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Performance Standards and Test Protocols for Radiological Equipment

Number 4 — Detection and Alert Instrumentation

Publication No. 2D/10

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Home Office Scientific Development Branch
Sandridge
St Albans
AL4 9HQ
United Kingdom

Telephone: +44 (0)1727 865051
Fax: +44 (0)1727 816233
E-mail: RNStandardsEnquiries@homeoffice.gsi.gov.uk
Website: http://science.homeoffice.gov.uk/hosdb/

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Abstract

This document is the fourth in a set of five performance standards. The purpose of the standards is to ensure best current capability across a broad range of radiological equipment and provide a national benchmark against which any radiological equipment can be assessed. This assessment will help to improve the quality and consistency of radiological equipment used by emergency services in the event of CBRN incidents. The primary purpose of this equipment is to alert the user to the presence of radiation.

The first element of this document establishes appropriate and targeted technical performance criteria against which radiological equipment can be assessed. These criteria are identified as ‘essential’ requirements. A second element of this document will aim to stimulate the development of radiological equipment beyond current best measurement capability, with particular focus on end user requirements. These criteria are identified as ‘desirable’ requirements.

The test methodologies to be used are specified. Testing should be carried out on at least three fully operational production instruments for the duration of the tests, although exception could be made for specialist equipment. A user manual for the instruments shall also be provided to carry out the tests. It should be noted that some tests might cause significant damage to the instrument, and so agreement from the manufacturer should be sought before any destructive tests are performed. Destructive tests should only be performed on a single instrument where possible. If any tests are excluded then these shall be stated.

The five standards in the series each relate to one of the following categories: dose rate instrumentation, contamination-monitoring instrumentation, electronic personal dose meters, portable spectrometry/ identification systems and detection/alert devices. Each standard addresses the following broad areas: radiological, environmental, electrical and ergonomic aspects of performance.

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1 Introduction

To assess an instrument's suitability for its use by emergency services in the event of CBRN incidents, a number of tests are required. The tests detailed in this report are designed to not only assess the instrument's radiological performance under laboratory conditions, but also test the environmental, electrical and mechanical aspects, which may affect the instrument's performance out in the field.

1.1 Detection and Alert Instrumentation

This standard addresses instruments that can be used to detect (and alert the user to) the presence of ionising radiation fields. These devices are a very recent innovation in the field of radiological protection. They have designs that incorporate relatively high sensitivity detectors, certainly for the overall size of the device, with the intention of providing an early alarm and/or alert to the presence of radioactive material. In going down this route, the designers have essentially sacrificed what would conventionally be considered good radiological performance, for overall sensitivity. Unsurprisingly, when compared to current standards, their conventional radiological performance is relatively poor. It is important to recognise that these devices have no sensible contamination capability. They are only sensitive to penetrating X and gamma radiation and hence the nuclides for which they are likely to be applicable are ^{241}Am, ^{137}Cs, ^{60}Co, ^{192}Ir, ^{226}Ra and ^{75}Se. They will not provide an alert to the presence of any sources of alpha or beta radiation, unless there is an associated photon field.

2 Reference Documents

This document has been compiled with reference to the following documents:

IEC 60846:2004	Radiation protection instrumentation. Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation.
IEC 62327:2006	Radiation protection instrumentation. Hand-held instruments for the detection and identification of radionuclides and for the indication of ambient dose equivalent rate from photon radiation.
IEC 60529:1992	Degrees of protection provided by enclosures (IP code).
IEC 62401:2007	Radiation protection instrumentation. Alarming personal radiation devices (PRD) for detection of illicit trafficking of radioactive material.
ANSI N42.33-2003	American National Standard for Portable Radiation Detection Instrumentation of Homeland Security.
ISO 4037-1:1996	X and gamma reference radiation for calibrating dose meters and dose rate meters and for determining their response as a function of photon energy. Part 1: Radiation characteristics and production methods.
ISO 4037-2:1997	X and gamma reference radiation for calibrating dose meters and dose rate meters and for determining their response as a function of energy. Part 2: Dosimetry for radiation protection over the energy ranges 8 to 1.3 MeV and 4 to 9 MeV.
ISO 4037-3:1999	X and gamma reference radiation for calibrating dose meters and dose rate meters and for determining their response as a function of energy. Part 3: Calibration of area and personal dose meters and the measurement of their response as a function of energy and angle of incidence.
ISO 6980-1:2006	Nuclear energy — Reference beta-particle radiation. Part 1: Methods of production.
ISO 8529-1:2001	Reference neutron radiations — Part 1: Characteristics and methods of production.
ISO 8529-2:2000	Reference neutron radiations — Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterising the radiation field.

ISO 8529-3:1998	Reference neutron radiations — Part 3: Calibration of area and personal dosimeters and determination of their response as a function of neutron energy and angle of incidence.
NPL GPG 14	Measurement Good Practice Guide No 14: The Examination, Testing and Calibration of Portable Radiation Protection Instruments.
RPD-OP-004-2006	Suitability of Radiation Monitoring Equipment — Comparison of Type-test Data. (RESTRICTED — Commercial).

3 Terminology

3.1 Special Word Usage

The following word usage applies:

- The word “shall” signifies a mandatory requirement.
- The word “should” signifies a recommended specification or method.
- The word “may” signifies an acceptable method or an example of good practice.

3.2 Definitions

3.2.1 SI Units

The units of the ‘International System of Units’. Multiples and sub-multiples of the SI units will be used in accordance with the SI.

3.2.2 Sievert

The SI unit of dose equivalent is the joule per kilogram (J kg^{-1}), which has been named the Sievert (Sv) by the International Commission on Radiological Protection (ICRP).

$$1\ Sv = 1\ J\ kg^{-1}$$

3.2.3 Ambient dose equivalent $H^*(10)$

Dose equivalent at a point in a radiation field that would be produced by the corresponding aligned and expanded field; in the ICRU sphere at a depth of 10 mm and on the radius opposing the direction of the aligned field. The ICRU sphere (ICRU report 33, 1980) is a 30 cm diameter, tissue equivalent sphere with a density of 1 g cm^{-3}.

3.2.4 Ambient dose equivalent rate $\dot{H}^*(10)$

Ratio of $dH^*(10)$ by dt, where $dH^*(10)$ is the increment of ambient dose equivalent in the time interval dt.

$$\dot{H}^*(10) = \frac{dH^*(10)}{dt}$$

The SI unit of ambient dose equivalent rate is the Sievert per second (Sv s^{-1}). Units of ambient dose equivalent rate are any quotient of the Sievert, or its multiples or sub-multiples, by a suitable unit of time (e.g. µSv h^{-1}).

3.2.5 Other units of indication

This type of instrument is designed to detect radiation and alert the user to the presence of radiation. Instruments currently available in this category provide this information in a variety of different ways. For example, some instruments may have an indication of radiation intensity such as displaying a number of lights in a bar-graph display, displaying a number from 0 to 10, or even displaying counts per second or a dose rate indication. Others may just make different noises depending on the type or intensity of the radiation field, or will simply provide an indication that a radiation source is present.

3.3 Operating Modes

3.3.1 User mode (Routine)

The default operating mode whilst the instrument is being operated by non-expert users. Any parameters that may affect the operation of the instrument shall be protected via password or other appropriate security measures. The ability to view these parameter settings is desirable, but they shall be protected to prevent any changes. This mode may also be referred to as ‘simple’ mode.

3.3.2 Monitor mode

In this mode the instrument shall monitor its surrounding area for any significant changes in background levels. These may be caused, for example, by a radioactive source passing through its surrounding area. This mode shall not require any input from the user other than to select the type of alarm: audible, visual or vibrate.

3.3.3 Search mode

In this mode the instrument shall provide an alarm (audible, visual or vibration) related to the magnitude of the radiation field encountered. For example, with increasing radiation the frequency or pitch of the audible alarm, or the intensity of the vibration alarm, may be increased to enable the user to search and find, without the requirement to constantly watch the instrument.

3.3.4 Supervisor mode (Restricted)

An advanced operating mode that can only be accessed by an expert user, via password or other appropriate security measures, to edit parameters that will affect the operation of the instrument, i.e. calibration parameters, alarm thresholds, etc. This mode may also be referred to as ‘advanced’ or ‘expert’ mode.

3.4 Test Nomenclature

3.4.1 Acceptance test (Pre-use test / Test before first use)

The acceptance test shall demonstrate that the instrument conforms to type-test data. The acceptance test checks for any potential faults and provides a reference of performance for comparison with subsequent routine tests for the lifetime of the instrument. Further information on the tests required can be found in current UK guidance, such as the NPL Measurement Good Practice Guide 14 (GPG14).

