Selection, use and maintenance of portable monitoring instruments

Ionising Radiation Protection Series No 7

Introduction

The Ionising Radiations Regulations 1999 (IRR99)[1] require employers to ensure that levels of ionising radiation in controlled or supervised areas are adequately monitored (regulation 19). This is to:

- determine levels of radiation and contamination so that appropriate control measures can be implemented;
- provide a safeguard against breakdowns in controls or systems;
- detect changes in radiation or contamination levels; and
- check that areas have been (and remain) correctly designated.

This information sheet does not contain all of the requirements of IRR99 as these (and further guidance) can be obtained in *Work with ionising radiation*,[2] the Approved Code of Practice and guidance supporting the Regulations (see particularly paragraphs 339-366). Employers must ensure that a suitable monitoring instrument is used and should always consult a radiation protection adviser (RPA) on the type and extent of the necessary monitoring programme and the choice of monitoring instrument.

Selecting instruments can be confusing and will depend on the nature and quality of the radiation and the physical and chemical state of any radioactive contamination. Some working environments demand a particularly robust instrument. Tables 1 to 3 are based on an NRPB report[3] and provide guidance on suitable monitoring instruments for different radiation sources and workplace applications.

Care and general maintenance

IRR99 requires equipment to be properly maintained so that it remains suitable for the purpose for which it was intended. 'Maintained' is defined as 'maintained in an efficient state, in efficient working order and good repair'. All instruments have strengths and weaknesses and require reasonable care in use. Users should:

- keep the instrument clean; repair minor damage (loose screws, missing feet) as soon as possible; where appropriate keep the instrument in a well-fitting case.
- regularly check switches, screw connections, cables, detector foils and heads. Probes and their connecting cables are fragile and require careful handling. A faulty connector or damaged cable often causes an intermittent high response. A small hole in a detector foil on the front window of a scintillation detector could result in no reading (detector swamped) or a very high reading. Damage and/or dirt build up greatly affects detection of low energy beta/alpha particles.
- check battery terminals and ensure adequate power to prevent false readings. Check contacts for wear and corrosion; check that connectors produce good contact; check for damage to connector wires. Remove batteries if not being used for some time.
- avoid temperature extremes/rapid changes. Condensation can produce electronic failure, and ion chambers are particularly susceptible.
- protect from working environment; contamination of end window often causes unexpected high background on a contamination monitor.
- not make adjustments to instruments unless suitably trained and qualified.

Remember to consult a radiation protection adviser on all aspects of care, maintenance and testing of monitoring instruments.

Employers must ensure that significant faults are repaired or that faulty equipment is replaced with a suitable and tested alternative. Where the nature of the repair could affect the performance and calibration of the instrument, employers should ensure that the instrument is re-tested after repair.

Before each use, check battery function, background radiation and contamination, and functionality of the instrument. Suitable checks include:

- zero setting;
- looking for visible signs of damage;
- testing the instrument's response to a check source.

Checks should be repeated after monitoring or surveying an area.

Use and maintenance of an instrument should always be in accordance with the manufacturer's instructions.

If an instrument indicates an unexpectedly high dose rate, believe it and leave the area as soon as possible. Do not assume that it is an instrument failure. (Only once away from the high dose rate area should the instrument functionality be assessed.)

Table 1 γ, x, β dose rate

KEY: (A) Generally the best type for the circumstance (B) Satisfactory (C) Satisfactory in some circumstances but not in others

