4 m, as a result of air attenuation. However, the effective air attenuation function will be facility scatter and irradiation geometry dependent.

0340. Figure 3.3 – Effective Air Attenuation Measurements for uncollimated ^{241}Am source, is an example of high facility scatter, in the case of these measurements an uncollimated ^{241}Am source of the Mainance type was analysed. The measurements were taken with an isotropic 3000 cc chamber instead of the standard, non-isotropic, 600 cc chamber (which will show a similar trend but less marked). The 60 keV photon energy of ^{241}Am is scattered relatively isotropically in all directions by the walls of the irradiation room, whereas ^{137}Cs and ^{60}Co higher energy photons are scattered in the direction of travel of the incident photon field. With the ^{241}Am plot room scatter more than compensates for air attenuation producing an enhanced dose rate measurement relative to that predicted by the inverse square law. This example is an extreme case but illustrates how room scatter can be identified by means of such analysis and presentation.

0341. The radiation beam shall only be used where the ratio calculated above lies within the range 0.95 to 1.05, (the lower limit is for a 4 m track), a ratio greater than 1.05 indicates the presence of a greater than 5% scatter contribution. This criterion does not apply to overload testing.

Derivation of Neutron Monitor Response

0342. GPG49 summarises the process of calibrating a neutron monitor as follows:

> "a *neutron area survey monitor is calibrated by measuring its response at a reference position in a standardised neutron field. Usually the field is produced using a radionuclide neutron source with known emission rate and anisotropy factor. The calibration is normally expressed in terms of ambient dose equivalent rate. This is derived by the application of a conversion factor to the neutron fluence rate at the monitor position*"

0343. The methods available for testing and calibrating Neutron Monitors are outlined in NPL GPG14, with additional information relating to estimation of uncertainty of measurements given in NPL GPG49. Calibration is usually expressed in terms of ambient dose equivalent rate in a standardised neutron field. This requires the use of a stable and adequately characterised neutron source, which may be either a radionuclide source such as ^{241}Am-Be or ^{252}Cf, or an accelerator source, such as D-D or D-T, producing a neutron spectrum appropriate for the intended use of the monitor. Traceability to national standards may be obtained by the use of suitably calibrated sources or transfer standard instruments.

0344. Neutron sources are usually calibrated in terms of their neutron emission rate and an energy dependant conversion coefficient used to calculate the ambient dose equivalent field at the monitor position. It is therefore important that the scattered neutron contribution is minimised in order to achieve a valid calibration using neutron fields as specified in ISO 8529. It is standard practice that the scatter contribution should be estimated using two independent methods, typically an experimental measurement such as the shadow cone technique and a Monte Carlo calculation, and the results compared. The effects of neutron scatter will vary with the design of neutron monitor and its distance from the source. Appropriate corrections should therefore be applied, for anisotropy of the source and air attenuation of the neutron beam. A typical uncertainty budget is shown in Table 3.1. Note that the values given in this table are only typical, and must be determined for each specific test configuration.

0345. When a transfer standard instrument is used to provide traceability of measurement the uncertainties in the neutron field are dependant on the reproducibility of the instrument design and its positioning. A transfer standard instrument is therefore required for each design of instrument calibrated.

Quantity	Value	Uncertainty (δx_i)	Probability distribution	Divisor	$(\partial_f/\partial x_i)/y$	C_i/y	U(y) (%)	ν_i or ν_{eff}
Mean reading of monitor, M	100 μSvh^{-1}	4 μSvh^{-1}	normal	1	$(M - Mb)^{-1}$	100 / 99.6	4.0	9
Mean background reading, M_b	0.4 μSvh^{-1}	0.6 μSvh^{-1}	normal	2	$(M - Mb)^{-1}$	100 / 99.6	0.3	9
Conversion coefficient, h_{AmBe}	391 pSv cm^{-2}	4%	normal	1	1	1	4.0	∞
Emission rate, E	$1.035x10^7$ s^{-1}	$7.24x10^5$ s^{-1}	normal	1	1 / E	10^{-5} / 1.035	0.7	∞
Anisotropy, f_a	1.0493	0.0073	normal	2	$1 / f_a$	100 / 1.0493	0.35	∞
Attenuation correction factor, f_{aa}	0.9922	0.0099	normal	2	$1 / f_{aa}$	100 / 0.992	0.05	∞
Room scatter, f_{sc}	1.145	0.026	normal	2	$1 / f_{sc}$	100 / 1.145	1.23	∞
Distance between source and detector	1.030m	0.0021 m	rectangular	√3	2 / x	200 / 1.03	0.23	∞
Position of effective centre	1.030m	0.001 m	rectangular	√3	2 / x	200 / 1.03	0.11	∞
Calibration factor, C_{AmBe}	1.307		normal			$U(C_H)$	5.86	41
Expanded uncertainty (k=2.02)	0.157		normal			U	12	41