3.4.2 Routine test (Periodic test)

This test confirms that the performance of the instrument has not deteriorated since the acceptance test. It is more than a simple check. Further information on the tests required can be found in current UK guidance, such as the NPL Measurement Good Practice Guide 14 (GPG14).

It is recommended that the performances of the instrument's electrical and mechanical systems are also inspected during the routine test. For example, batteries, cables, connectors and controls shall be inspected and repaired or replaced where necessary. Depending on the severity of the repair, it may be necessary to repeat the acceptance tests if, for example, the detector has been repaired or replaced.

3.4.3 Type-test

This test is performed on at least one or more standard production instruments picked at random. Ideally, all non-destructive tests should be performed on at least three standard production instruments. Destructive tests, however, may be performed on just a single instrument. The type-test investigates all aspects of the instrument's design to show the extent of compliance with pre-defined specifications.

4 General Requirements

Instruments tested using this standard are either personal (carried on the body) or portable (hand-held). Both types are used to indicate the presence and general magnitude of radiation fields, and shall quickly alert the user to any small increases of radiation levels with a low occurrence of false alarms. Whilst these types of instruments are not intended to provide a measurement of dose equivalent rate, the manufacturer may provide this feature.

4.1 Quantities and Units

The instrument shall give an indication of increasing or decreasing dose rate (see paragraph 3.2.5).

Although it is recognised that many instruments of this type may not provide an indication in terms of dose equivalency, for consistency, tests shall be performed in the ambient dose equivalent quantity. Instruments of this type should not be tested in any personal dose-equivalent quantity.

Where the instrument does not have any significant dose rate capability then the manufacturer shall state that the instrument is not intended as a dose rate measuring device.

4.2 Measuring Ranges

4.2.1 Essential

The instrument shall to indicate the presence and general magnitude of radiation fields up to 10 μSv h^{-1}.

4.2.2 Desirable

The instrument shall to indicate the presence and general magnitude of radiation fields up to 100 μSv h^{-1}.

4.3 Storage and Transport

4.3.1 Essential

The instrument shall be supplied in a bespoke foam-lined carry-case. The case shall be waterproof and impact resistant. The case shall have provision to store the batteries when removed from the instrument. The instrument should not be stored for long periods of time with the batteries installed.

The instrument shall be designed to operate within the requirements of this document following storage or transport during a period of at least

3 months in the supplied carry case at any temperature between -25 °C and +50 °C.

4.3.2 Desirable

It is desirable that the carry-case can protect the instrument during any possible air transport at low ambient pressure. Where this is not possible and the instrument could be damaged by air transport, this shall be clearly stated on the instrument and the case.

5 Standard Test Conditions

5.1 Reference Conditions

Reference conditions are given in the table below. Except where otherwise specified, the tests in this standard shall be carried out under the standard test conditions as indicated in table 1 below.

Table 1: Reference conditions and standard test conditions

Influence Quantity	Reference Conditions	Standard Test Conditions
Photon radiation	Gamma radiation from ^{137}Cs	Gamma radiation from ^{137}Cs, ^{241}Am, ^{60}Co
Neutron radiation	^{252}Cf or ^{241}Am(Be)	^{252}Cf or ^{241}Am(Be)
Stabilisation time	15 minutes	Minimum of 15 minutes
Warm up time	1 minute	Minimum of 1 minute
Ambient temperature	20 °C	18 to 22 °C(1)
Relative humidity	65%	55% to 75%(1)
Atmospheric pressure	101.3 kPa	86.0 to 106.6 kPa(1)
Power supply voltage	Nominal power supply voltage	Nominal power supply voltage ±10%
Angle of incidence of radiation	Calibration direction supplied by manufacturer.	Direction given ±5%
Orientation of instrument	To be stated by the manufacturer.	Stated orientation ±5%
Instrument controls	Set up for normal operation.	Set up for normal operation.
Radiation background	1 μSv h^{-1} or less if practical	Known field less than 1 μSv h^{-1}
Contamination by radioactive elements	Negligible	Negligible

(1) The actual values of these quantities at the time of test shall be stated.

5.2 Reference Radiations

Unless specified otherwise in individual methods within this document, the nature, construction and conditions of use of radiation sources should be in accordance with the relevant parts of ISO 4037 or ISO 6980. Alternatively, other low activity reference sources may be used so long as they are traceable to recognised standards.

If the complete range of dose rates is not available from a single source of radiation, then additional sources, normalised to the original source of radiation, may be used.

Where an X-ray set is used to generate reference radiations, its output should be monitored by means of a monitor ionisation chamber which is permanently mounted in the radiation beam, as specified in ISO 4037-2:1997. This is to ensure that the X-ray set is stable. Where a monitor chamber is not available, the X-ray set output shall be measured immediately before and after any irradiation, and any fluctuations found shall be accounted for.

The value of the quantity to be measured at the point of test shall be known with an uncertainty of less than 10%. All dose rates shall be traceable to national standards.

5.3 Instrument Orientation

The instrument under test shall be placed in an orientation with respect to the direction of the radiation field, as indicated by the manufacturer, and with the marked reference point accurately positioned at the point of test in the radiation field. In the absence of a marked reference point, the geometric centre of the detector shall be used. The instrument orientation and reference point used must be clearly stated in the test report.

6 Radiological Performance Requirements

This type of instrument is designed to detect radiation and alert the user to the presence of radiation. Instruments currently available in this category provide this information in a variety of different ways. For example, some instruments may have an indication of radiation intensity, such as displaying a number of lights in a bar-graph display, displaying a number from 0 to 10, or even displaying counts per second or a dose rate indication. Others may just make different noises depending on the type or intensity of the radiation field or will simply provide an indication that a radiation source is present.

This wide variety makes defining specific criteria quite difficult and so not all tests detailed in this section will be relevant.

For many of the tests listed, it may be advantageous to use the following technique: where the instrument only has an indication of radiation intensity split into broad divisions (e.g. it displays a number from 0 to 10 or a number of lights etc.), then the required testing should be performed at the point of change between two indications. This is to ensure that the indication can be more accurately related back to the intensity of the radiation field.

6.1 Linearity of Response (Rate Function)

This test is required where the instrument has any indication of dose rate that is nominally linear with dose rate. It is acknowledged that this may not always be an easy test to perform.

6.1.1 Essential

With the instrument set up as specified by the manufacturer's instructions and under standard test conditions, the relative intrinsic error in the response to the reference gamma radiation shall not exceed ±50% over the entire effective range of ambient dose equivalent rates.

6.1.2 Desirable

With the instrument set up as specified by the manufacturer's instructions and under standard test conditions, the relative intrinsic error in the response to the reference gamma radiation shall not exceed ±20% over the entire effective range of ambient dose equivalent rates.

6.1.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

For the purpose of this test, the value of the true ambient dose equivalent produced by the reference gamma radiation at the point of

test shall be known with an uncertainty of less than 10% at a confidence level of 95%.

6.1.4 Method of test

Expose the instrument to ambient dose equivalent rates of approximately 20%, 40% and 80% of each order of magnitude up to the upper stated limit. Verify that the readings are within the specified limits. The relative intrinsic error is defined as the ratio of the dose equivalent rate meter's indication to the conventionally true value.

Equation 1. Radiation detection instrumentation linearity of response:

$$I = \frac{H_i}{H_t}$$

where H_i is the (mean) indicated dose equivalent rate value above background and H_i is the conventionally true dose equivalent rate value at the point of reference.

6.2 Response Time (Alarm Function)

The manufacturer shall state the maximum response time of any instrument alarm from background to a dose equivalent rate that is 50% greater than the alarm level.

When the instrument is subjected to a step increase in dose equivalent rate, the time taken to alarm shall be determined.

The response time test provides a measure of the time taken for an alarm to be triggered. The word alarm signifies anything that would alert the user and may be an audible, visual or vibrating alarm. Alarms such as the source indication alarm and the personal protection alarm should be tested where available.

6.2.1 Essential

The instrument's alarm shall be triggered when the instrument is exposed to a radiation level that is 50% greater than any alarm threshold within 3 seconds of the step change. The alarm shall be audible and visual.

Where the instrument has an indication directly related to dose rate, the displayed indication shall be within ±30% of the final radiation rate within 10 seconds.

6.2.2 Desirable

The instrument's alarm shall be triggered when the instrument is exposed to a radiation level that is 50% greater than the alarm threshold within 1 second of the step change. The alarm shall be audible and visual.

Where the instrument has an indication directly related to dose rate, indication shall be within ±30% of the changed radiation rate within 5 seconds.

6.2.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

For the purpose of this test, the value of the true ambient dose equivalent produced by the reference gamma radiation at the point of test shall be known with an uncertainty of less than 10% at a confidence level of 95%.

