No. 29

Measurement Good Practice Guide

The Examination, Testing and Calibration of Installed Radiation Protection Instruments

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Foreword

This Good Practice Guide has been written by the UK Ionising Radiation Metrology Forum* in collaboration with the radiation user community. It describes recommended procedures for the examination, testing and calibration of installed radiation protection instruments. Test procedures recommended in this document are not legally binding: they are general methods based on current accepted good practice.

The current statutory requirement for installed radiation protection instrument tests is stated in the Ionising Radiations Regulations 1999. All employers who work with ionising radiation must ensure that levels are adequately monitored and instruments are suitable for this purpose.

Although the testing regimes presented here are for general application, qualified persons responsible for the calibration of radiation protection instruments may modify them, with the agreement of the Radiation Protection Adviser, as necessary to suit their particular purpose, provided that the employer is satisfied that the overall quality of the testing is not compromised.

* The Ionising Radiation Metrology Forum consists of representatives of UK establishments and organisations actively involved in radiation measurement for protection purposes. It is the aim of the forum to facilitate the exchange of information regarding UK calibration facilities and their efficient use by those required to comply with these regulations.

The Examination, Testing and Calibration of Installed Radiation Protection Instruments

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1 Introduction

The examination and testing of radiological protection instruments is a legal requirement for those carrying out work with ionising radiations[1, 2]. Sufficient equipment must be available to comply with the regulations and the instruments must be examined, tested and calibrated at appropriate intervals to ensure that they remain fit for use. Due to the size and nature of installed monitoring equipment, it is not normally possible to transport these instruments to a suitable calibration laboratory. Therefore, periodic examination and testing of such equipment would normally take place in the workplace. This minimises risk of damage caused by removal, transport and re-installation of equipment: it also permits tests of auxiliary indicators, such as remote warning lights.

This Good Practice Guide provides recommended procedures for the general examination, testing and calibration of installed radiation protection instruments. It follows a similar format to GPG14[3], which provides advice for portable radiation protection instruments. Recommendations made in documents published by national and international organisations, including the United Kingdom Accreditation Service (UKAS), the International Organisation for Standardisation (ISO), the International Electrotechnical Commission (IEC) and International Atomic Energy Authority (IAEA)[4] have been consulted during the preparation of this Guide.

The procedures detailed in this guidance provide the minimum level of testing that is recommended for instruments used in normal operating conditions. There may be special cases where testing requirements will go beyond these recommendations, where instruments are used in conditions outside those envisaged in the standards above. In such circumstances, the Employer may need to design appropriate test procedures.

The objective of testing is to demonstrate that the instrument is suitable and fit for use. Any reference sources used in the testing of such equipment must be of appropriate energy to the radiations used in the area. The testing regimes contained herein have no legal standing and Employers may implement their own schemes, provided they ensure compliance with the relevant regulations.

A glossary of terms is contained in Section 9.

The types of instrument that are covered by this guidance are described in Section 3. The examination and testing of installed neutron and criticality monitors, and air monitoring equipment are not covered in this Guide.

2 Testing Regime

For the purposes of this guidance, a **test** is defined as a procedure to evaluate an instrument's performance in order to establish its suitability, or its continued fitness, for a particular type or types of measurement in operational radiological protection. A test will involve an element of **calibration**, which may be defined as the measurement of the response of the instrument to known radiation fields. It is important to recognise that the terms **test** and **calibration** are not synonymous: this is because a test will also involve a degree of **examination**, which may include, for example, an inspection of the mechanical and electrical state of the instrument.

The tests recommended for installed radiation monitors are the Tests Before First Use and subsequent Periodic Tests, to be performed at suitable intervals in compliance with current regulations. The findings of these tests must be compared with any previous test information and the appropriate Type Tests to confirm that the instrument is meeting its specification, is suitable and remains fit for use. In many cases**,** the Type Tests and the Tests Before First Use are carried out by or on behalf of the instrument manufacturer. Periodic Tests are generally carried out by the Employer.

A **function check** is a simple test carried out to ensure, by observation that the instrument is working correctly. It does not require the use of radiation check sources. It is usually carried out together with routine maintenance such as detector cleaning, checking foils, etc. The frequency of **function checks** must fit the application of the instrument and must be determined by the Employer.

2.1 Type Tests

Before purchasing an instrument, it is the responsibility of the Employer to ensure that it is suitable for the intended use. Decisions about instrument selection should be made taking into account advice from the Radiation Protection Adviser (RPA), information from the manufacturer and other authoritative data that might be available.

The body of information regarding the characteristics and expected performance of instruments is called Type Test data and is usually based on recommendations from international organisations such as IEC, ISO, etc. A number of IEC documents exist

which detail the tests that are appropriate for the Type Testing of particular types of instrument. Typical documents for testing installed instrumentation are BS IEC 60532[5] for X- and gamma-ray dose rate monitors, IEC 61098[6] for alpha, beta and alpha/beta contamination monitors and IEC 61137[7] for low energy X- and gamma-ray contamination monitors. Although no standard fully addresses contamination frisking monitors, parts of IEC 60325[8], the standard for portable contamination monitors, may also be applied to this type of equipment. These documents were under review at the time of printing, and will be reissued before 2003, or in the case of IEC 61137, withdrawn; any future changes to these documents must also be adhered to. Type Tests are very comprehensive and may require specialised facilities: the tests should be performed by someone with appropriate expertise and insight into the use of instruments, in a laboratory with secondary standard or similar status, for example, a laboratory accredited by UKAS, using International Commission on Radiological Units and Measurements (ICRU) specified measurement quantities and ISO specified calibration sources.

The results of any tests carried out during the lifetime of an instrument should be compared with Type Test data to ensure that it continues to operate as expected: therefore, it is necessary to have access to the Type Test data for each instrument tested. For the purpose of the tests in this guidance, the minimum Type Test data required are the results of tests equivalent to those defined in the Tests Before First Use for a particular instrument type (these tests are listed in Table 1).

For most new instruments, the manufacturers or suppliers provide Type Test data that will enable the Employer to decide the necessary scope of Tests Before First Use. In the absence of Type Test data, the Employer should perform their own Type Test to establish their own baseline data at the Tests Before First Use stage.

2.2 Tests Before First Use

Assuming that the instrument is delivered in good condition and set up according to its specifications, the Tests Before First Use should demonstrate that the instrument conforms to type and determine its suitability for the intended use. The tests should be carried out first in conditions which are as similar to those used for the Type Test, and should be conducted as close in time as possible before the installation. A Periodic Test should be conducted as soon as possible after installation and the results will form the benchmark for future tests. Both tests are required to ensure that any effect on the

response resulting from the installation (such as back scattering) is quantified. These tests should provide a check for any potential faults and identify any limitations of the instrument with respect to its intended use. The tests may be undertaken by the manufacturer, the Employer or an independent laboratory. The Test Before First Use is especially important for installed instrumentation, since it may be the only opportunity to test the instrument to the same range of tests that would normally be applied to a portable instrument on a periodic basis.

Table 1 summarises the tests required for the Tests Before First Use of installed gamma dose rate and contamination monitors. The recommended procedures for each of the tests are provided in Sections 4 and 5. Some of these tests may need to be repeated periodically as the performance of an instrument can vary with age, key components may deteriorate or fail, and damage may occur during use: these are some of the reasons for the subsequent Periodic Tests.