Table 3.1 Typical Uncertainty Budget for NMS017 neutron monitor

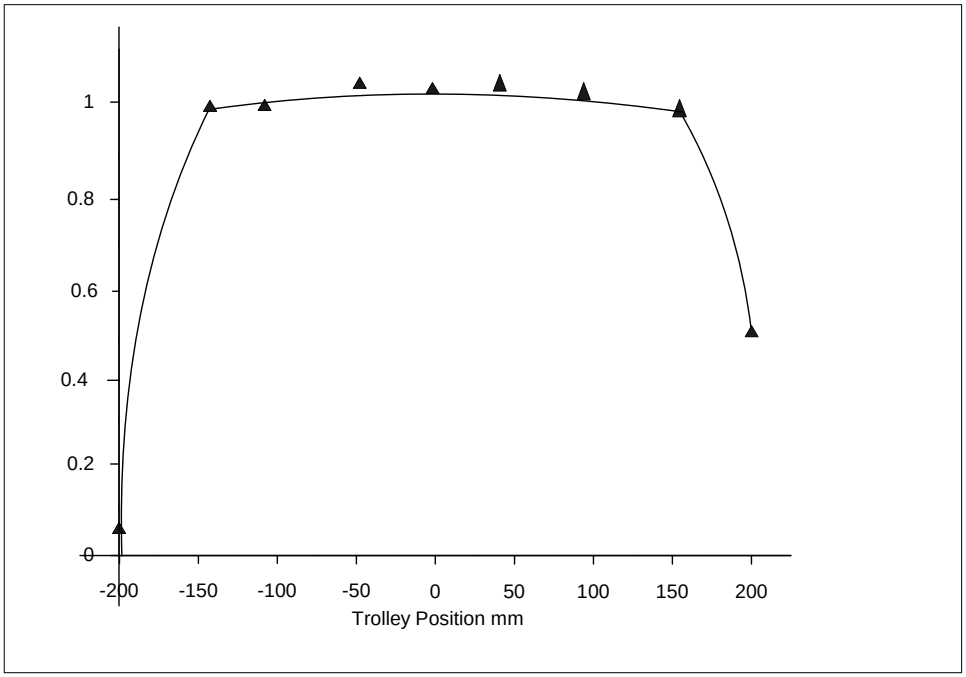

Figure 3.1 - Typical Beam Profile

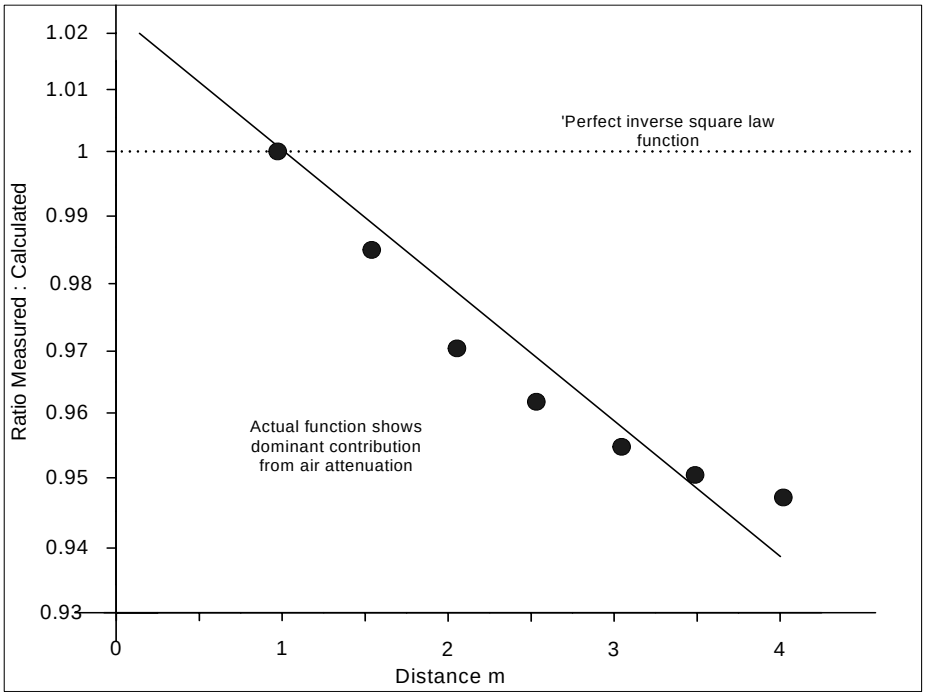

Figure 3.2 – Effective Air Attenuation Measurements for collimated ^{137}Cs source

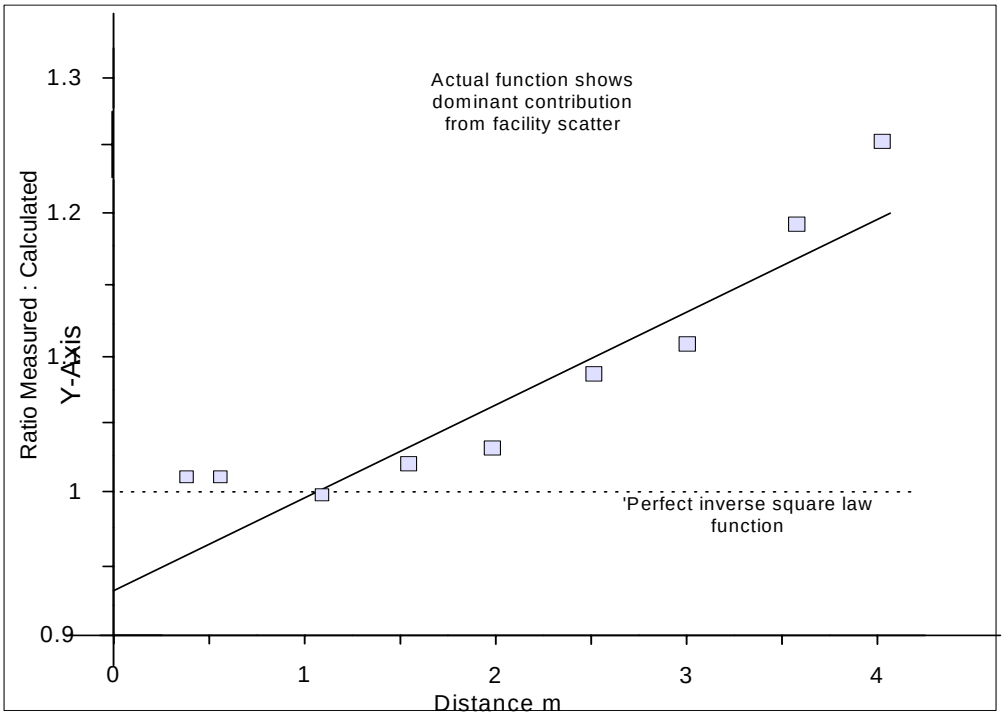

Figure 3.3 – Effective Air Attenuation Measurements for uncollimated ^{241}Am source

APPENDICES

Appendix 1 - Terms, Definitions and Abbreviations

ALARP As Low As Reasonably Practical

Ambient Dose Equivalent
See H*(d)

Approved MOD Radiation Calibration Facility
A calibration facility that has been achieved a satisfactory assessment against the requirements of JSP 425

AWE Atomic Weapons Establishment

BIPM Bureau International des Poids et Mesures

Calibration A measurement of the response of the equipment to a known radiation fields.

Calibration Facility A facility used for the calibration or testing of RDME

CBRN DT Chemical Biological Radiological and Nuclear Delivery Team

CESO Chief Environment and Safety Officer

CO **Commanding Officer**
The most senior officer of a ship, unit or establishment. Commanding Officer includes the Commandant, Officer Commanding, Captain, Master, Head of Establishment, D/PT Leader and Medical Officer-in-Charge

Contamination The unintended presence of radioactive material on surfaces, areas, personnel or objects or in gases or liquids.