6.2.4 Method of test

With the instrument mounted in its calibration orientation, as specified by the manufacturer, determine the minimum dose rate that causes the source indication alarm to be triggered.

From a background dose rate of less than 1 μSv h^{-1}, quickly increase the dose rate, within 1 second, to a dose rate 50% higher than the minimum dose rate which causes the alarm to be triggered. The time for the alarm to be triggered shall be recorded.

The instrument meets the relevant criteria if the alarm is triggered within the specified time for 9 out of 10 tests.

Where available the test shall be repeated for the personal protection alarm.

6.3 Automatic Background Subtraction

6.3.1 Essential

Not currently defined.

6.3.2 Desirable

The instrument should not trigger an alarm due to a sudden increase in natural background. This could occur when working in close proximity to building materials, such as granite or ceramic tiles, etc. The maximum automatic background subtraction should not be greater than 0.5 μSv h^{-1}. The user shall have the option to disable this function.

There should also be an option to display the value of background currently being subtracted.

6.4 Detection of Gradually Increasing Radiation Levels

6.4.1 Essential

Where the instrument has a source indication alarm trigger threshold that is set automatically, this threshold shall not be affected by slowly increasing radiation levels, which may be caused when the instrument is slowly approaching, or being approached by, a radiation source.

6.4.2 Desirable

The instrument may incorporate a basic spectrum analyser to store natural background spectrums. Any increase in the natural background with a broadly similar spectrum could then be identified as not being a radiation source, whilst any true radiation source could be easily identified as such.

6.4.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

6.4.4 Method of test

Expose the instrument to an ambient dose sufficient to ensure that the lowest source indication alarm has been triggered. This position is later referred to as the test point.

Next, with the source still exposed, move the instrument to a distance further away from the test point, where the dose rate is less than 1 μSv h^{-1}. Allow the instrument to stabilise and the source indication alarm to cease.

Then, with the source still exposed, slowly move the instrument back towards the test point at a speed of no greater than 0.1 ms^{-1} and then stop at the test point. The time taken for the source indication alarm to be triggered after the instrument arrives at the test point shall be recorded.

To meet the essential criteria, the time taken to trigger the alarm on arrival at the test point must be less than 2 seconds for 8 out of 10 tests.

6.5 Overload Performance

6.5.1 Essential

When exposed to dose rates greater than its measuring range, the instrument shall remain ‘off scale’ at the higher end of the scale (or display an overload indication) within 3 seconds of the exposure. The instrument must remain in this overload state whilst exposed to this or a greater radiation field, and should not return ‘on scale’ or display any indication of dose rate until the exposed dose rate is within measuring

range. On completion of the overload test, the instrument shall function correctly in a time period of less than 5 minutes.

NOTE: The overload test may be ignored for instruments which are likely to be damaged by performing this test. If this test is omitted, this must be clearly recorded in the test report.

6.5.2 Desirable

As requirement above, but with the following change: on completion of the overload test, the instrument shall function correctly in a time period not exceeding 2 minutes.

6.5.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

For the purpose of this test, the value of the true ambient dose equivalent produced by the reference gamma radiation at the point of test shall be known with an uncertainty of less than 10% at a confidence level of 95%.

6.5.4 Method of test

The instrument shall be exposed to 10 mSv h^{-1} for a period of at least 5 minutes.

After the overload test, the instrument's performance shall return back to normal within the time specified by the manufacturer.

6.6 Photon Energy Response

This test shall be performed in one of two ways depending upon whether the instrument has an indication directly related to dose rate or only provides an alarm to indicate the presence of radiation.

6.6.1 Essential

The instrument's response to incident photon radiation between 60 keV and 1.25 MeV shall not vary by more than ±50% from the response to the ^{137}Cs (662 keV) reference gamma radiation source.

6.6.2 Desirable

The instrument's response to incident photon radiation between 20 keV and 1.25 MeV shall not vary by more than ±30% from the response to the ^{137}Cs (662 keV) reference gamma radiation source.

6.6.3 Test radiation

The photon energy response of the instrument shall be determined using the narrow-spectrum series of X-radiation qualities. In addition,

the gamma radiations of ^{137}Cs, ^{241}Am and ^{60}Co shall be used depending upon sufficient dose rate range.

The recommended reference radiation sources are:

- narrow series of X-radiation qualities, as defined in ISO 4037-1
- ^{241}Am or filtered X-rays of approximately 60 keV
- gamma (γ) radiation from ^{137}Cs at 662 keV
- ^{60}Co at 1.25 MeV (mean energy).

6.6.4 Method of test

6.6.4.1 For instruments with an indication directly related to dose rate

Ideally, the same instrument indication should be used for each radiation energy used. Where this isn't possible, the instrument indication for each energy used shall be corrected for intrinsic error of the indicated rate.

Measurements shall be performed starting with high energies and repeated with lower energies until the first energy where the response normalised to that obtained for ^{137}Cs provides a normalised response of less than 0.5.

For dose equivalent rate meters, the response normalised to ^{137}Cs is defined as:

Equation 2. Photon energy response, calculation of normalised response:

$$I_{norm} = \frac{I_{energy_n}}{I_{Cs^{137}}}$$

Where I_{energy_n} = response at energy n

n = 20 keV to 1.25 MeV

$I_{Cs^{137}}$ = response at ^{137}Cs

6.6.4.2 For instruments that only provide an alarm to indicate the presence of radiation

Starting with the highest energy first, for each specified test radiation, determine the minimum intensity of radiation that causes a 'source indication' alarm to be triggered.

The dose rates obtained shall then be normalised to ^{137}Cs.

6.7 Polar Response

6.7.1 Essential

For angles of ±45°, in both horizontal and vertical planes, the source indication alarm shall be triggered when exposed to a dose rate 20% greater than that required to trigger the alarm at 0°.

Where the instrument has an indication directly relating to dose rate, the response normalised to the reference radiation at 0° shall be unity ±30%.

6.7.2 Desirable

For angles of ±90°, in both horizontal and vertical planes, the source indication alarm shall be triggered when exposed to a dose rate 20% greater than that required to trigger the alarm at 0°.

Where the instrument has an indication directly relating to dose rate, the response normalised to the reference radiation at 0° shall be unity ±20%.

6.7.3 Test radiation

This test shall be performed with ^{137}Cs, ^{241}Am (or the equivalent filtered X-radiation).

Where applicable, the test shall also be performed with the lowest energy found during the energy response measurements that produced a normalised response greater than 0.6.

The conventionally true ambient dose equivalent (rate) produced by the reference radiation at the point of test shall be known with an uncertainty of less than 10% at the 95% confidence level.

6.7.4 Method of test

With the instrument mounted in its calibration orientation (referred to as 0°), as specified by the manufacturer, determine the minimum dose rate that causes the source indication alarm to be triggered.

Generate a dose rate that is 20% greater than that which causes the source indication alarm to be triggered. This is the dose rate that shall be used throughout the test. The source indication alarm should now be permanently triggered.

Next, the instrument shall be rotated about its reference point to angles of ±45° and from angles 0° to ±90° in 10° steps. This shall be performed in two planes: vertical and horizontal. At each step, expose the instrument to the same dose rate as before and record if the source indication alarm is triggered. Where available, any indication directly relating to dose rate shall also be recorded for each step.

6.8 Response to Neutron Radiation (Alarm and Response Time)

This test is only required where the instrument has a neutron capability.

6.8.1 Essential

The instrument shall indicate the presence of neutron radiation and trigger an alarm within 10 seconds of the exposure when exposed to a neutron field.

6.8.2 Desirable

The instrument should indicate the presence of neutron radiation and trigger an alarm within 2 seconds of the exposure when exposed to a neutron field.

6.8.3 Test radiation

A ^{252}Cf or $^{241}Am(Be)$ neutron source that can provide approximately 3 μSv h^{-1}. The neutron source shall be shielded with sufficient lead to reduce any gamma radiation to a negligible amount.

6.8.4 Method of test

Firstly, the instrument should be set up as per the manufacturer's instructions in an area where the neutron background level is negligible.

Next, the neutron field shall be increased from the background level to the specified level within a period of not more than 2 seconds.

This test shall be repeated. The test specification is met if the instrument indicates the presence of neutrons within the specified period after the field was increased for 8 out of 10 times.

Where available, this test should be repeated with a moderated neutron field obtained by placing the neutron source in a 30 cm diameter moderation sphere.

6.9 Response to Neutron Radiation in the Presence of Photons

This test is only required where the instrument has a neutron capability.