2.3 Periodic Tests

It is the responsibility of the Employer to define the frequency of Periodic Tests based upon considerations of the age of the equipment, the environment in which it is used, the frequency of use, etc. It is the recommendation of this guidance that examination, testing and calibration should be performed at least annually. However, the requirements of any regulations published in the future must be adhered to.

The purpose of Periodic Testing is to check that the performance of an instrument has not significantly deteriorated and remains fit for use, and to confirm the performance findings of the Tests Before First Use. Although it is more than just a simple check, highly specialised facilities are not necessarily required for Periodic Testing: however, the facilities should be capable of making measurements to a known accuracy.

The tests required for the Periodic Tests are summarised in Table 1 and are generally similar to those for the Tests Before First Use. For gamma monitors, the tests of linearity and of energy and directional dependence are not generally required in Periodic Tests. Details of the gamma monitor tests are provided in Section 4. Similarly, for contamination monitors, the tests of uniformity of response over the detector area and the response to a high activity source may not be necessary. Details of the contamination monitor tests are provided in Section 5.

Because the instrument may have suffered from wear and tear or misuse, attention should be paid to the performance and the condition of its electrical and mechanical systems. For example, cables, connectors and detector windows should be examined and any necessary repairs carried out before the radiological response of the instrument is tested. If the repair is likely to affect the radiological response of the instrument, the Qualified Person should consider the degree of acceptance testing that is required (section 2.5). The condition of any warning lights/audible alarms should also be checked, and any lights or indicators to which a user has to respond must be operating correctly.

2.4 Routine Tests

The critical role that many installed monitors play in maintaining safe working conditions is such that a subset of the Periodic Tests should be conducted on a more frequent basis e.g. weekly or monthly. It is the recommendation of this guide that some of the Periodic Tests should be performed routinely and these tests are indicated in Tables 2 and 3.

The Employer should satisfy himself, on the basis of a risk assessment, that the frequency of Routine Tests and the recommended subset of tests is sufficient for his own work situation. Typical criteria to consider in the risk assessment would include the mean time between breakdowns, the probability of a failure to danger, and the occupancy of the area which the monitor serves.

2.5 Retest After Repair

After any event that could affect the performance of the instrument, for example, if the detector head has been repaired or replaced, it may be necessary to repeat some of the Tests Before First Use. The degree of testing depends on the nature of the repair. A detector will not require retesting with a high activity source after a foil change; determination of the response to a low activity source will suffice. A detector replacement on a gamma monitor will require a repeat of the energy and directional response tests described in this document.

If a repair is likely to change the radiological response of the instrument, the magnitude of the adjustment should be recorded. This may be achieved by recording a before and after repair reading. The purpose of taking a reading before the repair is

that the Employer may have made quality measurements with the instrument prior to the repair and calibration, and if the change in response was significant then he may decide to either repeat his measurements or normalise his recorded measurements.

2.6 Pass / Fail Criteria

The results of the Tests Before First Use and Periodic Tests of an instrument should be compared with the Type Test data to confirm that the instrument still conforms to type and remains fit for use.

It is strongly recommended that Periodic Test results be compared with the results of previous Periodic Testing of the instrument. This practice will highlight, for example, the situation where an instrument which consistently produced a response which is greater than that indicated in Type Test data, suddenly gives a significantly lower response that still lies within acceptable limits. In this case, the instrument may pass the Periodic Test but its performance should be regarded as suspect.

Whenever an instrument is adjusted during the course of a Periodic Test or Test Before First Use, a statement indicating the nature and magnitude of the adjustment should be made on the test report or calibration certificate. During Routine Tests, the Test House should not undertake an adjustment that would affect the radiological performance of the instrument; if it falls outside the limits described in this document, the Test House should fail the instrument and undertake a Periodic Test after the adjustment. If the instrument requires a repair, the Qualified Person should consider whether another Test Before First Use is required (Section 2.5).

An instrument may fail the Tests Before First Use or Periodic Tests if the results of any component of the appropriate tests are not within the acceptable limits defined in Tables 2 and 3, or if the instrument's performance is deemed unsatisfactory by the Employer.

Table 1 Summary of Tests Before First Use and Periodic Tests

INSTRUMENT	TESTS BEFORE FIRST USE	PERIODIC TESTS
Gamma Monitors	Function Check Background Indication Alarm Check Response to High Dose Rates Linearity Energy Dependence Directional Dependence	Function Check Background Indication Alarm Check Response to High Dose Rates
Contamination Monitors	Function Check Background Indication Alarm Check Response to Contamination Plateau Check Response to High Activity Source Uniformity of Response	Function Check Background Indication Alarm Check Response to Contamination Plateau Check

3 Instruments

The type, nature and intensity of radiation that an instrument may encounter, and the conditions under which it may be used should be considered when selecting an instrument. The Employer should seek advice from his RPA when an instrument selection is made.

Installed radiation protection instruments will normally consist of an audible and/or visual alarm indication as a minimum. In addition, some instruments may also have a readout meter in the form of an analogue, digital or bargraph reading, or a combination of all three. Unless all tests are to be performed in all output modes, the particular mode normally employed should be confirmed with the instrument user and adopted for the tests: a statement of the readout mode tested should be made on the certificate or test report.

Some instruments allow adjustments to be made to their indication, for example, adjustments to the operating voltage for determination of plateaux. Care should be taken to ensure that instruments are set up according to manufacturer's recommendations before testing the radiological response. If the instrument has been used for quality measurements prior to the tests, measurements should also be taken prior to any adjustment. The settings used during the tests, including the operating voltage if appropriate, should be noted on the certificate or test report. Any significant deviations from the recommended settings should also be reported.

3.1 Gamma Monitors

A gamma monitor is designed to display an audible or visual alarm (or both) when the local dose rate exceeds the preset alarm threshold on the instrument. It may also display the local dose rate on a meter. Most modern gamma monitors have a low level alarm facility. This alarm is often held off with a radioactive priming source. These facilities allow the instrument to perform self checks continuously: the instrument electronics will inform the user if there is a detector fault such that the expected pulse rate from the detector is not received by the associated electronics. Instruments without either a priming source or low level alarm will have no built in detector checks.

For the tests defined in this guidance, installed gamma monitors may be divided into three classes:

Class A	Monitors with a priming source and with a low level alarm.
Class B	Monitors with a low level alarm only.
Class C	Monitors with no priming source and with no low level alarm.

These classes are relevant to the background indication test and the alarm test frequency.

The tests required to establish the linearity, energy dependence, directional dependence and other relevant characteristics of these monitors are detailed in Section 4. Table 2 is a quick reference guide for these monitors and provides a brief description of each of the tests.

3.2 Contamination Monitors

The three types of personnel contamination monitor are described below. Modern installed contamination instruments monitor the background count rate while they are not monitoring personnel. The monitor therefore compensates for any changes in background. Tests are required to ensure that the alarm threshold will operate at an appropriate contamination level.

It is important that the alarm threshold on these instruments is set to alarm at the appropriate surface contamination level.

Appendix A describes a suitable method for setting up the alarm thresholds on each type of contamination monitor.

3.2.1 Hand and Foot Monitors

Typically these instruments are supplied to monitor hand only, feet only or both simultaneously. The detectors are static and the hands and/or feet are monitored when in contact with the detector. The monitoring time is fixed depending on how the instrument has been initially set up. An outline of the tests required is given in Table 3 and more information is provided in Section 5.

