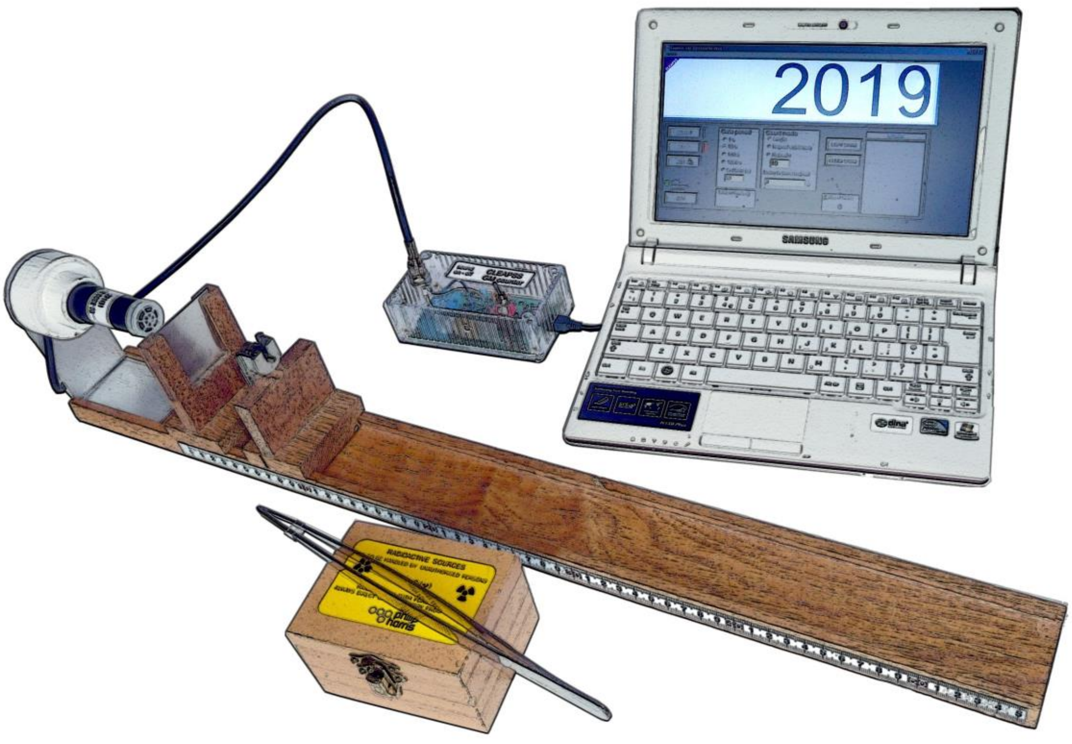
CLEAPSS

L93 Managing Ionising Radiations and Radioactive Substances in Schools and Colleges

November 2019 (with minor revisions September 2022. See the next page)

Managing Ionising Radiations and Radioactive Substances in Schools and Colleges. L93 2019



CLEAPSS publications are normally strictly confidential, with circulation restricted to members and associate members only. However, this revised edition is made publicly available to promote teaching practical radioactivity in schools, and in a well-managed way.

This guide updates the 2018 edition. As with previous editions, it is written primarily for schools and colleges in England, Wales and Northern Ireland. The good practice it sets out is also relevant to the Isle of Man, Jersey and Guernsey schools, although disposal arrangements are different.

Scottish schools should refer to the guidance from SSERC.

This guide L93 is revised periodically to keep up-to-date with legislation and with improvements in radiological protection. Make sure you have the latest version, available from the CLEAPSS website.

L93 is written so that if schools follow the advice, they will meet the regulations on acquiring, managing and finally disposing of radioactive sources used in science teaching. Where employers have adopted L93 as their guidance for employees, school staff must adhere to this guidance. If this causes problems, schools can contact CLEAPSS in the first instance to help resolve the problem.

Acknowledgements:

CLEAPSS is grateful for the help of about a dozen Radiation Protection Advisers, the staff of various government departments and enforcement agencies and others who worked with us on this and previous editions, to make what we believe to be well-reasoned judgements in areas where there are differences of opinion between professionals working in radiation protection and science education. We hope this publication will help everyone involved to ensure that practical teaching about radioactivity continues to be carried out legally and safely.

In England the Department for Education (DfE) advises that:

"Schools and colleges may want to refer to the updated L93 guidance *Managing Ionising Radiations and Radioactive Substances in Schools and Colleges* produced by CLEAPSS. This document offers advice and guidance to schools and colleges to support practical work involving radioactive substances. The Department for Education is particularly grateful to CLEAPSS for making this important and helpful guidance available to all schools and colleges."

The front cover image was based on a photograph of a set-up featuring some equipment made at CLEAPSS. The counter unit connected to the laptop can be made following GL118. The GM tube holder was 3D printed, and information and code for 3D printed versions of the source holder, absorber holder and bench is available from CLEAPSS in guide GL296.

2022 Revision. This relates to the legal requirement that employers must document that adequate information has been given to other persons who are directly concerned with the work with the sources. 'Other persons' is taken to include school students. See page 23, 6.2.1, page 26 rows 14 and 17, and page 91, Use log.

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Abbreviations

ALARP	As low as reasonably practicable
DfE	Department for Education (England)
GM tube	Geiger-Müller tube
EPR	Environmental Permitting Regulations
HSE	Health and Safety Executive
HSENI	Health and Safety Executive for Northern Ireland
ICRP	International Commission on Radiological Protection
NIEA	Northern Ireland Environment Agency
NRW	Natural Resources Wales
PHE	Public Health England
RPA	Radiation Protection Adviser
RPO	Radiation Protection Officer
RPS (Schools)	Radiation Protection Supervisor (Schools)
RWA	Radioactive Waste Adviser
SEPA	Scottish Environment Protection Agency

1 Introduction

1.1 About this guide

This guide is designed to support practical work involving radioactive substances in secondary-level schools. It explains how to handle, use and store them safely and securely. The advice aims to define good practice in the use of radioactive substances in secondary education.

If you follow this guide, then keeping and working with radioactive substances in school science is very safe.

After in introduction, the guide is divided into four parts:

Part A: Arrangements for keeping radioactive sources. This explains about initially setting up the arrangements for using radioactive substances for practical work in the school or college, and periodically reviewing that the arrangements meet the legal requirements. This part is for subject leaders and for the person in the science department who is responsible for these arrangements – usually called the Radiation Protection Supervisor (Schools), abbreviated to RPS (Schools).

Part B: Using radioactive sources. This gives practical guidance for teachers and technicians who use or handle radioactive sources. It tells you what you need to know and do when carrying out practical work with ionising radiations, including model Standard Operating Procedures, which you can adapt for use in your school or college, and the precautions for working with specific kinds of radioactive sources.

Part C: Further Guidance. This is written for the person in the school or college who is responsible for the radioactive sources – the RPS (Schools). It gives the additional information the RPS (Schools) needs to know on keeping, working with and disposing of sources, including reference material and information for dealing with various incidents, disposing of, and transporting sources.

Part D: Templates. Forms, checklists, etc that you may copy and adapt.

1.1.1 Employers

The guide also provides a reference for employers, setting out good practice in school science. Where employers have adopted this as their standard of good practice they should make it clear to employees that they are expected to adhere to this guidance.

1.2 Teaching about ionising radiations

Radioactive substances are essential tools in many areas of scientific research. Ionising radiations are used widely in medicine, food processing, imaging, tracing chemical reactions, archaeological investigations, fire protection, electricity generation, the pharmaceutical industry and industrial processes including paper and steel making.

Everyone is exposed to background radiation of varying levels, depending on where they live and what they do. Ionising radiations are not detectable by the senses and, partly for this reason, they either tend to be feared to an irrational degree or just ignored. Teaching about ionising radiations helps people to develop balanced attitudes to the subject, neither blasé nor apprehensive. For many students, studying ionising radiations at school may be their only opportunity to achieve this.

The various national curricula for science include work on atoms and radioactivity, so everyone who teaches science to this level should know how to handle radioactive substances and perform demonstrations. Beyond GCSE, the study of ionising radiations forms an important part of many science courses, in which responsible students can safely carry out investigations themselves under careful supervision. Practical work in this subject provides a unique opportunity to carry out meaningful investigations at the atomic level. A wide range of support materials for teaching about ionising radiations is readily available, many free of charge.

1.2.1 Radiological protection

Radiological protection is currently founded on the assumption that any ionising radiation, no matter how low the dose level, has the potential to cause harm.

There are three key principles of radiological protection:

- Justification: showing that the benefits will outweigh any detriment that the radiation might cause.
- Optimisation: keeping all exposures as low as reasonably practicable (ALARP).
- Dose limitation: keeping the doses for workers below specified limits.

These principles come from the ICRP[1] and apply to the potential for accidental exposures as well as predicted exposures. In education, we try to design activities with ionising radiation to achieve the learning objectives while keeping the exposures of students and staff as low as reasonably practicable, and certainly well below legal dose limits. Working with the sources correctly, a teacher could carry out hundreds of demonstrations in a year before acquiring a dose as high as that from annual exposure to a typical background level. The doses students receive when observing demonstrations would be lower still.

1.3 Further help and guidance

If you are unclear about your work with radioactive sources, you can contact the CLEAPSS *Helpline* (as long as your school or college is a member – see http://science.cleapss.org.uk). You may also be able to contact your employer's Radiation Protection Adviser (RPA) for advice (or, in many local authorities, the initial contact may be the Radiation Protection Officer). However, the RPA's legal role is to advise the employer on compliance with the Ionising Radiations Regulations and help employers maintain good standards of radiological protection, not to provide a general radiological helpline to employees.

1.3.1 Other related CLEAPSS documents

We publish other supporting guidance for teaching radioactivity and on equipment. CLEAPSS members can download these documents from our website. There are too many to list here, but the ones particularly relevant to L93 are in the next table.

Documents mentioned in L93	Notes
PS46A *Radiation Protection in School Science: Guidance for Employers – Information for local authorities* **PS46B *Radiation Protection in School Science: Guidance for Employers – Information for independent schools & colleges (including foundation & voluntary-aided schools & academies)***	These discuss options for Radiation Protection Adviser services.

[1] International Commission on Radiological Protection, publication 103: ISBN 978-0-7020-3048-2.

PS75 ***Should the RPS be a teacher or a technician?***	Explains why the RPS (Schools) should be a teacher.
PS78 ***Radioactive Sources for School Use***	This lists radioactive sources that CLEAPSS has concluded conform to specification L256.
PS13 ***Pregnant, new & breastfeeding mothers and school science***	Advice on the minimal risks to pregnant women posed by practical school science.
L256 ***Specification of Radioactive Sources for School Use***	A specification written at the request of the DCSF (now DfE) intended for manufacturers, suppliers and employers.
GL138 ***Choosing a Geiger-Muller tube and a counter or ratemeter***	Discusses equipment suitable for schools.
GL220 ***Disposal of Waste Sealed Sources***	Guidance on grout/bin disposal route.
GL221 ***Restoration or disposal of a lead-pot box for radioactive sources***	Guidance on repairing (or disposing of) the lead pot, wooden box, hasps and hinges.
GL258: Guidance for school employers undertaking registration of the use of school-science radioactive teaching sources	Explains the registration process.
GL314: Make-it guide. Standard test source for checking a GM counting system	Guide on how to make your own test source when leak-testing

2 The legal background

There are four distinct areas of regulation that govern most of the acquisition, use and disposal of the radioactive substances used in school science. These sets relate to:

1 Using ionising radiations safely.
2 Environmental protection.
3 Transporting radioactive substances safely and securely.
4 Government control in the education sector.

	Regulations	Notes
Set 1	**Using ionising radiations safely** The Ionising Radiations Regulations 2017 – which relate to England, Scotland and Wales The Ionising Radiations (Northern Ireland) Regulations 2017	These specify how employers must ensure the safety of their employees who work with ionising radiations (and others affected by their work). Schools are not exempt and if the practical work comes within the scope of these regulations, you must follow them. The Health and Safety Executive (HSE), and the Health and Safety Executive for Northern Ireland (HSENI) are the enforcement agencies.
Set 2	**Environmental protection** The Environmental Permitting (England and Wales) Regulations 2010, as amended The Radioactive Substances Act 1993 as amended, in Northern Ireland The Radioactive Substances Exemption (Northern Ireland) Order 2011	These regulate the acquisition, security and disposal of radioactive substances. The enforcement agencies for these laws are the Environment Agency (EA) for England, Natural Resources Wales (NRW) for Wales, the Scottish Environment Protection Agency (SEPA) for Scotland and the Northern Ireland Environment Agency (NIEA) for Northern Ireland.
Set 3	**Transport regulations** The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG)	You will not often need to transport the radioactive material. These regulations affect suppliers of sources, and contractors undertaking your waste disposal. The enforcement agency is the Office for Nuclear Regulation. There is a conditional authorisation

	The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (Northern Ireland) 2010 CDG 2009 Authorisation No. 500 rev 1 CDG 2010 Authorisation NIEA/1	that exempts some low-level waste for transport in normal refuse.
Set 4	**Government control of education** The Education (Hazardous Equipment and Materials) (England) Regulations 2004	These regulations require some colleges to get approval from the DfES before using radioactive sources. These apply only in England and are a remnant of incomplete revocation of regulations.

You are not expected to obtain and study this legislation. CLEAPSS has done this, obtained advice from radiation protection professionals and enforcement agencies, and incorporated it into this guidance in plain English. We explain what you need to do to meet the requirements of the laws that cover health and safety, environmental protection, transport and security.

2.1 Schools and colleges in Northern Ireland

In this guide, if a reference is made to the Ionising Radiations Regulations 2017 – which relate to England, Scotland and Wales – the equivalent in Northern Ireland are the Ionising Radiations (Northern Ireland) Regulations 2017. Similarly, if this guide refers to the Environmental Permitting (England and Wales) Regulations 2010 as amended, the equivalent in Northern Ireland is the Radioactive Substances Act 1993 as amended and the Radioactive Substances Exemption (NI) Order 2011. But the legislation is essentially the same.

The term 'permit' is used in England and Wales for the environmental regulator's permission to acquire and dispose of radioactive material. In Northern Ireland, the equivalent terms are 'registration' for permission to acquire radioactive material, and 'authorisation' for permission to dispose of it.

Any reference to the environmental regulator in this guide should be taken as Northern Ireland Environment Agency (NIEA) and any reference to the health and safety regulator should be taken as the Health and Safety Executive for Northern Ireland (HSENI)

2.2 Schools and colleges in Wales

The environmental regulator for Wales is Natural Resources Wales (NRW). Any reference to the environmental regulator in this guide should be taken as Natural Resources Wales.

2.3 Schools and colleges in Scotland

Schools and colleges in Scotland should refer to the SSERC guidance. The environmental regulator for Scotland is the Scottish Environment Protection Agency (SEPA)

Part A: Arrangements for keeping radioactive sources

This part covers setting up the arrangements for the first time, acquiring new or replacement sources, and reviewing the school's arrangements. It is written for subject leaders or others to whom these tasks have been delegated.

You will also need to review and change your arrangements when moving buildings, or when buildings are being refurbished.

3 Making the arrangements: the steps you need to follow

This section explains all the arrangements you need to make, step by step, to help you meet the various legal requirements for acquiring and keeping any sources of ionising radiation. It would also be sensible to use these steps to review your arrangements periodically, or if your school changes its status (eg changes from a local authority school to an academy), or if you are planning to move to a new building, or your buildings are being refurbished.

	Action	See section
Step 1	Make sure you have a good educational justification for acquiring the source(s).	3.1
Step 2	Decide who will be responsible for managing the radioactive source(s) and arrange training if needed.	3.2
Step 3	Check that the sources are suitable for school science use. (These are sources limited to those marked in a green border in section 6. Having to dispose of unsuitable sources, or obtain a permit, is expensive.)	3.3
Step 4	Obtain permission from your employer.	3.5.1
Step 5	The employer consults and appoints a Radiation Protection Adviser (RPA) if necessary.	3.4
Step 6	Obtain advice from your RPA on the source(s) you intend to acquire.	3.3 & 7.2
Step 7	Obtain government department approval. This applies to only VI and FE colleges in England (and schools in Scotland). You can assume approval in England if you stay within the standard school holding.	3.5.3
Step 8	Check that you have suitable monitoring equipment, easily available, and in working condition.	3.7
Step 9	Plan appropriate storage for the source(s) (including temporary storage during moves or building refurbishment).	4
Step 10	The employer obtains a registration from the HSE to store/use sources of ionising radiations. Using typical school science sources without a registration is illegal.	3.5.4
Step 11	Let the Fire and Rescue Service know where the store is, and the activity of the sources you have or are acquiring.	3.5.5
Step 12	Order the source from a reputable supplier.	3.6

3.1 Make sure there is good educational reason for acquiring the source(s)

This applies to all sources. You need to be able to justify why the school needs them. This is straightforward: it should be linked to the practical work for good teaching of the science curriculum. For example, it is justifiable to buy a set of standard cup-type sources, or a half-life demonstration source, if the school does not already have them; similarly, replacing a cobalt-60 source because its activity has become too low, or replacing sources that are at the end of their safe working life, is justified. Your employer may have its own requirements, but there is no formal requirement for you to supply a written justification. But you do need to be able to explain the justification.

What isn't justified is acquiring sources – eg donations from industry or other schools – just because they are cheap or free. It would also be difficult for a school to justify acquiring a high-activity source that requires an environmental permit. Some schools have accepted unsuitable donations, only to find out later the considerable cost of disposal, sometimes running into thousands of pounds.

3.2 Decide who will be responsible for managing the radioactive sources

In this guide, the person in charge of the school's sources is known as a Radiation Protection Supervisor (Schools) – or RPS (Schools), the title generally used in schools.

Owing to the management responsibility involved in this role, the RPS (Schools) should be a member of the science teaching staff, typically the subject leader (or deputy) or senior physics teacher (see PS75). They should understand the principles of radiological protection, and how to apply this guide to school science.

We recommend that the RPS (Schools) should not be a technician. This is mainly because technicians do not usually have a sufficient authority, overview and active involvement with all aspects of the use of radioactive sources, including classroom practices, and they may find it difficult to enforce compliance with the Standard Operating Procedures. However, a good arrangement is to appoint a technician as the Assistant RPS (Schools) to the RPS (Schools), with day-to-day oversight of the logging system, etc.

See section 7.1 for more details of the role and responsibilities of an RPS (Schools). It is important that the RPS (Schools) knows these responsibilities and carries them out.

3.2.1 Training for the RPS (Schools)

The employer must ensure that the person appointed is competent and fully understands their role. The head of science needs to check that the RPS (Schools) can undertake this role, and arrange any training they may need. We strongly recommend that the RPS (Schools) attends a course specifically designed for school-level work.[1] Refresher training should be arranged if there are significant changes in legislation or radiological protection.

3.3 Choose sources that are suitable for school science use

The types of source and quantities specified in the 'Standard School Holding' (see section 3.3.1) are suitable for school science use. When choosing a particular source, we strongly recommend that you follow the guidance in PS78, *Radioactive sources for school use*, which lists specific radioactive sources aimed at schools and available in the UK. This indicates which sources CLEAPSS has concluded conform to a specification

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[1] CLEAPSS runs a suitable course designed for schools in England, Wales and NI.

for suitable sources originally drawn up at the request of the Department for Children, Schools and Families (now DfE).

New sealed sources should meet a minimum specification of ISO 2919:2012 C23312. Note that sealed sources manufactured by Spectrum Techniques (USA) and from the Hevesy Laboratory at DTU, Risø, Denmark, when checked (2018) do not meet this standard and therefore should not be acquired.

The older cup sources from Philip Harris, Griffin & George and Panax were not tested to this ISO standard, but tests carried out by the National Radiological Protection Board (now Public Health England) and others have shown that these sources are robust and can continue to be used if they are in good condition and checked yearly.

If you choose radioactive sources that are not included in the Standard School Holding, it could cost you considerably more, both to acquire and dispose of them, because the sources may require permitting from the environmental regulator. Before acquiring sources, we recommend that you should discuss your choices first with CLEAPSS (if your school is a member) or your RPA.

3.3.1 The Standard School Holding

Schools should only keep the radioactive sources they need for good teaching. It is important not to build up an unjustifiably large number of sources. The Standard School Holding lists the sources that schools could be expected to keep.

Standard school holding
Up to 1.2 MBq (~30 μCi) as sealed sources (but see section 3.3.2). That is six 185 kBq (5 μCi) sources. The nominal activity[1] of any source must not exceed 400 kBq (10 μCi). New sealed sources must meet ISO 2919:2012 C23312.
Uranium compounds in totally encapsulated disc sources[2].
Protactinium generator for half-life experiments.[3]
Gas mantle radon-220 (thoron) generator for half-life experiments. [4]
Caesium-137/barium-137 elution source for half-life experiments, each up to 40 kBq.[5]
Low-activity cloud chamber sources, eg thoriated tungsten welding electrodes (TIG electrodes).
Small specimens of naturally radioactive rocks.
Low-level radioactive consumer artefacts such as smoke alarms, gas mantles in a sealed bag, small items of Vaseline glass, and Fiestaware.

1 That is, the original activity of the parent radionuclide as stated on the source or its container. Although most sources will become less radioactive over time, some types will become more radioactive initially because of their decay chain.

2 No specific limit other than what is justified for curriculum use, up to the maximum holding of 100 g total of uranium compound.

3 DIY versions should be phased out - see section 6. No specific limit other than what is justified for curriculum use, up to the maximum holding of 100 g total of uranium compound.

4 No specific limit other than what is justified for curriculum use

5 As many Cs-137 elution sources as are justified for curriculum use, to a maximum of 10 sources. **Do not acquire the 370 kBq version of the elution source because it exceeds the exemption limit.**

3.3.2 Notes on the Standard School Holding

The 1.2 MBq limit for sealed sources is not a legal limit, but a limit established over decades as a sensible amount to meet the normal curriculum requirements. If you exceed this limit a little, speak to your RPA; it is not usually a problem. In some circumstances, schools can keep more than a total of 1.2 MBq of sealed sources, but you would have to justify this (eg if the school is on a split site) and get the agreement of your employer, acting on the advice of the Radiation Protection Adviser (RPA). But keeping radioactive sources greatly exceeding 1.2 MBq in total would be difficult to justify under the ALARP principle.

Thorium compounds are not part of the Standard School Holding except for consumer artefacts (eg gas mantles and thoriated TIG rods) and radioactive rocks.

The guidance in this document may not be adequate for dealing with sources that are outside of the Standard School Holding. Also, for sources not included in the Standard School Holding, be aware that the exemption limits for disposing of sources are sometimes lower than the exemption limits for acquiring and keeping them. If you have a source that exceeds the exemption limits for disposal, it could be costly when you come to dispose of it.

The Standard School Holding includes some consumer items that contain enough radioactive substances for the radiation to be detected by a Geiger-Müller (GM) tube. These include, for example, a smoke alarm and thoriated TIG welding rods. They must not be modified or mutilated. You should not keep radioluminescent items.

3.3.3 Containers for the sources

Each radioactive source should be kept in a suitably labelled container – normally the container in which the source was supplied. This allows the source to be identified easily and carried safely. For example, the common cup source is kept in a lead pot inside a wooden box. See section 6 for guidance on what kind of containers to use for each of the sources commonly found in schools.

The labelling on each container should identify the source(s) inside and include a trefoil warning sign, with the wording ‘radioactive material’. If the school has more than one of the same type of source, each source must be uniquely identified. If necessary, mark the outside of the container with the unique identifier.

3.3.4 Exempt material

Low amounts of certain radioactive substances are conditionally exempt from needing a permit from the environmental regulator. These are called ‘exempt’ materials. Schools are recommended to keep no more than the Standard School Holding, which is well within these exemption limits.

The term ‘exempt’ is misleading: it is better to think of these low-activity materials as ‘conditionally exempt’. If you acquire sources that take you above the exemption limits, you will need a permit from the environmental regulator, and that is costly.