6.9.1 Essential

The instrument shall not trigger its neutron alarm whilst it is only exposed to an ambient gamma dose equivalent rate of less than 100 μSv h^{-1} at the reference point of the detector.

The instrument shall indicate the presence of neutron radiation whilst being exposed to gamma radiation if a neutron source is also present.

6.9.2 Desirable

Not currently defined.

6.9.3 Test radiation

A ^{252}Cf or $^{241}Am(Be)$ neutron radiation source which can provide approximately 3 μSv h^{-1}. The neutron source shall be shielded with sufficient lead to reduce any gamma radiation to a negligible amount.

The recommended gamma reference radiation source is ^{137}Cs.

For the purpose of this test, the value of the true dose equivalent rate produced by these radiation sources at the point of test shall be known with an uncertainty of less than 10% at a confidence level of 95%.

6.9.4 Method of test

Firstly, with the instrument set up as per the manufacturer's instructions, expose the instrument to a ^{137}Cs radiation source providing an ambient dose equivalent rate of approximately 100 μSv h^{-1} at the reference point of the detector. The distance between the ^{137}Cs source and the detector shall be at least 50 cm.

Ensure that the neutron alarm is not triggered within a continuous exposure time of 5 minutes.

Next, whilst the instrument is still exposed to the ^{137}Cs radiation field as specified above, also expose the instrument to the specified neutron source.

This test shall be repeated. The test specification is met if the instrument triggers its neutron alarm within 10 seconds after the neutron source exposed for 8 out of 10 times.

6.10 Accuracy of Dose Equivalent Rate Alarms

The source indication alarm and the personal protection alarm shall be tested where available.

6.10.1 Essential

When the instrument is subjected to a dose rate that is 5% lower than the dose rate to which the alarm is set, the alarm shall not be triggered more than 5% of the time.

When the instrument is subjected to a dose rate that is 5% greater than the dose rate to which the alarm is set, the alarm shall remain triggered more than 95% of the time.

6.10.2 Desirable

Not currently defined.

6.10.3 Test radiation

The reference radiation shall be ^{137}Cs gamma radiation.

The conventionally true dose equivalent rate produced by the reference radiation at the point of test shall be known with an uncertainty of less than 10% at the 95% confidence level.

6.10.4 Method of test

The instrument shall be set up and placed in its calibration orientation as specified by the manufacturer.

Next, the instrument should be subjected to a dose equivalent rate that is 5% lower than the dose rate to which the alarm is set. In a period of 10 minutes record the total length of time the alarm is triggered.

Next, the instrument should be subjected to a dose equivalent rate that is 5% greater than the dose rate to which the alarm is set. In a period of 10 minutes record the total length of time the alarm is triggered.

7 Alarms

7.1 General

For the purpose of this standard, an alarm is taken to be anything that draws the user's attention to the device.

If alarm trigger points are settable then they shall be protected from unauthorised and accidental changes.

If any alarm can be switched off or reduced in intensity then they shall be protected from unauthorised and accidental changes.

Where it is possible to turn off or reduce intensity of any alarm then the meter shall have a vibrating alarm.

7.2 Audible Alarm

7.2.1 Essential

Audible alarms shall exceed 100 dBA at a distance of 30 cm and be within the frequency range of 1 to 4 kHz. The maximum sound level for audible alarms shall not be greater than 120 dBA at the minimum hearing distance from the instrument.

An option to mute the alarm shall be provided, but only available through the supervisor mode to prevent inadvertent muting of the alarm.

Where multiple alarms are available, each alarm shall have a unique sound.

Any alarm shall not sound similar to any other emergency service equipment alarms, such as distress signals or low oxygen alarms. Where possible, alarms should be distinguishable from these by amplitude, frequency modulation or pattern.

Examples of emergency service equipment alarms currently in use are defined below:

- Honeywell O2 meter: audible alarm with a pure tone at 3875 Hz.
- Diktron: various audible alarms with an upper frequency of 2900 Hz (±200 Hz).

7.2.2 Desirable

The intensity of the alarm should be fully adjustable from off to the maximum sound level. This is particularly important for covert operations.

Where it is possible to adjust the alarm intensity, the instrument shall have a vibrating alarm.

The instrument should have the ability to attach earphones.

7.3 Visual Alarm

7.3.1 Essential

The visual alarm (such as a flashing light or display indication) shall be positioned so that, if triggered, the operator will easily notice it.

7.3.2 Desirable

Where the visual alarm is of high intensity, such as a beacon or similar, then the intensity of the visual alarm should be fully adjustable from off to the maximum brightness level. This is particularly important for covert operations or during use in dark conditions.

Where it is possible to adjust the alarm intensity, the instrument shall have a vibrating alarm.

7.4 Vibrating Alarm

A vibrating alarm is desirable for use in covert operations or in situations where other alarms may cause distress.

7.4.1 Essential

The vibrating alarm shall have sufficient intensity to be easily felt by the user through gloved hands.

7.4.2 Desirable

If it is possible to turn off or reduce the intensity of any visual or audible alarms, then the dose meter shall have a vibrating alarm.

8 Electrical Performance Requirements

8.1 Power Supply (Batteries)

The object of this element of the test is to evaluate the battery test mode of the instrument, so as to demonstrate that it provides a valid check on the state of the batteries and connectors. In addition to low voltage checks, the test simulates the presence of a good battery, but with significant corrosion on the battery terminals or connectors. This can be achieved by connecting the instrument under test to a variable power supply and a variable resistor in series.

An estimation of the battery life shall be determined from information on the current drawn by the instrument under realistic operating conditions.

The total number of batteries or cells required to power the instrument shall be noted, and the ease of their supply and replacement determined.

8.1.1 Voltage dependence

This test is designed to simulate any problems that may occur as the instrument's batteries discharge through normal use.

8.1.1.1 Essential

Unless the instrument is displaying the low battery indication, all functions shall operate correctly, and the mean instrument indication will not vary by more than ±20% from the indication recorded with an optimal battery voltage.

8.1.1.2 Desirable

Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±10% from the indication recorded with an optimal battery voltage.

8.1.1.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

8.1.1.4 Method of test

With the instrument's internal batteries removed, connect the instrument to a variable power supply, a variable resistance and a means to monitor the voltage and current in the circuit. The power supply shall be set to supply the optimal battery operating voltage, and the variable resistance shall be negligible.

With the instrument in background conditions, decrease the supply voltage in small decrements and record the supply voltage, instrument indication and any other observations until the instrument switches off. Particular attention should be made as to when the low battery indication is triggered or if the indication varies by more than ±10% from the indication recorded with an optimal battery voltage.

This test should then be repeated with the instrument exposed to a selection of dose equivalent rates that will exercise all of the instrument's detectors. If possible, a dose rate should be chosen that doesn't trigger any audible or visual alarms.

Finally, this test should be repeated with the instrument exposed to a dose equivalent rate that triggers the audible or visual alarms.

8.1.2 Current dependence

This test is designed to simulate the presence of a good battery but with significant corrosion on the battery terminals or connectors.

8.1.2.1 Essential

The current drawn by the instrument shall be as low as possible.

Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±20% from the indication recorded with an optimal battery voltage.

8.1.2.2 Desirable

Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±10% from the indication recorded with an optimal battery voltage.

8.1.2.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

8.1.2.4 Method of test

With the instrument's internal batteries removed, connect the instrument in series to a variable power supply, a variable resistance and a means to monitor the voltage and current in the circuit. The power supply shall be set to supply the optimal battery operating voltage and the variable resistance shall be negligible.

With the instrument in background conditions, increase the series resistance in small increments and record the supply voltage, resistance, current drawn, instrument indication and any other observations until the instrument switches off. Particular attention should be made as to when the low battery indication is triggered or if

the indication varies by more than ±10% from the indication recorded with an optimal battery voltage.

This test should then be repeated with the instrument exposed to a selection of dose equivalent rates that will exercise all of the instrument's detectors. If possible, a dose rate should be chosen that doesn't trigger any audible or visual alarms.

Finally, this test should be repeated with the instrument exposed to a dose equivalent rate that triggers the audible or visual alarms.

8.1.3 Battery test function (applicable to all instruments)

The instrument shall have a means to assess the battery condition. The battery condition shall be indicated to enable the operator to assess when the battery condition is no longer suitable.

The rating for the battery test function should be based upon data provided by the voltage and current dependence tests.

8.1.3.1 Essential

The battery test shall provide an accurate assessment of the condition of the cells and their suitability for further powering the instrument.

8.1.3.2 Desirable

Not currently defined.

8.1.3.3 Failure

This indicates a battery test with serious deficiencies that could result in incorrect measurements being made.