3.2.2 Frisking Monitors

These instruments will consist of a probe connected to a monitoring assembly via an external cable. The users will monitor themselves by moving the probe slowly over their body. Unlike the other contamination monitors described here, the distance between the body area being monitored and the probe is variable and will depend on the self-monitoring method adopted by the user. This instrument therefore has two additional variables (distance and speed) which will add to any uncertainty in the result. An outline of the tests required is given in Table 3 and more information is provided in Section 5.

In some situations a portable contamination monitor may be fixed permanently to a location, and used as a frisking monitor. In this situation, the monitor should be tested in accordance with the recommendations of GPG14[3].

3.2.3 Exit (Personnel) Monitors

These instruments are designed to monitor radioactive contamination on the body quickly and efficiently. Typically this is achieved by an array of detectors mounted close together. These also incorporate the hand and foot detectors as described in Section 3.2.1. Tests required for these instruments include a measurement of the response to a large area source, measurement of the response to a high activity source and uniformity of response over the detector area. A brief description of these tests is provided in Table 3 while detailed information can be found in Section 5.

Table 2 Tests Required for Gamma Monitors

TEST REQUIRED	COMMENTS
FUNCTION CHECK Check indicator lights are functioning; visual check of physical condition. Check alarm using the check function, if available. Check display operates correctly.	
BACKGROUND INDICATION Check and note the background indication.	Class A monitors will display a constant elevated background.
ALARM CHECK HIGH DOSE RATE Expose the instrument to a dose rate no more than 50 % above the preset alarm threshold.	
LOW DOSE RATE Confirm that the low level alarm may be activated	Low dose rate test only applies to Class A and Class B monitors.
RESPONSE TO HIGH DOSE RATES Expose the instrument to a dose rate in excess of that which it could reasonably encounter in practice, for at least thirty seconds. A minimum dose rate of 10 $mSvh^{-1}$ should be used.	Where there is a significant risk to the person performing this test, i.e. when it is necessary to use a dose rate much greater than 10 $mSvh^{-1}$, the use of a calibration laboratory may be more appropriate.
LINEARITY Mount the instrument in the calibration orientation, with its reference point at the point of test in the radiation field of a ^{137}Cs source. Measure the instrument's response to the field for each range or decade of the instrument, up to the maximum dose rate it could reasonably encounter in the workplace, even in accident conditions.	^{60}Co may be used if ^{137}Cs is not available. Where more than one display exists, check all displays.
ENERGY DEPENDENCE Mount the instrument in the calibration orientation, with its reference point at the point of test in the radiation field of a 60 keV (^{241}Am) photon source. The dose rate from the 60 keV source should be adjusted until the instrument reading is close to one of those obtained for ^{137}Cs in the linearity test. Determine the instrument's response to the 60 keV source.	Filtered X-radiation from the ISO low or narrow series may also be used, particularly for high dose rate detectors.
DIRECTIONAL DEPENDENCE Using the same dose rate and photon energy as for the energy dependence test, determine the instrument's response at $\pm\theta$, where θ is an angle between 45° and 90°.	The angle θ will typically be 90°, however it may be more appropriate to use a smaller angle if the instrument does not have a useful response at 90°.

PASS / FAIL CRITERIA	TESTS BEFORE FIRST USE	PERIODIC TESTS	ROUTINE TESTS	DETAILED REFERENCE
	Yes	Yes	Yes	Section 4.1
No significant deviation in indication from previous test, unless there has been a change in the ambient conditions.	Yes	Yes	Yes	Section 4.2
	Yes	Yes	No*	Section 4.3
	Yes	Yes	No	Section 4.3
If the high dose rate used is above the range of the instrument, the overload indication should operate for the duration of the test. The instrument performance should return to normal after the test.	Yes	Yes	No	Section 4.4
Agreement to within ± 30% of true dose rate.	Yes	No	No	Section 4.5
The ratio of the 60 keV response to the ^{137}Cs response (from the linearity test) should agree within ± 30% of that in Type Test data.	Yes	No	No	Section 4.6
Agreement to within ± 30% of Type Test data.	Yes	No	No	Section 4.7

* Category C monitors will require this check as part of the Routine Test

Table 3 Tests Required for Contamination Monitors

TEST REQUIRED	COMMENTS
FUNCTION CHECK Visual check of physical condition. Clean foot monitors if appropriate. Check gas flow and supplies.	
BACKGROUND INDICATION Check whether the background indication differs from the normal level.	
ALARM CHECK Check with a calibrated source of the appropriate emission type to demonstrate that the alarm is working correctly at the alarm level.	
RESPONSE TO CONTAMINATION Check the efficiency of the detector with the appropriate nuclides given in Appendix D.	
PLATEAU CHECK For beta detectors Check the ^{14}C efficiency and compare to previous records. For alpha/beta detectors Using an ^{241}Am check source, evaluate the proportion of alpha counts in the beta channel. Using a high energy beta source, evaluate the proportion of beta counts in the alpha channel.	If this test shows a significant change, the instrument may not be set up at its optimum operating voltage.
RESPONSE TO HIGH ACTIVITY SOURCE Expose the detector to a source of activity at least 10 times greater than that used for the alarm check .	
UNIFORMITY OF RESPONSE Use a 50 cm^2 source to determine the instrument response at various positions over the detector window. Calculate the mean response over the whole window.	Only instruments with detector areas in excess of 150 cm^2 need be tested.

PASS / FAIL CRITERIA	TESTS BEFORE FIRST USE	PERIODIC TEST	ROUTINE TEST	DETAILED REFERENCE
	Yes	Yes	Yes	Section 5.1
	Yes	Yes	Yes	Section 5.2
	Yes	Yes	Yes	Section 5.3
Results should agree within ± 10% of historical data, and ± 30% of type test data.	Yes	Yes	No	Section 5.4
If the efficiency differs by more than 10% from that derived from the last plateau check, re-determine the optimum operating voltage (plateau). The beta in alpha ratio should not exceed 0.01. The alpha in beta ratio should not differ by more than 10% from the previous annual check, otherwise re-determine the optimum operating voltage.	Yes	Yes	No	Section 5.5
An alarm must be generated.	Yes	No	No	Section 5.6
No results should be outside of 30% of the mean result.	Yes	No	No	Section 5.7

4 Specific Tests for Gamma Monitors

Table 1 lists the tests which are applicable to the Tests Before First Use and the Periodic Tests for all the instrument types covered in this Guide. Table 2 provides a brief summary of the tests for gamma monitors and their pass/fail criteria: the tables are not comprehensive and should not be used without reference to the detailed information in the text. The tests do not have to be performed in the order in which they are listed in the tables and may be undertaken in an order, which is convenient to the Test House. If the response to high dose rates of dose rate monitors is not tested first, it is important to check that this test, when conducted subsequently, has not adversely affected the instrument performance.

Full procedures for the performance of all of the tests are provided in the remainder of this Section.

4.1 Function Check

Perform a visual check of the physical condition of the instrument. Check indicator lights are functioning. Note the threshold at which the alarm is activated. Check the alarm using the check function if available. This should ensure that both audible and visual indicators work correctly.

If the instrument has an analogue display and may be powered down, check that the needle indication rests at the zero position when it is not measuring radiation i.e. it zeroes correctly. If the instrument has a digital display and has a display check function, check that all segments of the display work correctly.