CJO Chief of Joint Operations

Closed source A radioactive source from which the dispersal of the radioactive material is minimised by sealing, bonding or other means. This term includes bonded sources, homogeneous sources, laminated sources and sealed sources.

Committed dose The effective or equivalent dose that will be accrued by the body or a tissue over a 50-year period following the intake of radioactive material.

DE&S Defence Equipment and Support

Directional Dose Equivalent
See H'(d)

DT Delivery Team

Dose rate	The rate at which a person or part of a person would receive a given dose of ionising radiation.
Dosimeter	A device used for measuring absorbed radiation doses.
Dosimetry	The measurement of radiation doses. It applies to both the devices used and to the technique.
Dstl	Defence Science and Technology Laboratory
Dstl ESD	Defence Science and Technology Laboratory Environmental Sciences Department
Equipment	For the purposes of this publication equipment is defined as an individual item i.e. a dose rate meter or a kit comprising an instrument with associated probe and accessories i.e. Mini Monitor 900 with 42B probe.
Equipment Sponsor	The responsible organisation for the introduction and through life support of equipment.
Establishments	Includes all Naval, Army, Air Force, and MOD civilian (including Defence Agency) establishments and attachments.
Examination	An inspection of the mechanical and electrical state of the instrument.
Functional Check	A check carried out using a radioactive source to demonstrate the consistency of response of equipment before and / or during use.
Gray (Gy)	The SI unit of absorbed dose; defined as an energy deposition of 1 J.kg-1 of irradiated material.
GPG	**Good Practice Guide** A publication produced via the National Physics Laboratory detailing the industry recommended processes and procedures for a specific topic area.
H*(d)	Ambient Dose Equivalent - the dose equivalent that would be produced by the corresponding expanded and aligned field in the ICRU sphere at a depth, d, on the radius opposing the direction of the aligned field. (H*(10) soft tissue at a depth of 10 mm)
H'(d)	Directional Dose Equivalent - the dose equivalent that would be produced by the corresponding expanded field, in the ICRU sphere at depth, d, on a radius in a given direction (H'(0.07) skin)
H_p(d)	Individual Dose Equivalent, Penetrating - the dose equivalent at the point on the surface of the body under a tissue equivalent hemisphere of radius, d, whose centre is located at that point. (H_p (10) Personal monitoring dosimetry)

HASS	**High Activity Sealed Source** A sealed source containing a radionuclide whose activity at the time of manufacture is equal to or exceeds the activity levels specified in EC Directive 2003/122/Euratom i.e. that the activity equals or exceeds 0.01 of the corresponding A1 value given in the IAEA Regulations for the safe transport of radioactive material. A selection of radionuclide's activity levels are listed in Annex 25A. Radioactive waste, GTLSs and GTLDs and nuclear fuel are not considered to be high activity sealed sources.
High Dose-Rate Test	A high dose-rate is the exposure of the equipment to a dose-rate that is equal to the maximum dose-rate that the equipment is likely to see in its operational service. The high dose-rate test is used where an overload cannot be performed due to the non-availability of a sufficiently high method of generating the dose-rate required for the overload test.
HMNB	Her Majesty Naval Base
HoE	Head of Establishment
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
Individual Dose Equivalent	See $H_p(d)$
Instrument log	A record of RDME maintenance, repair and calibration.
Ionising radiation	Gamma (γ) rays, X-rays (either from radionuclide's, X-ray equipment or produced as a by-product of some other apparatus), alpha (α) particles, beta (β) particles and neutrons.
IRMF	Ionising Radiation Metrology Forum
IRR99	Ionising Radiations Regulations 1999
JSC SCM	Joint Support Chain Support Chain Management
JSP	Joint Service Publication
KeV	Kilo electron Volt
Limited Calibration	Limited calibration is where the calibration has not been completed in accordance with the full protocol detailed in the MRCQP Protocol Manual.
MOD	Ministry Of Defence
MRCQP	MOD Radiation Calibration Qualified Persons Committee