You must allow the regulator access to your records and premises if they want to check you are meeting the conditions for exemption. It is highly unlikely they will want to do this unless they think you are seriously breaching environmental regulations.

These are the conditions for exempt substances:

- Keep adequate records of any exempt radioactive substances, including a record of where the sources are stored and any disposals (see section 8).
- The radioactive substances or their containers should be labelled as radioactive, as far as reasonably practicable.
- Do not modify or mutilate sealed sources or cause radioactive material to escape outside the source.
- Look after the radioactive substances so that they are unlikely to become lost or stolen, or unlawfully released into the environment. If more than a certain amount is lost or released into the environment, you must tell both the environmental regulator and the HSE promptly – see section 9.2.6 and 9.3.

Be careful here: radioactive substances that are termed 'exempt' in relation to the environmental regulations on radioactivity are still likely to be regulated by other laws such as those on using radioactive substances safely, or those on disposing of them if they are chemically hazardous.

Some natural radionuclides, eg potassium-40 and rubidium-87, are regarded as 'not radioactive' and are unconditionally exempt from the environmental legislation on radioactivity. These are termed 'out-of-scope' materials.

See section 13 for more details of the conditional exemption limits.

3.3.5 X-ray equipment

X-ray equipment (such as a Tel-X-Ometer) is not part of the Standard School Holding. The school can keep one (but not use it) if it is disabled by removing the mains plug and the equipment is clearly labelled 'Do not use'.

You need to get advice from your RPA before using any X-ray equipment or apparatus that emits X-rays such as an electron microscope. Special training, different operating procedures and contingency plans will be required (see section 14).

If using X-ray equipment was not declared when obtaining a registration from the HSE, your employer will need to re-register to declare this use.

3.4 The employer appoints a Radiation Protection Adviser (RPA)

The requirement for appointing an RPA arises from the Ionising Radiations Regulations. If the employer uses radioactive sources, the employer must consult a suitable RPA as necessary for advice on the regulations. The regulations expand on 'as necessary', and apart from a few exceptions (for example if sources are below certain levels of activity) employers are required by law to appoint an RPA. There has been erroneous advice from some health and safety consultants on this; if you are not sure, contact us for advice. The RPA's role is to provide advice on compliance with the regulations and to help employers improve standards of radiological protection.

Before you start, it is essential to know who your employer is and the name of the RPA that they have consulted or appointed. Many local authorities use the CLEAPSS RPA scheme (see section 3.4.1).

If your employer has no RPA, you may need to explain to your employer that they need to consult and, if necessary, appoint one. If you are delegated to find a suitable RPA on behalf of your employer, contact us for help if you need it.

RPAs must hold a valid certificate of competence and be formally recognised as competent by the HSE, so it is very unlikely an adviser, teacher or technician can legally act as an RPA. (Until 2005, an RPA did not necessarily need to hold such a certificate.) Most RPAs are qualified through the RPA2000 scheme and it is simple to verify an RPA has a current certificate by checking online (www.rpa2000.org.uk). Note that the law also requires the RPA to be 'suitable', so the employer needs to check the RPA has adequate experience and expertise in managing small sources for teaching.

3.4.1 The CLEAPSS RPA scheme for local authorities

In this scheme the local authority appoints one of their staff as a Radiation Protection Officer (RPO) – this is usually a science adviser or a health and safety adviser. The local authority then appoints an RPA contracted by CLEAPSS. The RPO carries out the routine monitoring role, by visiting schools periodically and checking their records and procedures, and liaises with the RPA. For more information see PS46A *Radiation Protection in School Science: Guidance for Employers – Information for local authorities.* In the CLEAPSS RPA scheme for local authorities, the school should not normally need to deal directly with the RPA. For a routine enquiry, the school should contact the CLEAPSS *Helpline* or, where relevant, the RPO.

3.5 Sort out the permissions and notifications

3.5.1 Get permission from your employer

You need permission from your employer to acquire and use sources of ionising radiation. This is because the employer has specific legal duties (although many will usually be delegated to the head of science and RPS (Schools)). You must let your employer know before your school starts working with radioactive sources because your employer may have to obtain registration from the HSE first – see section 3.5.4. If your school changes status – eg changes from a local authority school to an academy – the employer may change too, and the new employer may need to obtain registration.

It is normally enough to get permission from your head teacher, and for local authority schools from the local authority's Radiation Protection Officer (RPO). If there isn't an RPO, then ask the local authority's health and safety adviser. Some employers may have a form that you need to complete.

Some employers may place additional restrictions on what sources can be acquired and used in science. While you must follow these restrictions, they can be challenged if you think they are excessive. Contact CLEAPSS: we can offer to discuss the restrictions with the employer.

3.5.2 Who is the employer?

The employer is the organisation, or person, with whom the employees have their contracts of employment. At the time of writing (2019), the situation is as follows.

Schools, including English academies, and colleges in England and Wales
In community and voluntary controlled schools, the employer is the local authority (previously local education authority (LEA)). Even in federations of community and voluntary controlled schools where there is a federated governing body, the local authority is still the employer.

In English academies, the employer will be the trust or governing body, including a shared governing body of a federation of academies. Where academies are part of a multi-academy trust (MAT), the MAT is the employer.

In voluntary aided and foundation schools, free schools and some independent schools, the employer will be the trust or governing body, including a shared governing body of a federation of these schools.

For independent schools, the employer may be a trust or the proprietor.

In post-16 colleges, the employer will be the corporation of the college.

In some PFI (private finance initiative) schools, the employer for the teachers is as above, but some ancillary staff (including technicians) may have a different employer. Where two or more employers share the same premises they must collaborate on health and safety matters.

Schools in Northern Ireland
The Education Authority (EA) replaced the Education & Library Boards in 2015.

For teachers, the EA is the employer in controlled schools (including controlled integrated and controlled grammar schools); the Council for Catholic Maintained Schools (CCMS) is the employer in Catholic maintained schools, and the school's Board of Governors is the employer in voluntary grammar, grant-maintained integrated and most Irish medium schools (except for the few controlled Irish medium schools).

For technicians, the EA is the employer in all schools except voluntary grammar and grant-maintained integrated schools where the school's Board of Governors is the employer.

3.5.3 Get permission from the government education department

Other than for sixth form colleges and further education colleges in England, schools and colleges in England, Wales and NI no longer need permission from the relevant government department for education to acquire and use radioactive sources.

For sixth form colleges and further education colleges in England, permission may be assumed if the college agrees to keep within the Standard School Holding and follow L93 - there is no need to contact the DfE. If a sixth form or further education college in England wants to obtain permission for acquiring sources of ionising radiation not in the Standard School Holding, write to the DfE, Skills Provider Base Division, Sanctuary Buildings, 20 Great Smith St., London SW1P 3BT.

3.5.4 Obtain registration from the HSE

Since February 2018, employers must obtain authorisation from the HSE (HSENI in NI) before engaging in any 'practice' involving sources of ionising radiations. Notifications from before 2018 do not count. A practice includes storage, transport, and use of ionising radiations, so there is no get-around by claiming the sources are stored but not used. The HSE uses a graded approach to authorisation that reflects the level of risk. Broadly, for lower-risk work, notification is required; for medium-risk work[1], registration; and for higher-risk work, consent. The use of ionising radiations in school science nearly always falls into the medium-risk level, and if so, school employers must obtain a registration before the sources are used. It is the

[1] Medium risk is where the total holding of each of the following exceeds the relevant threshold: for Am-241, Pu-239, Ra-226, Sr-90, Cs-137, uranium and compounds: 10 kBq; for Co-60: 100 kBq; for thorium compounds: 4.7 kBq. There is also a summation rule if there is more than one radionuclide involved, which is usually the case in school science. Employers must also notify the HSE if their radon level exceeds an annual average concentration of 300 Bq m^{-3}.

employer who has the duty to register. We have produced guidance, GL258, which we recommend the school employer follows. If the task of registration is delegated to you, we recommend you adhere to this guidance.

The registration only needs to be done once, so another registration is not needed for acquiring additional sources listed in the Standard School Holding. It is the employer's details and type of practice(s) that are registered, not the sources that are held (the registration process does not ask for any list of sources) hence the employer needs to register just once, even if the employer has many sites.

The registration does not have to be done again unless there is a significant change in employer's details or practice with ionising radiations, in which case a new registration must be obtained.

In NI, there is no charge for registration. For the rest of the UK, the HSE (not CLEAPSS) makes a single charge of £25 (2019).

Radon in buildings falls within notification, not registration. This is a matter for the school employer, not the science department. GL258 includes advice to school employers on what to do about this.

3.5.5 Tell the Fire and Rescue Service

It will be part of the school's fire risk assessment to tell the Fire and Rescue Service where the radioactive substances are stored. This will usually be done by the school premises manager, who normally liaises with the Fire and Rescue Service on building-related fire safety matters, but you need to check it has been done. Make sure they appreciate that these radioactive substances are low activity, roughly no more than one order of magnitude above a domestic smoke detector.

3.6 Order the radioactive source from a reputable supplier

You need to make a judgement on whether a supplier is reputable. Is the quality of their sources suitable for your use? And if there is a problem with the source, would they resolve the matter reasonably? If you are unsure, members can contact us for advice through the CLEAPSS *Helpline* or on 01895 251496.

3.6.1 Placing an order for a radioactive source

When placing an order for a radioactive source, you may need to confirm to the supplier that the school or college is allowed to hold that source and the employer has approved its acquisition, although this is rare now. If there is any difficulty over this, please contact us. Some suppliers may require a letter from your RPA.

Whenever a new radioactive source is purchased, the RPS (Schools) must keep copies of all the relevant paperwork (eg the delivery note, invoice, instructions and safety data sheets). Schools have found these documents extremely useful, for example when the source eventually needs to be disposed of.

3.6.2 Delivery arrangements with the supplier

When you order a radioactive source, make sure it will be secure the moment your school receives it. Do not assume the delivery company will do this for you. Liaise with the supplier to make sure that when the radioactive material is delivered, it is signed for by a responsible person at the school and then taken without any delay directly to your science department and stored securely. Avoid deliveries during school vacations unless you can be sure of these arrangements. There have been incidents where schools have lost control of sources because the parcel became misplaced after delivery during a school vacation – the school reception signed for the delivery but nobody could account for what happened to it afterwards.

3.7 Monitoring equipment

Every establishment which keeps radioactive substances must have suitable detection equipment. The equipment must be in working order and easily available – borrowing equipment from elsewhere when required is not acceptable.

'Monitoring' is checking the radioactive material remains where you expect it to be, for example the routine checking of sealed sources. This is an important part of the risk assessments. Schools and colleges often have just one set of detection equipment that is used both for teaching and for monitoring, usually a GM tube connected to a suitable measuring instrument.[1] This is fine provided the detection equipment is adequate for monitoring – see section 11.1. Small detectors may be adequate for use in teaching but completely unsuitable for monitoring for low-level contamination. CLEAPSS or your RPA can advise you on choosing detection equipment.

4 Storage, labelling and security

4.1 Plan where the sources will be stored

Safe, secure storage of radioactive material is essential. Plans for new buildings or refurbishments should always include clear storage arrangements for any radioactive substances. Your employer must check that the store is suitable, but this is likely to be delegated to you. The sources should be stored in a secure steel store cabinet that is in a secure, lockable store room accessed by science staff only. For good security and to reduce handling time, the store room should be in an area easily accessible from where the radioactive sources will be used. In existing buildings there is not always a suitable separate store room, in which case the steel store cabinet should be in a secure store cupboard in the science preparation area.

The cabinet should not be located in an outdoor store room because of the reduced security and increased risk of environmental damage to the sources.

The steel store cabinet should be installed in good time before acquiring the sources. Make sure the premises manager is told where the radioactive sources are kept.

4.1.1 Make sure there is adequate physical security for the store room

The store room must be restricted to science staff only, using a good-quality unique lock. Do not store radioactive sources in a teaching laboratory. A lockable science store room off a prep room or off a laboratory is ideal; a lockable cupboard in a prep room is acceptable. A store room used by the cleaners, or a general stationery cupboard used by school staff, or a boiler room, or an outside store are all examples of completely unsuitable store rooms.

Ground floor store rooms with standard glazed windows on an external wall are too easily broken into. If this is your only realistic choice of store room, you will need to improve the physical security, for example by fitting obscured laminated glazing. We

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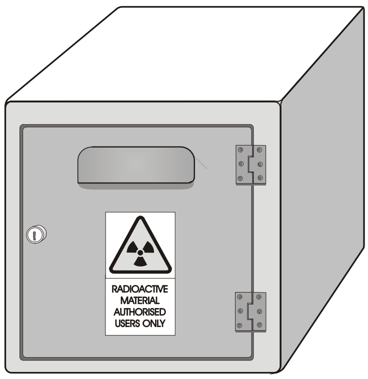
1 See CLEAPSS guide GL138, *Choosing a Geiger-Muller tube and counter or ratemeter*, the CLEAPSS *Laboratory Handbook*, section 12 and CLEAPSS guide R92 *The Measurement of Radioactivity*.

don't advise fitting external bars etc across windows as it may unintentionally flag that there is 'something inside worth stealing'.

4.1.2 Construction of the steel store cabinet

The cabinet must be:

- A strong fire-resistant steel cabinet. This is likely to retain the radioactive substances after a fire or structural failure of part of the building, and will be easily identifiable. School science suppliers offer steel cabinets designed for this purpose. A lead container or lead-lined wooden container alone is inadequate.
- Roughly 380 mm cube.
- Fitted with a lock so that only authorised science staff can open the cabinet.



Preferred steel store cabinet (fixed securely)

Warning trefoil sign for the cabinet, with recommended text

Do not line the cabinet with lead sheet. It provides little shielding from the gamma emissions of cobalt-60 and radium-226.

4.1.3 Locating the steel store cabinet in the store room

The cabinet should be securely fixed to the fabric of the building (or bolted to a fixed bench), to minimise the risk of unauthorised removal. This should be done professionally, to avoid damage to the building or its services. Locate the cabinet so it is easy to get to and easy to check the sources are present.

In choosing the location of the cabinet, make sure it is:

- at least 2 m (ignoring walls, floors and ceilings) from where anyone spends extended periods of time – in a room adjacent to the store room, this is at least 2 m from where a member of staff regularly sits; in a prep room, this is at least 2 m away from the technician's desk and the washing-up sink,
- at least 1 m (ignoring walls, floors and ceilings) from where students sit, assuming there are different students there throughout the day.

If there are visible overhead water pipes, avoid positioning the cabinet directly underneath them if practicable.

4.1.4 Other restrictions on the store room

Schools rarely have the luxury of a dedicated store room for the steel store cabinet. It is acceptable that the store room is used for storing other science department items, but with the following restrictions:

- No bulk stocks of highly flammable substances. The Fire and Rescue Service are unlikely to accept the risks arising from storing the sources near to flammable substances.
- No corrosive materials, to reduce the risk of damage to the sources.
- Only science department equipment. It is not acceptable to share the store room with non-science staff.

4.1.5 Labelling the steel store cabinet and store room

The outside of the cabinet must be labelled securely. The standard coloured warning trefoil sign shown above must be used. The text, 'Radioactive material, authorised users only' is also recommended. Good quality signs are available from various suppliers.[1] You can also create a laminated sign using the CLEAPSS document E232 *Common Safety Signs & Hazard Symbols*.

A fire prevention officer may ask you to put an additional trefoil warning sign on the door of the store room where the steel store cabinet is located. Generally, we advise against this. It advertises the presence of radioactive sources and it may encourage vandalism or theft, or raise unnecessary concern. You should review these risks before labelling any doors.

4.1.6 What to keep in the steel store cabinet

Only radioactive sources and their immediate containers should be kept in the cabinet. This should ensure that:

- the cabinet needs to be opened only when sources are used or checked;
- other items are not confused with the radioactive sources; and
- if there is a leak or spill, only the minimum number of items is at risk of contamination.

If the cabinet has shelves, we suggest placing the radioactive sources on different shelves as follows:

- small radioactive artefacts on a higher shelf;
- standard sealed sources on a middle shelf, with gamma sources (particularly cobalt-60 and radium-226) towards the centre back if possible; and
- protactinium generators in secondary containment in a tray at the bottom of the store, to minimise the risk of wider contamination in the event of a spill.

It is useful to fix a copy of the list of sources inside the cabinet (see section 16.2). Alternatively, individual labels may be fixed inside the cabinet to show where each one should be kept. These measures make inventory checks easier.

Do not label non-radioactive items of equipment with the warning trefoil (for example GM tube holders and absorbers). Years later, someone may reasonably assume it is a source or a contaminated item, and so waste time and money checking whether it actually is radioactive.

4.1.7 The key to the steel store cabinet

Access to the cabinet key must be controlled; the key to the cabinet should be kept in a secure place which is only available to employees who are authorised by the RPS (Schools) to handle radioactive substances. It is a good idea to keep a spare key in

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[1] For example, Seton Ltd (www.seton.co.uk) and Safetyshop (www.safetyshop.com).

another secure place outside the science department, in case of fire for instance. We do not recommend attaching the store key to the use log because this offers little security.

4.2 Dose rates from stored school sources, and 'leakage'

Schools sometimes raise concerns to CLEAPSS about radiation from sources in storage. They may refer to it as 'leakage'. This is not the right use of the term because a 'leak' from a sealed source is when radioactive material becomes physically loose from the source and causes contamination of the surroundings. To check for leakage, you check for contamination.

When you shield a radioactive source with thick material, you can block all the alpha and beta emissions, but even thick lead will only reduce the gamma emissions, not block them entirely. If you put a GM detector near the steel cabinet, it is normal to detect some gamma radiation if there are gamma sources in the cabinet. The HSE guidance (L121) advises arranging storage so that the dose rate outside of a store should not exceed 2.5 microsieverts per hour. Provided only sources listed in the Standard School Holding are stored following the guidance above, this dose rate should not be exceeded.

4.3 Relocating the sources during school moves, refurbishments etc

This has been the most common cause of incidents. The highest risk of losing the radioactive sources is during school moves to new buildings, closures, rebuilds and refurbishments, radioactive sources and cabinets have been misplaced, and in some cases lost entirely.

As soon as you know that changes are ahead, liaise with your employer about how the sources will be dealt with. Employers have a legal duty to ensure that a clear plan is in place for the safety, security, transfer (or disposal) of any radioactive substances, taking advice from their RPA. If you are in this situation and plans for your radioactive sources are not clear, please ring the CLEAPSS *Helpline* well before the intended move. Check your inventory is up-to-date before any move too.

Do not assume contractors or school technicians will take care of relocating sources.

Part B: Using radioactive sources

What all teachers and technicians who handle sources need to know to use them safely.

5 Authorised users

5.1 School science staff

Science teachers and technicians with adequate knowledge and training may handle all the radioactive sources – see the next paragraphs for more details. All sources, whatever their activity, should never be left unattended by the teacher or technician who has them in their charge, except in emergencies such as a fire alarm.

5.1.1 Teacher qualifications

Permanent science teaching staff will generally be qualified to handle radioactive sources,[1] although they will normally need some radiation protection training, which can be provided in-school.

Trainees, some temporary staff, or teachers with science as a second subject may not be suitably qualified. If they are to handle sources, they must be supervised by a teacher who *is* qualified, until the RPS (Schools) considers that they have gained enough knowledge and experience.

5.1.2 Support staff qualifications

Technical support staff can have various qualifications and experience. It is important that technicians are confident and competent if they are to handle radioactive sources.

The RPS (Schools) should decide what tasks (if any) they are given. This varies among schools. In some, technicians do not handle radioactive sources at all; teachers always collect sources and return them to the store. In others, technicians transfer sources to laboratories and carry out annual monitoring.

5.1.3 Pregnant women and new mothers (staff or students)

It is important for a pregnant employee to let her employer know as soon as she is aware that she is pregnant, so that the employer can advise her of any special precautions or changes needed to working procedures.[2] This also applies to students who may be pregnant. The employer must carry out a risk assessment in relation to working with radioactive sources; this is likely to be delegated to the RPS (Schools).

If the Standard Operating Procedures are followed (see section 6.5), nobody working with radioactive substances in schools will receive a dose anywhere near the limits specified by the regulations.

A pregnant woman or a new mother may continue to carry out normal procedures with sealed sources. However, if she is concerned about the risk to her child, it would be advisable to ask someone else to carry out the work. To avoid unnecessary concern, we advise that pregnant women and new mothers do not carry out leak tests,

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[1] This assumes that schools have the Standard School Holding (see section 3.3.1). More stringent requirements would apply in the few schools that use sources outside of this category.

[2] See CLEAPSS leaflet PS13 *New & expectant mothers taking part in school science*.

contamination checks or work with unsealed sources (eg dealing with spills of radioactive substances).

5.1.4 Students under 16

Students below the age of 16 should not be allowed to handle radioactive sources (although there are some exceptions – see the next paragraph). At this level, practical work with radioactive material is largely restricted to demonstrations by the teacher. As in general for demonstrations, students should normally be kept at least 2 m away from the radioactive sources.

However, students who are responsible enough may use devices containing low-level radioactive sources (eg small cloud chambers and radioactive rocks) in standard experiments. The sources should be enclosed, and the students must be closely supervised. This is to prevent students contaminating their fingers, particularly from touching radioactive rocks, which should be stored in suitable transparent containers.

5.1.5 Students aged 16 and over

Students aged 16 or older in Year 12 (sixth form) (or Year 13 in Northern Ireland) and above may handle sealed sources within the Standard School Holding to carry out standard investigations of the properties of ionising radiations. The teacher in charge must be satisfied that the students are responsible enough, and that they have been shown how to use them and have seen and understood the Standard Operating Procedures. The teacher must closely supervise all work.

These students may also use a half-life source (listed in section 6.7) under the close supervision of a member of staff authorised to handle these sources. The member of staff must have recent experience in using the source and must demonstrate how to use it before letting the students do it themselves.

The sources must be inspected for signs of damage as soon as they are returned to the teacher. The procedure for doing this is explained in section 11.

5.2 Staff training

You must be confident that you can handle and use the sources safely, including following the Standard Operating Procedures and what to do if you drop or spill a source. Ask your RPS (Schools) about training. (For the RPS (Schools), see section 7.1.2 on training other staff.)

6 Working with radioactive sources

6.1 Using the monitoring equipment

You need to know how to use the monitoring equipment – usually a GM tube and a counter. If the equipment is faulty or unavailable, tell the RPS (Schools). The equipment has to be suitable for the task; an end-window GM tube with a diameter less than 15 mm is not suitable for checking for low levels of contamination. If you are not sure, ask your RPS (Schools) whether you have the right equipment and if you are using it correctly.

6.2 Security

Make sure you understand the security arrangements. The school always needs to know where the sources are. If you are unsure about the security arrangements, ask your RPS (Schools).

An authorised member of staff should collect the sources from the store, ideally just before they are to be used, and return them to the store straight after use. The sources must be looked after at all times by an authorised member of staff whenever they are outside the locked store. Do not leave them unattended. Sometimes they need to be kept somewhere else, temporarily, just before or after a lesson (eg if the laboratory is a long way from the normal store). If so, the sources, in their containers, may be locked for short periods in another cupboard or drawer.

Before you return the sources directly to the normal store, check that the sources are correct and present in their containers.

6.2.1 Records for security: the use log

Every time you take a source out of the store, you must fill in the use log. Put the date and time, the source(s), your name and details of the teaching group.

Once the lesson is over and you put the source back in the store, complete the use log again. Give the date and time, sign it, and confirm that adequate information was given to the students. If appropriate, add any comments to the sheet (eg if the source was dropped). See section 16.5 for a use log template.

6.3 Risk assessments

All employers must have suitable and sufficient risk assessments in place if people are working with radioactive substances. If your employer has adopted this document for their risk assessments, you need to follow the guidance.

In this guide, the risk assessments are in two parts:

1. **A set of general safety precautions** that apply to working with all radioactive substances. These are called Standard Operating Procedures.[1] Model Standard Operating Procedures are set out in section 6.6, and can be downloaded from our website as a Microsoft Word-compatible document (DL93).