4.2 Background Indication

The following classes are as defined in Section 3.1

Class A

Gamma monitors will be provided with a priming source and therefore should display a stable background indication. If the background is not stable, or is elevated compared to previous results, this should be noted on the test report. If this change in

indication is not due to a change in the ambient background, this should be investigated. Ideally, if the indication is significantly below the typical indication, this should have triggered the low level alarm.

Class B

Gamma monitors are similar to Class A monitors: they will self-check the background count and alarm in the absence of any counts.

Class C

Gamma monitors do not have any low level alarm functionality. Extra care should be taken to ensure that the instrument is functioning.

4.3 Alarm Check

High Level

Expose the instrument to a dose rate no more than 50 % above the defined alarm threshold and confirm that the alarm indicator is activated.

If the monitor is routinely exposed to a reproducible radiation field e.g. radiation cell interlock monitor, proof that the monitor responds in an expected manner may satisfy this check.

Class C monitors must undergo an alarm check on a routine basis. Where the instrument is operating in an area with an enhanced background dose rate, such that instrument reading is always within the first decade of the measurement, the Employer may justify the relaxation of the routine alarm check. However, the Employer should note on a routine basis that the monitor continues to detect the enhanced background dose rate.

Low Level

Activate the Low Level Alarm. This may be achieved by disconnecting the detector temporarily, rebooting the instrument, or using a low level alarm check facility. This test will show that the instrument has an adequate system for detecting a faulty detector or associated cabling.

4.4 Response to High Dose Rates

In the workplace, unexpectedly high dose rates are possible from, for example, shielding failure. Gamma monitors are designed to alarm before a high dose rate is reached. However, a limited test is required to ensure that the instrument will also alarm at a dose rate that is considerably greater than that used for the alarm check. For example, in some older instruments it is known that the indication may fall back/ under-read to below the alarm level when exposed to very high dose rates. This test is designed to indicate such problems. This test is especially important for dual detector instruments which contain both high and low dose rate detectors, and where the high dose rate detector, due to its high range, is not tested during the alarm check.

A suitable dose rate for this test is at least 10 $mSvh^{-1}$. Where there is a significant risk to the user performing this test, i.e. when it is necessary to use a dose rate much greater than 10 $mSvh^{-1}$, the use of a calibration laboratory may be more appropriate. For dual detector instruments, the dose rate must be high enough to initiate the high dose rate detector.

In order to undertake this test, it may be appropriate to place a check source with its associated jig (if appropriate), in close proximity to the detector. The source (and jig) will be calibrated by exposing the same source in the same orientation to the same type of a calibrated instrument immediately after a full linearity test. In this way, the source may be calibrated using the instrument as a transfer standard (see Section 6).

It is important to ensure that this test does not damage the instrument. Therefore these tests should be conducted before the alarm check.

The Employer may show that the instrument will not under-read at high dose rates due to the nature of its design, and that the alarm will always latch on once initiated. In this case, the Employer may be able to provide a technical justification for not undertaking this test. This justification must take account of potential deterioration of the detector with time e.g. corrosion.

4.5 Linearity of Response

The instrument under test should be mounted in the calibration orientation, with its reference point (marked calibration point on the detector or detector housing), or in the absence of a marked calibration point, the geometric centre of the detector, at the point of test in the radiation field from ^{137}Cs gamma radiation. ^{60}Co may be used as an alternative source of gamma radiation for this test, or a combination of both gamma radiations, where the appropriate range of dose rates from ^{137}Cs is not available. The instrument's response to the field should be measured for at least one dose rate in each range or decade of the instrument, up to the maximum dose rate, which it could reasonably encounter in the workplace, even under accident conditions. In addition, for those instruments that are not provided with priming sources, the response of the instrument should be tested in the lowest 25% of the lowest range or decade; this will ensure that the instrument will respond to low dose rates. If the response of an instrument is found to be unsatisfactory, it may be possible in some cases for the instrument to be adjusted to give an acceptable response over its range of use. Any adjustment made should be reported on the test report by displaying a before and after adjustment reading (or response).

Where appropriate, the test report should give the instrument response, or calibration/multiplication factors which enable the user to convert the instrument indication to dose rate, or quote that the instrument's response is acceptable within a specified range of dose rates, or that it has been adjusted to be acceptable within the range. The instrument responses in the known calibration fields should be within ±30% of unity i.e. readings within ±30% of the true dose rate. Any untested ranges or decades should be clearly indicated on the test report.

4.6 Energy Dependence of Gamma Monitors

The energy dependence of instruments used to measure dose rates in the workplace is governed by the type of detector and, in some cases, on the setting up of the electronic system of the instrument. The following test is designed to confirm that the response of the instrument does not vary with energy in a manner which is significantly different to that quoted in the Type Test data. The test utilises the information obtained in the linearity test described above, and combines it with a test procedure using an ^{241}Am photon radiation source. This test should identify any major faults in the detector.

Information at one energy (corresponding to ^{137}Cs or ^{60}Co) should have been obtained in the linearity test described in Section 4.5. For many instruments, a test at a much lower energy is required to confirm that the energy dependence corresponds, within acceptable limits, to that quoted in Type Test data. This is because incorrect assembly or the use of wrong materials during repair may have a negligible effect on instrument response at high energies, while having a more significant effect at low energies.

The instrument should be mounted in the calibration orientation with its reference point (marked calibration point of the detector or detector housing), or in the absence of a marked calibration point, the geometric centre of the detector, at the point of test in the radiation beam. The recommended radiation energy is 60 keV (^{241}Am gamma radiation), although an appropriate X radiation quality from the ISO low or narrow series of reference filtered X radiation[9] may be used. The dose rate from the ^{241}Am or X radiation should be adjusted until the instrument indication is close to one of those from ^{137}Cs or ^{60}Co used in the linearity measurement. The true dose rate, at the point of test in the ^{241}Am or X radiation field, should then be determined and the instrument response or calibration/multiplication factor derived.

The ratio of the 60 keV response to that for ^{137}Cs or ^{60}Co gamma radiation should be calculated and compared with same ratio derived from the Type Test data. The ratios should agree to within ±30%.

4.7 Directional Dependence

The majority of instruments are intended to respond isotropically to radiation incident over a wide range of angles, i.e. they are expected to have little directional dependence. This characteristic is normally investigated during Type Testing. However, it is possible during instrument manufacture to produce gross defects in directional dependence by, for example, missing out components in the energy compensation filter of a Geiger-Müller detector or in the internal, energy-correction components of an ionisation chamber. These errors may not be detected in the energy dependence test.

The directional dependence test can normally be performed by rotating an instrument's detector housing in the horizontal plane about its calibration reference point and measuring its response in each orientation. The response at 0° should be compared with the response at ±θ° where θ is an angle between 45° and 90°.

Although typically θ will be 90°, the Test House may prefer not to test it at an angle where a known blind spot occurs. Note that in the workplace, since the monitor is likely to be mounted on a wall, irradiation from ±90° is unlikely. Depending on the proposed use of the instrument, it may also be necessary to carry out a similar test in the vertical plane, especially for a cylindrical detector (or detector housing) which the Employer may choose to mount in the +90° (end on) orientation. For photon dose rate monitors, the same radiation quality, normally ^{241}Am gamma radiation, should be used as in the energy dependence confirmation. A relatively low energy is preferable to ^{137}Cs or ^{60}Co gamma radiation because the test is much more sensitive at the lower energy. It is essential that all detectors are tested. Appendix C discusses angles which are suitable for testing different detector designs.