Circumstance	GM detectors				Ion chambers		Proportional Counter	Scintillation detectors				See Notes
	Steel wall energy compensated	Thin window energy compensated	Thin end window (uncompen -sated)	Large energy compensated connected to a scaler and timer	Conventional chamber	High pressure chamber	Energy compensated connected to a scaler + timer	Dose rate monitors (marked in $\mu Sv\ h^{-1}$)	Large plastic scintillators (marked in counts s^{-1})	Large sodium iodide detectors	Thin window sodium iodide detectors	
Radiography using energetic gamma emitters	A	B	-	-	B	-	-	B	-	-	-	
Radiography using very high energy x-rays (> 1 MeV)	B	B	-	-	A	-	-	B	-	-	-	1
Radiography using lower voltage x-rays	C	A	-	-	B	-	-	B	-	-	-	2
Flash x-rays	-	-	-	-	A	-	-	-	-	-	-	3
Industrial sterilisation units	A	B	-	-	C	-	-	B	-	-	-	4
Transport of large gamma emitting sources	A	B	-	-	B	-	-	B	-	-	-	
Level gauging using gamma sources	A	B	-	-	B	-	-	B	-	-	-	
Crystallography x-ray equipment	-	A	B	-	C	-	-	-	-	-	C	5
Finding lost gamma sources	-	-	-	-	-	-	-	-	A	A	-	6
Adventitious x-ray generators (finding leaks) (monitoring leaks)	- -	- A	B C	- -	- B	- -	- -	- B	- -	- -	A -	7
X, γ dose rates from radiopharmaceuticals etc	-	A	-	-	B	-	-	B	-	-	-	
Thickness gauging using low energy x-ray tubes or low energy x, γ sources	-	-	A	-	B	-	-	-	-	-	-	8
Environmental γ dose rates	-	-	-	A	-	B	B	B	-	-	-	
Beta thickness gauges	-	-	A	-	B	-	-	-	-	-	-	9

Table 2 Neutron dose equivalent rates

Note: All neutron monitors will give an indication in very high intensity x-ray fields from linac medical therapy machines unless provided with an inhibition facility.

Type	**Good points**	**Bad points**
Spherical BF_3 detector	Reasonably light. Good γ rejection	Poor energy response
Spherical ^3He detector	Reasonably light	Poor energy response. Reduced γ rejection
Spherical LiI (Eu) scintillator	Reasonably light	Poor energy response. Poor γ rejection
Cylindrical BF_3 detector	Good energy response. Good γ rejection	Heavy

Table 3 Contamination

KEY: (A) Generally the best type for the circumstance (B) Satisfactory (C) Satisfactory in some circumstances but not in others

Radiation	GM		Proportional		Scintillation					Solid state alpha	See Notes
	Mica window	Thin steel or glass	Thin window refillable	Sealed xenon filled	Zinc sulphide	Dual phosphor	Organic scintillator	Plastic scintillator	Thin windowed thin sodium iodide	Large area thin windowed	
Alpha	-	-	B	-	A	A	-	-	-	B	10
Beta (E_{max} > 0.5 MeV)	B	B	A	A	-	B	A	B	-	-	11
Beta (E_{max} = 0.16 MeV)	B	-	A	A	-	-	A	-	-	-	-
X, γ (5 keV – 140 keV)	-	-	-	A	-	-	-	-	A	-	-
Mixed alpha and Beta (E_{max} > 0.5 MeV)	-	-	B	-	-	A	-	-	-	-	-
Mixed alpha and beta (E_{max} = 0.16 MeV)	-	-	A	-	-	-	-	-	-	-	-
Mixed beta (E_{max} > 0.17 MeV) and x, γ (5 keV - 140 keV)	-	-	-	A	-	-	-	-	-	-	-

Note that positron emitters can be treated as beta emitters of the same energy.

Notes to tables

1 Some techniques use high voltage X-rays generated using betatrons or other pulsed sources. These can cause problems with pulse-counting detectors. A pulse-counting detector, such as a Geiger Müller (GM) tube, can be used up to the point that the count rate per second rises to about 30% of the pulse repetition rate of the generator in Hz. At higher count rates, an instrument will increasingly under-read. Ultimately, the instrument will detect each generator pulse. At this point, the instrument may be indicating a dose rate which is a tiny fraction of the true dose rate. So before using a pulse-counting detector with these kind of generators, the user needs to know the pulse repetition frequency of the generator, N, and the sensitivity of the detector in (counts s^{-1}) / (µSv h^{-1}), A. The maximum credible indicated dose rate is then 0.3 N/A.
GM detectors also have a response which rises with energy above 1MeV which tends to produce the opposite effect of an over-response with high energy machines.

