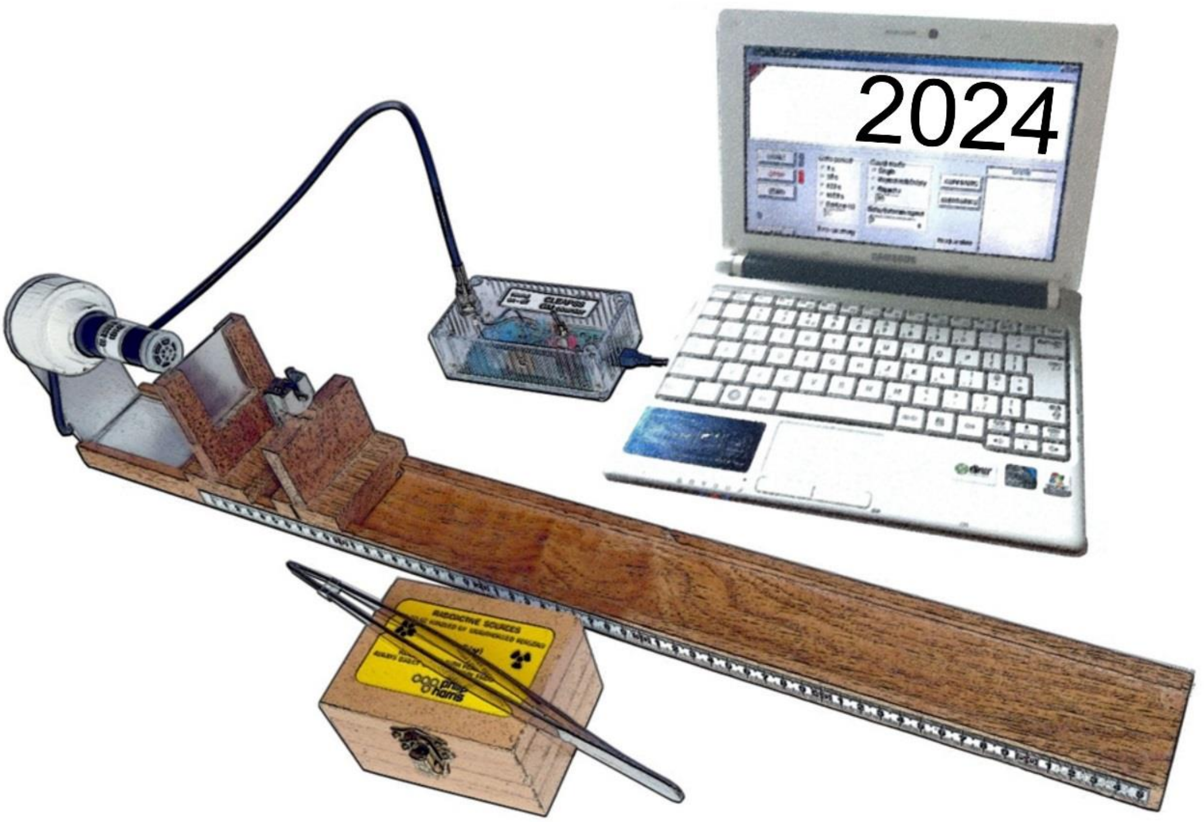
CLEAPSS

L93

Managing Ionising Radiations and Radioactive Substances in Schools and Colleges

February 2024

(Minor revisions October 2024)



Sections 6.5, 6.6.1, 9 and 15 need to be completed by the RPS(Schools)

CLEAPSS publications are normally confidential with circulation restricted to members and associate members only. However, we continue to provide L93 unrestricted as a service to secondary schools and colleges to promote teaching practical radioactivity in a well-managed way.

This guidance is designed to be plain English and straightforward to follow. It is for secondary science teaching in schools, sixth form and FE colleges in England, Wales and Northern Ireland. It is also relevant to schools in the Isle of Man, Jersey and Guernsey schools (although disposal arrangements are different). Schools in Scotland should refer to guidance from SSERC.

L93 is not regulation and there is no legal requirement to follow it. Rather, it is a well-established industry best practice guide. In revising this edition, we have liaised extensively with the enforcement agencies and obtained consensus on proportionate interpretations of the various regulations. The HSE has stated that if a school follows this advice and requirements contained in L93, they should be able to demonstrate compliance with Ionising Radiations Regulations 2017.

Important note

L93 is designed to be used as-is without modification or omission. If you ignore, omit or change parts or sections of the advice that are relevant to you in a way we would not advise, you will likely invalidate the risk assessments or environmental exemptions. In some schools where this has happened, it has led to regulatory breaches and action by the enforcement agencies. Where school employers have chosen L93 as their source of radiation protection advice, employees including school staff must adhere to it. If this creates an issue, member schools can contact us for help to resolve matters appropriately.