The ratio of the 60 keV response at the selected angle to the 60 keV response at 0° should not differ from the Type Test data by more than 30%. If the difference exceeds 30%, the Qualified Person may decide, after consultation with the Employer and taking account of the fixed geometry of the instrument, that the instrument is suitable for use. In this situation, an appropriate remark should be made on the calibration certificate.

5 Specific Tests for Contamination Monitors

5.1 Function Check

Perform a visual inspection, including the case and display and if necessary, connecting cables. Check background response and clean foot monitors if required. Check gas flow and supplies if appropriate; the flow rate in should equal the flow rate out of the detectors. For scintillation probes, check for light sensitivity.

If the instrument has an analogue display and may be powered down, check that the needle indication rests at the zero position when it is not measuring radiation. If the instrument has a digital display and has a display check function, check that all segments of the display work correctly.

For gas flow systems, the detector response should be checked at least close to the outflow - if there are leaks in the detector, the gas pressure will be least near the outflow.

5.2 Background Indication

These monitors will typically have some form of background compensation. In this way a high background gamma dose rate may not necessarily affect the readings. However, it is also possible for a high background gamma dose rate on a single detector to reduce the effectiveness of the background compensation of the whole instrument. Similarly, a contaminated window on a detector may also reduce the effectiveness of the compensation. If the facility exists, check the background count rate on each detector.

5.3 Count Rate Alarm Test

Test with a calibrated source to demonstrate that the alarm is working correctly at the alarm threshold. The radiation emissions from the source should be of appropriate type and energy to the radiations that could be found in the area.

Due to the impracticalities of manufacturing sources of exact emission rate, it is acceptable to use test sources which will give rise to count rates up to 200% above the alarm threshold.

In the case of Exit (Personnel) Monitors, diagnostic software may allow testing of more than a single detector at the same time. Check a sample selection of body detectors using a systematic procedure. Every detector should be tested at least once every three months. Appendix A describes a suitable method for setting alarm levels on contamination monitors.

5.4 Response to Contamination

Perform an efficiency test with at least one radionuclide of the appropriate radiation emission that the instrument is designed to measure. Appendix D lists suitable radionuclides for each type of radiation emission, for several workplace environments. Where the instrument is designed to measure alpha and beta (or photon) contamination, the instrument should be tested to both an appropriate alpha (^{241}Am) and beta (or photon) emitting radionuclide. The response to photon contamination test should be undertaken where there is a potential for contamination from photon emitting radionuclides. Compare the results to historical data.

This guidance does not specify a suitable distance between the test sources and the detector. However it is important that the test geometry is reproducible; a source in contact with the detector is likely to be the most reproducible geometry. The efficiency data derived from these tests is not necessarily the efficiency from which alarm levels are derived (see Appendix A).

If an instrument has many detectors e.g. an Exit Monitor, the time taken to test each detector would be reduced significantly by using sources of greater activity than those used to conduct the alarm test e.g. > 5 kBq. The high activity source will allow the Test House to select shorter counting times to provide statistically significant results. This is especially true where the instrument detectors show a high count rate due to background gamma radiation. However, the Test House should be aware that the instrument detectors might have a significantly lower response to high activity sources, than to the alarm test sources. Type Test data and the Response to a High Activity Source Test (Section 5.6) will demonstrate whether the detectors have a linear response.

5.5 Plateau Check

In the case of Exit, Hand & Foot and Frisking monitors with alpha/beta detectors, evaluate the proportion of counts from an alpha emitting source in the beta channel and counts from a beta emitting source in the alpha channel and compare with data from the previous plateau check. The beta source used should have a high energy beta emission e.g. ^{36}Cl and the alpha source should be ^{241}Am. The beta-in-alpha ratio should not exceed 0.01. The alpha-in-beta ratio should not differ by more than 10% from the previous annual check, otherwise re-determine the optimum operating voltage. Note that the alpha in beta ratio may increase with the activity of the test source. Therefore it is important to use a source that will give rise to a count rate within the range specified in Section 5.3.

For beta only detectors, check the ^{14}C response and compare to previous records. If the response differs by more than 10% from that derived from the last plateau check, re-determine the optimum operating voltage. For instruments intended to measure low energy photon contamination, use ^{55}Fe instead of ^{14}C.

The plateau check is a suitable test to undertake after a simple repair e.g. foil change.

5.6 Response to High Activity Source

Some monitors may fail to alarm at count rates well in excess of the alarm threshold, for the same reasons as given in Section 4.4. A high activity test should use a source at least ten times that used for the alarm test. The alarm should operate when exposed to this source. A suitable source activity is 10 kBq.

Ideally the source should be the same isotope, construction and dimensions as the source used for the alarm test. Alternatively the response from the high activity source should be compared with the response from a source of the same isotope and construction, but with an activity similar to that used for the alarm test. If the response varies significantly between the two sources then this information should be considered when selecting sources for the Response to Contamination test (Section 5.4).

5.7 Uniformity of Response

Instruments with a detector area in excess of 150 cm^2 should be checked to ensure that their response to appropriate radiations is reasonably uniform over the whole area of the detector. This test is designed to identify areas of the detector which have an inadequate detection efficiency and is particularly important for scintillation detectors where the scintillator can become detached from its support plate or light guide.

This test will normally not require more than a four position check using a source of area less than 50 cm^2. The energy of the emissions from the source should be less than or equal to the lowest energy radionuclides the instrument is intended to detect. To determine the uniformity of a detector, divide the detector area into quadrants and measure the instrument response in each quadrant. The pass/fail criterion for the test is that no individual area should have a response, which is less than 75% of the mean response.

6 Facilities and Traceability

The majority of the tests described in this document would be performed in the workplace rather than the calibration laboratory. However the Tests before First Use should be performed in an appropriate radiation facility, which ensures measurements are traceable to national standards. The facilities and traceability required in order to undertake tests on an installed instrument in a calibration laboratory are no different to those required for a portable instrument. This document will not discuss the facilities and traceability that are required for a calibration laboratory, since they are described in detail in GPG14[3].

6.1 Workplace Gamma Monitors

In general, the Periodic Testing will take place in the workplace. Therefore no specialised facilities will be required for these tests. However, the Test House should use sources incorporated into calibration jigs wherever practical, which will ensure reproducible geometry when exposing the instrument detector, and minimise exposures to the personnel undertaking the tests. It is acceptable for the sources within these jigs to be in close proximity to the instrument detector i.e. less than 10 cm. Due to the greater uncertainties associated with sources that are incorporated into jigs, such as source to detector positioning and the additional uncertainties associated with radiation scatter in the workplace, an uncertainty of ±10% of the dose rate is acceptable on the output of workplace calibration sources.

The Test House should undertake a Periodic Test as soon as practical after installation, and compare the results to those from the Test Before First Use, which had taken place in the calibration laboratory. In this way the instrument may be treated as a tertiary (transfer) standard, since it provides a direct comparison between the workplace calibration jig and calibration laboratory, thereby providing traceability to national standards. The comparison should also show any changes in response that may have occurred due to damage during the process of transport and installation. The Test House should ensure that a representative sample of installed instruments are used for establishing the calibrated dose rates from the calibration jig, to ensure that a faulty instrument has not been used as a transfer standard.

The Test House should undertake an independent comparison for each type of instrument installed in the workplace. It is possible that a procedure that uses the same calibration jig on different types of instrument will give significantly different results due to different detector characteristics.