NMI	National Metrology Institution (The NMI of the UK is NPL)
NPL	National Physical Laboratory
NE	Nuclear Enterprises Trade name, Now Thermo electron
NICC	Nuclear Instrumentation Calibration Course
Overload Test	An overload test is the exposure of the equipment to a dose or dose-rate that is at least 10 times greater than the full scale of the equipment.
Periodic / Annual Test	A test to confirm that the equipment performance has not deteriorated.
PMMA	Poly Methyl Methacrylate (Perspex)
RMI	Radiation Monitoring Instrument
RPI	Radiation Protection Instrument
Prior risk assessment	Before the commencement of a new activity involving work with ionising radiation a suitable and sufficient assessment of the risk to the employee or other person shall be made. This assessment shall identify the measures required to restrict the exposure of the employee or other person. Where the risk exists from a reasonably foreseeable accident, the employer, shall prevent or with the use of a contingency plan limit the consequences of such an accident, and provide employees with appropriate information, instruction and training to restrict the exposure.
RPIC	Radiation Protection Instrument Committee
QP	**Qualified Person** A person appointed by the employer having the necessary expertise, training and experience in instrumentation theory and practice to undertake or to supervise the examination and testing of RDME to meet the requirements of the *Ionising Radiations Regulations 1999.*
RPA	**Radiation Protection Adviser** A person or corporate body appointed by the employer to advise him on the observance of the *Ionising Radiations Regulations* 1999 and on other health and safety matters in connection with ionising radiations.
RPS	**Radiation Protection Supervisor** Within the MOD it is a person appointed in writing by the Commanding Officer in respect of a particular process or processes to ensure that work is carried out in compliance with JSP 392.
RSO	**Radiation Safety Officer** Within the MOD it is an officer appointed by the Commanding Officer for the purpose of administering his responsibilities under these instructions.

Radionuclide	A radioactive species of atom characterised by its mass number, atomic number and nuclear energy state.
RDME	Radiation Detection and Monitoring Equipment (RDME) is split into three categories: RDME used for Health and Safety (H&S) and Nuclear Accident Response Organisation (NARO) is identified in this leaflet as RDME (H&S) this group includes equipment identified as RPI, RMI. RDME (MED&DENT) used in support of medical, dental and veterinary equipment testing shall be managed in accordance with JSP473 Joint Service Regulations For The Engineering Support Of Medical, Dental And Veterinary Equipment. The JSP outlines the policies and procedures to be adopted in the inspection and maintenance of Medical equipment used by the UK Armed Forces and its Agencies. RDME used to meet operational war fighting requirements is identified in this leaflet as RDME (OP).
Sealed source	A source containing any radioactive substance whose structure is such to prevent, under normal conditions of use, any dispersion of radioactive substances into the environment, but it does not include any substance inside a nuclear reactor or any nuclear fuel element.
SI	Système International
Sievert (Sv)	The SI unit of equivalent dose; defined as the product of the absorbed dose (in Gy) and the radiation-weighting factor. It provides an indication of risk to health, principally of cancer, in humans.
Source Terms	The traceable radiation output of a reference standard. For air KERMA rate emissions this would equate to a unit of Gray per hour at a specified distance. For contamination standards this would equate to the decay corrected emission rate in the 2 Π plain using the certificated rate as the reference value. For Neutrons this will be the certificated or measured fluence rate for the reference source
Special form	Radioactive material that is in the form of an indispensable solid or in a sealed capsule so constructed that it can only be opened by destroying the capsule.
SRD	System Requirement Document. A document detailing the system requirement. The document will include the quantified and qualified

requirements of the system including the operational and environmental conditions for which the equipment will be used.

SoTR Statement of Technical Requirement. Similar to a SRD but used for standalone RDME that is not part of an overall integrated system. The document will include the quantified and qualified requirements of the RDME including the operational and environmental conditions for which the equipment will be used.

Test A procedure to evaluate equipment performance in order to establish its suitability, or its continued fitness, for a particular type or types of measurements.

Test Before First Use A test to confirm that the equipment conforms to type test data.

TLS Through Life Support.

Type Test An assessment of an equipment to ensure that the equipment is fit for purpose as defined within the User Requirement Document.