8.1.4 Battery test function (applicable only to digital instruments)

The instrument shall have a means to estimate the remaining battery life under the normal and maximum load conditions expected during use. The battery condition shall be indicated and the operator alerted when the battery condition is becoming unsuitable for the instrument to meet the requirements in this document.

The rating for the battery test function should be based upon data provided by the voltage and current dependence tests.

8.1.4.1 Essential

During normal operation the battery condition shall be monitored such that the operator is alerted when the expected remaining life of the battery falls below 30 minutes.

8.1.4.2 Desirable

During normal operation the battery condition shall be monitored such that the operator is alerted when the expected remaining life of the battery falls below 1 hour.

8.2 Batteries

8.2.1 General

Consideration shall be given to the fact that below -10 °C the capacity of most types of battery significantly decreases with decreasing temperature.

8.2.1.1 Essential

Batteries shall be installed in separate compartments to the instrument electronics.

Batteries shall be easily accessible for replacement and routine maintenance. The correct polarity shall be clearly indicated on the instrument.

In the event of a CBRN incident, instrumentation will be required to operate in the field. The instrument, therefore, shall be capable of running solely on a battery supply. Any chargers supplied should be capable of recharging the batteries from a vehicle 12 volt cigarette lighter socket as well as a standard 240 volt mains supply.

8.2.1.2 Desirable

All batteries should be easy to change in the field without a special tool.

Batteries should be of a standard recognised type and be easy to obtain off the shelf from retail suppliers. The preferred commercially available battery size is AA (also known internationally as LR6 or MN1500). Standard type rechargeable batteries are acceptable (see requirements for rechargeable batteries in section 8.2.3).

8.2.2 Bespoke batteries

Bespoke batteries are acceptable if they can sustain the operation of the instrument for a significant increase of time over standard batteries. If bespoke batteries are required, then a second (spare) battery must be supplied and, in addition, a reliable supply of additional batteries shall be guaranteed for a minimum of 10 years.

8.2.3 Rechargeable batteries

8.2.3.1 Essential

All rechargeable batteries shall be able to be charged independently of the instrument. A second set of rechargeable batteries and a fast charger shall be supplied. A fully discharged battery shall be able to be fully recharged within 2 hours.

8.2.3.2 Desirable

It should be possible to operate the instrument whilst its installed batteries are recharging. There should be an indication of the current status of charging.

8.2.4 Battery lifetime

8.2.4.1 Essential

After fresh or fully recharged batteries have been fitted, the instrument must be capable of operating under standard test conditions with no alarms or illumination features in operation for at least 12 hours.

After fresh or fully recharged batteries have been fitted, the instrument must be capable of operating under standard test conditions with ALL alarms and illumination features in operation at their maximum intensity for at least 1 hour.

8.2.4.2 Desirable

After fresh or fully recharged batteries have been fitted, the instrument must be capable of operating under standard test conditions with no alarms or illumination features in operation for at least 24 hours.

After fresh or fully recharged batteries have been fitted, the instrument must be capable of operating under standard test conditions with ALL alarms and illumination features in operation at their maximum intensity for at least 2 hours.

8.3 External DC or AC Power Supplies

8.3.1 Essential

For the majority of uses, the instrument will be powered solely by a battery supply. If rechargeable batteries are supplied, then some means of charging these batteries shall also be supplied. Power supplies for charging the batteries shall include one or more power adapters to enable charging from a standard UK 240 volt mains supply and from a nominal 12 volt vehicle electrical system. Protection against over voltage and reverse polarity shall be provided.

8.4 Electromagnetic Compatibility

The instrument shall be electronically compatible and not interfere with emergency service communications equipment, including UHF hand-held radios, VHF main schemes radios and mobile radios. The electronic interference tolerance of the unit shall be quoted.

An example of frequencies currently utilised by emergency service communication equipment is defined below:

- 380 to 400 MHz

9 Mechanical Requirements

9.1 Mechanical Shock (Drop Test)

9.1.1 Essential

The instrument shall be able to withstand a drop from heights of 1 metre on to a hardwood surface without severe mechanical damage. The drop shall not affect the indicated dose rate reading by more than 20%.

9.1.2 Desirable

The instrument shall be able to withstand a drop from heights of 1 metre on to a concrete surface without severe mechanical damage. The drop shall not affect the indicated dose rate reading by more than 10%.

9.1.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

For the purpose of this test, the value of the true ambient dose equivalent produced by the reference gamma radiation at the point of test shall be known with an uncertainty of less than 10% at a confidence level of 95%.

9.1.4 Method of test

First, the instrument's response to the appropriate reference nuclide shall be determined in a reproducible geometry.

Next, the instrument shall be dropped on to each face in turn from a height of 1 metre onto the specified surface. After each drop, the instrument's response to the appropriate reference nuclide shall be confirmed and recorded. The instrument shall also be checked for any mechanical damage or loose fittings and any observations recorded.

9.2 Vibration

The physical condition of the instrument shall not be affected by harmonic loadings of 2 g applied for 15 minutes in the frequency range 10 to 33 Hz, i.e. all electrical connections and mechanical fastenings shall hold and not become loose.

9.2.1 Essential

The mean response of the instrument shall not vary by more than 20% as a result of these vibrations.

9.2.2 Desirable

The mean response of the instrument shall not vary by more than 10% as a result of these vibrations.

9.2.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

For the purpose of this test, the value of the true ambient dose equivalent produced by the reference gamma radiation at the point of test shall be known with an uncertainty of less than 10% at a confidence level of 95%.

9.2.4 Method of test

The instrument shall be exposed to photon radiation in reproducible geometry and the mean indication determined. The instrument shall then be subjected to harmonic loadings of 2 g applied for 15 minutes in each of three planes. At least one test shall be performed within each of the ranges 10 to 21 Hz and 22 to 33 Hz. After each vibration the mean indication will be determined using the same radiation conditions and geometry as before. All pre- and post-vibration readings shall be recorded, as well as the physical condition of the instrument.

9.3 Mechanical Impact (Microphonic Tests)

9.3.1 Essential

Under microphonic conditions, which may occur from low intensity impacts, the instrument's response shall remain within ±30% of the pre-test values.

9.3.2 Desirable

Not currently defined.

9.3.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

9.3.4 Method of test

First, the instrument shall be exposed to photon radiation in reproducible geometry and the mean indication determined.

Next, the instrument case shall be subjected to three impacts on each side of its case. Each impact shall have an intensity of approximately 0.2 Joules. The instrument indication shall be recorded after every impact.

An impact intensity of approximately 0.2 Joules may be generated, for example, by dropping a 200 g weight from a height of 10 cm.

[Gravitational energy (Joules) = Mass (kg) × Gravity (N/kg) × Height raised (m)]

10 Environmental Performance Requirements

Instruments shall be so designed and constructed as to be capable of performing their intended function in full safety in changing environmental situations.

10.1 Environmental Protection

The manufacturer should state the environmental protection classification of the instrument. Where this is not supplied, a visual inspection of probable ingress shall be performed and recorded.

10.1.1 Essential

The instrument shall have an IP rating of at least IP54. Instruments shall be designed to resist ingress from dust, wind-driven rain, high humidity or condensation. If the instrument has been disassembled for any reason the manufacturer shall state which seals or gaskets would need to be replaced to retain acceptable weather protection.

[IP 5x — dust protected: ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with the satisfactory operation of the apparatus or to impair safety.]

[IP x4 — protected against splashing water: water splashed against the enclosure from any direction shall have no harmful effects.]

10.1.2 Desirable

The instrument should have an IP rating close to IP67. Instruments should be designed to resist water ingress from temporary immersion.

[IP 6x — dust tight: no ingress of dust.]

[IP x7 — protected against temporary immersion: ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time.]

10.2 Temperature Stability

The object of this test is to determine the dependency of the instrument response on temperature.

10.2.1 Essential

The worst case percentage change of the indications at -10 °C and +40 °C compared to the indication at 20 °C for both radiation levels shall be less than 50%.

10.2.2 Desirable

The worst case percentage change of the indications at -10 °C and +60 °C compared to the indication at 20 °C for both radiation levels shall be less than 20%.

10.2.3 Test radiation

The recommended reference radiation source for photon and β dose rate instruments is ^{137}Cs.

10.2.4 Method of test

The instrument shall be placed in a climatic chamber initially set to an operating temperature of 20 °C and allowed to stabilise for a minimum of 60 minutes. Both the instrument background reading and a higher indication produced by a radioactive source shall be recorded.

The chamber temperature shall be increased to the specified upper temperature and the instrument left for a minimum of 4 hours to achieve thermal equilibrium. The instrument response at background and the higher indication shall be recorded.

This test shall then be repeated with a temperature of -10 °C.