2 Steel-walled energy-compensated GM detectors should only be used where the potential of the X-ray set exceeds 150 kV if exposure to the direct, unshielded beam or to scattered radiation is possible. If only transmission through intact shielding is anticipated, they may be used down to 50 kV.

3 X-rays from short pulse X-ray equipment, particularly battery-powered security equipment, can only be measured using an ionisation chamber instrument in the dose mode. It is not possible to make measurements in the dose rate mode.

4 It is essential that any instrument chosen for use with industrial sterilisation units has a proven capacity to continue to give its overload indication up to the maximum dose rate the instrument could encounter, taking account of possible interlock failures etc.

5 Leakage radiation from crystallography X-ray equipment is generally dominated by K X-rays from the target and is less influenced by the tube potential than other X-ray techniques. It is important that the monitor chosen has a known and good response to those energies. The radiation also tends to be in narrow beams, which means that large area detectors, such as most ion chambers, underestimate the dose rate in the beam.

6 Plastic scintillators are less efficient per unit area but are less expensive and tougher. Sodium iodide based scintillators can be found as hand-held multi-channel analyser (MCA) units which offer isotope identification. Both are also useful for finding gamma-contaminated areas.

7 The sodium iodide detectors may be too sensitive and may show full scale deflection, reducing their ability to find the leak.

8 Access tends to be poor, which can make ion chamber instruments difficult to use, and the beam can be narrow. These problems favour the end window GM. However, when using a GM, estimation of the true directional dose equivalent rate requires some knowledge of the radiation spectrum.

9 These devices produce a complicated mixture of X and beta radiation. Access tends to be poor, which can make ion chamber instruments difficult to use, and the beam can be narrow. These problems favour the end window GM. The normal approach is to assume the Cs-137 gamma response is appropriate, which will normally produce either a small underestimate or an acceptable overestimate.

10 The solid-state alpha detectors tend to be more susceptible to electrical interference.

11 The xenon-filled counters tend to have a higher background count rate, particularly where there are low energy gamma emitters present.

References

1 *Ionising Radiations Regulations 1999* SI 1999/3232 The Stationery Office 1999 ISBN 0 11085614 7

2 *Work with ionising radiation. Ionising Radiations Regulations 1999. Approved Code of Practice and guidance* L121 HSE Books 2000 ISBN 0 7176 1746 7

3 *Guidance on the choice, use and maintenance of hand-held radiation monitoring equipment* R326 National Radiological Protection Board 2001 ISBN 0 85951 461 7

Available from: Information Office, NRPB, Chilton, Didcot, Oxon, OX11 0RQ, telephone 01235 822742, fax 01235 822746, e-mail information@nrpb.org.uk; or can be downloaded from their website at www.nrpb.org.uk

Further information

Safe use of work equipment. Provision and Use of Work Equipment Regulations 1998. Approved Code of Practice and guidance L22 (Second edition) HSE Books 1998 ISBN 0 7176 1626 6

Recommendations for the presentation of type test data for radiation protection instruments in hospitals IPSM Report No 69 Institute of Physics and Engineering in Medicine 1994 ISBN 0904 181 70 7

National Physical Laboratory *The examination, testing and calibration of portable radiation protection instruments.* Good practice guide No 14 NPL 1999 ISSN 1368 6550

Available from the National Physical Laboratory, Teddington, Middlesex TW11 OLW.

While every effort has been made to ensure the accuracy of the references listed in this publication, their future availability cannot be guaranteed.

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA Tel: 01787 881165 Fax: 01787 313995 Website: www.hsebooks.co.uk (HSE priced publications are also available from bookshops.)

For information about health and safety ring HSE's InfoLine Tel: 08701 545500 Fax: 02920 859260 e-mail: hseinformationservices@natbrit.com or write to HSE Information Services, Caerphilly Business Park, Caerphilly CF83 3GG. You can also visit HSE's website: www.hse.gov.uk

This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

Printed and published by the Health and Safety Executive 11/01 IRIS7 C100