UKAS United Kingdom Accreditation Service

Unsealed radioactive substance
Any radioactive substance that is not a closed source. It includes non-radioactive objects contaminated with radioactive substances.

Uranium Depleted uranium: Uranium containing less than 0.72% U-235 by weight.
Natural uranium: Uranium containing the naturally occurring distribution of uranium isotopes (approximately 99.28% uranium-238 and 0.72% uranium-235 by weight).

Useful beam The X-rays that come from the target and emerge through the aperture of an X-ray tube.

URD User Requirements Document**.** A document detailing the capability requirement. The document will include the quantified and qualified capability including the operational and environmental conditions for which the equipment will be used.

Appendix 2 - Normative References

The following referenced documents are applicable to this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ionising Radiation Regulations 1999
Statutory Instrument

ACOP Work with Ionising Radiation Approved Code of Practice and Guidance

NICOP Clearance and Exemption Principles, Processes and Practices for Use by the Nuclear Industry A Nuclear Industry Code of Practice

ISO 8529-2001 Reference Neutron Radiations

ISO 8769-1996 Reference Sources for the Calibration of Surface Contamination Monitors - Beta -emitters (maximum beta energy greater than 0.15 MeV) and alpha - emitters.

ISO 8769-2-1996
Reference Sources for the Calibration of Surface Contamination Monitors - Part 2: Electrons of energy less than 0.15 MeV and photons of energy less than 1.5 MeV.

BS ISO 4037-1 X and Gamma reference radiation for calibrating dosimeters and dose rate meters and for determining their response as a function of photon energy - Part 1. Radiation Characteristics and Production Methods.

BS ISO 4037-2 X and Gamma reference radiation for calibrating dosimeters and dose rate meters and for determining their response as a function of photon energy - Part 2. Dosimetry for radiation protection over the energy ranges 8 keV to 1.3 MeV and 4 MeV to 9 MeV

BS ISO 4037-3 X and Gamma reference radiation for calibrating dosimeters and dose rate 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 their angle of incidence.

BS EN ISO 17025:2005
General Requirements for the Competence of Testing and Calibration Laboratories

JSP 392 Radiation Safety Handbook

JSP 800 Vol 4b Dangerous Goods by Road, Rail and Sea

JSP 375 MOD Health and Safety Handbook

JSP 471 Defence Nuclear Emergency Response

JSP 515 Hazardous Stores Information System

JSP 886 Defence Logistics Support Chain Manual

National Physical Laboratory Good Practice Guide (GPG) 14
The Examination, Testing & Calibration of Portable Radiation Protection Instruments

National Physical Laboratory Good Practice Guide (GPG) 29
The Examination, Testing & Calibration of Installed Radiation Protection Instruments

National Physical Laboratory Good Practice Guide (GPG) 49
The Treatment of Uncertainty in Radiological Measurements

National Physical Laboratory Good Practice Guide (GPG) 11
A beginner's Guide to Uncertainty of Measurement

National Physical Laboratory Good Practice Guide (GPG) 30
Practical Radiation Monitoring

National Physical Laboratory Good Practice Guide (GPG) 113
The Examination, Testing & Calibration of Electronic Personal Dosimetry.

Health and Safety at Work etc Act 1974 (as amended).
Health and safety of persons at work an enabling act

Management of Health and Safety at Work Regulations 1999
The Management of health and safety of persons at work

Environmental Protection Act 1990 (as amended)
An enabling act covering environmental protection.

Radioactive Substances Act 1993
Use, keeping and disposal of radioactive material

Ionising Radiations Regulations 1999 (IRR99)
Radiation protection of persons against ionising radiation arising from any work activity.

The Ionising (Medical Exposure) Regulations 2000
Protection of persons undergoing examinations or treatment involving the use of ionising radiations.

The Radiation (Emergency Preparedness emergency and Public Information) Regulations 2001 (REPPIR)
Protection of the public through preparedness for radiation accidents with the potential to affect members of the public.

The Radioactive Material (Road Transport) (Great Britain) Regulations 2002
Transport of radioactive material by road

The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004.

Transport of radioactive material by rail.

Air KERMA Cavity Standards, L Büermann and D T Burns, 9 June 2008.