The calibration jig may be used for all subsequent Periodic Tests. However, the jig and associated sources should undergo a recalibration at least every four years. As part of the recalibration, an example of each type of instrument that is used should be sent to a calibration laboratory in order to re-establish traceability via a transfer standard and the subsequent intercomparison described above should be repeated.

6.2 Workplace Contamination Monitors

Elaborate calibration facilities are not normally required for contamination monitors. However, sources incorporated into calibration jigs are generally used for the Periodic Testing of installed instruments. Calibration jigs will typically allow the Test House to establish a reproducible geometry quickly, as well as minimising the contact between the person undertaking the test and the source. Figures 1 to 3 show some examples of contamination monitor calibration jigs such as a "standard hand" for a hand monitor (Figure 1); calibration jig for a frisking monitor (Figure 2), and a ladder source for an Exit monitor (Figure 3). Source jigs, which expose two or more detectors simultaneously e.g. a double sided standard hand, should only be used where the instrument shows an indication from each detector independently. Otherwise source jigs that expose only a single detector at any one time should be used.

Contamination monitor calibration sources will typically be tertiary standards, which have been compared, not with the primary standard, but with an appropriate secondary standard. Tertiary standards should be calibrated against a secondary standard at least every four years and be the subject of at least an intercomparison check every two years. As tertiary standards are generally more frequently used at a working level, they are more vulnerable to loss of calibration and therefore require more regular calibration against the secondary standard.

7 Certification of Tests

The results of tests performed under the current regulations should be communicated to the Employer in a formal manner. The precise format of a test certificate or report is not specified in the regulations.

7.1 Calibration Laboratory

The information provided for an installed instrument that is tested in a Calibration Laboratory is the same as that required for a portable instrument. The following basic information should be provided by the Test House:

(a) name and address of customer;

(b) description of the instrument (including type and serial no.);

(c) limitations of the calibration performed including identification of the ranges not tested;

(d) type of test, i.e. Tests Before First Use, Periodic Test or Retest After Repair;

(e) basic description of the test, any specific instrument settings used (including the operating voltage if this is variable), and any adjustments or repairs performed;

(f) results of the tests undertaken to satisfy this document including a statement of the uncertainty with the confidence level at which the uncertainty is quoted for numerical results;

(g) record of the background dose rate or count rate and any relevant environmental conditions during the tests;

(h) the value of any conversion coefficient or P-factor applied to the results;

(i) statement that the test was carried out for the purpose of the regulations;

(j) name and signature of the QP supervising the test;

(k) name, address and contact details (e.g. telephone number or Email address) of the Test House which performed the test;

(l) the date of the test.

In addition to the information listed above, further details should be provided when surface contamination monitors have been calibrated. The sizes of the calibration sources used for the determination of alpha, beta or photon response and the orientation in which they were used with respect to the source should be indicated. Where a contiguous portions measurement has been made, the value of any correction factor used should be clearly stated.

7.2 Workplace Testing

The results of Periodic or Routine tests for an installed instrument do not typically require the issue of a certificate for each instrument. However the Test House should indicate all the information listed above through a combination of documented test procedures that describe the tests to be undertaken and a test report which provides the information that is unique to the instrument. In general the test report only needs to specify the following:

(a) Location of the instrument;
(b) Type and serial number of the instrument;
(c) Type of test e.g. Routine or Periodic;
(d) Results of the testing, including background indications;
(e) Name and signature of QP.

7.3 Test Label

As test reports are usually filed away for quality assurance purposes and tend not to accompany instruments in the workplace, it is recommended that instruments themselves are labelled with the following information after testing:

(f) description of the instrument (including type and serial no.);
(g) date of calibration or test;
(h) test reference.

If an instrument fails to meet the pass/fail criteria of any component of a test, the Test House should prominently label the instrument as failed and make some indication of the nature of the failure on the certificate or test report. Where an instrument may be used by workers for self monitoring e.g. Exit Monitor, it is especially important that the Test House indicates to both the Employer and the user that the instrument is not fit for use.

8 Quantities and Units

Throughout this document the term ‘dose’ has been used as a general term to refer to the ICRU operational quantity ambient dose equivalent. The definition of this quantity is described in detail in GPG14[3] and ICRU 47[10].

For gamma monitors designed to indicate dose rate, the instrument response is the instrument reading divided by the true ambient dose equivalent rate.

For contamination monitors, the traceable quantity is the surface emission rate of the reference source used to calibrate the instrument response for a particular radionuclide. Instrument calibration certificates often quote the instrument response in terms of the number of source emissions but may also quote the response in terms of the activity of contamination. To convert the instrument response from emissions (cps per emission per cm^2) to activity (cps per Bq per cm^2), a P-factor must be applied (see Section 4.9.3 of GPG14).

9 Definitions

Employer	The person or establishment who is legally responsible for the maintenance of the equipment.
Qualified Person (QP)	A person who possesses the necessary expertise in instrumentation, theory and practice appropriate to the instrumentation to be tested. This person may have responsibility for developing test protocols, taking account of the intended use of the instrumentation, as stated by the Employer.
Priming Source	A radioactive source, which is incorporated into the instrument and is in close proximity to the detector. The instrument measuring assembly will receive a constant signal from the detector, which is above a typical background signal. When the pulse rate from the detector drops below a predefined level, this will initiate a low level fail alarm.
Low Level Alarm	An alarm that is activated when the pulse rate, or current from the detector falls below a certain level. Typically this alarm will be activated by a failure of the detector or by damage to the cabling between the detector and the processing unit of the instrument.
Test House	This indicates the organisation undertaking the testing of the instrument. This may include: an independent calibration laboratory; a contract company who undertake the instrument testing in the workplace; or a department under direct management control of the Employer who undertakes testing in the laboratory or in the workplace. Ideally the Test House should hold UKAS accreditation for all the testing that it undertakes.