2. **Specific risk assessments and useful information** for particular kinds of radioactive substances commonly used in schools. There is a specific risk assessment for each of the sources covered in this guide in section 6.7.

For a particular radioactive source, you use the Standard Operating Procedures with the extra information and guidance in the relevant specific risk assessment. In liaison with your employer and RPA, the RPS (Schools) may need to adapt the model Standard Operating Procedures and specific risk assessments a little, depending on the school’s circumstances and the exact nature of work the sources are used for. Contact CLEAPSS or the RPA (via the RPO for local authorities who subscribe to the CLEAPSS service) for advice if you are not sure on this.

6.3.1 Make sure you are aware of the risk assessments and Standard Operating Procedures

You need to understand the Standard Operating Procedures and the specific risk assessments for the radioactive sources you are using or working with. The RPS (Schools) is responsible for making sure that all staff and students who handle or use

[1] They are sometimes called ‘local rules’. However, this term has a specific meaning in the Ionising Radiations Regulations that is not generally applicable to schools, so the term ‘Standard Operating Procedures’ is preferable here.

radioactive substances understand them. If anyone does not have a full understanding, the RPS (Schools) should give the training they need before authorising them to handle the sources.

6.3.2 Make sure you are aware of the contingency plans for incidents involving radioactivity

If the risk assessment shows that an accident is reasonably foreseeable, you must have contingency plans for dealing with it. Make sure you see the contingency plans. For the RPS (Schools) there is more information on this in section 9.

6.4 Standard school activities with ionising radiations

The Standard Operating Procedures and specific risk assessments in this guidance assume that the practical work you are carrying out will be the standard school activities with ionising radiations. These are practical activities that reasonably could take place in any secondary school, although some are not relevant to students under 16. They could be regarded as part of the essential curriculum to which all students are entitled, depending on the level at which they are working.

Standard school activities with ionising radiations are practical investigations on:

- the existence of ionising radiations;
- different methods of detecting ionising radiations;
- the existence of background radiation and naturally occurring radioactivity;
- the different types of radiation and their main properties;
- the randomness of radioactive emission in time;
- the ranges of radiations in air and other materials, and shielding;
- the inverse square law for uncollimated gamma radiation;
- how to determine the half-life;
- observing tracks in a cloud chamber;
- back-scattering of beta radiation; and
- the deflection of beta radiation by a magnetic field.

For these activities, carried out with sources from the standard school holding and following the risk assessment in this section, the effective dose received by the demonstrator and students will be insignificant.

If any practical work you are doing is not included in this list, you will need to get advice from your RPA. The guidance in this document may not be adequate for practical work outside of these standard school activities.

6.5 Standard Operating Procedures for using radioactive sources

The Standard Operating Procedures – in addition to normal laboratory rules and procedures – give basic contact details for the school and employer, and explain the general good practice that is required when using any radioactive material. Section 6.6 shows model Standard Operating Procedures. The RPS (Schools) needs to complete these for your school.

6.6 Model Standard Operating Procedures

Standard Operating Procedures: Contact information		
School or college		
Employer (Circle one only. For 'local authority' or 'other', insert name.)	Local authority Governing body Other	1. ………………………. 2. n/a ………………… 3. ……………………….
Radiation Protection Supervisor (Schools) (RPS (Schools))	Name ………………………………….. Internal telephone ……………………… E-mail …………………………………..	
Radiation Protection Adviser (RPA)	Name …………………………………..	
Fill in the contact details for the RPA, unless the local authority subscribes to the CLEAPSS scheme. In that case, tick the box below, and give the names of both the RPA and the Radiation Protection Officer (RPO), but give the contact details only of the RPO. RPA via CLEAPSS scheme ☐	**RPA:** Telephone ………………………. E-mail ………………………………….. **RPO:** Name ………………………………….. Telephone …………..………………… E-mail …………………………………..	
Contact for advice: CLEAPSS	+44 (0)1895 251496	

Standard Operating Procedures: Document locations	
Document	**Location**
Radioactive source history	
Use log for radioactive sources	
Monthly simple check log book	
Annual detailed check of radioactive sources	
List of authorised users of radioactive sources	
List of radioactive sources held	

Standard Operating Procedures to be used with the specific risk assessments	
1.	The practical work with radioactive substances must have an educational benefit. Consider the maturity and behaviour of the students when planning to use radioactive sources in teaching.
2.	In addition to these Standard Operating Procedures, you must follow the specific risk assessments for particular sources in section 6.7 of the CLEAPSS guide, L93 *Managing Ionising Radiations and Radioactive Substances in Schools and Colleges*, as modified by the school in liaison with CLEAPSS or your RPA.
3.	Practical work with students should be carried out in a laboratory and supervised by a qualified science teacher who has an adequate training and understanding of radioactivity hazards and basic radiological protection techniques.
4.	There must be suitable working detection equipment, eg GM tube and counter.
5.	The RPS (Schools) must be satisfied that any person authorised to work with the sources is competent to do so safely. See L93 section 7 on training.

6.	Anyone working with ionising radiation has a responsibility to restrict their personal exposure as far as reasonably practicable.
7.	While alpha radiation causes little exposure outside the body, be mindful it is far more dangerous should the alpha-emitting material enter the body, eg by swallowing or inhaling alpha-emitting radioactive material.
8.	If you are pregnant or breastfeeding, tell your RPS (Schools) before starting any work with ionising radiation.
9.	General safety regulations mean you must not eat, drink or apply cosmetics when working in the laboratory, including working with the ionising radiation.
10.	Wear any protective equipment indicated by the specific risk assessment. Before working with the radioactive substances, cover any wounds or skin damage with a suitable waterproof dressing. It is essential that protective equipment is the right size for you, and you know how to fit it and wear it correctly. Make sure you have been shown how to do this, including how to face-fit masks, if specified.
11.	Keep a sensible distance from the source. Use a tool to handle sealed sources that don't have an integral handle. Keep your fingers away from the source – typically 100 mm away – eg by using long forceps. Some sources emit more radiation in a particular direction (collimated or non-isotropic sources) – keep these positioned so that the main radiation field is directed away from anyone. Keep any source at least 300 mm away from the rest of the body.
12.	Spend as little time as practicable near to the radioactive source.
13.	Only use one source at a time in any one investigation. If the experiment involves comparing two or more sources, only one should be out of its container at a time.
14.	Students under the age of 16 (at the start of their current school year) should not use radioactive sources other than those in small cloud chambers (the source must remain inside the chamber during the lesson), thoriated gas mantles in a sealed bag, and radioactive geological specimens (kept in suitable containers which are not easy to open). Record on the use log that adequate information has been given to the students. All other work with radioactive sources must only be demonstrated by the teacher.
15.	For demonstration practical work, arrange the students so they are at least 2 m away from the sources.
16.	Responsible students aged 16 years and older (at the start of their current school year) may use sources within the Standard School Holding. Each student must understand these Standard Operating Procedures and the relevant specific risk assessment.
17.	Whenever students work with radioactive sources, you must give full training and, where appropriate, provide written instructions. Students must be closely supervised by a member of staff at all times. Record on the use log that adequate information has been given to the students.
18.	A member of staff must check sources immediately after use by students. Report any suspected damage to your RPS (Schools), who will decide if further action or monitoring is required. Keep a record of any unusual incident involving a source with the appropriate source history and make a note in the use log.
19.	The security of all radioactive substances is vital. The use log must be completed whenever a radioactive source is removed from, or returned to, the secure store. When signing the use log, you must check that the sources are actually present in their containers.

20.	Once sources have been removed from their secure store, they must never be left unattended by a member of staff, unless they are in a secure temporary store. Always return sources to the normal secure store as soon as possible after use.
21.	When carrying sources (even in their containers), the handling time should be minimised. Make sure you have a clear, uncluttered route to the destination, without students milling around. If the journey is likely to take more than a couple of minutes, put the source in an additional container (eg a plastic bucket) to keep it away from the body (ie the trunk).
22.	If the fire alarm sounds, follow the school's fire safety procedure. Safety of people takes priority. Focus on evacuating the students without delay. If a source is in use when the alarm starts, return it to its immediate container if this can be done quickly. Do not take the sources outside of the lab or prep room. Tell the senior fire warden, and the Fire and Rescue Service if they attend the alarm, where the sources are. Also tell the RPS (Schools) as soon as possible. You must not return to the building until the senior fire warden says it is safe to do so. For alarms that turn out to be a drill, a false alarm, or a minor fire far from the laboratory, when it is safe to return to the building, make sure that the RPS (Schools) or another authorised member of staff is allowed back into the building first so they can secure the sources before the students return.
23.	If the source is dropped or spilt, follow the 'Spill or drop' guidance on the specific risk assessment for the source and section 9, Managing incidents involving radioactivity. For any drop or spill, inform the RPS(Schools) promptly.
24.	Wash your hands after you have finished using radioactive materials, even if only using sealed sources.

Additional notes

End of the Standard Operating Procedures Dated ________________

6.7 Specific risk assessments for using radioactive sources

The following sheets provide specific risk assessments for using the radioactive sources found in schools and colleges that meet the Standard School Holding. They are to be used in conjunction with the Standard Operating Procedures. Your RPS (Schools) in liaison with your radiation protection adviser, may have adapted them to cover special circumstances in your school – if so, you should follow any extra conditions and guidance.

Note that there are some types of source, indicated in the list below with an asterisk, where our specific risk assessment advises that they are taken out of use and disposed of. Our risk assessment is that they can no longer be used safely, or are no longer justified.

CLEAPSS type number	Source
1	Radioactive rocks
2	Smoke alarm
3a	Radioluminescent (radium-paint) timepieces*
3b	Spinthariscopes*
3c	Radioluminescent instruments that are not timepieces or spinthariscopes*
4a	Scintillation plate*
4b	Becquerel plate*
5	Radium paint diffusion (Taylor) cloud chamber source*
6	Expansion (Wilson) cloud chamber source
7	Perspex slide sources – Labgear*
8a	Cup sources
8b	Panax source S4
8c	Isotrak educational sources (recessed in aluminium rod)
9a	Protactinium generator (Philip Harris or ScienceScope)
9b	Protactinium generator (DIY version)*
10	Radon-220 (thoron) generator (powder version)*
11	Radon-220 (thoron) generator (gas mantle version)
12	Gas mantles (thoriated)
13	Caesium-137 elution source
14	Uranium-coloured domestic glassware and ceramic items
15	Thoriated tungsten welding electrode
16	Uranyl(VI) nitrate-6-water (uranyl nitrate)*
17	Uranium and thorium compounds as radiochemicals*
18	Uranium oxide encapsulated disc source

6.7.1 The specific risk assessments

There is a colour-coded frame around each specific risk assessment, as follows:

Green solid border indicates that the source is currently available from suppliers and is suitable for school use. The sources still need to be checked periodically to make sure they remain in a safe condition.

Brown broken line border indicates that the source is no longer available from suppliers. In many cases, they are old and near to the end of their safe working lives. Their continued use should be reviewed carefully. In most cases, replacement with a source of the same or similar design is not recommended.

Red double line border indicates a source that should be taken out of use and disposed of unless a specific risk assessment approved by the school's RPA justifies continuing to use it.

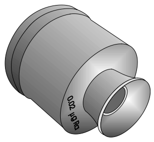
Most of the rows in the specific risk assessments are self-explanatory, but the following notes may be helpful.

- The type number in the top left of each specific risk assessment is the CLEAPSS type number, which is used for reference in other CLEAPSS documents.
- An 'Availability' section gives a note on current suppliers if the sources are available.
- A 'Standard School Holding' section gives the relevant Standard School Holding from section 3.3.1. This is a guide to what a school can normally justify keeping. It derives from a government education department former administrative memorandum. The Standard School Holding is well below the limits for Environmental Permitting Regulations exemption.
- There is no row on disposal for the sources that are on green or dotted-brown bordered risk assessments. This is because the risk assessments are about using the sources, not about disposing of them. Also, disposal is not straightforward and the guidance does not fit into a few lines. See section 12 for guidance on disposal.
- Radioactive sources often emit more than one type of ionising radiation. The most significant radiations are given for each source. The radiations in brackets mean radiation types normally shielded by the source construction, either deliberately or otherwise. These may need to be taken into account when planning investigations about the properties of the different radiations.
- Several references are made to large forceps to keep the hands well away from the source when working with radioactive sources. We recommend using 300 mm extra-long stainless steel forceps (eg catalogue code SN-07288-14 from Cole-Parmer Instrument Co. Ltd.: www.coleparmer.co.uk).
- Where an FFP3 dust mask is advised, wear a dust mask (half-mask respirator) manufactured to European Standard EN149 category FFP3 (eg RS, stock no. 133-248).

Type number 1	Radioactive rocks	
Description		Supplied as a set, for example by Philip Harris or Griffin & George. These usually contain thorium or uranium minerals. Typical radioactive minerals offered by educational suppliers are allanite, autunite, davidite, monazite, phosphuranylite, uraninite and torbenite. The school's geography or geology department may also keep rocks of this type, sometimes collected in the field by enthusiasts. The RPS (Schools) may wish to ensure that the control measures described here are applied equally to these.
Use	To demonstrate that natural rocks contain radioactive minerals. A rock should be regarded as radioactive if the count rate at the surface is more than 50% above the background count.	
Original activity	Varies, but can be up to 8.5 kBq g^{-1}.	
Radionuclide	Thorium-232: 1.4 x 10^{10} years and/or uranium-238: 4.5 x 10^{9} years and decay chains. Uranium in rocks also comprises about 0.7% uranium-235.	
Main radiations	α, β, γ	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to rock fragments being inhaled, absorbed through the skin or through wounds, or swallowed. Radon gas in the decay chain can cause contamination of surroundings. Thorium and uranium compounds are also toxic.	
Risk assessment	The external dose rates and risks of loose material are significant, but the risks are low with the control measures in place.	
Control measures	Purchase radioactive rocks from educational suppliers. Only keep small samples – as a rough guide no more than 10 cm^3 each sample – and keep in a sealed plastic bag or other sealed transparent container when using them to avoid the spread of contamination. Avoid much larger samples. Always follow the Standard Operating Procedures for the use of radioactive sources. Radioactive rocks should be treated in the same way as other radioactive sources.	
During use	The rocks should not be touched with the hands. They are best left in their transparent containers. Beware of loose contamination.	
Inspection	Annually or after use by students. A rock should be checked for damage and any chips or fragments disposed of. Forceps or disposable gloves should be used to handle rocks. Take care to avoid chipping the rock with the forceps. Handling time with gloves should be kept short.	
Leak test of source	Not required.	
Contamination check of container	Annually or if damage to the rock is suspected. The container should be cleaned if necessary.	
Storage and labelling	Radioactive rocks are best stored in sturdy, transparent plastic bags or containers with secure lids. A plastic bag is better if the rock is friable (crumbly). The containers should be labelled with a radioactive warning sign and the name of the rock, and kept in the steel store cabinet or a locked display cupboard. If rocks are displayed, they must be kept in a locked cabinet at least 500 mm away from the person viewing them. The count rate at the viewing position must be similar to the background count rate.	
Spill or drop	Wear a lab coat and disposable gloves. If a rock is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Available from Philip Harris and other suppliers.	
Standard School Holding	No limit, other than what is justified for curriculum use.	

Type number 2	Smoke alarm	© CLEAPSS 2019
Description		Most domestic smoke alarms use an ionisation chamber smoke detector. This is a small metal chamber containing a radioactive source. If smoke enters the chamber, the level of ionisation reduces, decreasing the flow of electric current in a circuit and triggering a siren.
Use	To show that many domestic smoke alarms contain a radioactive source. To explain the widespread agreement that the very low radiological risk, compared to the substantial benefits in life-saving, make it well worth installing such devices in the home.	
Original activity	Typically 37 kBq (1 µCi).	
Radionuclide and half-life	Americium-241: 432.6 years.	
Main radiations	α, γ. The α radiation is not normally detectable because of shielding by the ionisation chamber wall.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The residual risk is low with the control measures in place. Note: these control measures are not required for smoke alarms when used in the home, as they are extremely unlikely to suffer damage in the normal position, fixed to the ceiling. Climbing a stepladder to reach the alarm is likely to present a far greater risk to health and safety than the radioactive material in the smoke alarm.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Do not dismantle detectors other than removing the outer case cover to show the ionisation chamber.	
During use	The plastic cover of the smoke alarm may be opened for observation, to detect ionising radiation and to insert the battery. Under no circumstances should the metal ionisation chamber be opened. The test button or smoke can be used to trigger the alarm.	
Inspection	Annually and after use by students. Check that the ionisation chamber is undamaged.	
Leak test of source	Annually or if damage is suspected. The accessible surfaces of the ionisation chamber should be wipe tested. This applies only to smoke alarms used as examples of radioactive sources. Do not leak test installed smoke alarms.	
Contamination check of container	Not required unless leakage is suspected.	
Storage and labelling	A smoke alarm should be put in a strong, sealable plastic bag (to avoid any contamination from other sources). The bag should be labelled with a radioactive warning sign and kept in the steel store cabinet.	
Spill or drop	Wear a lab coat and disposable gloves. If a smoke alarm is dropped, it is most unlikely that any radioactive spill will occur. If it is damaged, sweep the fragments into a strong plastic bag and tie it up. Check the area for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Sold by hardware stores.	
Standard School Holding	Up to five 40 kBq Am-241 smoke detectors. Some older detectors are Ra-226, and some are above 40 kBq – do not acquire these.	

Type number 3a	Not recommended – dispose Radioluminescent (radium-painted) timepieces (including dials removed from them)	
Description		Clocks and watches with radium paint so they radioluminesce (glow in the dark). Note that although the radioluminescence gradually decreases over the years as the paint deteriorates, to the point where it barely glows in the dark, the radioactivity remains almost unchanged.
Original use	To demonstrate radioluminescence using a radioactive material.	
Original activity	Luminous dials: there is little information available. Timepieces have been reported at 5 to 50 kBq.	
Radionuclide and half-life	Radium-226 (promethium-147 and tritium have also been used). Ra-226: 1600 years; Pm-147: 2.6 years; tritium: 12.6 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Reason for withdrawal from use	These are at least 50 years old, and invariably the radium paint has deteriorated. The paint can flake away, often too small to be seen easily.	
Hazard	Internal irradiation of the body due to flakes of luminous paint being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The risk of contamination from the radium paint is unacceptably high. Radium-painted timepieces are now only an item of historic interest; it does not show a modern application of radioactivity.	
Storage and labelling	The item should be placed in a sealed bag and labelled 'DO NOT USE'. Place this in the steel store cabinet and make arrangements to dispose of it promptly.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

Type number 3b	Not recommended – dispose Spinthariscopes	© CLEAPSS 2019
Description		A device used to view scintillations from a low-activity radioactive source, often a spot of radium paint, with a screen that scintillates.
Original use	To demonstrate radioluminescence.	
Original activity	The Philip Harris spinthariscopes were 740 Bq (0.02 µCi). The Griffin types are of similar activity.	
Radionuclide and half-life	Usually radium-226: 1600 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Reason for withdrawal from use	These are old and there is no straightforward way of checking the condition of the actual source inside.	
Hazard	Internal irradiation of the body due to flakes of self-luminous paint being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The source could have deteriorated inside but there is no easy way of checking.	
Storage and labelling	The item should be placed in a sealed bag and labelled 'DO NOT USE'. Place this in the steel store cabinet and make arrangements to dispose of it promptly.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

Type number 3c	Not recommended – dispose Radioluminescent instruments that are not timepieces	
Description		Radium-based paint was in regular use in the first half of the 20th century to make various objects self-luminous in the dark. Old military items can have high activities from radium paint.
Original use	To demonstrate radioluminescence.	
Original activity	There is little information available. Marine compasses can be up to 400 MBq.	
Radionuclide and half-life	Usually radium-226 (promethium-147 and tritium have also been used). Ra-226: 1600 years; Pm-147: 2.6 years; tritium: 12.6 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Reason for withdrawal from use	The activity can often be well above the current exemption limit. These devices were never exempt under the previous exemption orders, and, strictly, schools should not have acquired them. The paint deteriorates and the radium paint becomes brittle and can flake away, often too small to be seen. The phosphorescent material degrades with age and no longer produces significant luminescence. Radon outgassing can cause significant contamination.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to flakes of self-luminous paint being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	This type of instrument can present a greater risk than other sources commonly used in schools. Luminous instrument dials (especially military instruments such as altimeters and compasses) are often well above 200 kBq of Ra-226 and should not be kept.	
Storage and labelling	The item should be placed in a sealed bag and labelled 'DO NOT USE'. Place this in the steel store cabinet and make arrangements to dispose of it promptly.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

Type number 4a	Not recommended – dispose Scintillation plate	© CLEAPSS 2019
Description		Various designs featuring spots of radium paint on a plate. The Panax design has two radium paint spots; one is much weaker than the other. The Panax plates are in boxes of 20 labelled PS-308. The picture left shows a Panax plate and the boxed set it was taken from.
Typical dimensions	Varies. Panax type scintillation plates are length 65 mm, width 25 mm, thickness ~ 2 mm.	
Original use	To observe radioluminescence, and individual scintillations with a magnifier.	
Original activity	Depends on type, and often it was not specified. From measurements carried out by CLEAPSS on the Panax type, the higher activity spot is about 4 kBq, the lower activity spot is about 100 Bq. Other types are likely to be similar.	
Radionuclide and half-life	Usually radium-226, 1600 years. .	
Main radiations	α, β, γ including emissions from the decay chain.	
Reason for withdrawal from use	The paint deteriorates and the radium paint becomes brittle and can flake. The phosphorescent material degrades with age and no longer produces significant scintillations. The Panax boxed set produces radon which causes significant contamination inside the storage cardboard box and on nearby surfaces.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to flakes of self-luminous paint being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The sources are well beyond their recommended working life and a risk assessment does not support extending their service life. The radium can easily be damaged and cause contamination. If you need to handle the plates or boxed set, do it by the edges with gloved hands and avoid touching or knocking the paint spots.	
Storage and labelling	The items, or boxed set, should be placed in an air-tight plastic bottle and labelled 'DO NOT USE'. Place the bottle in the steel store cabinet and make arrangements to dispose of the plates promptly. If the plates are in their cardboard box, don't take them out. Just dispose of the whole box.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

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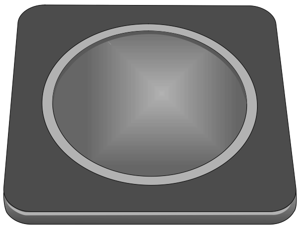
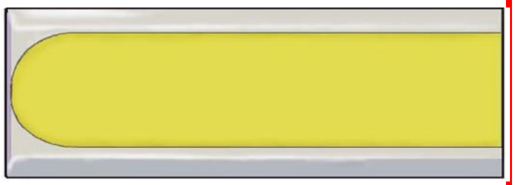
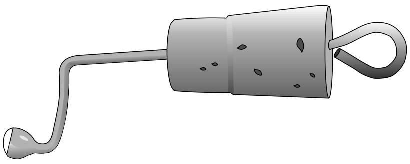
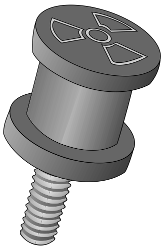
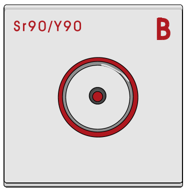
Type number 4b	Becquerel plate	© CLEAPSS 2019
Description	A radioactive substance lines a recess in a plastic plate, normally protected by a transparent cover or case. Most were originally supplied by Griffin & George, Philip Harris and Panax.	
		