Intentionally blank

Appendix 3 - Comparison of JSP 425 with the requirements of BS EN ISO 17025:1005

BS EN ISO 17025:2005		JSP 425 6th Edition
1	Scope	Preface
2	Normative references	Appendix 2 - Normative References
3	Terms and definitions	Appendix 1 - Terms, Definitions and Abbreviations
4	Management Requirements	0144
4.1	Organization	0139
4.2	Management system	0144 - 0145
4.3	Document control	0144
4.3.1	General	0145
4.3.2	Document approval and issue	0150
4.3.3	Document changes	0150
4.4	Review of requests, tenders and contracts	not covered
4.5	Subcontracting of tests and calibrations	0174.
4.6	Purchasing services and supplies	not covered in 425 covered by ISO 9002
4.7	Service to the customer	not covered in 425 covered by ISO 9002
4.8	Complaints	not covered in 425 covered by ISO 9002
4.9	Control of nonconforming testing and/or calibration work	0171 - 0172
4.10	Improvement	not covered
4.11	Corrective action	0171
4.11.1	General	0171
4.11.2	Cause analysis	0171
4.11.3	Selection and implementation of corrective actions	0171
4.11.4	Monitoring of corrective actions	not covered
4.11.5	Additional audits	not covered
4. 12	Preventive action	not covered
4.13	Control of records	0165
4.13.1	General	0165
4.13.2	Technical records	0165
4.14	Internal audits	0144 0145
4.15	Management reviews	0145
5	Technical requirements	Though out the JSP
5.1	General	Chapter 1 - The Examination and Testing of Radiation Detection and Monitoring Equipment
5.2	Personnel	0130 - 0143
5.3	Accommodation and environmental conditions	0117 - 0129
5.4	Test and calibration methods and Methods of validation	0149 - 0155
5.4.1	General	0150
5.4.2	Selection of methods	0152 - 0155
5.4.3	Laboratory-developed methods	0155
5.4.4	Non-standard methods	0153

BS EN ISO 17025:2005		JSP 425 6th Edition
5.4.5	Validation of methods	0152
5.4.6	Estimation of uncertainty of measurement	0156 - 0160
5.4.7	Control of data	Not covered
5.5	Equipment	0117 - 0129
5.6	Measurement traceability	Chapter 2 - Radiological Standards, Traceability and Quantities
5.6.1	General	Chapter 2 - Radiological Standards, Traceability and Quantities
5.6.2	Specific requirements	Chapter 2 - Radiological Standards, Traceability and Quantities
5.6.3	Reference standards and reference materials	Chapter 2 - Radiological Standards, Traceability and Quantities
5.7	Sampling	not covered not required
5.8	Handling of test and calibration items	0173
5.9	Assuring the quality of test and calibration results	0110 - 0129
5.10	Reporting the results	0162 - 0169
5.10.1	General	0162 - 0169
5.10.2	Test reports and calibration certificates	0162 - 0169
5.10.3	Test reports	0162 - 0169
5.10.4	Calibration certificates	0162 - 0164
5.10.5	Opinions and interpretations	not covered
5.10.6	Testing and calibration results obtained from subcontractors	not covered
5.10.7	Electronic transmission of results	not applicable
5.10.8	Format of reports and certificates	0162 - 0164
5.10.9	Amendments to test reports and calibration certificates	not covered

Appendix 4 – List of Approved MOD Radiation Calibration Facilities

This is a list of calibration facilities which have achieved a satisfactory audit report in accordance with this JSP.

Secondary Standard Facilities

Calibration Facility, Dstl Environmental Sciences Department, Alverstoke
Technical Services, AWE Plc, Aldermaston

Tertiary Standard Facilities

Calibration Facility, Dstl Environmental Sciences Department, Alverstoke

Nucleonic Calibration Facility, BAE Systems Ltd, HMNB Portsmouth

Babcock Radiological Calibration Facility, Devonport Royal Dockyard

BNS Calibration Facility, Rosyth Royal Dockyard

Nucleonic Calibration Facility, HM Naval Base Clyde

Nuclear Instrumentation Centre, Instrumentation & Calibration Services Department, BAE Systems Maritime - Submarines

Nucleonic Calibration Facility, Vulcan NRTE