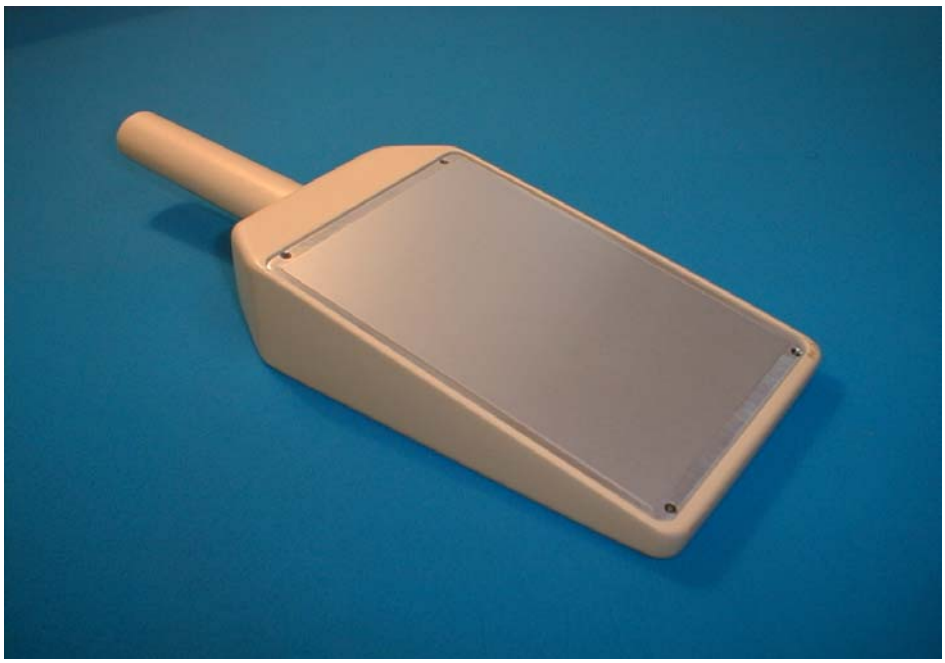

Figure 1 Hand Contamination Monitor Calibration Jig

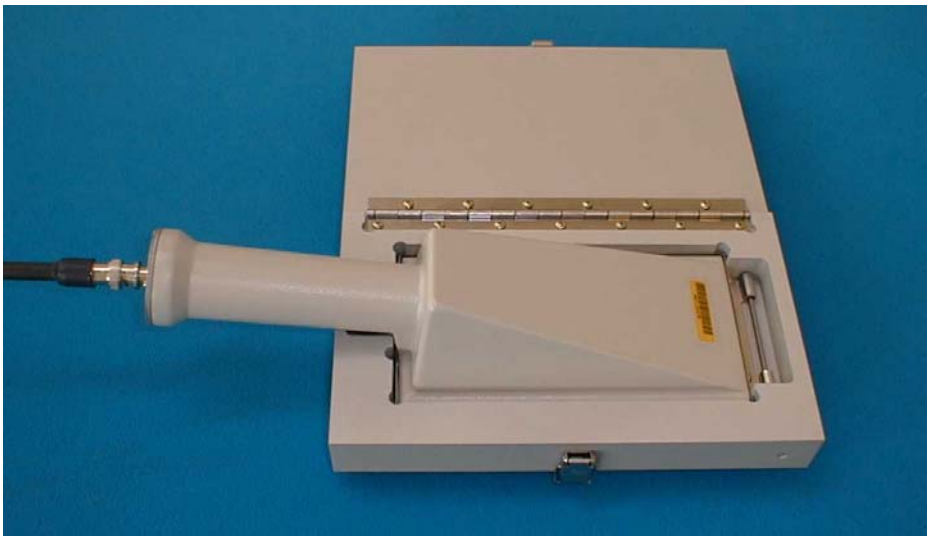

Figure 2 Frisking Contamination Monitor Calibration Jig

Photograph of Isotrack™ source reproduced with permission of AEA Technology plc.

Figure 3 Exit Contamination Monitor Calibration Jig (Ladder)

Appendix A Setting of Alarms on Contamination Monitors

A1 General

The setting of the alarm threshold on a contamination monitor is the responsibility of the Employer, in consultation with the RPA. This appendix describes a method, which may be used to set the alarm thresholds. However, simply following this method does not guarantee that the monitor will alarm when the Employer's activity action levels are exceeded, due to many other factors including attenuation of the radiations by clothing and air.

ICRP 75[11] suggests that contamination may be averaged over 100 cm^2 of clothing or skin and over 300 cm^2 for the hands and feet, when deciding whether contamination levels exceed those allowed outside a controlled area. The employer may choose to consider these suggested areas when deciding on the active area of check sources, and the associated alarm thresholds.

The issues associated with setting alarm thresholds are different for each type of contamination equipment. In the case of Exit Monitors, the hand and foot detector alarm thresholds may be set in a similar fashion to those on a Hand and Foot Monitor, whereas there are different considerations for the clothing detectors.

A2 Hand and Foot Detectors

These detectors are found in both Hand and Foot Monitors and Exit Monitors. Typically they are set to monitor for both alpha and beta/photon radiation. Common action levels for surface contamination are 4 Bq cm^{-2} for beta contamination and 0.4 Bq cm^{-2} for alpha contamination. Some organisations may have a higher action level for low energy beta and pure photon emitters e.g. ^{14}C and ^{55}Fe. The surface to be monitored will be in contact with the grille of the detector. A suitable source has an active area of 150 cm^2; the check radionuclide should be one of those listed in Appendix D.

Assuming the action levels above, the alarm threshold for the beta detector should be set to alarm at a count rate equivalent to 600 Bq; for the hand detector this equates to 1200 Bq on both sides of the hand i.e. 300 cm^2. As suggested in Section 5.3, a source of activity greater than 900 Bq (50% greater than the alarm threshold) may be used for both the Alarm Check and the Response to Contamination Test. The count rate at which to set the alarm threshold should be derived from the detector efficiency.

A3 Clothing Detectors on an Exit Monitor

The surface that the clothing detector monitors is unlikely to be in contact with the detector. IEC 61098[5] gives a method for evaluating the body average efficiency for an array of clothing detectors, which takes account of the variation in sensitivity in both the horizontal and vertical planes. The manufacturer should provide the relationship between the contact 4π efficiency and the 4π body average efficiency. For a typical Exit monitor which uses gas flow proportional detectors, for a high energy beta emitting source, the ratio between the contact efficiency, and the body average efficiency of the array of detectors is at least a factor of two. Therefore, in the absence of manufacturers' data, when deriving the count rate alarm threshold for clothing detectors, the Employer should divide the contact detector efficiency by a factor of at least two to take account of the geometry effects. The efficiency of the body detectors is likely to vary, even though many of them are identical in design. When calculating the body average efficiency, the contact efficiency should be assumed to be the efficiency of the lowest efficiency detector. For lower energy beta emitters, the geometry effects will be more significant.

A power station has undertaken some practical tests[12] on a modern Exit monitor with clothing samples spiked with ^{60}Co contamination. These tests have shown that even when alarm levels on clothing detectors are set to the Minimum Detectable Activity level, there is a risk that contamination levels at slightly in excess of the action level i.e. 4 Bq cm^{-2}, on certain parts of the body with a poor geometry i.e. the knees, will not trigger an alarm.

The relationship between contact detector efficiency for the nuclide of interest and body average efficiency should be evaluated during Type Testing, or if necessary, during the Test Before First Use. Although some clothing detectors are able to monitor for alpha contamination, extreme caution should be advised since an Exit Monitor is poorly suited to monitoring for alpha activity on the body.

A4 Frisking Probes

The geometry of the surface to be monitored is both uncertain and user dependent, since it requires some knowledge of the speed of frisking and the distance between the active surface and the probe. The Probe will typically undergo its Response to Contamination Test in a jig provided by the manufacturer, where the source to probe spacing is typically between 3 mm and 10 mm. The derived efficiency should be

divided by a factor of two when deriving the alarm threshold, in order to take account of the variations in geometry.

Appendix B Workplace Testing of a Gamma Monitor

The radiation tests on a gamma monitor will require the use of a test jig. This is especially true for the high dose rate test. A test jig will have the dual benefit of providing a reproducible geometry for the tests and minimising the doses to the Test House operator. Where the Employer owns more than one gamma monitor of the same type, he should consider the design or purchase a test jig.

In some situations, it may be impractical to manufacture a test jig. For example where the accessibility of the monitor is poor, or where the monitor is of an unusual one-off design. In such situations, the Test House may choose to use a hand held source, normally incorporated into a rod. The Employer and the Test House should ensure that the doses to the operator are as low as reasonably practicable (ALARP), especially where the activity of the test sources is in excess of the equivalent of 1 MBq of ^{137}Cs.

For the high dose rate test, a dose rate indication of the order of 10 mSv h^{-1} is required. This dose rate would be achieved by a projector style exposure unit, containing a source of at least 10 MBq of ^{137}Cs, which is available from a number of manufacturers. This unit has the additional benefits of clearly showing when the source is exposed, and will include some radiation interlocks. A typical unit will be portable with a mass of approximately 10 kg.