This guide 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.

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.”

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 implementing the regulations. We hope this publication will help everyone involved to ensure that practical teaching about radioactivity continues to be carried out legally and safely.

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 are available from CLEAPSS in guide GL296.

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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
IRR17	Ionising Radiations Regulations 2017
NIEA	Northern Ireland Environment Agency
NRW	Natural Resources Wales
ONR	Office for Nuclear Regulation
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 using radioactive substances in school science is very safe.

The guide is divided into four parts:

Part A: Arrangements for keeping radioactive sources. This explains about 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, etc. Additional information, eg 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 that employees 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, much 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 are even lower.

1.3 Further help and guidance

If you are unclear about your work with radioactive sources, you can contact the CLEAPSS *Helpline* – 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
PS046: Radiation Protection in School Science: Guidance for Employers	These discuss options for Radiation Protection Adviser services.
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.
GL118 Making a GM counter unit for displaying the counts from a GM tube onto a screen by a data projector	As used on CLEAPSS RPS courses
GL138 Choosing a GM 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 radioactive teaching sources	Explains the registration process.

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

2 The legal background

Five distinct sets of regulation govern most of the acquisition, use and disposal of the radioactive substances used in school science. These relate to:

1. Using ionising radiations safely.
2. Environmental protection.
3. Transporting radioactive substances safely and securely.
4. Security of fissile materials.
5. 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 2016 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) The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (Northern Ireland) 2010 CDG 2009 Authorisation No. 500 rev 2 and CDG 2010 Authorisation NIEA/1	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 that exempts some low-level waste for transport in normal refuse.
Set 4	Security of materials controlled by a nuclear non-proliferation treaty Nuclear Safeguards (EU Exit) Regulations 2019	Secondary schools, 16 to 19 Academies and sixth form colleges are exempt from these regulations. Other types of educational establishments are not.
Set 5	Government control of education The Education (Hazardous Equipment and Materials) (England) Regulations 2004	These regulations require further education institutions to get approval from the DfE before using radioactive sources. These apply only in England and are a remnant of incomplete revocation of regulations*.

*The revoking legislation is The Education (Hazardous Equipment and Materials in Schools) (Removal of Restrictions on Use) (England) Regulations 2008 and The Education (Hazardous Equipment in Schools) (Removal of Restrictions on Use) (Wales) Regulations 2017.

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 Dose limits, and the dose from natural background radiation compared to a school source

Radiation doses are measured in sieverts (Sv); see section 15. In the UK, the annual effective dose from naturally-occurring background radiation is usually between 1 and 10 mSv to a person, and on average about 2.3 mSv. If medical exposures are included, the average increases to about 2.7 mSv. 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. See Section 15 for dose rates from school sources. (Sections 15 and 17 in L93 replace the withdrawn document GL016)

The UK legal maximum annual effective dose for an employee over the age of 18 is 20 mSv and for trainees 16 –18, it is 6 mSv. School students are classed as members of the public and the annual limit is 1 mSv. The annual limit for an equivalent dose to hands and feet is 500 mSv for employees, 150 mSv for trainees and 50 mSv for members of the public. Effective and equivalent doses from using school sealed sources will be greatly less than these limits if you follow the guidance in this document.

2.2 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 is 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)

2.3 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.

2.4 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 if 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 CLEAPSS (or for non-CLEAPSS members, 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. However, you do need to be able to explain the justification.

What isn't justified is acquiring sources, such as 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 RPS(Schools) is not the same as an RPS, a radiation protection supervisor. The names are similar, but the roles are very different. An RPS is a legal role required for so-called 'designated areas'; these do not apply to schools using sources within the standard school holding.

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 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 on 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] The RPS (Schools) should attend refresher training periodically - within 5 years of the date of their last training, or sooner if there are significant changes in legislation or radiological protection.

3.3 Choose sources that are suitable for school science use

The types of sources 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 those sources CLEAPSS has concluded conform to a specification for suitable sources originally drawn up at the request of the Department for Children, Schools and Families (now DfE).