	Becquerel plate	Panax-type yellow plate. Also in black.
Typical dimensions	Length 38 mm, width 38 mm, thickness 4 mm.	Length 85 mm, width 30 mm, thickness 4 mm
Original use	Used to produce blackening (fogging) of photographic film, replicating Henri Becquerel's accidental discovery of radioactivity. However this is rarely done now, particularly as photographic film is no longer commonplace.	
Original activity	Depends on type, but uranium types are usually less than 100 kBq.	
Radionuclide and half-life	Uranium oxide paint or encapsulated uranium oxide powder. Panax types also have dummies with manganese oxide. Some Panax plates are yellow in colour. These contain uranyl nitrate, and some are dummies with sulfur. Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: 4.5 x 10^9 years.	
Main radiations	α, β including emissions from the decay chain.	
Reason for withdrawal from use	The Panax plate seals regularly fail and cause contamination. The uranium oxide coating on other types commonly show deterioration, losing their integrity and causing contamination.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The sources are well beyond their recommended working life and a risk assessment does not support extending their service life.	
Storage and labelling	The non-radioactive dummies should be taken out and disposed of separately as chemical waste. The radioactive items should be placed in a sealed bag and labelled 'DO NOT USE'. Place the bag in the steel store cabinet and make arrangements to dispose of plates promptly.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

Type number 5	Diffusion (Taylor) cloud chamber radium paint source	© CLEAPSS 2019
Description		This source is part of a diffusion (Taylor) cloud chamber from Griffin & George, Irwin and others. It is a sample of radium-based luminous paint in a small metal cup attached to a thin, cranked rod, which is mounted in a cork. See specific risk assessment 15, *Thoriated tungsten welding electrode* for an alternative.
Typical dimensions	Length 70 mm, height 25 mm, diameter of cup 5 mm. Some have a plain end. Some types a spots of paint in a plastic block.	
Use	Observation of tracks produced by ionisation due to alpha particles.	
Original activity	Typically 0.74 kBq (0.02 μCi).	
Radionuclide and half-life	Radium-226: 1600 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Reason for withdrawal from use	The plated ends are regularly showing corrosion with loss of radium paint. The paint binder also fails owing to the years in a radiation field. Often the missing paint is not noticed until the source stops working in the cloud chamber. There is a much safer alternative, the thoriated TIG welding rod. See CLEAPSS source type 15.	
Hazard	Internal irradiation of the body due to flakes of the paint particles being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The sources are well beyond their recommended working life and a risk assessment does not support extending their service life, particularly as small paint particles are easily overlooked and could easily cause personal contamination.	
Storage and labelling	Place them in a sealable plastic bag and label 'DO NOT USE'. Place the bag in the steel store cabinet and make arrangements to dispose of sources promptly.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

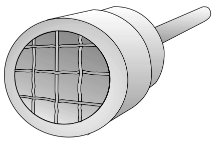
Type number 6	Expansion (Wilson) cloud chamber radium source	© CLEAPSS 2019
Description		This source is part of an expansion (Wilson) cloud chamber. It consists of a metal foil radium source shaped into a cylinder around the centre of a brass assembly that screws into the chamber. Supplied by Philip Harris as part of an expansion cloud chamber apparatus.
Typical dimensions	Diameter 7 mm, height 8 mm (excluding threaded shaft).	
Use	Observation of tracks produced by ionisation due to alpha particles.	
Original activity	Typically 37 kBq (1 µCi).	
Radionuclide and half-life	Radium-226: 1600 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.	
During use	This source should be kept in its cloud chamber. It should not be touched.	
Inspection	Annually and after use by students. Check the source (left in the cloud chamber) remotely for damage, eg with a small mirror or an inexpensive USB endoscope (snake scope).	
Leak test of source	Annually or if damage is suspected. The outer surfaces should be tested.	
Contamination check of container	Due to the very small amounts of radon gas emitted from radium sources, the inside of the cloud chamber should be checked annually and decontaminated if necessary. This is also required if leakage is suspected.	
Storage and labelling	It is usually best not to try to remove the source from this type of cloud chamber because the thread can be tight and removal may damage the source. Therefore the whole chamber should be labelled with a radioactive warning sign and stored in a labelled, locked cupboard, preferably near to the main store cabinet. It is normally best not to keep the whole cloud chamber in the steel store cabinet itself, because it would be difficult to clean if contaminated by other sources. It may also be too large to fit in the cabinet.	
Spill or drop	Wear a lab coat and disposable gloves. If a cloud chamber source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	These sources have not been available for many years. At the end of the useful service life, replace the expansion cloud chamber with a diffusion cloud chamber that uses a thoriated TIG rod as a source (CLEAPSS type 15).	
Standard School Holding	The total activity of all sealed sources should not exceed 1.2 MBq, and no single sealed source should be above 400 kBq. If practicable, choose sources no greater than 200 kBq.	

Type number 7	No longer recommended – dispose Perspex slide sources – Labgear	© CLEAPSS 2019

Description	 The active substance or foil source is held in a plastic slide with epoxy resin. Strontium-90, americium-241 and radium-226 foil sources have small holes in the plastic slide. The cobalt-60 source has a small pellet of cobalt metal wire. The thorium-232 source is a powder mixed into the epoxy resin. Some slides have a protective wire mesh.
Typical dimensions	Length 50 mm, width 50 mm, thickness 3.5 mm.
Original use	To investigate the basic properties of ionising radiations.
Original supplier	These sources have not been available for many years. The supplier was Labgear Ltd. The foils were from Nycomed Amersham.

Radionuclide and half-life (years)	**Co-60 5.27**	**Sr-90 28.8**		**Am-241 432.6**	**Ra-226 1600**	**Th-232 1.4 x 10^{10}**
Main radiations	γ, β	β		α, γ	α, β, γ	β, γ (α)
Original activity kBq (µCi)	37 (1) 185 (5)	37 (1)	185 (5)	3.7 (0.1) 185 (5)	185 (5)	37 (1)
Labgear code	C	B	E	A	D	F

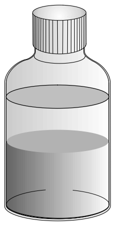
Reason for withdrawal from use	The plastic is degraded by the radiation field. There is also evidence that the foil surfaces are likely to have degraded to an unsafe condition.
Risk assessment	The sources are well beyond their recommended working life and a risk assessment does not support extending their service life. The radium source has a relatively high beta field and it should not be handled directly.
Storage and labelling	Place a 50 mm square sheet of 2 mm thick aluminium slide or 1 mm thick lead slide on each side of the radium-226 and strontium-90 sources to shield the beta radiation. Place each Labgear source in an individual small container and label them 'DO NOT USE'. Make arrangements to dispose of the sources promptly.
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.
Disposal	See section 12.

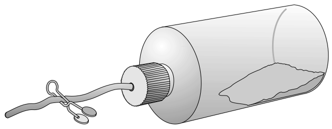
Type number 8a	Cup sources				© CLEAPSS 2019
Description	 This is the most common type of sealed source used in schools and colleges, originally supplied by Philip Harris, Griffin, Panax and others. The radioactive substance is sintered into a metal foil and is usually secured at the base of a metal cup by a circlip, but sometimes it is glued in place. In some newer designs of foils, the radioactive material is anodised into the foil surface. The open end of the cup is covered with wire mesh. It has a stem for handling and mounting. Details of the radionuclide and original activity are usually stamped on the back of the cup, next to the stem. A serial number may be engraved there too. Cup sources are supplied in a small lead pot with a lead lid, inside a suitably-labelled wooden container.				
Typical dimensions	Length 22 mm, diameter 13 mm, stem diameter 4 mm.				
Use	To investigate the basic properties of ionising radiations.				
Original activity	3.7 kBq (0.1 µCi) to 370 kBq (10 µCi), depending on type. Most commonly 185 kBq (5 µCi).				
Radionuclide and half-life (years)	**cobalt-60** **5.27**	**strontium-90** **28.8**	**americium-241** **432.6**	**plutonium-239** **2.41 x 10^4**	**radium-226** **1600**
Main radiations	γ (β)	β	α, γ	α	α, β, γ
Colour code (if present)	Green	Yellow	Brown	Blue	Red
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.				
Risk assessment	The residual risk is low with the control measures in place.				
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.				
During use	This type of source should be manipulated by the stem and kept at least 100 mm from the hand – long forceps are ideal. Only one source should be used at a time. Between investigations, the source should be returned to its container.				
Inspection	Annually and after use by students. Check the whole source for signs of damage. View the active foil surface using a plane mirror on the bench, or remotely with a digital camera. Never point the foil surface towards your eyes. Keep a record of any blemishes, particularly to the foil surface.				
Leak test of source	Annually or if damage is suspected. The outer surface should be tested.				
Contamination check of container	Not required unless leakage is suspected. For radium sources, small amounts of radon gas can be emitted, so an annual check should be made on the containers of these sources, and they should be cleaned if necessary.				
Storage and labelling	The source should be stored in its lead-lined container, labelled with a radioactive warning sign and kept in the steel store cabinet.				
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.				
Availability	Currently sold by Edu-lab, Philip Harris, SciChem and Timstar.				
Standard School Holding	The total activity of all sealed sources should not exceed 1.2 MBq. No single sealed source should be above 400 kBq. If practicable, choose sources no greater than 200 kBq.				

Type number 8b	Panax source S4	© CLEAPSS 2019
Description		This was a relatively high-activity collimated beta source. It is from a Panax teaching kit. The source has a slit, which is normally covered by a close-fitting aluminium cup. The manufacturer did not put a warning trefoil on the plastic base, or put it into any special container, so it is easily mistaken for a piece of apparatus such as an absorber. The activity will be lower than when new owing to the 28 year half-life.
Typical dimensions	Length 50 mm, width 45 mm, depth 25 mm (including collimator and metal storage cap).	
Use	To investigate deflection of beta radiation by a magnetic field.	
Original activity	330 kBq (9 µCi).	
Radionuclide and half-life	Strontium-90: 28.8 years.	
Main radiations	β.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.	
During use	This type of source should be held by the plastic edges. The aluminium cap should be removed with plastic forceps, making sure your hand is not placed in front of the source slit. The aluminium cap should be replaced immediately after you have finished the investigation using the source.	
Inspection	Annually and after use by students. Check the whole source for signs of damage. There is no point in remotely looking into the source slit because little of the foil can be seen.	
Leak test of source	Annually or if damage is suspected. The outer surface should be tested.	
Contamination check of container	Not required unless leakage is suspected.	
Storage and labelling	Put a small radioactivity warning sign directly on the plastic body. The source should be stored in a suitable small container, labelled with a radioactive warning sign and kept in the steel store cabinet.	
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	These sources have not been available for many years. They can be used until the end of their safe working lives. Replacement with another source of this high an activity is not recommended.	
Standard School Holding	The total activity of all sealed sources should not exceed 1.2 MBq. No single sealed source should be above 400 kBq. If practicable, choose sources no greater than 200 kBq.	

Type number 8c	Isotrak educational sources				© CLEAPSS 2019
Description			The source assembly is made up of a source (a sealed stainless steel capsule or a metal foil or disc), housed in a recess in an aluminium rod. The rods are supplied in a metal cylinder, which can hold one (as shown in the illustration) or more rods in a 'well'. The radioactive end of the rod is stored downwards into the metal cylinder well.		
Typical dimensions	Length 85 mm, diameter 12 mm. The source is recessed 8 into the end of the rod.				
Use	To investigate the basic properties of ionising radiations.				
Original activity	74 kBq (2 µCi), 370 kBq (10 µCi) for the larger Cs-137 source, and 342 kBq (9.2 µCi) for a mixed nuclide source.				
Radionuclide and half-life (years)	**cobalt-60** **5.27**	**strontium-90** **28.8**	**americium-241** **432.6**	**sodium-22** **2.6**	**caesium-137** **30.1**
Main radiations	γ (β)	β	α, γ	β^+	γ, β
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.				
Risk assessment	The residual risk is low with the control measures in place.				
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.				
During use	This type of source should be held by the non-source end of the aluminium rod, with the source end directed away from the body. *Make sure you know which is the source end*. Only one source should be used at a time. Between investigations, the source should be returned to its container, the source end of the rod goes into the metal cylinder well.				
Inspection	Annually and after use by students. Check the whole source for signs of damage. View the recessed surface using a plane mirror on the bench or remotely with a digital camera. Never point the foil surface towards your eyes. Keep a record of any blemishes, particularly to the source surface.				
Leak test of source	Annually or if damage is suspected. The outer surface should be tested, but avoid contact with the actual active surface of the source.				
Contamination check of container	Not required unless leakage is suspected.				
Storage and labelling	The source should be stored in its metal cylinder, in its original can packaging labelled with a radioactive warning sign and kept in the steel store cabinet.				
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.				
Availability	Currently supplied by SciChem.				
Standard School Holding	The total activity of all sealed sources should not exceed 1.2 MBq. No single sealed source should be above 400 kBq,				

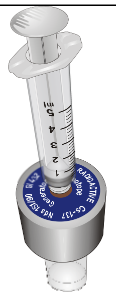
Type number 9a	Protactinium generator (Philip Harris or ScienceScope type) NOT DIY versions. See Type 9b	
Description		A thin-walled fluoropolymer bottles containing an aqueous solution of acidified uranyl(VI) nitrate beneath an organic solvent. The cap is sealed onto the bottle, and there is usually an additional exterior seal. The acid is moderately concentrated hydrochloric acid. The solvent in some designs becomes a thick goo over time, and ceases to work. Keep in mind the limited service life and the cost of disposal. Disposal must be by registered waste carrier, and the costs are currently several £100s.
Use	When the bottle is shaken, protactinium passes into the top organic liquid layer. Its decay can then be investigated by placing a GM tube very close to the organic layer.	
Original activity	Old Philip Harris version: 45 kBq (1.2 µCi). Sciencescope and current Philip Harris version: 20 kBq (0.5 µCi).	
Radionuclide and half-life	Uranium-238: 4.5 x 10^9 years, decay chain thorium-234: 24 days and protactinium-234m: 72 s. Uranium also comprises up to 0.7% uranium-235.	
Main radiations	Mainly β, (α blocked by the bottle wall)	
Hazard	Concentrated hydrochloric acid is corrosive. Organic solvent, depending on design (eg pentyl ethanoate (amyl acetate)), is harmful and flammable. See CLEAPSS *Hazcards* for specific information on chemical hazards. Uranyl(VI) nitrate is toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The external radiation is low. The greatest risk is from contamination if the bottle is damaged through poor handing or storage. The residual risk is low with the control measures in place..	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Do not attempt to make your own protactinium generators.	
During use	Never try to open the generator bottle. Wear disposable gloves, splash proof goggles and lab coat when working with and using the generator bottle. Before use, inspect it for any damage. Use the generator bottle over a tray to contain the solution if it does spill. The bottle may be held by hand, but for no longer than necessary. Shake the bottle gently over the tray. Immediately after use, return the bottle, upright, into its secondary outer container. A spill kit (see *Spills or drop* below) should be readily available. Report spills immediately.	
Inspection	Annually, as well as before any use. Check for any signs of damage or deterioration.	
Leak test of source	Annually or if damage is suspected. Dry wipe around the cap and any suspect areas but do not open the bottle.	
Contamination check of outer container	Annually or if leakage is suspected. Check the container the bottle stands in and clean if necessary. If you find contamination, the bottle or the cap seal is probably failing.	
Storage and labelling	The bottle should be labelled on the lower half, indicating that it is a radioactive protactinium generator. There should also be a label on a cover or a strip of adhesive tape over the cap stating that it must not be removed. Keep the bottle upright in a larger plastic container with a tight-fitting lid. This should also be labelled. Store the protactinium generator bottle, in its secondary container, in the steel store cabinet. If there is a leak from the generator, the secondary container will help prevent hydrochloric acid fumes damaging other sources.	
Spill or drop	Wear a lab coat, splash proof goggles and disposable gloves. Spills of a few cm^3 can be mopped up with a tissue. Contain larger spills with a mineral absorbent and scoop it into a bucket with sodium carbonate and water. Check the surface where the spill occurred for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Version currently sold by Philip Harris and resellers.	
Standard School Holding	No specific limit, other than what is justified for curriculum use. The total mass of uranium held as a radiochemical should not exceed 100 g.	

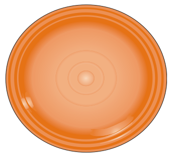
Type number 9b	Protactinium generator (DIY versions) **CLEAPSS now advises that schools do not make protactinium generators.** School-made generators that are over five years old should be disposed of now. If you have one less than five years old, you may keep it for another two years, after which you should dispose of it. Replace it with a type 9a, 11 or 13 source.	© CLEAPSS 2019
Description		A bottle containing an aqueous solution of acidified uranyl(VI) nitrate beneath an organic solvent. There are various designs and recipes, the common organic solvent is pentyl ethanoate (amyl acetate). The acid is moderately concentrated hydrochloric acid. The generators tend not to give good results after several years, probably due to a gradual deterioration of the organic solvent and impurities in it.
Use	When the bottle is shaken, protactinium passes into the top organic liquid layer. Its decay can then be investigated by placing a GM tube very close to the organic layer.	
Original activity	It depends on the formulation.	
Radionuclide and half-life	Uranium-238: 4.5 x 10^9 years, decay chain thorium-234: 24 days and protactinium-234m: 72 s. Uranium also comprises up to 0.7% uranium-235.	
Main radiations	Mainly β, (α blocked by the bottle wall)	
Hazard	Concentrated hydrochloric acid is corrosive. The organic solvent, depending on design (eg pentyl ethanoate (amyl acetate)), is harmful and flammable. See CLEAPSS *Hazcards* for specific information on chemical hazards. Uranyl(VI) nitrate is toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	There is a significant risk from the failure of the cap seal or bottle. The plastic bottles in school-made versions become degraded by the contents, particularly the bottle seals. There have been many cases of serious contamination and damage caused by failed bottles.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.	
During use	Never try to open the generator bottle. Wear disposable gloves, splash-proof goggles, and lab coat when working with and using the generator bottle. Before use, inspect it for any damage. Use the generator bottle over a tray to contain the solution if it does spill. The bottle may be held by hand, but for no longer than necessary. Shake the bottle gently over the tray. Immediately after use, return the bottle, upright, into its secondary outer container. A spill kit (see *Spills or drop* below) should be readily available. Report spills immediately.	
Inspection	Annually, and before any use. Check for any signs of damage or deterioration. If the cap is accessible, check that it remains secure and the bottle has not deteriorated.	
Leak test of source	Annually or if damage is suspected. Dry wipe around the cap and any suspect areas, but do not open the bottle.	
Contamination check of outer container	Annually or if leakage is suspected. Check the container that the bottle stands in, and clean if necessary. If you find contamination, the bottle or the cap seal is probably failing.	
Storage and labelling	The bottle should be labelled on the lower half, indicating that it is a radioactive protactinium generator. There should also be a label on a cover or a strip of adhesive tape over the cap stating that it must not be removed. Keep the bottle upright in a larger plastic container with a tight-fitting lid. This should also be labelled. Store the protactinium generator bottle, in its secondary container, in the steel store cabinet. If there is a leak from the generator, the secondary container will help prevent hydrochloric acid fumes damaging other sources.	
Spill or drop	Wear a lab coat, splash-proof goggles, and disposable gloves. Spills of a few cm^3 can be mopped up with a tissue. Contain larger spills with a mineral absorbent and scoop it into a bucket with sodium carbonate and water. Check the surface where the spill occurred for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Not applicable	
Standard School Holding	No specific limit, other than what is justified for curriculum use.	

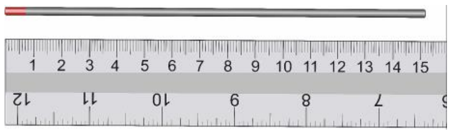
Type number 10	No longer recommended – dispose Radon-220 (thoron) generator (powder version)	
Description		Originally called a thoron generator, but more correctly termed a radon-220 gas generator. It is a plastic squeeze bottle containing about 20 g of a thorium compound in powder form (usually thorium hydroxide or carbonate). Very small quantities of radon-220 gas are produced by the radioactive decay series of thorium. To let radon gas out, but keep the powder in, two discs of chamois leather are fitted in the cap to act as a filter. Some used a muslin bag to hold the powder in the bottle. They usually have a tube and Mohr clip fitted.
Typical dimensions	No standard bottle size, but usually less than 50 mm diameter and less than 150 mm length.	
Original use	Generating radon-220 for demonstrating and measuring the half-life of a radioactive material.	
Original supplier	Panax, Philip Harris, Griffin.	
Radionuclide and half-life	Thorium-232 and decay chain. Thorium-232: 1.4×10^{10} years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Reason for withdrawal from use	The plastic becomes degraded by age and the radiation field. Thorium powder is very radiotoxic by inhalation. The gas mantle version of the radon generator presents a much lower risk.	
Risk assessment	This type of radon generator can present a greater risk than other sources commonly used in schools. These sources are now well beyond their recommended working life and a risk assessment does not support extending their service life given that there is a safer alternative.	
Storage and labelling	*The bottle must not be opened*. Place the radon generator in a sealed bag and label it 'DO NOT USE'. Keep it in the steel store cabinet. Make arrangements to dispose of it promptly	
Spill or drop	Wear a lab coat, disposable gloves and dust mask (FFP3). If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

Type number 11	Radon-220 generator (gas mantle version)	
Description		A polythene squeeze bottle containing thoriated gas mantles (mantles impregnated with thorium oxide). Very small quantities of radon-220 (thoron) gas are produced by the radioactive decay series of thorium. When the generator is not in use, a Mohr clip on a single rubber tube prevents gas escaping. In the version manufactured by Cooknell, the radon generator is connected to an ionisation chamber and an integral picoammeter.
Use	When the bottle is squeezed, radon gas travels along the tube into a port on a separate, closed, ionisation chamber, where the short half-life of the gas can be determined. The exhaust port on the chamber is by fitting a small party balloon over the port. Unsealed systems should not be used.	
Original activity	Typically 6 kBq (0.16 µCi) (four gas mantles).	
Radionuclide and half-life	Thorium-232: 1.4 x 10^{10} years, and decay chain, including radon-220: 56 seconds.	
Main radiations	α, β, γ including emissions from the decay chain.	
Hazard	Thorium compounds are toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The thorium is impregnated into the gas mantle fabric, so the release of any significant thorium dust will be unlikely. Radon gas should not escape if the apparatus is used carefully – even if it did, the concentration in the air would be extremely low. Caution is needed if the bottle splits or the top needs to be removed, as there can be fragments of mantle which could be released. The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Gas mantles are regarded as low-level radioactive artefacts.	
During use	The bottle must not be opened. An extremely small volume of radon gas is required, so the bottle should only be squeezed gently two or three times. The Cooknell ionisation chamber is sealed, and should not be opened.	
Inspection	Annually, as well as before and after each use. If the bottle, filter or tubing show any sign of deterioration or damage, that component must be replaced. If the bottle needs to be opened, special precautions, as for spills and drops below, must be followed.	
Leak test of source	Annually or if damage is suspected. Do not open the bottle. The outer surfaces and the cap should be leak tested by dry wipe.	
Contamination check of container	Not required unless fragments of mantle are suspected of having escaped from the bottle. If so, the plastic storage bag should be checked and replaced if necessary.	
Storage and labelling	With the clip closed, disconnect the tube and bottle from the apparatus. The bottle with tube should be placed in a strong, self-sealing plastic bag and kept in the steel store cabinet. The bottle should have a small label indicating that it contains thoriated gas mantles for generating radon. Another label close to the cap should make it clear that the top must not be removed.	
Spill or drop	If the bottle breaks, the gas mantles may release a few fragments, so care is needed. Wear a lab coat, dust mask (FFP3) and disposable plastic gloves. Carefully pick up the bottle and gas mantles with a tissue and place them in a bag. Dab the bench area with sticky tape to pick up any fragments. Check the area for contamination, and decontaminate it if necessary. See section 9.2	
Availability	Currently sold by Cooknell Electronics Ltd (Weymouth) and Timstar.	
Standard School Holding	No specific limit, other than what is justified for curriculum use.	