10.3 Temperature Shock

10.3.1 Essential

Instrument should be capable of working up to temperatures of +60 °C.

10.3.2 Desirable

Not currently defined.

10.3.3 Test radiation

The recommended reference radiation source for photon and β dose instruments is ^{137}Cs.

10.3.4 Method of test

The instrument shall be placed in a climatic chamber initially set to an operating temperature of 20 °C and allowed to stabilise for a minimum of 60 minutes. Both the instrument background reading and a higher indication produced by a radioactive source shall be recorded.

Next, the chamber temperature shall be increased to the specified upper temperature within 5 minutes. The readings at background and the higher indication shall be repeated and recorded every 15 minutes for 2 hours.

Next, the chamber temperature shall be returned to the original temperature of 20 °C within 5 minutes. The readings at background and the

higher indication shall be repeated and recorded every 15 minutes for 2 hours.

Finally, the chamber temperature shall be decreased to -10 °C within 5 minutes. The readings at background and the higher indication shall be repeated and recorded every 15 minutes for 2 hours.

10.4 Low Temperature Start-up

10.4.1 Essential

The instrument shall switch on and operate correctly at -10 °C.

10.4.2 Desirable

Not currently defined.

10.4.3 Method of test

The instrument shall be placed in a climatic chamber initially set to an operating temperature of -10 °C and allowed to stabilise for a minimum of 2 hours. The instrument shall then be switched on and operated normally.

10.5 Humidity Stability

10.5.1 Essential

The instrument shall be capable of working at relative humidity levels between 20% and 90% RH. The variation of the relative response due to humidity shall be less than ±20%.

10.5.2 Desirable

The variation of the relative response due to humidity shall be less than ±10%.

10.5.3 Test radiation

The recommended reference radiation source is ^{137}Cs.

10.5.4 Method of test

The instrument shall be placed in a climatic chamber initially set to an operating temperature of +35 °C and a relative humidity of 65% RH. The instrument shall be left switched off in these conditions for a minimum of 24 hours. In the last 30 minutes of this period, the instrument should be switched on and both the instrument background reading and a higher indication produced by a radioactive source shall be recorded.

Keeping the temperature at 35 °C, increase the relative humidity inside the chamber to 90% RH. The instrument shall be left switched off in these conditions for a minimum of 24 hours. In the last 30 minutes of this period, the instrument should be switched on and both the instrument background reading and a higher indication produced by a radioactive source shall be recorded.

This test shall then be repeated with a relative humidity of 20% RH.

NOTE: For this test the reference response is determined at +35 °C and not +20 °C.

10.6 Submersion

10.6.1 Essential

The level of water resistance shall be clearly stated in the manual. Where the level of water resistance has not been tested then this shall be stated in the manual.

10.6.2 Desirable

The instrument should be capable of satisfactory operation after being fully submerged underwater for 5 minutes.

10.6.3 Method of test

The instrument shall be submerged underwater at a depth of approximately 30 mm for a period of at least 5 minutes and then thoroughly dried. Both the instrument's background reading and a higher indication produced by a radioactive source shall be recorded.

10.7 Explosive Atmospheres

Circumstances can be foreseen where it is necessary for instruments to be used in flammable atmospheres or close to explosive devices.

10.7.1 Essential

The manufacturer shall clearly state the level of intrinsic safety.

10.7.2 Desirable

The instrument should be intrinsically safe. Potential ignition sources, such as sparks, electric arcs or high surface temperatures, should not occur.

Instruments shall be designed so that the opening of equipment parts, which may be sources of ignition, is only possible under non-active or intrinsically safe conditions. Where it is not possible to render the equipment non-active, a warning label shall be affixed to the opening part of the equipment.

11 Maintenance Requirements

The manufacturer must define the time limit that the instrument will be supportable for spares and repairs. This shall be a minimum of 10 years. The manufacturer shall provide details of technical support and advice options as well as recommendations and information on the testing and maintenance regime required.

The instrument shall be supplied with a comprehensive instruction manual. In addition, a maintenance manual shall be available upon request.

The instrument shall contain a sufficient amount of easily accessible test points to facilitate fault location. Any maintenance aids, such as fault diagnosis software, extension leads and special maintenance tools, shall be available from the manufacturer upon request.

Unauthorised access to all the set-up functions of the equipment shall be prevented (see paragraph 3.3 Operating Modes).

12 Ergonomic and Usability Requirements

12.1 General

The object of this assessment is to give some idea of the ease of regular use of the instrumentation. Owing to the nature of the parameters assessed, the ratings are, to a large extent, subjective and should be based on impressions gained during the testing and handling of the instruments. Factors to be considered are:

- ease of operation;
- clarity of the display;
- ease of decontamination;
- susceptibility to damage.

12.1.1 Essential

Features are reasonably satisfactory.

12.1.2 Desirable

Features are fully satisfactory and could not be usefully improved.

12.1.3 Failure

Indicates a poor feature that could be irritating or inconvenient during regular use.

12.2 Size

12.2.1 Essential

12.2.1.1 Personal instrument (worn on the body)

The dimensions of the instrument shall not exceed 200 mm in length, 50 mm in depth and 100 mm in width, excluding any clip or retaining device.

12.2.1.2 Hand-held instrument

The instrument shall fit into a volume of less than 2 litres.

12.2.2 Desirable

12.2.2.1 Personal instrument (worn on the body)

The dimensions of the instrument shall not exceed 100 mm in length, 30 mm in depth and/or 80 mm in width, excluding any clip or retaining device.

12.2.2.2 Hand-held instrument

The instrument shall fit into a volume of less than 1 litre.

12.3 Weight

12.3.1 Essential

12.3.1.1 Personal instrument (worn on the body)

Instrument shall be as light as possible with a maximum weight of 400 g.

12.3.1.2 Hand-held instrument

Instrument shall be as light as possible with a maximum weight of 2 kg.

12.3.2 Desirable

12.3.2.1 Personal instrument (worn on the body)

Instrument shall be as light as possible with a maximum weight of 200 g.

12.3.2.2 Hand-held instrument

Instrument shall be as light as possible with a maximum weight of 1 kg.

12.4 Case Construction

12.4.1 Essential

The instrument case shall be smooth, rigid, shock resistant, splash proof and dust resistant. An additional rubberised outer to minimise damage can be utilised, but where this is removable it shall not affect the instrument's radiological performance.

A means for fixing the instrument to clothing shall be provided; for example, a strong clip or lanyard to allow for freedom of movement whilst carrying out strenuous work. Special attention should be given to the necessary orientation of the detector and, in addition, to ensure that any control, display or visual alarm is located such that they are visible to the operator.

12.4.2 Desirable

Any supporting straps/lanyards should be adjustable and compatible for use while wearing personal protection equipment (PPE); for example, a full gas-tight suit.

12.5 Resistance to Contamination (Ease of Decontamination)

12.5.1 Essential

The instrument shall be easy to decontaminate, ideally without any areas where contaminants could become difficult to remove. A smooth non-porous external surface that is free from crevices is recommended. The instrument may be fitted with an additional protective cover providing this doesn't affect any aspects of the instrument's performance.

12.5.2 Desirable

Not currently defined.

12.6 Transportation

12.6.1 Essential

Not currently defined.

12.6.2 Desirable

Capable of surviving high altitude air transport.

12.7 Cabling and Connections

12.7.1 Essential

All cabling shall be substantial and have strain relief where it is terminated. Rugged connectors shall be used and these should be securable. The integrity of non-securable connectors shall be protected.

12.7.2 Desirable

Not currently defined.

12.8 Switches and Controls

12.8.1 Essential

All switches and other controls shall be designed to ensure that the instrument can be properly operated whilst minimising accidental operation of any controls. All switches and controls shall have a

positive feel so that they can be operated by touch alone. Buttons, switches and controls should be well-spaced.

12.8.2 Desirable

All switches and controls should be illuminated such that their location and function can be identified in dark conditions. The spacing between each switch or control should at least 15 mm so as to increase the ease of operation of the instrument while the operator is in full gas-tight PPE.

NOTE: The finger diameter of the gloves used with full gas-tight PPE is approximately 25 to 30 mm.

12.9 Ease of Operation

12.9.1 Essential

The instrument must be designed so that it can be used safely and efficiently without a high level of specialist knowledge.

The instrument must be easy to operate with the operator in full gas-tight PPE.

12.9.2 Desirable

The instruments should be controlled via a menu operation with “soft-keys”. One-handed operation is possible.

12.10 Detector Location

For the majority of detection and alert instruments, the detector should be integral.

12.11 External Markings

All external markings shall remain permanently fixed under both normal conditions and those during normal decontamination procedures.