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

New sealed sources should meet a minimum specification of ISO 2919:2012 C23312. Sealed sources manufactured by Spectrum Techniques (USA) and from the Hevesy Laboratory at DTU, Risø, Denmark, when checked (2022) 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 subsumed in the UK Health Security Agency) 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, then the risk assessments in L93 do not apply. 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 discuss your choices first with CLEAPSS 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 that are listed in CLEAPSS PS78. For example, that is six 185 kBq (5 µCi) sources (see section 3.3.2). 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, but not DIY versions.[3]
Gas mantle radon-220 generator for half-life experiments. [4]
Caesium-137/barium-137 elution source for half-life experiments, each up to 40 kBq.[5]
Low-activity thoriated tungsten welding electrodes (TIG electrodes).
Small specimens of naturally radioactive rocks.
Low-level radioactive consumer items such as smoke alarms, gas mantles in a sealed bag, small items of Vaseline glass, and Fiestaware.

3.3.2 Notes on the Standard School Holding

CLEAPSS PS78 list includes the common cup style, and Isotrak rod style, sealed sources. 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

[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 disposed of - 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.**

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 items (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. Section 6.6 gives more information.

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. (See section 13 for the numerical values of the 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 unlikely they will want to do this unless they think you are seriously breaching environmental regulations.

The conditions for exempt substances are:

- 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 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 sections 9.2.6 and 9.3).

Be careful: 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.

3.3.5 X-ray equipment

X-ray equipment (such as a Tel-X-Ometer) is not part of the Standard School Holding.

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 you have a Tel-X-Ometer, you do not have to dispose of it if it is not in use. Make sure the key is locked away securely and there is a clear large notice on the equipment that it must not be used until advice has been given by a suitable RPA, and the advice implemented.

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. 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.

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 education employers and brokering organisations

CLEAPSS is an RPA Body and can offer an RPA service to local authorities (LA), multi-academy trusts (MAT), and some school-support organisations brokering CLEAPSS services. Your employer can usually purchase the CLEAPSS RPA service through a nearby LA, MAT or brokering service. For more details on the CLEAPSS RPA service, see our guide RPA001 available from the CLEAPSS website.

In the CLEAPSS RPA scheme, the employer (LA or MAT) or brokering service, appoints one of their staff as a Radiation Protection Officer (RPO). This is usually a health and safety adviser. The employer then appoints CLEAPSS as its RPA. The RPO carries out the routine monitoring role, by visiting schools periodically and checking their records and procedures, and liaises with CLEAPSS if there are any concerns.

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 (section

3.5.4). If your school changes status, such as 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 (2024), 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. This is done online through the HSE's RADAN system. 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 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 the employer's details or practice with ionising radiations, in which case a new registration must be obtained.

The HSE makes a small single charge for the registration, around £26 (2024).

Radon in buildings falls within notification, not registration. This is a matter for the school employer, not the science department. The employer must consider the risks from radon in all their workplaces. The CLEAPSS guide GL406 advises 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 five times a domestic smoke alarm.

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* 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 with 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.

[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}.

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 holidays unless you can be sure of these arrangements.

3.7 Equipment for monitoring

Every establishment which keeps radioactive substances must have suitable detection equipment for monitoring. 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.

The equipment for monitoring must be in working order and easily available. Borrowing equipment from elsewhere when required is not acceptable. 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 detecting low-level contamination. CLEAPSS or your RPA can advise you on choosing suitable equipment.

4 Storage, labelling and security

4.1 Source storage

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. Store the sources in a secure steel storage cabinet that is in a secure, lockable store room, accessed by science staff only. Install the steel cabinet in good time before acquiring or relocating any sources. 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 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.

Make sure the premises manager is told where the radioactive sources are kept, and the location is added to the school's fire risk assessment/plan.

4.1.1 Other restrictions on the store room

Schools rarely have the luxury of a dedicated store room for the steel storage 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 flammable substances.
- No corrosive materials, to reduce the risk of damage to the sources.
- No pressurised gas cylinders of corrosive or flammable gases, or oxygen.
- Only science department equipment. It is not acceptable to share the store room with non-science staff.

[1] See CLEAPSS guide GL138, Choosing a Geiger-Muller tube and counter or ratemeter.

4.1.2 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, a general stationery cupboard used by school staff, a boiler room, or an outside store are all examples of completely unsuitable store rooms.

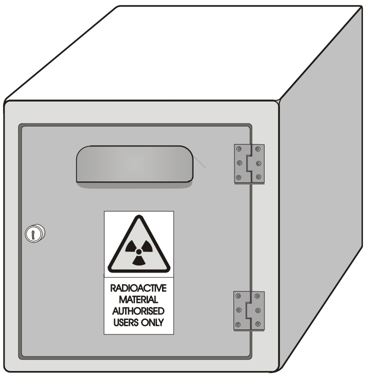
Ground floor store rooms with standard glazed windows on an external wall are too easily broken into. If this is your only realistic choice of a store room, you will need to improve the physical security, for example by fitting obscured laminated glazing. We don't advise fitting external bars etc across windows as it may unintentionally flag that there is something inside worth stealing.