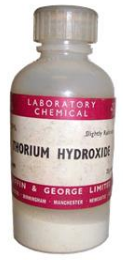
Type number 12	Gas mantles (thoriated)	© CLEAPSS 2019
Description		Gas mantles, intended for use with camping gas and similar lamps, comprise a fabric impregnated with various compounds (to increase luminosity). When first used in a lamp, the fabric burns away, leaving a fragile mesh of ash. Some mantles use thorium compounds because these give high luminosity. These are becoming difficult to obtain as most brands now no longer use thorium.
Use	To show that ‘domestic’ objects may be naturally radioactive. Also useful as a simple check source to test detection equipment is functioning.	
Original activity	Of one mantle, typically 1 kBq (0.03 µCi).	
Radionuclide and half-life	Thorium-232: 1.4×10^{10} years, and decay chain.	
Main radiations	α, β, γ including emissions from the decay chain.	
Hazard	Thorium compounds are very toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	Gas mantles are available to the general public. The concentration of radon in the air would be extremely low. And certainly before the mantle is burnt, there is little risk of inhalation of thorium dust, because the thorium is impregnated into the fabric of the mantle. The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Gas mantles are regarded as low-level radioactive artefacts. Do not use burnt gas mantles because the fine ash easily causes contamination	
During use	Keep the unused gas mantle, including the plastic or cellophane envelope in which it is supplied, into a small sealable plastic bag.	
Inspection	Check that the mantle is in good condition and not fraying.	
Leak test of source	Not applicable.	
Contamination check of container	Not required unless it is suspected fragments of mantle may have escaped from the bag.	
Storage and labelling	Gas mantles should be put in a strong, sealable plastic bag, labelled with a radioactive warning sign and kept in the steel store cabinet.	
Spill or drop	Wear a lab coat and disposable gloves. If a gas mantle is dropped, it is unlikely that any radioactive spill will occur. Check the area for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Camping shops, hardware stores. Many stockists only supply non-radioactive gas mantles, and this is usually stated on the packaging.	
Standard School Holding	No limit, other than what is justified for curriculum use.	

Type number 13	**Caesium-137/barium-137 elution source**	© CLEAPSS 2019
Description		The Isotrak generator comprises a small plastic cylinder containing 33 kBq of caesium-137 absorbed in an ion-exchange resin. When the system is eluted (ie, a special solution is passed through it using a syringe), the decay product barium-137m is removed from the generator in the solution. This allows the barium-137m decay to be monitored with a GM tube. The eluent (low hazard) is a very pure, slightly acidic solution of sodium chloride. Note that an earlier design of this type of generator used a different eluent which is completely unsuitable for the current Isotrak design.
Typical dimensions	Diameter 40 mm, length 60 mm (including two plastic storage caps).	
Use	The generator will yield up to 1000 small liquid samples containing the barium-137m isotope. The short half-life of this can be easily measured.	
Original activity	Typically 33 kBq (0.9 µCi).	
Radionuclide and half-life	Caesium-137: 30.1 years; barium-137m: 2.6 minutes.	
Main radiations	γ (β)	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The dose rate near the surface is low, so in the short time the generator and eluate are handled, the equivalent dose on the hands will be negligible. There is a risk arising from undesirable release of caesium-137 into the eluate. Data from the supplier shows that the bleed-through using the eluent provided with the generator is very low: less than 50 Bq cm^{-3}. The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Only staff who have been trained in using this source should handle it.	
During use	Wear disposable gloves, a lab coat and eye protection. Work over a drip tray lined with absorbent material such as paper. Check that the correct eluent (ie, as supplied with the source) is used. Do not attempt to make your own eluent, it could ruin the source..	
After use	After at least 30 minutes, the eluate can be poured down the drain and flushed with several litres of water. The disposable gloves and paper liner can be placed in a plastic bag, tied off (do not label the plastic bag) and placed in the normal refuse. Monitor the area immediately around where the source was used to check there is no contamination.	
Records	On the use log, record, list the name(s) of anyone who handled the source and note the volume eluted.	
Inspection	Annually, as well as before and after each use. Check for any signs of damage or deterioration.	
Leak test of source	Annually or if damage is suspected, by dry wipe of the plastic body.	
Contamination check of container	Annually or if leakage is suspected. It is sufficient to check the container the source is kept in. Clean if necessary. If you find contamination, the source may be leaking so further investigation is required.	
Storage and labelling	The source should be stored in its original container, labelled with a radioactive warning sign and kept in the steel store cabinet.	
Spill or drop	Wear a lab coat, disposable gloves and eye protection. If a source is dropped, or the eluate is spilt, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Supplied by HTSL and others.	
Standard School Holding	No individual source may exceed 40 kBq. You can hold up to 10 of these sources if you can justify it. Note: the versions of this source above 40 kBq are not exempt from EPR permitting.	

Type number 14	**Uranium-coloured domestic glassware and ceramic items**	© CLEAPSS 2019
Description	 	Glass and ceramic items with radioactive compounds added (eg uranium oxide). These include green vaseline glass and the red/orange glaze on older Fiestaware crockery.
Typical dimensions	Not applicable.	
Use	To show that some domestic items are radioactive. Using a GM tube close to the item, an increased count is demonstrated, compared with background radiation. Vaseline glass may also be shown to fluoresce under ultraviolet radiation (see other CLEAPSS guidance on the safe use of ultraviolet).	
Original activity	Vaseline glass is typically less than 2% uranium by mass. The glaze used on radioactive Fiestaware is typically less than 15% uranium by mass. The count rate by a GM detector can be surprisingly high.	
Radionuclide and half-life	Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: 4.5×10^9 years.	
Main radiations	α, β, γ including emissions from the decay chain of uranium-238 and uranium-235.	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiations of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed. Uranium compounds are also very toxic.	
Risk assessment	The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Do not handle items more than is needed for the demonstration. Be wary of acquiring items that give high surface count rates – above 100 counts per second with a ZP1481 almost touching the glass or ceramic surface with the GM end cap removed.	
During use	Use in a tray, to contain fragments in the event of damage. This also allows direct handling time to be kept to a minimum.	
Inspection	Annually, as well as before and after any use. Items which are chipped or cracked should be disposed of.	
Leak test of source	Annually or if damage is suspected. The outer surfaces of the item should be tested.	
Contamination check of container	Not required unless leakage is suspected.	
Storage and labelling	These items may be kept in protective packaging (eg bubble wrap), inside a sturdy container or strong plastic bag. Use a label with a radioactive warning sign and the words ‘ceramic/glassware with low radioactive content’.	
Spill or drop	If one of these glass or ceramic items is dropped and breaks, the greater hazard will be from sharp edges. However, care must also be taken to avoid contamination from the low amounts of radioactive material present. Wear a lab coat, dust mask (FFP3) and disposable gloves. Use forceps to transfer larger broken fragments onto several layers of newspaper. Carefully sweep up the remainder with a dustpan and soft brush and put it onto the newspaper. Wrap the fragments and dust in the newspaper and bind it with sticky tape. Put it into a sturdy plastic bag and tie it off. Check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Availability	Available through second-hand and antiques dealers.	
Standard School Holding	No limit, other than what is justified for curriculum use.	

Type number 15	Thoriated tungsten welding electrode	© CLEAPSS 2019
Description		Thoriated tungsten electrodes are intended for TIG (Tungsten Inert Gas) welding, and typically contain about 1% or 2% thorium oxide. (Rods with a red tip have 2%.) They may be available in packs of 10 but can usually be purchased individually.
Typical dimensions	Diameter 3 mm, length 150 mm. Other diameters are available.	
Use	Can be used in a diffusion (Taylor) cloud chamber in place of the small radium paint sources, which are no longer available. The cloud chamber may need to be modified by having an additional 3.5 mm hole drilled 7 mm above the chamber floor. The electrode is held in place by inserting it into a bung or cork at each end.	
Original activity	Red-tipped (2%) rods are about 3.2 kBq.	
Radionuclide and half-life	Thorium-232: 1.4 x 10^{10} years, and decay chain.	
Main radiations	α, β, γ including emissions from the decay chain.	
Hazard	Thorium compounds are very toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.	
Risk assessment	The rods are readily available to the general public. The surface equivalent dose rate is very low. The thorium is evenly dispersed throughout the rod (during manufacture, tungsten and thorium oxide powder are sintered into a metal alloy electrode and the thorium is firmly bound into the metal). It is almost inconceivable that thorium could be released, even if the rod were roughly handled. (Small amounts of thorium are released when grinding the electrode, or to a lesser extent during welding.) The residual risk is low with the control measures in place.	
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources. Thoriated tungsten electrodes are regarded as low-level radioactive artefacts. Use electrodes that conform to BS EN ISO 26848:2004	
Inspection	Check that the electrode surface is clean and free from obvious defects.	
Leak test of source	Annually, carry out a simple wipe test (using dry filter paper).	
Contamination check of container	Not required.	
Storage and labelling	Remove from the cloud chamber and put them back in the plastic storage case in which they are normally supplied. Keep with other radioactive sources in the steel store cabinet-.	
Spill or drop	Due to the design, it is almost inconceivable that thorium oxide would be released even if the electrode were broken. See section 9.2.	
Availability	SWP brand, type WT20 supplied through welding supplies shops.	
Standard School Holding	No limit, other than what is justified for curriculum use.	

Type number 16	No longer recommended – dispose Uranyl(VI) nitrate-6-water (uranyl nitrate) See source type number 17	
Description		

Type number 17	No longer recommended – dispose Uranium and thorium compounds as radiochemicals (including uranyl nitrate)	
Description		These are classed as unsealed sources. Often their use was not related to their radioactive properties. Uranyl zinc acetate and uranyl magnesium acetate are laboratory reagents that were used to test for sodium. Uranyl acetate, uranyl zinc acetate and uranyl magnesium acetate are used as stains in electron microscopy. Uranium oxide was used in glazes to give green and orange colours. One of the Panax kits has sachets of uranium and thorium compounds to show their radioactivity.
Typical dimensions	Not applicable.	
Original use	Various.	
Original supplier	Various.	
Radionuclide and half-life	Uranium - mainly uranium-238 with up to 0.7% uranium-235 - and decay chains. Uranium-238: 4.5×10^9 years. Thorium-232 and decay chain. Thorium-232: 1.4×10^{10} years.	
Main radiations	α, β, γ including emissions from the decay chains.	
Reason for withdrawal from use	No relevance to the current science curriculum. Uranyl nitrate should not be kept because school-made protactinium generators are no longer recommended.	
Risk assessment	The risk cannot be justified because the radioactive substances are redundant in schools.	
Storage and labelling	Place each bottle or sachet individually in a sealed bag and label it 'DO NOT USE'. Keep them in the steel store cabinet. Make arrangements to dispose of them promptly.	
Spill or drop	Wear a lab coat and disposable gloves and dust mask (FFP3). If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.	
Disposal	See section 12.	

Type number 18	**Uranium oxide encapsulated disc source** © CLEAPSS 2019
Description	 Uranium oxide is encapsulated in a thin envelope, usually an aluminium planchet with an aluminium face permanently sealed together. This source came from the Joint Matriculation Board (JMB) in the 1970s and they were supplied for an A-level practical examination.
Typical dimensions	Diameter 20 mm, thickness ~2 mm.
Use	Used as a check source, mainly a beta emitter from the Pa-234m in the decay chain.
Original activity	JMB version is 1.1 kBq (0.03 µCi).
Radionuclide and half-life	Uranium oxide. Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: 4.5 x 10^9 years.
Main radiations	α, and β emissions from the decay chain. α emissions blocked by the aluminium envelope.
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed. Uranium oxide is also very toxic.
Risk assessment	The residual risk is very low with the control measures in place.
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.
During use	These sources should be handled by the edges, either by gloved hand, or with plastic forceps. Avoid metal tongs or other tools that could damage the source envelope. The metal front is quite thin and could be punctured by careless handling.
Inspection	Annually and after use by students.
Leak test of source	Annually or if damage is suspected. Check for evidence of the seal failing around the circumference of the source.
Contamination check of container	Not required unless leakage is suspected.
Storage and labelling	Make sure there is durable labelling on one side of the disc stating the activity and that it is uranium oxide. The source can be kept in a small plastic container and kept in the steel store cabinet.
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.
Availability	These sources have not been available for many years. Replacement school-made sources are not recommended.
Standard School Holding	No specific limit, other than what is justified for curriculum use. The total mass of uranium should not exceed 100 g.

Part C: Further guidance

This section is written for the RPS (Schools). It is what you as the RPS (Schools) need to know additionally on keeping, working with and disposing of sources.

7 Roles and responsibilities

7.1 The role of the RPS (Schools)

7.1.1 Working with radioactive sources

You have the day-to-day responsibility for the security, safe storage, use and monitoring of radioactive sources in the school, and for ensuring that staff understand the Standard Operating Procedures and model risk assessments. You should be based at the school, but it is not essential for you to be actually on site for the routine use of the sources by an authorised teacher or technician. If you know the sources are going to be used when you are off site, make arrangements so you can be contacted if the need arises.

You need to:

- be directly involved with work using ionising radiations, including practical teaching;
- be able to exercise the authority to ensure that all work with radioactive sources follows the school's Standard Operating Procedures and specific risk assessments;
- be aware of the hazards, risk assessments and control measures for each radioactive source kept by the school or college;
- be able to supervise, though you need not be present all the time;
- make sure that all teachers and technicians (especially new ones) who need to handle or use sources have had the training they need; and
- know what to do in an emergency (see section 9).

The head of science has the main responsibility for monitoring that teaching is effective and safe, not the RPS (Schools). If you become aware of unsafe practice in teaching practical radioactivity, or staff not complying with the Standard Operating Procedures, you should inform the head of science.

7.1.2 Training of other members of staff

Teachers and technicians will often be working with sources and supervising practical work, so you must be satisfied that everyone involved is well-enough informed and trained to carry out these procedures safely. The training could be carried out in-house, eg at departmental meetings.

You need to provide basic in-school training, which should cover:

- the importance of following the Standard Operating Procedures;
- security and storage arrangements;
- record keeping;
- how to handle each type of radioactive source safely using the specific risk assessments;
- the general principle of keeping exposure as low as possible;
- choosing the right equipment for detecting radioactivity;

- how to set up and use the equipment correctly, particularly monitoring equipment;
- appropriate methods for carrying out standard school experiments;
- what to do if a source is dropped or spilt, and other contingencies; and
- when to seek help and advice from the RPS (Schools).

Training is particularly important for newly qualified or newly recruited staff. Don't assume any prior knowledge – equipment often differs considerably from school to school. Keep a brief record of the training provided.

You should compile a list of all the teachers and support staff who are authorised to handle the radioactive sources (see section 16.6 for a template). The list could be kept with the use log (see sections 8.2 and 16.5) or included as an appendix to the science department's health and safety policy. The list needs to be kept updated as staff move on and new staff are trained. Otherwise, this can contribute to poor security.

7.1.3 Complete a copy of the Standard Operating Procedures and contingency plans

We suggest you put a copy of the Standard Operating Procedures for your school or college (from the model in section 6.6) and contingency plans (see section 9) where they are easily available to the teachers and technicians. You need to keep the Standard Operating Procedures up-to-date. You could keep a laminated set of them with the apparatus used for teaching about radioactivity.

Make any additional notes to the Standard Operating Procedures – eg, if the store cabinet is in a store room that opens into a busy corridor, then collecting the sources needs to be avoided at lesson changeover. It might also be useful to include the location and contact details in the science department's health and safety policy.

7.1.4 Checking that the specific risk assessments are suitable for your school

You should check that the specific risk assessments for different sources cover the circumstances of your school. The risk assessments assume the students are suitably mature and well-behaved. If there are serious behaviour problems in a particular class, use of radioactive sources may be inappropriate.

Make sure you have specific risk assessments for all the sources you hold. If you are unsure whether a specific risk assessment applies, contact CLEAPSS or your RPA for advice. It may be possible to adapt specific risk assessments a little in some circumstances, but this has to be agreed with your RPA.

7.1.5 Security and monitoring

To ensure that all radioactive sources in the school are kept safely and securely, you must make sure:

- the radioactive sources are all accounted for and kept in a secure store;
- all equipment is maintained in good working order;
- the radioactive sources are all inspected and monitored for contamination periodically (see section 11); and
- all the records required are accurate, up-to-date and kept in a secure place. See section 8.

You must be confident that each time after radioactive sources have been used, they have all been put back in the store, and that the use log has been completed. If a source becomes lost, it is helpful to know when it was last seen. So, once a month, and at the start and end of the summer vacation, you should arrange a simple visual check of the steel store cabinet just to see that the containers of the sources are inside and the sources are in their containers. For example, for the sealed sources housed in lead pots in wooden boxes, open the box lid, then lift the inner lead lid just a little with long forceps to check there is a source in the pot. It is not necessary to actually take the source out of its immediate container. Make a simple record of the check in a log book (see section 16.3 for a template). This task could be done by a technician. It doesn't count as a 'use' and doesn't need to be logged in the use log.

At least once a year a more detailed store check is needed[1]. For a detailed check that the sources are all present in the store, each container needs to be removed from the store and opened, and the source checked to see that it accords with the container labelling and the inventory. This needs to be recorded (see section 16.8 for a template). This counts as a 'use' of the sources, so it should also be recorded as an entry in the use log. The detailed check could be done at the same time as the leak tests are carried out.

7.1.6 Making sure leak tests are undertaken

Once a year, arrange for the sealed sources to be leak tested. Section 11 explains how to do the testing. This could be done at the same time as the yearly inventory check.

7.2 The role of the Radiation Protection Adviser (RPA)

The role of the RPA has been defined by the Health and Safety Executive (HSE). The RPA has a duty to advise the employer on radiological protection and compliance with the Ionising Radiations Regulations.

There are various statutory matters on which a employer must consult an RPA, but many of these would not normally apply to schools. The matters that are likely to be relevant are:

- appropriate risk assessments for each activity involving work with ionising radiation;[2]
- drawing up contingency plans;
- selecting and using personal protective equipment (PPE);
- storing and accounting for sources; and
- training.

An RPA may also give pragmatic advice on radiological protection matters, such as acquiring suitable sources. While this guide gives advice for schools that RPAs will be happy to endorse, it does not remove the need for employers to appoint RPAs.

7.2.1 Visits to schools and colleges

If an individual school or college appoints their own RPA, the RPA (or a competent representative) will usually want to visit the school occasionally to monitor what is

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[1] . A year is an appropriate interval between detailed store checks given that the use log is always completed correctly, the steel store cabinet is always locked and the key is kept securely, and monthly simple checks are made.

[2] Specific risk assessments for the radioactive sources used in schools are provided in section 6.6.

going on, although there is no legal requirement for this. If the local authority or other organisation uses the CLEAPSS RPA scheme, a trained officer from the local authority/organisation, called the RPO, will visit instead.

Emergencies involving ionising radiation in schools are very unlikely. If an emergency does happen, the RPA can be expected to give advice. However, the RPA is not responsible for dealing with the emergency, clearing away any contamination or disposing of unwanted or damaged sources. These are all the responsibility of the employer, and led initially by the RPS (Schools).

7.3 The role of the Radiation Protection Officer (RPO)

See CLEAPSS guide RPA002 for more details. This role applies to the CLEAPSS RPA service (see section 3.4.1). In this scheme, a local authority or other organisation appoints one of its officers as a Radiation Protection Officer (RPO). (This is not a legal term, just a convenient description of their role.) The RPO is the link between the schools and the RPA. The schools in the scheme will not normally need to contact the RPA directly, except perhaps in an emergency. CLEAPSS provides training for RPOs in the scheme.

In this scheme, the RPO will visit each school periodically to monitor whether they are managing the radioactive sources properly, and reassure their employer that the arrangements for radiation protection are working. The RPO should not routinely send the RPA copies of reports. Any shortcomings identified in the report need to be resolved by the Head of Science. It is not for the RPA to chase up.

The RPO must give information to the RPA about the sources held by the schools. The advice given by the RPA is passed on to the schools by the RPO, and the RPO ensures that it is implemented.

8 The records that are required

The school must have an appropriate record-keeping system to account for the radioactive substances and show they are being managed correctly. Keep the records securely (paper and digital) so the information can't be accessed by unauthorised people. This applies equally to personal data (which comes under the General Data Protection Regulation). Records can be kept digitally but make sure you have backups, and equally secure. If the record requires a signature, print a copy periodically and sign it, and discard the previous printed copy.

8.1 Records of history, maintenance and disposal of the sources

Keep an individual record for each source – ie, the radioactive source history – including, where possible, the:

- unique name or reference number, including the serial number if there is one;
- radionuclide (and chemical name for radiochemicals);
- original activity of the parent nuclide;
- delivery date and supplier; and
- information from the supplier that came with the source;

Keep this securely for as long as the source is kept. This is part of the conditions for exemption from needing a permit for the source.

See section 16.4 for a template. Keep results of inspections and leak tests on these individual records. If you no longer have the source, the history should include details of its disposal. If it was not disposed of through the normal refuse collection or sewerage system, the record should include written confirmation from the organisation accepting responsibility for it (including the name and address). When you dispose of a source, it is essential to update your inventory to reflect the change.

8.2 Use log

The use log should be completed every time a radioactive source is removed from, or returned to, the store. It should show:

- which source was used;
- the date and time when the source was removed from the store (with a signature);
- the name of the member of staff supervising the source while it is used;
- the teaching group (including the names of any students aged 16 years and above who used the source*);
- the date and time when the source was returned to the store (with a signature confirming that the source is present in its container); and
- any other comments.

See section 16.5 for a template. For data protection, the teacher should make the entry on behalf of the students so that the students cannot see previous entries. Or, use a new log sheet for the student(s) using the sources during that lesson. Explain to the students that the record is destroyed after 10 years (or the period specified by your school data retention policy).

8.3 Inventory records, and store-check records

Keep an up-to-date inventory of the radioactive materials you hold. See section 16.2 for a template. Keep records of the simple monthly store checks, and the annual inventory check. See section 16.3 and 16.8 for templates.

If your source inventory is a paper record only, it is good practice to keep an up-to-date backup copy securely in another building (for instance in the school office) in case the original is damaged in a fire, etc.

8.4 Retention and disposal of records

This applies to sources that are (or were) within the Standard School Holding.

Records that are no longer of any use may still hold sensitive information. Discarding records needs to be done so that the information cannot be recovered, and stopping it getting into the wrong hands and being used maliciously. Follow your employer's guidance on data retention, including how to discard information. However, your employer's guidance may not mention retention of records relating to radioactive sources specifically, in which case the following may be helpful.

The Ionising Radiation Regulations require leak test results to be kept for only two years or until the next leak test. However, we recommend keeping previous results for six years so that you can check there is no trend of rising contamination, particularly from radium sources which can cause small amounts of radon. The detector test record can be discarded when a new test is made.

We recommend discarding data in use-log records that is over 10 years old. Store check records must be kept for two years, so we recommend you discard records dating two years before the latest entry in the record.

Keep a list of authorised users - see section 16.6 for a template. Retain the up-to-date list, discard any that are out-of-date. There is no requirement to keep a record of previous authorised users.

See section 10.2 for retention of transport records.

8.4.1 Investigation reports

Investigation reports arising from an unauthorised dispersal, or wrongful disposal, or loss, or theft of radioactive material need to be retained for two years.

The analysis from the investigation arising from carrying out some or all of your contingency plans must be kept for two years from the date of the investigation, and where relevant, details on who was exposed and an estimate of the doses received. In rare circumstances, dose records need to be retained for 30 years or until the affected person(s) is 75. Contact CLEAPSS or your RPA before discarding such records.

8.4.2 Records of disposal

You do not need to keep records of disposal of very low level waste (eg used gloves, wipes etc) that goes in black bags directly into the dustbin with normal waste. Records for disposal of consumer items that can be purchased in shops (eg smoke detectors and thoriated TIG welding rods) that are disposed of with normal waste need only be kept for the current school year plus one further year.

For other radioactive waste, including sealed sources, thorium and uranium waste (solid or liquid) we recommend you keep a record of disposal for at least 10 years. See section 16.12 for a template. For sources that were originally part of a kit or equipment, we recommend you keep a record of disposal for ten years after the disposal of the rest of the kit or equipment. Otherwise, someone in the future, not knowing what has happened to the sources, may start an unnecessary investigation which might lead to reporting to the regulators. You should discard the source history record of a source when you discard the disposal record for that source.