Where a high dose rate is not required, a lightweight unit incorporating a less penetrating radionuclide source should suffice. Such a unit would utilise the 60 keV photon emissions from an ^{241}Am source. A source with an activity less than 1 GBq should provide dose rates up to 1 mSv h^{-1} to the detector. The test radionuclide is especially useful for uncompensated GM detectors where the response of the detector to 60 keV photons is considerably greater than that of a compensated detector. Due to the low penetration of 60 keV photons, the unit will require a minimum of shielding and should therefore be hand held with a mass of the order of 0.5 kg. However the Employer and the Test House should ensure that the gamma monitor detectors have a reasonable response to low energy photons, before utilising such a device. Stainless steel housed detectors may have a poor response to such a test jig.

Appendix C Directional Dependence Testing of a Gamma Monitor

Gamma monitors typically utilise Geiger-Muller (GM) detectors, ionisation chambers or, increasingly, silicon diode detectors. Conventional energy compensated steel walled GMs and most ionisation chamber detectors have good and predictable responses at ±90° to the calibration (reference) orientation for ^{241}Am gamma radiation. Therefore it is appropriate to test these detectors at ±90 ° (Fig. 4).

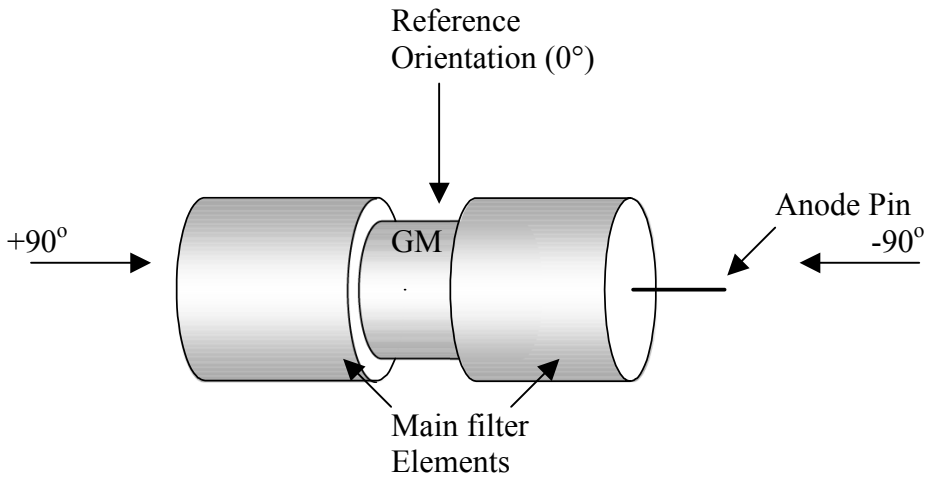

Figure 4 Typical Steel Walled Energy Compensated GM Detector

However, other detectors often do not: these include energy compensated thin end window pancake GM detectors; cylindrical ionisation chambers with steel walls; detectors with a high atomic number gas filling and a high length to diameter ratio; and most silicon diode detectors. In these cases, where the response at ±90° is often close to zero, the directional dependence should be tested at the largest convenient angle for which the detector is intended to produce a response within a factor of two of the response in the calibration orientation. Typically, for these detectors, it is appropriate to test at ±60° to the calibration direction (Fig. 5).

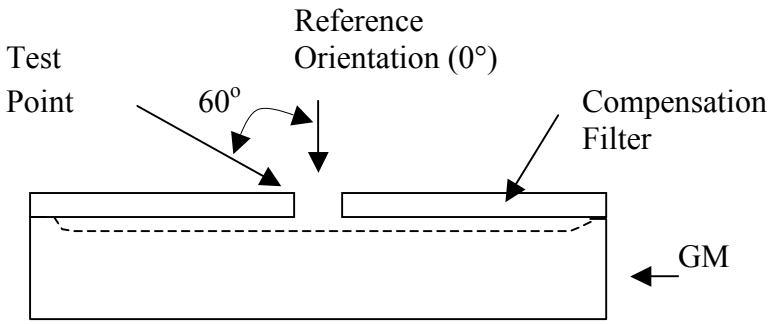

Figure 5 Pancake GM Detector

Appendix D Check Radionuclides for Contamination Monitors in Different Workplaces

Installed instrumentation may be found in a wide variety of industrial workplaces including hospitals, universities and nuclear power stations. Although the same model of instrument might be installed in each workplace, it may be required to measure very different types of radioactive contamination. The nuclides likely to be encountered in each workplace should be considered. Test nuclides should be chosen with energies at, or below the minimum energy of importance in the work place. For alpha contamination ^{241}Am is the recommended nuclide for such tests. However, during Tests Before First Use and Type Tests, it is important that the instrument has a good response to alpha radiation with energies significantly lower than the energy of alpha radiation from an ^{241}Am test source. The Table 4 below gives examples of nuclides which are suitable for Periodic and Routine Tests in different workplaces.

Workplace	Radiation Emission		
	Alpha	Beta	Photon
Nuclear Power Station: Magnox	^{241}Am	^{36}Cl, ^{14}C	N/A
Nuclear Power Station: AGR, PWR	^{241}Am	^{36}Cl, ^{14}C	^{55}Fe
Reprocessing Plant	^{241}Am	^{36}Cl, ^{14}C	N/A
Hospital	N/A	^{99}Tc	^{129}I
University	^{241}Am	^{36}Cl, ^{14}C	^{55}Fe, ^{129}I

Table 4 List of Suitable Check Radionuclides

References

1. The Ionising Radiations Regulations, 1999, HMSO, 1999.

2. Work with ionising radiation, approved code of practice, Ionising Radiation Regulations 1999, HMSO, 1999.

3. National Physical Laboratory, Measurement Good Practice Guide No.14, *The examination, testing and calibration of portable radiation protection instruments*, NPL, 1999.

4. International Atomic Energy Agency, *Calibration of Radiation Protection Monitoring Instruments*, Safety Series No. 16, IAEA, 2000.

5. International Electrotechnical Commision, *Radiation protection instrumentation - Installed Dose Ratemeters, Warning Assemblies and Monitors for X and Gamma Radiation of Energy between 50 keV and 7 MeV, Second Edition*, BS IEC 60532, 1992.

6. International Electrotechnical Commision, *Installed Personnel Surface Contamination Monitoring Assemblies for Alpha and Beta Emitters*, IEC 61098, 1992.

7. International Electrotechnical Commision, *Radiation protection instrumentation - Installed Personnel Surface Contamination Monitoring Assemblies - Low Energy X and Gamma Emitters*, IEC 61137, 1992

8. International Electrotechnical Commision, *Alpha, Beta and Alpha-Beta Contamination Meters and Monitors*, IEC 60325, 1981.

9. International Organisation for Standardisation, *X and Gamma Reference Radiations for Calibrating Dosemeters and Doserate meters and for Determining their Response as a Function of Photon Energy: Part 1: Radiation Characteristics and Production Methods*, BS ISO 4037-1, 1996.

10. International Commission on Radiological Units and Measurements, *Measurements of Dose Equivalents from External Photon and Electron Radiations*, ICRU Report 47,1992.

11. International Commission on Radiological Protection, *General Principles for the Radiation Protection of Workers*, ICRP Report 75, 1997.

12. Lunn and Renn, *Practical limitations of monitoring personal contamination at a PWR*, BNES, 2001.

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