The instrument shall be clearly marked with the following:

- manufacturer’s name;
- model type;
- unique serial number;
- the function of all controls (that are not displayed via soft menus) and indicators.

Instruments with internal radiation detectors shall have markings to clearly indicate the calibration reference point of each detector in at least two planes.

12.12 Visual Display

12.12.1 Essential

Whether the instrument has an analogue or digital display (or hybrid of the two), the display shall react instantly to any change of measuring range. In addition, the display shall clearly indicate the measuring quantity.

The display must be clear and easy to read under normal and extreme conditions, which include use in bright sunlight and in total darkness. The display shall have an illumination function that can be turned on/off and this must not time out. A provision to test for failure of the display shall be installed. The display should not be influenced by gravity.

In addition to the visual indication of dose, a visual and audible indication of exceeding a dose limit shall be provided. A facility for temporally muting the audible indication shall be provided.

12.12.1.1 Personal instrument (worn on the body)

The size of the display shall be at least 30 x 5 mm.

12.12.1.2 Hand-held instrument

The size of the display shall be at least 45 x 15 mm.

12.12.2 Desirable

The brightness of the display illumination should be fully adjustable from off to the maximum brightness. There should be an option for the illumination brightness to adjust automatically dependent on the ambient lighting conditions.

12.12.2.1 Personal instrument (worn on the body)

The size of the display shall be at least 50 x 15 mm.

12.12.2.2 Hand-held instrument

The size of the display shall be at least 70 x 40 mm.

12.13 Additional Indications

12.13.1 Low battery

12.13.1.1 Essential

An indication of the battery condition shall be displayed on the display.

12.13.2 Detector failure

12.13.2.1 Essential

The instrument shall detect when the detector has failed and alert the operator.

12.14 Firmware

12.14.1 Essential

In the design of any firmware-controlled instrumentation, special account shall be taken of the risks arising from faults in the program.

The software shall have a version number for identification. It shall be possible to display this identification whilst the software is running.

All commands or parameters shall be defined; i.e. they shall have a clearly defined function that can be processed by the instrument, otherwise the instrument shall identify them as invalid. Invalid commands shall not affect any data or functions of the instrument.

12.14.2 Desirable

If applicable, firmware stored in the dose meter should be easy to update. Any updates shall be possible using only a PC with USB or other standard communications port. The dose meter shall request re-calibration after any update and this shall be made clear to the operator on every occasion before any updates are made.

12.15 Data Logging

12.15.1 Essential

Not currently defined.

12.15.2 Desirable

The instrument should have a data logging capability, with a download facility for extracting and/or interrogating data and logging faults to a computer. In the event of a power/battery failure the instrument should retain this data.

12.16 Communication Interface

12.16.1 Essential

Not currently defined.

12.16.2 Desirable

The instrument should be able to communicate data to an external device, such as a computer. The type of data to transfer could include dose equivalent rate indication history with time and date and/or GPS location.

The data transfer shall be via a bi-directional serial port that meets the requirements of Ethernet, USB or other, by other electronic means, such as a standard removable media device (e.g. SD Card). The protocol used shall conform to applicable IEEE protocols (e.g. IEEE 802) and proprietary protocols shall not be used. The transferred data shall be of a format (e.g. ASCII) that can be easily imported into common analysis programs. The manufacturer shall provide a full description of the transfer format and, if required, proprietary software for data interpretation.

Whilst it is acceptable in some circumstances for data to be communicated wirelessly (e.g. via Bluetooth® or Wi-Fi), all instruments shall have the option to fully disable its radio communications.

13 Documentation

13.1 Type-test Report

The manufacturer shall make the relevant type-test report available to any user or potential user of the instrument. If requested, the type-test report shall be supplied in its entirety.

13.2 Calibration Certificate Requirements

A certificate shall be provided giving at least the following information:

- manufacturer's name or registered trade mark;
- instrument type and serial number;
- probe type and serial number (if applicable);
- types and energies of radiations for which the instrument is intended;
- reference point of device;
- calibration orientation relative to radiation sources;
- effective range of use.

13.3 Operation and Maintenance Manual

13.3.1 Essential

The manufacturer shall supply an operational and maintenance manual containing a minimum of the following information:

- operating instructions and restrictions;
- schematic electrical diagrams, spare parts list and specifications;
- troubleshooting guide;
- contact information for the manufacturer.

13.3.2 Desirable

The manufacturer should supply a quick reference guide that explains the basic operations.

14 Training

14.1 Essential

Not currently defined.

14.2 Desirable

Training simulator options should be available for realistic training.

Appendix A: Summary of Performance Criteria

A.1 Radiological

Table 2: Summary of radiological performance criteria

Requirement	Essential	Desirable
Linearity of response (rate function)	Linearity better than ±50%	Linearity better than ±20%
Response time (alarm function)	Alarm triggered when the instrument is exposed to a radiation level that is 50% greater than any alarm threshold within 3 seconds of the step change. Indication shall be within ±30% of the changed radiation rate within 10 seconds.	Alarm triggered when the instrument is exposed to a radiation level that is 50% greater than the alarm threshold within 1 second of the step change. Indication shall be within ±30% of the changed radiation rate within 5 seconds.
Background subtraction	Not currently defined.	Should not trigger an alarm due to a sudden increase in natural background.
Detection of gradually increasing radiation levels	Alarm trigger threshold is not affected by slowly increasing radiation levels.	The instrument may incorporate a basic spectrum analyser to store natural background spectrums.
Overload performance	Satisfactory overload indication within 3 seconds and return to normal function in < 5 minutes.	Satisfactory overload indication within 3 seconds and return to normal function in < 2 minutes.
Photon energy response	Across the specified energy range of the instrument the response shall not vary by more than ±50% from the response to ^{137}Cs.	Across the specified energy range of the instrument the response shall not vary by more than ±30% from the response to ^{137}Cs.
Polar response	For angles of ±45°, in both horizontal and vertical planes, the source indication alarm shall be triggered when exposed to a dose rate 20% greater than that required to trigger the alarm at 0°. Where the instrument has an indication directly relating to dose rate the response normalised to the reference radiation at 0° shall be unity ±30%.	For angles of ±90°, in both horizontal and vertical planes, the source indication alarm shall be triggered when exposed to a dose rate 20% greater than that required to trigger the alarm at 0°. Where the instrument has an indication directly relating to dose rate the response normalised to the reference radiation at 0° shall be unity ±20%.

Requirement	Essential	Desirable
Response to neutron radiation (alarm and response time)	The instrument shall indicate the presence of neutron radiation within 10 seconds of the exposure, when exposed to a neutron field and trigger an alarm.	For angles of ±90°, in both horizontal and vertical planes, the source indication alarm shall be triggered when exposed to a dose rate 20% greater than that required to trigger the alarm at 0°. Where the instrument has an indication directly relating to dose rate, the response normalised to the reference radiation at 0° shall be unity ±20%.
Response to neutron radiation in the presence of photons (only required where instrument has a neutron capability)	Shall not trigger its neutron alarm whilst it is only exposed to an ambient gamma dose equivalent rate of less than 100 μSv h^{-1} Shall indicate the presence of neutron radiation whilst being exposed to gamma radiation if a neutron source is also present.	Not currently defined.
Accuracy of dose equivalent rate alarms	When the instrument is subjected to a dose rate that is 5% lower than the dose rate to which the alarm is set, the alarm shall not be triggered more than 5% of the time. When the instrument is subjected to a dose rate that is 5% greater than the dose rate to which the alarm is set, the alarm shall remain triggered more than 95% of the time.	Not currently defined.

A.2 Alarms

Table 3: Summary of alarm performance criteria

Requirement	Essential	Desirable
Audible alarm	Audible alarms shall exceed 100 dBA at a distance of 30 cm and have a unique sound, which shall not sound similar to any other emergency service equipment.	Adjustable alarm intensity in conjunction with vibrating alarm.
Visual alarm	Positioned so that if triggered the user will easily notice it.	Adjustable alarm intensity in conjunction with vibrating alarm.

Requirement	Essential	Desirable
Vibrating alarm	The vibrating alarm shall have sufficient intensity to be easily felt by the user through gloved hands.	If it is possible to turn off or reduce the intensity of any visual or audible alarms, then the dose meter shall have a vibrating alarm.