If sources are disposed of through a registered waste carrier, you must keep the receipt paperwork from the registered waste carrier for at least two years. You must also retain the last leak test results for two years after the disposal. If the source is disposed of as hazardous waste, you must keep the consignment notes for at least three years – see section 12. You should receive a return from the final waste site, and this must be kept for three years.

8.4.3 School closure

If a maintained school closes, the records relating to radioactive sources held should be passed to the local authority or MAT, which could then lodge them with the County Record Office or equivalent (for a fee). If an independent school closes, the management should consult the Information and Records Management Society, Chester House, 68 Chestergate, Macclesfield SK11 6DY (tel. +44 (0)1625 664520), e-mail info@irms.org.uk

9 Managing incidents involving radioactivity

This section provides procedures for incidents, and contingency plans for exceptional circumstances, for schools working with the Standard School Holding.

As the RPS(Schools), you have the role, initially, of leading on managing the serious incident. In emergencies, contact CLEAPSS or your RPA (or RPO). Where emergency services become involved, they will take over the lead but you will likely be required to liaise with them.

It is important to distinguish a minor incident from a serious one. A minor incident does not cause contamination or exposure of any great concern, but the opposite is true for a serious one. A serious incident needs a contingency plan to be implemented; a minor incident does not and can be managed by straightforward laboratory procedures.

Serious incidents are rare in schools. The incidents that CLEAPSS hears about mostly relate to loss of the sources rather than anything else. Nevertheless, you should read through this section so you know what to do. It is good practice to keep a durable copy of all your plans and procedures – you can do this by printing this section (amended at the end with any additional information relevant to your school or college), laminating it and keeping it where it is easy to find quickly. Bring it to the attention of all staff authorised to use the radioactive sources. Make sure they know that any radiation incident should be reported promptly to you.

9.1.1 Personal protective equipment for people dealing with an incident

Whatever the type of incident, wear the appropriate personal protective equipment, particularly if it involves unsealed radioactive material. This is, usually, at least a lab coat, disposable gloves and eye protection. If fine powders are involved, such as from an old radon generator, wear an FFP3 disposable dust mask. And if a protactinium generator containing hydrochloric acid is spilt, wear suitable goggles or face shield.

9.1.2 Investigating and reporting an incident

After an incident has been resolved, you should investigate what caused it, and look at what needs changing so a recurrence is unlikely. It might mean, for example, improving your training procedures.

If you have to carry out some or all of your contingency plans, then an investigation by your employer is mandatory, along with changes that need to be made to reduce the chances of a recurrence. The employer must keep a record of the analysis for two years from the date of the investigation, and where relevant, who was exposed and an estimate of the doses received. This is likely to need advice from your RPA. See section 8.4.1

Loss, or large releases, of radioactive material must be reported to the regulators. See section 9.3.4 and 9.5

9.2 Minor incidents

Minor incidents include:

- a bench spill of a few millilitres of liquid, or a few grams of crystalline solid;
- a cup-style sealed source dropped onto the bench or floor;
- a fire drill or false fire alarm causing an evacuation of a lab (as part of a whole-school evacuation) during use of the sources;

- a trace of contamination on the hand or lab coat, of low activity, unlikely to cause skin damage, noticed immediately and easily removed.

Small amount of solid materials (eg uranyl nitrate): this can be swept carefully onto filter paper using a flat blade, and returned to an appropriate container.

Small amount of spilt liquid: cover the spill with a mineral absorbent (or tissues for very small quantities). See 12.4.2 for treating and disposing of the absorbent.

Dropped sealed source: pick it up with the handling tool and put it back into its normal container. Take it out of service immediately. Check the bench or floor area with a GM detector to confirm there has been no loss of radioactive material. After dropping a sealed source – or after any other event that may have damaged its integrity – carry out a visual inspection and leak test soon after following section 11.3.1 of L93. Do the visual examination indirectly, eg with a plane mirror or camera. If the source is undamaged and passes its leak test, it can be returned to use.

Fire alarm while the sources are in use: follow the school or college's fire safety procedure. Safety of people takes priority. If a source is in use when the alarm starts, return it to its immediate container if this can be done quickly. Do not take the sources outside of the lab or prep room – it is too easy to misplace them in the emergency. Tell the senior fire warden, and the Fire and Rescue Service if they attend the alarm, where the sources are. Also tell the RPS (Schools) as soon as possible. You must not return to the building until the senior fire warden says it is safe to do so.

For alarms that turn out to be a drill, a false alarm, or a minor fire far from the laboratory, when it is safe to return to the building, make sure that the RPS (Schools) or another authorised member of staff is allowed back into the building first so they can secure the sources before the students return. Your school fire evacuation procedure should flag this.

For a fire that could have damaged the sources, see section 9.3.5

Trace of contamination on the hand or lab coat; this relates to low-consequence contamination easily removed. If the contamination is on the lab coat, remove it promptly and carefully so as not to spread the contamination, then bag it for separate washing. For minor contamination on hands (or forearms), noticed immediately, place the skin promptly under a gently-running tap and wash off the contamination, avoiding splashing. Then cleanse the affected part by washing the skin gently with soap and cool water. Do not use solvents, or excessive rubbing, which might drive the contamination further into the skin and make things worse. For more serious personal contamination, refer to contingency plan 9.3.1

9.2.1 If a source is misplaced

If a source is missing, act promptly. First check carefully that it has not been:

- placed in the wrong container after use;
- placed in the wrong store after use;
- left inside the piece of equipment where it was last used.

If the source is located soon after it was mislaid and has caused no exposure of any concern, you should find out why this happened and make changes so it is unlikely to happen again.

If it transpires the source cannot be found, or has been stolen, this is more serious – see section 9.3

9.3 Contingency plans for serious incidents

It is inappropriate to rehearse these contingency plans. But they should link to your science department's other contingency plans. We advise that the radiation contingency plan does not feature in the school critical incident plan. (A CIP covers major disruption of whole school functioning, eg dangerous intruder, major fire, death of students. With school teaching sources, nothing is reasonably foreseeable that would directly bring the whole school to a halt.)

9.3.1 More serious contamination on a person

Decontaminate external contamination as soon as possible.

- Remove contaminated clothing and place it in a strong plastic bag, to be washed separately or disposed of.
- If the skin is contaminated, decontaminate it by washing with cool water, soap and soft tissues. Avoid spreading the water onto uncontaminated parts of the body. Extensive skin contamination may need removing by washing in a shower. Cleanse gently to avoid skin damage. Only if necessary, use a soft nail brush to gently scrub off more persistent material. Do not use solvents, or excessive rubbing, which might break the skin or drive the contamination further into the skin and make things worse. Put used tissues in a plastic bag for disposal.
- If the eyes are contaminated, irrigate them continuously for at least 10 minutes with gently flowing clean water – eg, using a rubber tube fitted to a cold water tap, just as you would for any other chemical in the eye.

If possible, do any straightforward cleansing and irrigation over a sink not too far from the area where the spill occurred; this will help stop the spread of the contamination to other areas. Continue the decontamination until all the radioactive material has been removed from the person.

9.3.2 Urgent medical treatment also required

Where people need urgent medical attention, call the emergency services and explain fully the nature of the incident, including details of any contamination. You may start to decontaminate the person as long as it does not aggravate their injuries or interfere with any first aid treatment. If significant radioactive material has entered a person's body, you need to call the emergency services, even if there are no other injuries, because the person must be given urgent medical attention.

The ambulance or paramedic service will give advice and will decide where the medical treatment should be given. You should inform your RPA, who may liaise with the emergency services on matters such as monitoring.

Follow your school or college's normal procedures for injury incidents. Treatment of the injured is the first priority, but take reasonable steps you can to reduce any contamination spreading. If there has been significant radioactive contamination, the first aider should wear appropriate personal protective equipment.

9.3.3 Large spills and contamination

Evacuate all people from the area who do not need to be there.

Contain the spill

An important and immediate thing to do after a spill is to stop the radioactive substance (and any other hazardous material) from spreading further. The actions to take depend on the type of spill. Do not use methods that will cause dust or aerosols.

Spilt liquids: place mineral absorbent, or towels, around the spill to stop the liquid spreading, particularly into drains or into the fabric of the building. To clear up, carefully retrieve the liquid where practicable and put it into a container, rather than using more mineral absorbent. There are several options depending on the type and activity of the liquid. For aqueous solutions of uranyl compounds, a large syringe is probably the simplest method. Contact CLEAPSS or your RPA for advice first.

Spilt powders (eg thorium powders used in old radon generators): cover the powder and the surrounding area with damp tissues or paper towels. Keep air disturbance to a minimum, eg close windows and doors. When the area has been secured and there is no risk of further spread of contamination, call CLEAPSS for special risk assessment and procedure, SPRA132, for dealing with powder spills.

9.3.4 If a source is lost or stolen

If straightforward checks have been made and the source has not been found, you need to organise a thorough search of all the science stores, labs and prep room(s). Check also waste stores. Use a torch to check in dark corners of drawers and cupboards. Completely empty the store cabinet. If necessary, members may consult CLEAPSS for suggestions. We emphasise the importance of double-checking.

If the search still fails to locate the source, someone in the school, usually the RPS (Schools), should tell the RPA. If the total amount lost, including other losses of radioactive material in the last 12 months, exceeds specified limits, you must report it to the environmental regulator and the HSE. The regulators may prosecute if you lose a source. The specified limits (which are much lower than those for unintended releases) for common school sources are given in the following table.

Radionuclide	Reporting threshold
Co-60	1 MBq
Sr-90+	100 kBq
Cs-137+	100 kBq
Ra-226+	100 kBq
Th-232 sec	10 kBq
U-238+	100 kBq
Pu-239	100 kBq
Am-241	100 kBq

(The suffixes 'sec' and '+' mean that the threshold relates to the activity of the parent radionuclide alone: there is no need to take into account the decay chain.)

For other radionuclides, the reporting threshold is column 6 of schedule 7 in the Ionising Radiations Regulations 2017 (the values are the same for all of the UK).

Suspected theft: If you suspect that the source has been taken unlawfully, the head teacher may also need to inform the police, particularly if there is reason to suspect that the source may be used for causing injury or scare in the community.

9.3.5 Major fire

If there has been a fire in which the sources may have been damaged, contact CLEAPSS and your RPA promptly for advice. Do not go into the area where the sources are located. This is a task for specialists in radiation protection and is usually arranged by the insurers. Obtain a copy of the inventory of sources so you can advise those undertaking the remediation.

9.3.6 Final monitoring, and disposal

After decontaminating and clearing up, it is important to carry out a reassurance test that any contamination on surfaces and equipment has been completely removed. Contamination may not be visible, so you need to check with a detector. Scan the area with a GM tube, keeping the end window within 5 mm of the affected surface but not touching it. The GM tube could be supported close to the surface using a clamp and stand (with the base on an uncontaminated surface). Investigate any places where the count rate seems to be higher than the background rate. If a 100 second count of the activity in a suspect area shows more than 1.5 times background, clean the area again using tissues and a detergent solution. Do this until further readings show the suspect area is at the background rate.

If the RPS (Schools) has any doubts about the success of the clean-up, the area must be protected, access to it must be restricted and appropriate warning notices put up. Contact CLEAPSS or your RPA for further advice. For example, you may need more sensitive instruments for monitoring contamination than are available in the school.

9.3.7 Reporting an unintended release of radioactive material

When any radioactive material has been released (other than by lawful disposal), if its activity is over certain limits, you must report this to the HSE and the environmental regulator. The limits are high enough that it is unlikely a school could exceed them if its sources are within the Standard School Holding, but contact CLEAPSS or your RPA for advice if you are not sure if an unintended release is reportable.

Additional notes:

10 Transporting radioactive sources

If you are permanently relocating the sources to a new site, see also section 4.3.

This section is for schools who wish to transport school radioactive sources between sites, by car, for themselves. See section 10.8 if you decide to use a commercial parcel carrier.

Transporting school radioactive sources by road should be kept to a minimum. If sources are often used in laboratories on different sites, it is better to have a separate store and set of sources at each location. If necessary, under these circumstances, the Standard School Holding may be exceeded for the school as a whole, as long as each site's sources are within the Standard School Holding.

Radioactive substances should never be transferred permanently to other schools or organisations without informing the employers involved, the RPA, and the RPOs where relevant.

The transportation of all radioactive substances is regulated by The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations. When packed correctly and following the procedures set out in this section, any source covered by the Standard School Holding will count as an 'excepted package', and this reduces the extent of the regulation considerably. But you still need a risk assessment and transport contingency plans, which this section gives you.

Check that the driver's car insurance is valid for transporting excepted packages. It may help to reassure insurers by explaining that the typical sealed sources are only one order of magnitude greater than the activity of domestic smoke detectors.

If you are unsure about transporting any radioactive material, ask CLEAPSS for advice. In some circumstances, your RPA may also be willing to advise you on this.

10.1 Registration with the HSE (HSENI in NI)

Transporting radioactive sources by public road is a practice, which means it needs to be registered beforehand with the HSE. If your registration does not include transport, then the employer will need to amend the registration to include it. See section 3.5.4.

10.2 Transport document

A transport document must be prepared – a copy should be kept at the school and the driver must take one with the package. The only information legally required for excepted packages is the names and addresses of the consignor and consignee, and the relevant UN number. However, it is good practice to sign and date the document and give a brief description of the contents of the package. There is an example of a suitable document in section 16.10.

Note the terms commonly used in transporting: a *consignment* is the package for transport, which is sent from a *consignor* to a *consignee*, by a *carrier*.

10.3 Transport risk assessment

The three main risks are loss of the sources, theft of the sources, or release of radioactive material following a vehicle incident. The risk of loss of theft can be kept low by driver awareness training. The risk of release can be kept low by good packaging.

10.4 Driver awareness training

If radioactive material is transported as excepted packages, no special driver training is required. However, drivers should have awareness training, which should include what to do in the event of an incident (ie a transport contingency plan[1]). This condition could be met if the driver is a member of the science staff who is familiar with working with the sources, and given a briefing by the RPS, using the following:

> Before leaving, you must:
>
> - Check that there is a completed consignor's certificate (transport document – see section 16.10 of L93) with the package(s), and that the number of packages tallies with the certificate.
> - Make sure there are clear arrangements by the consignee for the safe receipt of the sources at the delivery address. The sources must be formally handed over directly to a responsible person, and preferably signed for.
> - Check that the package(s) is/are in good condition for road transport.
> - Put the package(s) securely in the car, as far away as possible from the occupants, preferably locked in the boot if there is one.
> - Plan to take the most straightforward route. Where practicable, have sufficient fuel for the journey.
> - Have arrangements in place for backup transport in case the vehicle breaks down (eg membership of the AA, RAC or similar).
> - Carry a mobile phone with emergency contact numbers so you can communicate any problems promptly.
>
> En route:
>
> - Do not leave the vehicle without reasonable cause; if you have to leave it unattended – lock it.
> - In the event of a breakdown or minor accident in which no one is injured and the radioactive packages are undamaged, you should let the consignee know that there will be a delay and if necessary use the backup transport arrangements.
> - If there is a more serious incident (eg theft, loss or likely damage to the package), you should also tell the local police immediately, giving them details but taking care to avoid overreaction. You should also report the incident to your employer and make notes of the incident as soon as possible, as this could be useful in assessing exposure.

10.5 Packaging for excepted packages

The package must be able to hold its contents securely under any conditions likely to arise during routine transport. Also, the dose rate at any point on the external surface of the package must not exceed 5 μSv/h. This could be achieved by shielding or by packing the source at the centre of a relatively large container, making use of the inverse square law. If the guidance below is followed, these requirements will be met.

- **Strontium-90, plutonium-239 and americium-241. Cup or Isotrak type**, in their normal containers and shielding, can be transported in a stout cardboard box.
- **Radium-226, cobalt-60 and Caesium-137. Cup or Isotrak type** will require special packaging (unless the cobalt-60 has decayed to a low level) to bring the surface dose rate below the specified limits. You can do this by using a large cardboard box, packed with smaller boxes, so that the source normal container and shielding is at least 150 mm from any surface of the outer box. Only one source per package.
- A **uranium or thorium compound** (in an appropriate container) must be carried inside a screw-top plastic bottle inside a robust container, usually metal (eg a tool box), so that it is extremely unlikely to be damaged in a road accident.

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[1] See www.onr.org.uk/transport/emergency-arrangements-guidance.pdf for further details

- Transporting radioactive material in solution should be restricted to a 30 cm^3 protactinium generator. The generator should be put upright in a tough screw-top plastic bottle along with mineral absorbent (eg cat litter), sufficient to absorb twice the volume of liquid in the container. The screw-top bottle should be then securely packed inside a robust container, usually steel (eg a tool box), so that it is extremely unlikely to be damaged in a road accident.

Packages used more than once for transporting radioactive material should be checked that they have not become contaminated. It may be convenient to do this at the same time as other monitoring tasks are carried out. Keep a copy of the transport documents or consignment notes (see section 10.4) with a record of any checks for contamination on the packaging. Keep these records for at least two years.

10.6 Labelling for transport

No external signs are required on the vehicle.

The outside of an excepted package should show the relevant United Nations (UN) number and the names and addresses of the consignor and consignee. See section 16.11 for label templates.

The UN number is:

- **UN2910** for sealed sources, protactinium generators, uranium and thorium compounds, and cloud chamber sources.
- **UN2911** for 'instruments and articles', eg, expansion cloud chambers with non-detachable radioactive material.

The package itself must be marked 'Radioactive' on the internal surface with the standard radioactivity warning symbol. This label should be visible when the package is opened. Each item inside the package should also be suitably labelled.

10.7 Delivery of the sources

Deliver the sources directly to a responsible person who takes them promptly for secure storage in the science department. Check that these arrangements are in place before setting off. There have been incidents at schools where sources have been lost when the person delivering the sources just left them with the school reception.

10.8 Using a commercial parcel carrier

If you use a commercial carrier to transport your sources, take reasonable steps to select a suitable one. The carrier will probably have appointed a dangerous goods safety adviser, although this not a legal requirement if the carrier transports excepted packages only. The carrier must have obtained authorisation (registration or consent) from the HSE for the transport of radioactive material, including excepted packages and it would be reasonable for you to ask for evidence of this. We advise that you use a well-established carrier, and use a service that tracks your parcel. The driver must have been given awareness training for transporting excepted packages – you should ask for evidence that this has been done. You must tell the carrier exactly what is in your package, and check that the carrier has suitable emergency arrangements. You retain the responsibility for preparing the consignment note, and classifying, labelling and packaging the radioactive material. A carrier may want to do this on your behalf to make sure they are legally compliant. This is no problem, but you still need to make reasonable checks that it has been done correctly.

11 Maintenance of sealed sources and detection equipment

11.1 Suitable detection equipment

In schools and colleges, this equipment is usually a GM tube connected to a suitable measuring instrument; see CLEAPSS guide GL138 *Choosing a Geiger-Muller tube and a counter or ratemeter*. The low count rates involved in leak tests and contamination checks mean that the measuring instrument should be able to count discrete pulses from the GM tube. This type of instrument is known as a counter or a scaler.

Small diameter GM tubes (such as those often supplied with data-logger sensors), although adequate for many standard experiments, are not suitable for monitoring, because the window area is too small to reliably sweep across a surface and detect contamination. A thin-window GM tube (2-3 mg cm^{-2}) of at least 15 mm diameter is needed. For example, the ZP1481 GM tube (previously MX168) used for many years in schools. The LND72233 is an equivalent GM tube.

Formal calibration of the monitoring equipment is not required. It is expensive and unnecessary in normal circumstances for schools working with the Standard School Holding. If really necessary, the RPA may be visit the school with a calibrated instrument. However, this would usually involve a charge.

Occasionally, you may need to carry out more sensitive checks for contamination or dose rate. For example, when disposing of a source a specialist contractor might require this information. This might require more sophisticated monitoring equipment. Contact CLEAPSS for advice, or your RPA if you are not a member of CLEAPSS.

11.2 Leak tests and contamination checks

A sealed source 'leak' is when radioactive material becomes loose from the source; ie, the seal fails, and the loose material contaminates areas outside the source. Leak tests are performed on the sources themselves, while contamination checks are carried out on source containers, stores or surfaces where radioactive material may have been deposited. A sealed source is not necessarily 'leaking' just because you can detect radiation immediately outside its container. It is rare for sealed radioactive sources used in schools and colleges to be damaged, or to fail.

All sources should be inspected, but leak tests do not apply to all sources. Leak tests should be carried out only on sources as detailed in the specific risk assessments in section 6.7.

11.3 Frequency of inspection and leak tests of sealed sources

Annually (and any time you suspect the source may have been damaged, for example, if dropped on the floor). The Approved Code of Practice (ACOP - IRR17) says tests should be carried out at least every 2 years. Some take this to mean that a test every two years meets the regulations. It doesn't. Most school sealed sources are well beyond the nominal recommended working life given by the manufacturers. The justification for extending their working life is by more frequent checks. The HSE makes this clear in the ACOP.

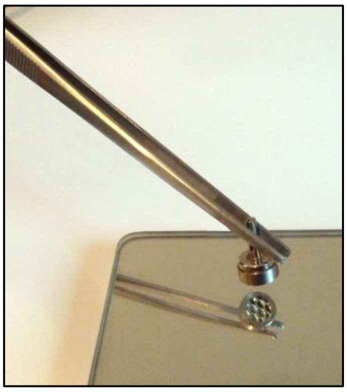
11.4 Carrying out inspections and leak tests

The RPS (Schools) should ensure that the school's sources are monitored for leaks and contamination. However, the actual work may be done by another member of staff who has been trained in this (eg a technician). This should not be too time-consuming if the process is organised carefully. The RPS (Schools) should make sure that records are updated when the tasks below are carried out (see section 8).

Follow the Standard Operating Procedures (see section 6.5) and the specific risk assessments in section 6.7. Wear a lab coat and disposable gloves (and exceptionally, an FFP3 dust mask if unsealed items containing powders are involved, and splash proof goggles when examining protactinium generators). Carry out the work over a tray.

11.4.1 Visual inspection

The visual inspection is essential and can identify a failing source well before the leak test. Choose a place in good lighting. The specific risk assessments in section 6.7 explain what to check for each type of source.



For sealed sources type 8a and c, use a mirror placed flat on the tray to view the metal foil behind the wire grid, or back of the recess, for a short time. Do not get close up to the source, and *never look directly into this type of sealed source or try to modify a source to look into it*. A digital camera with a macro facility and remote shutter release, or a USB snake scope, are other ways of remotely examining the source foil. However, some sources, such as the Panax type, have fine meshes that make it difficult to examine the foil.

		
1. Good condition. The foil is a shiny, silvery colour. Some foils are gold coloured.	2. Good condition. The glue is visible on the foil edge, with some foil scratches from manufacture	3. Poor condition. The foil is very discoloured. The source passed its leak test, but it should be disposed of

Check for any damage or deterioration, particularly to foils, plastic bottles and seals, which might cause the enclosed radioactive substance to escape. Sealed source foils should be shiny, mirror-like (although they may be dusty) and silvery or gold in colour. Note that foils were sometimes glued in place, and the adhesive can appear on the edge of the foil. The cobalt-60 source has aluminium metal behind the grid, so tends to be less shiny. If a source foil has any small blemishes, scratches etc that will not affect its safe use, make a note of these on the radioactive source history sheet (a photograph may be helpful). This can help in future inspections, allowing fresh damage or deterioration to be detected more easily. Large areas of brown or dark discolouration (see photo 3) indicate the foil is not in good condition.

11.4.2 Leak-tests: checking the detection equipment is suitably efficient

Carry out this check prior to the leak tests. Use a test source[1] to make sure the detection equipment responds suitably. The following procedure compares your GM tube with that of a new one; it was established at CLEAPSS using several, brand new GM tubes, both Centronic and LND brands.

You need this apparatus required for checking the detection equipment:

- GM tube (ZP181 or equivalent) in holder with lead.
- Counting unit (scaler).
- Clamp and stand.
- Potassium chloride test source (made to CLEAPSS design in GL314).
- Normal school plutonium or americium sealed source .
- A copy of the Test Record sheet (see 16.13).