A.3 Electrical

Table 4: Summary of electrical performance criteria

Requirement	Essential	Desirable
Voltage dependence	Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±20% from the indication recorded with an optimal battery voltage.	Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±10% from the indication recorded with an optimal battery voltage.
Current dependence	Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±20% from the indication recorded with an optimal battery voltage.	Unless the instrument is displaying the low battery indication, all functions shall operate correctly and the mean instrument indication will not vary by more than ±10% from the indication recorded with an optimal battery voltage.
Battery test function (applicable to all instruments)	The battery test shall provide an accurate assessment of the condition of the cells and their suitability for further powering the instrument.	Not currently defined.
Battery test function (applicable only to digital instruments)	Operator alerted when the expected remaining life of the battery falls below 30 minutes	Operator alerted when the expected remaining life of the battery falls below 1 hour.
Battery lifetime	At least 12 hours with no alarms or illumination features in operation. At least 1 hour with ALL alarms or illumination features in operation.	At least 24 hours with no alarms or illumination features in operation. At least 2 hours with ALL alarms or illumination features in operation.

A.4 Mechanical

Table 5: Summary of mechanical performance criteria

Requirement	Essential	Desirable
Mechanical shock (drop test)	Instrument withstands drops from 1 metre on to hardwood without severe mechanical damage or affecting the indicated dose rate reading by more than 20%.	Instrument withstands drops from 1 metre on to concrete without severe mechanical damage or affecting the indicated dose rate reading by more than 10%.
Vibration	Response shall not vary by more than 20% as a result of the specified vibrations.	Response shall not vary by more than 10% as a result of the specified vibrations.
Mechanical impact (microphonic test)	During microphonic conditions the dose meters response shall remain within ±30% of the pre-test values.	Not currently defined.

A.5 Environmental

Table 6: Summary of environmental performance criteria.

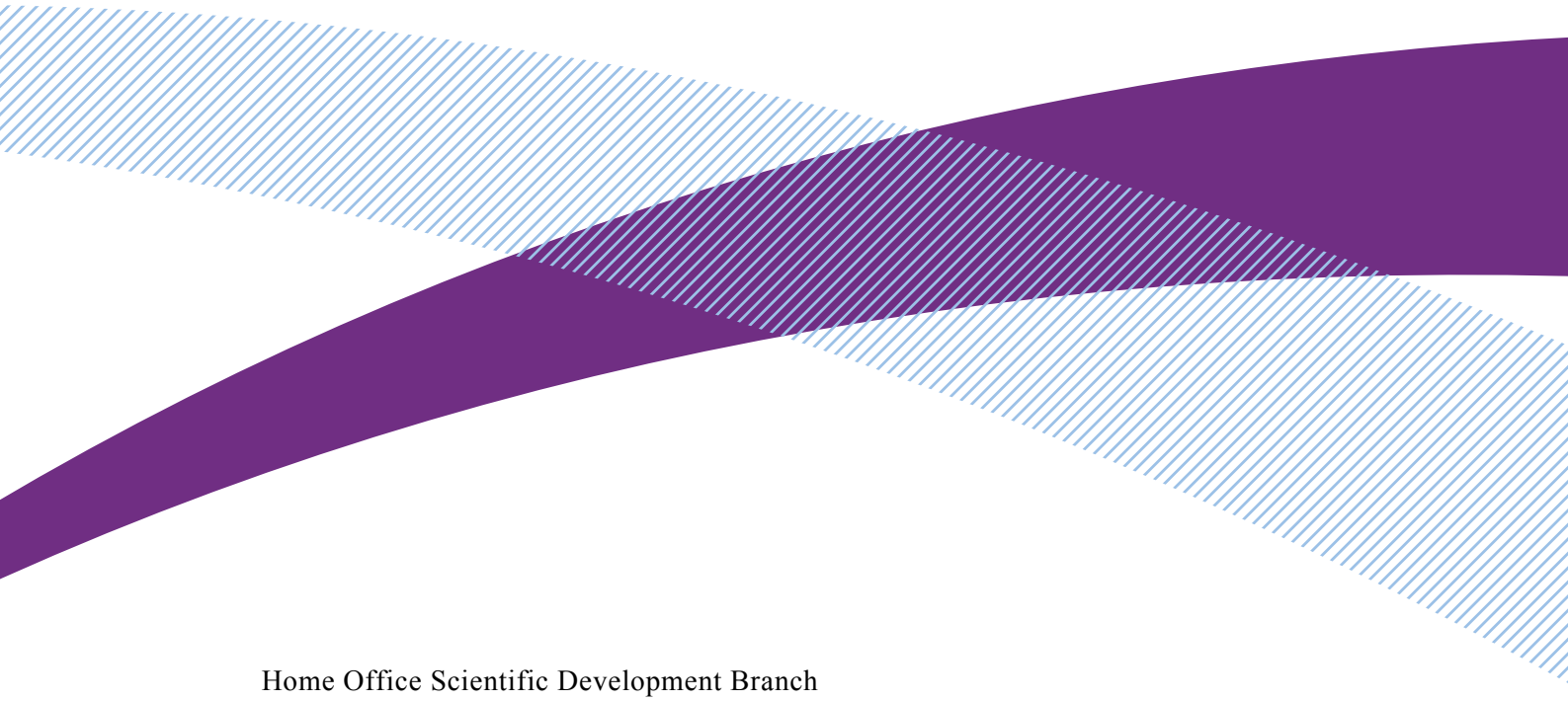
Requirement	Essential	Desirable
Environmental protection	IP rating of at least IP54.	IP rating close to IP67.
Temperature stability	A change of < 50% for indications at -10 °C and +40 °C compared to the indication at 20 °C.	A change of < 20% for indications at -10 °C and +60 °C compared to the indication at 20 °C.
Temperature shock	Capable of satisfactory operation up to +60 °C	Not currently defined.
Low temperature start-up	Shall switch on and operate correctly at -10 °C	Not currently defined.
Humidity stability	A change of less than 20% in indications for humidity levels between 20% and 90%.	A change of less than 10% in indications for humidity levels between 20% and 90%.
Submersion	The level of water resistance shall be clearly stated in the manual.	Capable of satisfactory operation after being fully submerged for 5 minutes
Explosive atmospheres	The manufacturer shall clearly state the level of intrinsic safety.	Intrinsically safe.

A.6 Ergonomic

Table 7: Summary of ergonomic performance criteria

Requirement	Essential	Desirable
General	Features are reasonably satisfactory.	Features are fully satisfactory and could not be usefully improved.
Size: personal instrument (worn on the body)	Shall not exceed 200 mm (length), 50 mm (depth), 100 mm (width), excluding any clip or retaining device.	Shall not exceed 100 mm (length), 30 mm (depth), 80 mm (width), excluding any clip or retaining device.
Size: hand-held instrument	Fits in to a volume of less than 2 litres.	Fits in to a volume of less than 1 litre.
Weight: personal instrument (worn on the body)	maximum weight of 400 g.	maximum weight of 200 g.
Weight: hand-held instrument	Maximum weight of 2 kg.	Light as possible with a maximum weight of 1 kg.
Case construction	Instrument case shall be smooth, rigid, shock resistant, splash proof and dust resistant.	Any supporting straps / lanyards should be adjustable and compatible for use while wearing PPE; for example a full gas-tight suit.
Ease of decon-tamination	Should not have any areas where contaminants could become difficult to remove.	Not currently defined.
Transportation	Not currently defined.	Capable of surviving high altitude air transport.
Cabling and connectors	Substantial cabling with strain relief where terminated. Rugged securable connectors.	Not currently defined.
Switches and controls	Designed to ensure that the instrument can be properly operated while minimising accidental operation of any controls.	Illuminated such that their location and function can be identified in dark conditions. The spacing between each switch or control should be at least 15 mm; this is to increase the ease of operation of the dose meter while the operator is in full gas-tight PPE.
Ease of operation	Designed so that it can be used safely and efficiently without a high level of specialist knowledge.	The instruments should be controlled via a menu operation with “soft-keys”. One-handed operation is possible.

Requirement	Essential	Desirable
Visual display: personal inst-rument (worn on the body)	Clear and easy to read under normal and extreme conditions. Minimum size of 30 x 5 mm.	Intensity of the display illumination should be fully adjustable. Minimum size of 50 x 15 mm.
Visual display: hand-held instrument	Clear and easy to read under normal and extreme conditions. Minimum size of 45 x 15 mm.	Intensity of the display illumination should be fully adjustable. Minimum size of 70 x 40 mm.
Firmware / software	The software shall have a version number for identification.	Firmware stored in the dose meter should be easy to update.
Data logging	Not currently defined.	Yes
Communica-tion interface	Not currently defined.	Be able to communicate with an external device such as a computer.



Home Office Scientific Development Branch
Sandridge
St Albans
AL4 9HQ
United Kingdom

Telephone: +44 (0)1727 865051
Fax: +44 (0)1727 816233
E-mail: RNStandardsEnquiries@homeoffice.gsi.gov.uk
Website: http://science.homeoffice.gov.uk/hosdb/