First, check the comparative beta efficiency.

1. Position the GM-tube vertically so the end window is pointing uppermost. If clamping is needed, clamp the tube holder, not the tube.
2. Remove the protective end cap carefully (usually white or blue with a 'spider's web' grille). The window is fragile and the GM tube will be ruined if it is damaged.
3. If the GM voltage on the counter is adjustable, set it to 450 volts.
4. Rest the test source on the GM tube, so the source rests on the metal rim, with the disc of potassium chloride directly covering the centre of the GM window.
5. Note the count, t, over a period of 1000 s, in the Test Record.
6. Remove the test source well away from the tube and record the background radiation count, b, over 1000 s. This is typically in the range 200 to 500, even 700 counts in high granite areas.
7. Replace the protective cap on the tube.
8. The comparative detector beta efficiency, as a percentage, is simply 100 x (t – b)/540. Record this on the Test Record sheet.

(The value 540 is from the typical count above background in 100 seconds with the test source, on new GM tubes)

Second – check the alpha response

Carefully position an americium-241 or plutonium-239 school sealed source about 3 mm from the GM-tube window. Check that the count decreases considerably when a piece of paper is placed in front of the source. Note that americium-241 also emits significant gamma radiation and the GM tube will still detect this through the paper. Do not use radium-226 as an alpha check source because it emits beta from the decay chain.

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1 A test source using naturally radioactive potassium chloride can be purchased from IPC Electronics, Holker School, Cark-in-Cartmel, Grange-over-Sands, Cumbria LA11 7PQ (website: www.ipcel.co.uk). Alternatively, you can make one (see CLEAPSS guide GL314). The test source is not calibrated, but made to a specific design to give repeatable results.

If the comparative beta efficiency is below 70%, or the alpha response test is failed, maintenance or replacement of some or all parts the system is needed.

It is possible for the GM tube comparative beta efficiency to exceed 100% due to variations in tube manufacture, tolerances in constructing the test source, and from the randomness of radioactivity. Additionally, in tests at CLEAPSS, the LND72233 type GM tube had a higher comparative beta efficiency, around 130%. But regard efficiencies over 150% for the ZP1481, or 175% for the LND72233, with some suspicion, and likely failures.

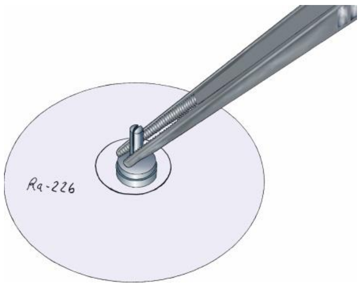
If the calculated efficiency significantly exceeds what is expected, this could indicate that the tube is reaching the end of its life. Halogen-quenched GM tubes such as the ZP1481 have a life expectancy of 5×10^{10} counts. Towards the end of their life, they may start to multiple-pulse for a single event. If the counter indicates a much higher background than expected, and when detecting background, the counter increments mainly in multiples, rarely in ones, the tube could be at the end of its service life. However, faulty circuitry can also cause the same effect.

Before purchasing a new GM tube, it is advisable to ensure that the holder, lead and counting system work properly, when used with another tube known to be working correctly. Check the GM tube was well away from other radioactive sources during the tests, or it is not somehow contaminated.

11.4.3 Carrying out the dry-wipe leak-test procedure

Remove the plastic front cap from the GM tube to maximise the detection efficiency. Set up the GM tube so that the tube window is close, about 2 mm, to a piece of filter paper beneath. The GM tube must not touch the paper. Use dry, clean ordinary cellulose filter paper (eg Whatman No 1). We recommend you set up a jig or clamp to do this. Take care the GM tube is a good fit in the socket and won't drop out; we suggest you use a few turns of PVC insulating tape around the circumference of the GM tube and holder to make sure it is securely held in.

With all radioactive sources well away, eg the other side of the lab, count the background radiation in the working area for 1000 seconds[1], then divide by 10 to get the count over 100 seconds. (This gives a reasonable estimate of the expected count per 100 seconds and reduces the chance of a false negative.) Then slide out the filter paper.



Place a fresh piece of the same filter paper on the tray. Draw a circle 20 mm diameter (eg draw around a penny). For cup sources, use forceps to take the source out of its container, and gently wipe the open end keeping it within the area of the 20 mm circle. For sources, including bottles, which cannot be wiped on paper easily, fold the filter paper to make a small pad with an area about the size of the GM tube window. Hold the pad of paper in your forceps and

[1] If the count over 1000 s exceeds 700, contact CLEAPSS because you will need to use longer counting times.

gently wipe it over the surfaces of the source. For a protactinium generator, wipe around the bottle seal. Test the radium-226 cup sources last – see 11.4.5

Put the source back in its container and move it back to where it was when the background count was taken.

If the filter paper was folded, unfold it flat. Slide the paper under the GM tube window, making sure it does not touch the window. Take the count over 100 seconds. If the count from the filter paper is less than 2 times background (that's the background count expected over 100 seconds) the source has passed the leak test.

Repeat this 'wipe and count' procedure for all the sources that require leak-testing. Use a fresh piece of filter paper each time.

When the inspection and leak test is completed, place all the used wipes and anything that may have very low-level contamination in a strong black plastic bag, the put this into another black bag and tie it up for disposal as low-level waste (see section 12.4.2).

11.4.4 Results of inspection and leak tests

For each source, record the actual count measured over the 100 s, and whether it passed or failed the leak test. Use the source history record for this (see section 16.4). If any of the sources appear to be damaged or fail the leak test, make a note of the action you have taken.

Any suspect source should be kept inside its normal container and placed in a strong plastic bag. This should be sealed, labelled 'Do not use' and kept in the usual store. Consult CLEAPSS (or the RPA[1]) for advice because the source may have to be disposed of. If the source is one of several in a boxed container, store the source separately in a temporary box, suitably bagged and shielded.

11.4.5 Radium sources

When leak testing the sources, test any radium sources last. The normal, slight emission of radon-222 gas by radium-226 sources may escape the source foil and deposit small quantities of radioactive decay products on the outside of the source and the inside of its container. As a result, a radium source may appear to fail its leak test because its outer surface is contaminated, even though the source is not leaking radium. Testing the other sealed sources first reduces the chance of cross-contamination from the handling tools to the other sources, possibly causing false positives. If the radium foil looks in good condition and shiny, then clean the outside of the source using a clean filter paper, held by forceps, dampened with ethanol. Clean the source container pot, and retest the source in a month. If the source fails again, it probably needs to be disposed of.

Note that if you have radium source where the foil surface looks discoloured brown or it fails its first leak test by a high count, say more than three times the background, this suggests the source should be disposed of.

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1 For schools who are not members of CLEAPSS. Membership can be through the Local Authority, Multi-academy Trust, or brokering organisation.

11.5 Contamination checks

The precautions are the same as those described for leak tests in 11.3. If you suspect that radioactive substances may have contaminated the surfaces of the cabinet or source containers, carry out a contamination check by the 'wipe and count' method described in 11.4. In particular, radium source containers should be checked every year and cleaned if necessary (see the next subsection).

Sometimes cup sources can appear dirty due to traces of lead carbonate (from corrosion of the lead-lined container). This can be cleaned off the source by holding the source with long-handled forceps and using a second pair of forceps to hold a piece of filter paper slightly dampened with ethanol. Do not clean the actual foil surface. Allow the source to dry before storing it. See GL221 *Restoration or disposal of a lead-pot box for radioactive sources* for how to clean the lead.

To clean a radium source container pot, clean it with a lint-free swab slightly moistened with ethanol or dilute detergent solution, but it must not be over-damp. Then wipe the inside of the pot with a piece of filter paper as in the leak test and check for contamination. Clean the container until the wipes show no further contamination. Allow the container to dry before returning it to the store. If the contamination persists, ask CLEAPSS or your RPA for advice.

12 Disposal of radioactive sources

12.1 Reasons for disposal

You may need to dispose of a radioactive source because:

- the source is listed as unsuitable (double red-framed) in section 6.7;
- the source is no longer exempt under the environmental regulations;
- the school has substantially more than the Standard School Holding without justification (this can happen when schools are amalgamated);
- the source is not suitable for use in schools (eg old military instruments with radium painted dials);
- the source has been damaged or is leaking (this is rare); or
- the source has a relatively short half-life and has become too weak (eg cobalt-60).

12.1.1 Unacceptable reasons for disposing of radioactive sources

CLEAPSS regularly receives *Helpline* enquiries from schools wishing to dispose of radioactive sources. In many cases, their reasons for disposal are unacceptable. Our responses are given below, with references to the relevant sections of this guide.

- *We have nowhere satisfactory to store the sources*
  The minimum storage requirement is normally easy to achieve (see section 4). If there are difficulties, consult CLEAPSS or the RPA.

- *We have security problems and are not happy to store sources at our school*
  If there are security problems, there are plenty of other items in the science department which pose risks at least as great as the theft of radioactive sources. The security problems need to be addressed.

- *None of our teachers know what to do with the sources*
  All qualified science teachers who teach about radioactivity should be confident in working with radioactive sources and carrying out basic demonstrations. Appropriate training should be given (see section 7.1.2).

- *We don't think radioactive sources are safe to use, and prefer to describe the demonstrations, show videos of them or use a computer simulation*
  The standard educational radioactive sources are very safe when used following the guidance from CLEAPSS. Pictures, videos and computer simulations may complement practical work in science, but they are no substitute for it.
- *We don't teach about radioactivity any more*
  Radioactivity is included in the various national curricula, and is an important part of advanced-level work in science (see section 1.2).
- *We can detect radiation from the source outside its container*
  This is perfectly normal for sources that emit gamma radiation (eg cobalt-60 and radium-226). Gamma radiation is the most penetrating, and will pass through all substances, including lead. A raised count rate around the container is expected.
- *The radium source is contaminating its pot*
  Radium sources emit small amounts of radon gas which can deposit radioactive decay products in the lead container. This is quite normal and is dealt with by routine decontamination (see section 11.4.1).
- *The sources are not working and need to be replaced*
  Often, when schools report a non-emitting source, we find that the measuring equipment is faulty or being used incorrectly, although cobalt-60 sources have too low an activity once they are several decades old.
- *We do not have any detection equipment to carry out investigations*
  The equipment needed is a GM tube and counter to check for leakage and contamination if radioactive substances are stored (whether they are used or not). Occasionally, the equipment needed may be found at the back of a cupboard.

  Many science departments already have data-logging equipment, and you may only need to buy a GM tube to go with it. Money from an ICT budget could be used for this purpose. Note, however, that some of the probes supplied with data-logging equipment may not be suitable for leak testing and contamination checks.

12.2 Legal responsibilities for disposing of waste

You have a duty of care to make sure your waste is managed properly and disposed of safely. You still have this duty even if you get someone else to collect your waste and dispose of it. You need to take reasonable steps to check that they will manage your waste properly.

When disposing of sources, you will need a risk assessment. This is generally covered by the Standard Operating Procedures in section 6.6 and the additional information in section 12.4 and its subsections, but you may need to customise them to suit your own circumstances.

For schools, there are three main areas of legislation that have to be considered when disposing of radioactive waste:

1 The Environmental Permitting Regulations (EPR) mean that generally you need a permit to dispose of radioactive waste. The permit sets conditions on the disposal. Fortunately, most school sources are conditionally exempt from needing permits.

2 If the radioactive waste is exempt from an EPR permit but it has other hazardous properties, for example, it may be toxic or corrosive, the disposal still needs to meet the regulations on hazardous waste.[1]

3 The transport of radioactive sources on public roads is controlled by the transport regulations, which place duties on both the 'consignor' and 'consignee'. However, radioactive material below certain activity thresholds is exempt from the transport regulations. If a registered waste contractor agrees to dispose of the waste for you, the contractor should deal with the transport regulations.

12.2.1 Radioactive Waste Adviser

In normal circumstances, schools do not need to appoint a Radioactive Waste Adviser (RWA). RWAs advise on waste disposal of radioactive substances, but they are only legally required for organisations who hold a permit (or in Northern Ireland an authorisation) to accumulate or dispose of radioactive waste. Schools do not need permits (or authorisations) if they are within the Standard School Holding.

You may need to consult an RWA in exceptional circumstances, for example, if you discovered that the school has an unsuitable source which it needs to dispose of. Ask for advice from CLEAPSS or the RPA. Many RPAs are also RWAs.

12.3 Keeping radioactive waste

Radioactive waste must be disposed of as soon as reasonably practicable after it has become waste. You have up to 26 weeks to dispose of sealed sources. It is illegal just to leave radioactive waste in a store because it is expensive to dispose of. You can only extend this time if the regulator agrees in writing that a longer period is allowed.

The waste must be stored with the same security as when the material was still in use. It is important to package and label the waste so it does not inadvertently become returned to use, or cause contamination.

12.4 How to dispose of radioactive waste

To find out how to dispose of your radioactive waste, go through the following table, starting at the first row and moving down row by row to see the first that applies. When you find the correct row, make sure you read and understand the detailed guidance referred to in the row.

There are limits to the amounts that can be disposed of at any one time, and within a period of time. See the notes in the table and section 13 for details.

The Standard Operating Procedures apply when disposing of sources - see section 6.5.

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[1] In Wales only, if your school produces 500 kg or more of hazardous waste in a year, the school must register with Natural Resources Wales as a producer of hazardous waste. This is the responsibility of the school senior management team, not the science department. It is highly unlikely that a science department alone will produce this quantity of hazardous waste in a year.

Table 12.4: Go through the following table, starting at the first row and moving down row by row to the first that applies

Source	Disposal routes	Notes
Radioactive rocks (CLEAPSS source type 1)	Dispose of the rocks by the dustbin route. See section 12.4.2	Do not dispose of large quantities at one time.
Domestic smoke detectors (CLEAPSS source type 2)	Consider recycling as smoke detectors if they are in good condition and not past their recommended working life. Smoke detectors that have a sealed source of americium-241 with an activity of no more than 40 kBq can be disposed of as waste electrical and electronic equipment (WEEE). They must not be disposed of by the dustbin route. Refer to your premises manager for the school's procedures for disposing of WEEE. Remove the battery and dispose of it separately at a battery recycling point.	There is an annual limit of 10 MBq on the disposal of sealed sources. For electrical and electronic equipment bought after July 2007, distributors must allow consumers to return the waste equipment without charge.
Consumer items: gas mantles, thoriated TIG electrodes, Fiestaware china, Vaseline glass (CLEAPSS source types 11, 12, 14 and 15)	Consider recycling if appropriate and if they are in good condition. Otherwise, unless you have large quantities, these are consumer items of very low risk, dispose of them by the dustbin route. See section 12.4.2	If you recycle items, make reasonable checks that they are transferred to a responsible person.
Very low-level solid waste (not uranium or thorium compounds)	This is waste such as used gloves, masks, wipes, washed bottles with no visible residues etc that may be contaminated by minor amounts of radioactive material, and if it were not for the radioactive contamination, would be classed as non-hazardous. Dispose of it by the dustbin route. See section 12.4.2.	The limit for any one dustbin disposal is 400 kBq per 0.1 m^3 of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.
Powder radon generators (CLEAPSS source type 10)	The powder is usually thorium hydroxide or carbonate. Despite what some textbooks say, these compounds are extremely hard to dissolve. It must be disposed of as hazardous waste by a registered waste carrier, who will remove the waste to an appropriately permitted disposal site. See section 12.4.4	The plastic bottles are known to become brittle and split. The thorium powder is fine and can create a dust. Put the generator into a sealed bag before disposal.

Source	Disposal routes	Notes
Protactinium generators (CLEAPSS source type 9a and 9b)	The organic component will have uranium contamination. The aqueous component will have traces of organic solvent in it. Both components of the generator are classed as hazardous waste and cannot go for disposal by the dustbin or sewerage routes, so there is no point opening the bottle. Dispose of it as hazardous waste through a registered waste carrier, who will remove the waste to an appropriately permitted disposal site. See section 12.4.4	Do not attempt to open the bottle.
Mineral absorbent contaminated by clearing spill from a generator	Mineral absorbent that has been used to soak up a small amount of a spill from a damaged protactinium generator can be washed and disposed of by the dustbin route. See 12.4.2.	For mineral absorbent used for large generator spills over 50 cm^3, or other spills, contact CLEAPSS for advice in disposal.
Aqueous uranium and thorium solutions (CLEAPSS source types 16 or 17 when dissolved in water)	These can be disposed of through the mains sewer, up to a limit of 500 g of uranium compound dissolved in solution, per year. The environmental impact assessment assumes that small quantities will be disposed of over the year – ie roughly 10 g a week, not 500 g in one day. See section 12.4.3. The disposal must go into a main sewer, not into a septic tank.	Sewage from schools is broadly domestic in nature[1], and therefore counts as domestic sewage. Consequently, school waste to the mains sewer is not normally subject to 'discharge consents', and small quantities of aqueous uranium and thorium compounds can be discharged directly to the sewer (as long as they are well diluted) without reporting it to the waste water company.
Liquid non-aqueous thorium or uranium waste (eg thorium or uranium compounds in an organic solvent)	It must not be disposed of down the drain or sewer. It will need to be assessed for its hazard and disposed of accordingly, probably by a registered waste carrier, who will remove the waste to an appropriately permitted disposal site. See section 12.4.4	You are unlikely to have liquid non-aqueous uranium or thorium waste in a school. If you do, contact CLEAPSS.

1 Water Discharge and Groundwater (from point source) Activity Permits (EPR 7.01), Environment Agency, 2011.

Source	Disposal routes	Notes
Solid uranium and thorium compounds (including insoluble compounds) (CLEAPSS source types 4b, 16, 17 and 18)	Small amounts of water-soluble thorium and uranium compounds can be dissolved and disposed of as aqueous waste. See the row on aqueous uranium and thorium solutions. Other solid uranium and thorium waste, including encapsulated thorium and uranium, is classed as hazardous waste. It must be disposed of by a registered waste carrier, who will remove the waste to an appropriately permitted disposal site. See section 12.4.4	Up to 500 g of solid uranium or thorium compounds can be disposed of per week. Small amounts of some compounds can be dissolved in acid by an experienced chemist and disposed of as aqueous waste. This is hazardous and requires a special risk assessment. Telephone CLEAPSS for advice. For thorium powder radon generators, see the row that specifically applies. This row does not apply to small quantities of consumer items.
Caesium-137 elution source (CLEAPSS source type 13)	A caesium-137 elution source not exceeding 40 kBq can be disposed of by the grout/dustbin route. See section 12.4.2	The limit for any one disposal is 400 kBq per 0.1 m^3 of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.
Radium paint diffusion cloud chamber sources, spinthariscopic and scintillation plates (CLEAPSS source types 3b, 4a, and 5	Radium paint cloud chamber sources, typically 740 Bq (0.02 μCi), can be disposed of by the grout/dustbin route. See 12.4.2 Scintillation plates and spinthariscopes can usually be disposed of by the grout/dustbin route because their activity is low, about 4 kBq per scintillation plate, and under 1 kBq for school spinthariscopes. See 12.4.2	The limit for any one disposal is 400 kBq per 0.1 m^3 of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.

Source	Disposal routes	Notes
Radium paint timepieces and instruments (but not spinthariscopes) (CLEAPSS source type 3a and 3c)	A watch or domestic clock can be disposed of by the grout/dustbin route if the radium does not exceed 40 kBq (or 200 kBq if it can be regarded as a sealed source; but a dial or hands that have been removed from a timepiece, or a timepiece with no front glass, is not a sealed source). See 12.4.2 The radium in radioluminescent instruments such as altimeters and compasses is usually well above 40 kBq (some into the MBq of activity) and cannot be disposed of by the dustbin route. Devices that are not permitted to be disposed of in the dustbin can only be disposed of by a registered waste contractor who has a permit for disposing of the waste you have, and who will remove it to an appropriately permitted site. See section 12.4.4	For the grout/dustbin route, the limit for any one disposal is 400 kBq per 0.1 m^3 of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.
Sealed sources (CLEAPSS source types 6, 7, 8a, 8b, 8c)	Waste sealed sources up to 200 kBq can conditionally be disposed of by the grout/dustbin route. See section 12.4.1. Sealed sources outside of these limits can only be disposed of by a registered waste contractor who has a permit for disposing of the waste you have, and who will remove it to an appropriately permitted site.	CLEAPSS guide GL220, available on request, explains how to do the disposal. It is important to follow this guidance because there are several conditions that must be met. The annual limit for disposal of this category of waste is 10 MBq.
Other sources not described above	Members should contact CLEAPSS for advice. The source is likely to require disposal through a registered waste carrier who has a permit for disposing of radioactive waste which covers the waste you have, and who will remove it to an appropriately permitted site.	Note that you cannot legally dispose of a source if you do not know what it is. Contact CLEAPSS, preferably by emailing a good quality sharply-focused picture. There is little point sending us fuzzy pictures, or pictures of something wrapped in lead foil.

12.4.1 Notes on disposing of sealed sources by the dustbin route[1]

Waste sealed sources not exceeding 200 kBq can be disposed of by the dustbin route. However, the disposal route is conditional; you cannot just throw the waste source into the laboratory bin and forget about it. You must meet the conditions for disposal, and you have a duty of care to take reasonable steps to see that the waste does not harm the environment or people involved in handling the waste.

We advise grouting the source prior to disposal. We recommend that you follow CLEAPSS guide GL220 *Disposal of waste sealed sources.* By doing so, you will meet your duty of care and the conditions and legal requirements for disposal. Contact CLEAPSS when you need a copy of GL220.

12.4.2 Notes on disposing of very low-level solid waste by the dustbin route[1]

This disposal route cannot be used for thorium or uranium compounds, or uranium Becquerel plates, because they are classed as chemically hazardous.

For radioactive waste permitted to be disposed of by the dustbin route, you do not need to tell contractor who collects the normal refuse specifically of this waste. Do not label radioactive waste disposed of with normal dustbin waste because this could cause unnecessary concern.

Radium-paint cloud chamber sources, spinthariscopes, scintillation plates and elution sources, if each does not exceed 40 kBq, can conditionally be disposed of by the dustbin route. They are best grouted before disposal. Follow CLEAPSS guide GL220.

Solid items such as gloves, wipes, small pieces of labware etc with minor radioactive contamination are usually very low level waste and can be disposed by the dustbin route. To be classed as very low-level waste, it has to meet these conditions:

- the radioactive contamination does not exceed 400 kBq and no single item is above 40 kBq;
- the mass of the radionuclide is less than 0.1% of the mass of the whole waste if the radionuclide is classed as (chemically) hazardous waste ; and
- if it were not for the radioactivity, the waste would be classed as non-hazardous.

For very low-level waste, obliterate any radioactive warning signs on the waste. Wrap any broken glass and sharps well to avoid anyone getting cuts. The waste should be double-bagged (put it into a black plastic bag, tie it off, then place that in a second black bag and tie it off) and put directly into the main outside refuse container for normal non-hazardous waste. It must be with at least 0.1 m^3 of normal waste (roughly a black-bag full), which can be bagged waste already in the refuse container.

Treat geological specimens in the same way, but do not dispose of large quantities at any one time; where practicable. Larger quantities, say more than five items, can be disposed of over several weeks in smaller amounts.

Mineral absorbent that has been used to soak up a small aqueous spill from a damaged protactinium generator can be disposed of as very low-level waste above if it is washed first. To do this, put it into a bucket and add a good amount of water to wash the absorbent thoroughly. Wear heavy-duty protective gloves and eye

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1 The dustbin route is the route for normal solid non-hazardous waste that goes into the main refuse bins, mostly in black plastic bags, and is collected regularly by a waste contractor – eg every week or fortnight.

protection. If the mineral absorbent contains large amounts of acid, add sodium carbonate, and if there are traces of organic solvent, add a little liquid detergent. (For the contents of a normal size protactinium generator, typical volume less than 50 cm^3, sodium carbonate should not be needed at this stage and most of the organic solvent is likely to have evaporated after the spill.) Carefully pour off the resulting liquid and dispose of it as aqueous waste down a fast-flowing prep room sink. Fill the sink and empty it at least once to make sure none of the radioactive substance collects in the traps. Clean the work surface areas. Allow the damp washed mineral absorbent to dry in the bucket, then double-bag it and dispose of it as very low-level waste. Wash the bucket after and return it to normal use.

12.4.3 Notes on disposing of aqueous radioactive solutions of thorium or uranium via the sewerage system

A solution of the compound is flushed away down a toilet connected to a main sewer (not a septic tank). You do not need to tell the waste water company because the quantities are very small.

The procedure needs considerable care, particularly if you are dissolving solids. Contact CLEAPSS for advice and a special risk assessment.

Do not attempt to dissolve the thorium compounds from old radon generators, which were usually thorium carbonate or thorium hydroxide. These do not dissolve significantly, even in concentrated acid, as tests by CLEAPSS have confirmed.

12.4.4 Notes on using a registered waste carrier for disposing of radioactive waste (including solid thorium and uranium compounds)

If neither the dustbin route nor sewerage route is an option for your waste, you will have to dispose of it by using a registered waste carrier.

When you arrange for someone to collect and dispose of your waste, you must make sure they are a registered waste carrier to demonstrate you took reasonable steps to ensure your waste was disposed of correctly. You can use the Environment Agency's online register to confirm that a contractor has a valid registration.

When using a registered waste carrier, check that they are taking your waste to a site that is permitted for your type of waste. At the time of publication, there are no sites in Northern Ireland authorised for the disposal of thorium and uranium. These compounds will therefore need to be transferred by a registered waste carrier to facilities located elsewhere in the UK which are appropriately permitted, so the cost will be higher.

If your waste is not exempt as radioactive waste (see section 13), the registered waste carrier will need to hold a suitable permit for taking and disposing of radioactive waste. The waste must go to a site that is permitted for the disposal of radioactive waste. You need to retain the receipt paperwork from the registered waste carrier so you can show the source was taken and disposed of lawfully. See section 8.4.

The registered waste carriers listed in the following table offer a service for disposing of radioactive waste from schools across all the UK. They will want enough details to characterise your waste before finalising and arranging collection. In some cases, you may need advice from CLEAPSS to make sure you give the correct information.

Waste contractor	Address	Comments
Active Collection Bureau Ltd	Socorro House Liphook Way, 20/20 Business Park Maidstone Kent ME16 0LQ Tel: 01622 356700 E-mail: sales@acb.co.uk Website: www.acb.co.uk	All types of radioactive waste, including sealed sources.
Eckert & Ziegler Environmental Services Ltd	3A Churchward Didcot Oxfordshire OX11 7HB Tel: 01235 514 310 E-mail: enquiries@ezag.com Website: www.ezag.com/eze	All types of radioactive waste, including sealed sources.
Grundon Waste Management Ltd	Thames House Oxford Road, Benson Oxfordshire OX10 6LX Tel: 01491 834340 E-mail: radsales@grundon.com Website: www.grundon.com	Disposal of thorium and uranium compounds and protactinium generators. Sealed sources up to 200 kBq. Other radioactive waste from unsealed sources also possible – enquire by e-mail.
Raditech	22 Phoenix Road, Crowther Industrial Estate, Washington, Tyne and Wear, NE38 0AD. Tel: 0191 4151287 sales@raditech.co.uk Website www.raditech.co.uk	Disposal of thorium and uranium compounds. Possibly protactinium generators. Other radioactive waste from unsealed sources also possible – enquire by e-mail.
Tradebe - Labwaste	23 Jacknell Rd, Hinckley LE10 3BS Tel: 01455 616673 E-mail: sales@labwaste.co.uk Website:www.tradebe.co.uk	Disposal of thorium and uranium compounds and protactinium generators. Other radioactive waste from unsealed sources also possible – enquire by e-mail.

If the waste is classed as hazardous, the waste contractor must fill in a consignment note that describes the hazardous waste correctly. You are responsible for completing certain parts of the consignment note, but often the contractor will complete it for you. If so, you must check carefully that the information is correct before the waste is taken away. The contractor must give you a copy of the consignment note, which you should file. This copy should be kept for at least three years after the waste is taken away. You should also receive a return from the final waste site stating what happened to your waste, which also needs to be kept for three years. See section 8.4.

12.5 Records of disposal

It is important to retain disposal records for your sources. See section 8.4. See also section 16.12 for an example of a disposal record sheet. You do not need to keep records of disposal of very low-level waste, eg used gloves, wipes etc, arising from managing your sources.

13 Exemption limits

These are exemptions relating to the control of radioactive substances by the Environmental Permitting Regulations.

13.1 Exempt quantities

The environmental regulations call these quantities of radioactive substances exempt, although they are better described as conditionally exempt. Radioactive materials below these limits do not need permits from the environmental regulator. (Don't confuse this with excepted packages, which relate to transporting radioactive materials.) See the next table for exempt quantities relevant to schools.

These exemption limits are different to hazardous waste limits, and this is important when disposing of substances such as thorium and uranium compounds. 'Exempt' does not mean exempt from every regulation on waste disposal.

Radioactive sources conditionally exempt	Acquisition and keeping quantity limits	Disposal quantity limits
Sealed sources	Individual sources not exceeding 4 MBq, to a total of 200 MBq	200 kBq source per 0.1 m^3 of normal waste, to a maximum of 10 MBq per year
Uranium and thorium compounds	5 kg in total	0.5 kg of solid uranium or thorium per week 0.5 kg of aqueous uranium or thorium (not including the mass of water) per year as solutions disposed of to the main sewer
Thoriated welding rods (not more than 4% thorium)	No limit	No limit
Gas mantles (including gas mantle radon generators)	As for thorium compounds	As for thorium compounds
Protactinium generators	As for uranium compounds	As for uranium compounds
Naturally radioactive rock specimens	No limit	No limit
Caesium-137/barium-137 elution sources	Individual sources not exceeding 40 kBq of Cs-137, to a total of 400 kBq	400 kBq for the total waste per 0.1 m^3 of inert waste, no single item exceeding 40 kBq, to a maximum of all very low level waste of 200 MBq per year
Smoke detectors	Each detector not exceeding 4 MBq No limit on number of detectors (strictly they should be installed to the premises)	As for sealed sources
Very low level waste		400 kBq for the total waste per 0.1 m^3 of inert waste, no single item exceeding 40 kBq, to a maximum of all very low level waste of 200 MBq per year

14 X-ray equipment

If you wish to use X-ray equipment such as Tel-X-Ometers, or apparatus such as electron microscopes that emit X-rays, you must get advice from your RPA beforehand. You will need a risk assessment – these will require different operating procedures and contingency plans to sealed sources, depending on the type of equipment. This is beyond the scope of L93. You will also need training on how to use the equipment safely, and a protocol so that only authorised users can operate the equipment.

The X-ray equipment must be thoroughly examined and tested to check that it has suitable shielding and safety controls such as interlocks, and that these are working properly, before first use and at suitable subsequent intervals. Old designs of X-ray equipment may not meet acceptable standards of shielding and safety.

14.1 Monitoring

If your school has apparatus that generates X-rays, by design or otherwise, the school will need a calibrated radiation monitor capable of detecting adventitious X-rays over the spectrum emitted. This would also need advice from your RPA.

14.2 Permissions and notifications

You need permission from your employer to use apparatus that emits X-rays. If you need to apply for permission to a government department to use sealed sources, you also need their permission to use X-ray equipment. The HSE will need to be notified 28 days before your intention to use a source of X-rays for the first time.

15 Doses of radiation

Measurements and calculations of radiation dose are sophisticated, and only a simplified explanation is given here to provide a basic understanding. The following radiation protection quantities come from the advisory body, the International Commission on Radiological Protection (ICRP).

- *Absorbed dose*: The absorbed dose is the quantity of energy given by ionising radiation to a unit mass of matter (such as living tissue), and is measured in gray (Gy). One gray is the amount of ionising radiation which delivers one joule of energy to a kilogram of absorbing material.
- *Equivalent dose*: Different ionising radiations have different biological effects, and this is taken into account by multiplying the absorbed dose by a radiation weighting factor. This leads to a term known as 'equivalent dose', measured in sievert (Sv), where:

equivalent dose	=	radiation weighting factor	x	absorbed dose

- *Tissue-weighting factor*: Some organs and tissues are more susceptible to harm from radiation than others. Another weighting, a tissue-weighting factor, is used to take this into account.
- *Effective dose*: Effective dose is a quantity based on the consequences of whole body exposure to radiation. It is the tissue-weighted sum of the equivalent doses in all the tissues and organs of the body, and it gives a broad indication of the detriment to health. It is intended for use as a protection quantity. Effective dose is usually

calculated using a sensitive dose meter and the dose is modelled to individual tissues by means of empirical formulae. Effective dose is also measured in sievert (Sv).

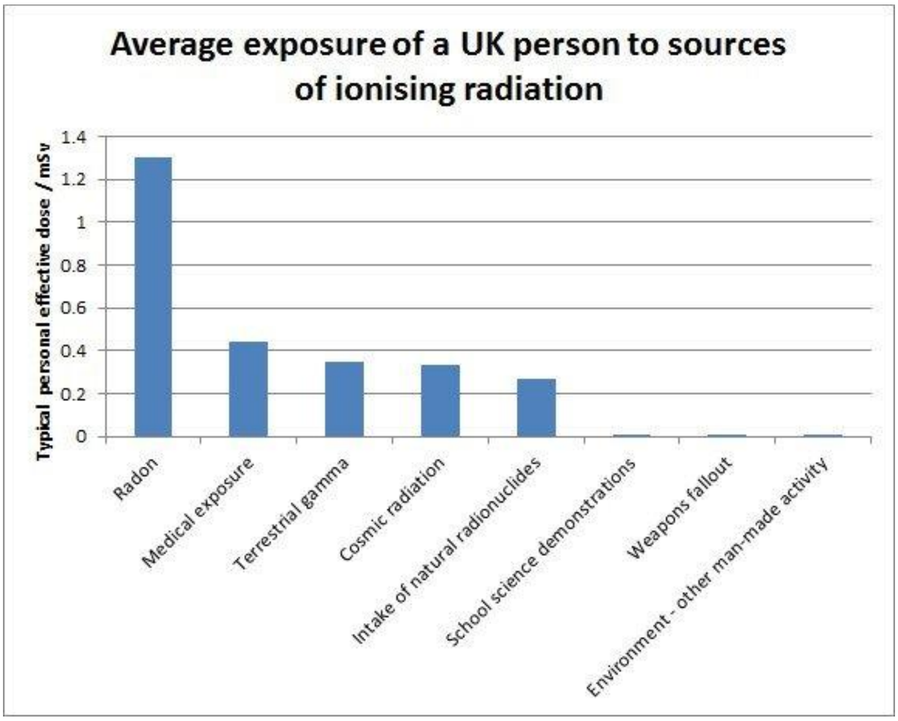
Note that the general term 'dose' (as used in this guide) usually means 'equivalent dose' or 'effective dose' depending on the context.

15.1 Dose from background compared to a school radioactive source

In the UK, the annual effective dose from background radiation is usually between 1 and 10 mSv, and on average about 2.7 mSv per person.[1] The effective dose received during a standard school demonstration carried out properly will be no more than 0.01 mSv. Consequently, a teacher could carry out several hundred demonstrations in a year before acquiring an additional dose equal to background level. Doses to students observing demonstrations will be far lower.

The legal maximum annual effective dose for an employee over the age of 18 is 20 mSv and for an employee under the age of 18 it is 6 mSv. For school students, they are classed as members of the public and the annual limit is 1 mSv.

The chart below, based on data from Public Health England, gives an indication of the radiation doses received from various sources in the United Kingdom. In general, the largest personal dose is from radon gas. For comparative purposes, we have shown the dose received from typical school science demonstrations.



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[1] Public Health England, *Ionising radiation exposure of the UK population: 2010 review*.

Part D: Templates

Modify these templates for checklists, record sheets, letters and forms as necessary to suit your needs. These are all available in Word format in document DL93 from the CLEAPSS website.

16 Useful checklists, record sheets, letters etc

These record sheets, letters etc can be copied freely for internal use in schools and colleges, but must not be used commercially without prior permission from CLEAPSS.

Section	Document
16.1	Checklist for the head of science or RPS (Schools) for managing radioactive sources in schools
16.2	List of radioactive sources held
16.3	Monthly simple store check
16.4	Radioactive source history
16.5	Use log for radioactive sources
16.6	Staff authorised to use/handle radioactive sources, and training
16.7	Label for protactinium generator
16.8	RPS checklist for radioactive sources and store
16.9	Withdrawn (Sample letter to supplier when purchasing radioactive sources)
16.10	Transport document (consignment note) for excepted package
16.11	Suitable labels for excepted packages
16.12	Example of a disposal record sheet
16.13	Detector test record

16.1 Checklist for the head of science or RPS (Schools) for managing radioactive sources in schools

<table>
<tr><th colspan="2">Item</th><th>Tick</th></tr>
<tr><td colspan="2">The employer has notified the HSE of the intention to use radioactive sources</td><td></td></tr>
<tr><td colspan="2">The employer has appointed a Radiation Protection Adviser (RPA)</td><td></td></tr>
<tr><td colspan="2">A Radiation Protection Supervisor (Schools) has been appointed</td><td></td></tr>
<tr><td colspan="2">The Standard Operating Procedures and contingency plans are in place</td><td></td></tr>
<tr><td colspan="2">The name and contact details of the RPS (Schools) and RPA have been included in the Standard Operating Procedures and/or in the science department’s health and safety policy</td><td></td></tr>
<tr><td colspan="2">For schools in the CLEAPSS local authority RPA scheme, the name of the Radiation Protection Officer in the local authority is on the Standard Operating Procedures</td><td></td></tr>
<tr><td colspan="2">The radioactive substances held are within the Standard School Holding, or have been justified and approved</td><td></td></tr>
<tr><td colspan="2">Appropriate, working monitoring equipment is easily available</td><td></td></tr>
<tr><td colspan="2">There are satisfactory storage arrangements for radioactive substances</td><td></td></tr>
<tr><td colspan="2">The Fire and Rescue Service has been told where the radioactive substances are kept (probably via the site manager on the school’s fire risk assessment)</td><td></td></tr>
<tr><td rowspan="5">Documentation is in place and kept up-to-date</td><td>The list of staff authorised to handle the sources is up-to-date</td><td></td></tr>
<tr><td>A radioactive source history exists for each source, including the results of inspections and leak tests</td><td></td></tr>
<tr><td>The use log is completed whenever sources are used</td><td></td></tr>
<tr><td>The monthly simple store-check record is up-to-date</td><td></td></tr>
<tr><td>The RPS (Schools) checklist for radioactive sources and store is completed annually</td><td></td></tr>
<tr><td colspan="2">The RPS (Schools) is satisfied that staff authorised to handle or use radioactive substances are appropriately trained</td><td></td></tr>
<tr><td rowspan="2">For each member of staff who handles or uses radioactive substances:</td><td>The RPS (Schools) is satisfied that they are familiar with and understand the Standard Operating Procedures</td><td></td></tr>
<tr><td>The RPS (Schools) has provided appropriate instruction and training</td><td></td></tr>
<tr><td colspan="2">The RPS (Schools) has ensured that appropriate instruction and training has been given to students aged 16 and above who handle sealed sources</td><td></td></tr>
<tr><td colspan="2">Signature:</td><td></td></tr>
</table>

16.2 List of radioactive sources held

Name /reference no of source	Radionuclide/ chemical name	Original activity/ mass	CLEAPSS specific risk assessment type number[1]

1 Type number that appears on the specific risk assessments in section 6.6 of CLEAPSS guide, L93 *Managing Ionising Radiations and Radioactive Substances in Schools and Colleges* (2019).

16.3 Monthly simple store check

Date of check	Comments	Signature

16.4 Radioactive source history

Unique name / reference number of source	
Radionuclide / chemical name	
Either the original activity (37 kBq = 1 µCi)	kBq uCi
Delivery date (attach original paperwork if possible)	
Supplier	
Supplier catalogue number	
Source serial number (sealed sources only)	
Source manufacturer	
Disposal date	
For a radiochemical, mass used up or disposed of	
Disposal route and details (Attach disposal record sheet and any paperwork from the waste contractor)	

Sealed sources: indicate significant blemishes, scratches etc, with dates when these were noted A sketch, or attach photograph of, the source. (Inspect foils with a mirror or digital camera)	

Inspection and leak tests (usually annual) following L93 procedure
Include comments on any action taken: eg decontamination of a radium source and its container, referral to RPA if a source appears to be damaged or leaking

Date	Back-ground reading	Leak test count (if relevant) including back-ground	Visual Inspection, and leak test if relevant, passed (yes or no)	Test carried out by	Comment (if any)

16.5 Use log for radioactive sources

Columns 1, 2 and 5 should be completed by the person(s) collecting and returning the sources to the store. Columns 3, 4 & 6 should be completed by the person supervising the activity. (See the notes in L93 section 8 on data protection)

1	2	3	4	5	6
Source(s) used	Date and time removed from store Signature required: all source(s) present in containers	Member of staff supervising source(s)	Teaching group Include names of any students aged 16 and above using source(s).	Date and time returned to store Signature required: all source(s) present in containers	Write 'Yes' in this column to confirm that adequate safety information was given to the student(s)

Use log, page number:

16.6 Staff authorised to use/handle radioactive sources, and training

Name of school:			
The following members of staff have been authorised by the RPS (Schools) to handle and/or use radioactive sources from the date shown (delete names when an individual leaves the school)			
Name	Date authorised	Training courses, briefings etc	Date of course etc

16.7 Labels for protactinium generator secondary containers

For the protactinium generator secondary container. See specific risk assessment 9b (section 6.7).

Corrosive (skin, eyes). Irritant (respiratory)

Radioactive

PROTACTINIUM GENERATOR

DO NOT OPEN THE GENERATOR BOTTLE

Follow special instructions provided.
Always use the bottle in a tray and keep a spill kit nearby.

In the event of a spill, cover with mineral absorbent and alert the Radiation Protection Supervisor (Schools) immediately.

Contains:
Concentrated hydrochloric acid
Uranyl(VI) nitrate-6-water
Organic solvent

16.8 RPS (Schools) checklist for radioactive sources and store

Date	Source list and histories up-to-date? (yes or no)	All sources present, inspected and leak tested? (yes or no)	Use log is up-to-date? (yes or no)	Store cabinet secure, and radioactive warning trefoil clear.	Signature of person in charge of radioactive sources in the school: RPS (Schools)

16.10 Transport document

Transport document (consignment note) for transporting radioactive sources as excepted packages by road

Transport document	
The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009	
Consignor (Name and address of school sending the package)	Consignee (Name and address of person receiving the package)
Contact phone number	Contact phone number
Contact name: RPS (Schools)	Contact name
United Nations number	UN 2910 / UN 2911 (delete inapplicable)
Description of radioactive substances	
Signed	
Date of commencement of journey	

16.11 Suitable labels for excepted packages

Name of consignor: School address: Telephone:
Excepted package, UN Class: 7 UN Number: UN 2910

Name of consignor: Address: Telephone:
Excepted package, UN Class: 7 UN Number: UN 2911

16.12 Example of a disposal record sheet

Record of disposal of radioactive source/material	
Name of school/college	
Address of school/college	
Description of source/material disposed of and CLEAPSS type number (if applicable).	
Source identifying code or serial number if applicable, eg any code used on the source container, or inventory reference	
Radionuclide and original activity in units of becquerel. If an unsealed compound, also state the approximate mass or volume.	
If the half-life has been taken into account, give the estimated activity at the time of disposal	
Date it was disposed of	
Disposal preparation, and disposal route, eg grout and dustbin	
For schools in the CLEAPSS RPA scheme, has the RPO been notified?	
For schools not in the CLEAPSS RPA scheme, has the RPA been notified?	
Name of the person authorising the disposal	
Signature of the person authorising the disposal	
Position of the person signing – eg RPS (Schools)	

16.13 Detector test record

Test record for a Geiger-Muller counting system	
Equipment used	**Serial no or unique identifier**
GM Tube (with protective cap removed, if fitted)	
GM Tube holder and lead	
Counting unit (scaler)	
Operating voltage (ideally set to 450V)	volts
Standard test source used	**Serial no or unique identifier**
K-40, naturally occurring in 300 mg KCl	
Measurements taken	**Actual count for 1000 seconds**
K-40 test source resting on GM tube window (t)	
Background (b) (typically 300 to 500 counts in 1000s)	
Comparative beta efficiency of system	
=100 (t – b)/540 (should be at least 70%)	= _______ %
Comparative beta efficiency	Pass/Fail (delete as appropriate)
Check for alpha detection	Pass/Fail (delete as appropriate)
Overall result (ie, 2 tests above passed)	Pass/Fail (delete as appropriate)
Test carried out by:	
Signed:	**Date:**

Definitions

Many of these definitions appear in the Ionising Radiations Regulations 2017.

Activity: The activity of a radioactive substance is the rate of decay of the particular radionuclide, measured in becquerel (Bq). A substance in which one atom disintegrates (or transforms) per second has an activity of one becquerel (1 Bq).

The old unit for activity was the curie (Ci), based on the activity of 1 g of radium. One curie is a very large activity (equivalent to 3.7 x 10^{10} Bq). Since older school radioactive sources are often labelled in µCi, the conversion table below may be useful (the activities listed are typical for school sealed sources).

Old units of radioactivity / µCi	SI units of radioactivity / kBq
0.1	3.7
0.125	4.6
5.0	185
9.0	333

Excepted package: A package of radioactive material for which the external dose rate is low enough that the package is conditionally exempt from many of the requirements of the transport regulations.

Exempt quantity: An amount or concentration of radioactive material which is exempt from many of the environmental regulations (but not other regulations) applying to radioactive substances, including the need for a permit, if conditions are followed. 'Conditionally exempt' would be a better term.

Half-life: The half-life of a radionuclide is the time taken for the activity to drop to half its initial level. It ranges from fractions of a second to millions of years, depending on the radionuclide.

Ionising radiation: The transfer of energy in the form of particles or electromagnetic waves of a wavelength of 100 nanometres or less, or a frequency of 3×10^{15} hertz or more, capable of producing ions directly or indirectly.

Radiation energy: The energies of the particles or photons emitted by radioactive substances are usually quoted in electron volts (eV). One electron volt is the increase in energy acquired by an electron which has been accelerated by a potential difference of one volt – ie, an increase in energy of 1.6×10^{-19} joules.

Radioactive substance: Any substance which contains one or more radionuclides, whose activity cannot be disregarded for the purposes of radiation protection.

Radiochemical: An unsealed radioactive substance used as a chemical.

Radionuclide: A radionuclide is an *atom* with an unstable *nucleus* which undergoes *radioactive decay*, emitting *ionising radiation*.

Sealed source: A source containing any radioactive substance in a structure which prevents, under normal conditions of use, any dispersion of radioactive substances into the environment. The term 'closed source' was used in older legislation.

Specific activity: The specific activity of a substance is the radioactivity per unit mass, usually expressed in becquerel per gram. Decay chains make calculations of specific activity more complicated. The following table gives data for the radioactive substances commonly used in schools and colleges.

Radioactive substance	Initial specific activity	Use
Uranyl(VI) nitrate-6-water	5.8 kBq g^{-1} for U-238 Manufactured from depleted uranium, which is mainly U-238. It will also have an equal activity of U-234. Owing to decay chain and traces of U-235, the actual activity is always greater – it could rise to a total of 24 kBq g^{-1}.	Protactinium generator
Thorium oxide	3.21 kBq g^{-1} for Th-232 But, owing to decay chain, old samples could rise to a total of 30 kBq g^{-1}	Radon-220 from gas mantles
Thorium minerals	Up to 0.3 kBq g^{-1}	Active rock samples
Uranium minerals	Up to 8.5 kBq g^{-1}	Active rock samples

Unsealed source: Radioactive material that could be dispersed in normal use, causing contamination. For example, uranyl nitrate in a reagent bottle is an unsealed source. The term 'open source' is used in older legislation and is still used occasionally.