4.1.3 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, with an internal shelf roughly mid-height.
- Fitted with a lock so that only authorised science staff can open the cabinet.

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



Preferred steel store cabinet (fixed securely)

Warning trefoil sign for the cabinet, with recommended text

4.1.4 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 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 different students sit there throughout the day.
- positioned so the cabinet contents can be viewed easily and directly by a person standing.

Do not position the cabinet so you have to stoop or kneel to see inside it, nor position it so high that steps are needed to see inside it.

If there are visible overhead water pipes, avoid positioning the cabinet directly underneath them if practicable. This is so the sources and cabinet do not become soaked should the water pipes break, eg during the winter. (Note: the radioactive sources do not affect the water or pipes.)

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 advise placing the radioactive sources on different shelves as follows:

- standard sealed sources on a middle shelf, with gamma sources (particularly cobalt-60 and radium-226) towards the centre back;
- 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; and
- small radioactive artefacts on any shelf.

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 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.

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

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, with gamma sources inside, it is normal to detect some gamma radiation. 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.

4.4 Nuclear safeguards: security of materials controlled by a nuclear non-proliferation treaty

Secondary schools of all types, 16-19 academies, and sixth-form colleges are exempt from reporting their holdings of uranium, thorium and plutonium to the Office for Nuclear Regulation (ONR). You still need to have up-to-date and accurate inventories of your holding. (The exemption does not apply if you have enormous quantities of these materials, e.g. more than 100 kg of uranium. This is unthinkable in a school.)

(Note that further education institutions (other than sixth form colleges), teacher training institutions, etc are not exempt from the regulations on nuclear safeguarding. Regardless of how little of these materials you hold, there is no exemption. If your establishment is part of a university, contact your RPA because the university may be registered as a qualifying nuclear facility with limited operation. However, to avoid regular reporting to the ONR, it may be simpler to find alternative sources that do come under these reporting requirements.)

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. No sources, whatever their activity, should ever 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. Technicians must be 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, 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 at the start of their school year 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

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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.

enclosed, and the students must be closely supervised. This is to prevent students from contaminating their fingers, particularly from touching radioactive rocks, which should be stored in suitable transparent containers.

5.1.5 Students aged 16 (or older) in Year 12 and above

Students aged 16 or older in Year 12 (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 of the class must teach the students the basics of radiological protection. The teacher must be satisfied that the students are responsible enough, and that they have been shown how to use the sources 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 6.6) 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. This includes following the Standard Operating Procedures and what to do if you drop or spill a source, including a spill of radioactive material on your clothes or skin. 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 of 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 to formally record when you took the source out of the store, and when you returned it. See section 8.2.

6.3 Risk assessments

If employees are working with radioactive substances, the employer must make suitable and sufficient risk assessments. To do this, the employer must consult with a suitable RPA, then implement proportionate safety precautions, including supplying information and training, to protect employees and others from harm and keep the remaining risks low. If your employer has adopted L93 for their risk assessments, you need to heed the information and guidance in it. Should you want more detail on how the risks were assessed in L93 to meet the regulations, see section 17.

In this guide, the safety advice and precautions are explained 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] In addition to normal laboratory rules and procedures, the Standard Operating Procedures give basic contact details for the school and employer, and explain the general good practice that is required to keep risks low when using any radioactive material. Model Standard Operating Procedures are set out in section 6.5.
2. **Specific-source risk assessment guidance** (in section 6.6) that gives additional information and precautions specific to each of the standard school holding sources.

For a particular radioactive source, use the Standard Operating Procedures along with the additional information and precautions in the appropriate specific-source risk assessment guidance.

6.3.1 Make sure you understand the Standard Operating Procedures and the information in the specific-source risk assessment guidance

Before using any of the sources, make sure you understand fully the Standard Operating Procedures and the information and precautions identified in the relevant specific-source risk assessment guidance. If you do not have a full understanding, the RPS (Schools) must give you the necessary training before authorising you to handle and use the sources. Check if there are any additional notes added to the Standard Operating Procedures.

Check that there is a specific-source risk assessment guidance for each of the radioactive sources that you are planning to use, and that each has been reviewed as suitable, with the name of the RPS(Schools) and the date of review at the end of the guidance.

Make sure you understand how to deal with foreseeable incidents involving radioactivity. If an incident could cause an exposure of concern (what the regulations call ‘a radiation accident’) you must have a contingency plan. For the RPS (Schools) there is detailed information on this in section 9.

6.4 Standard school activities with ionising radiations

The Standard Operating Procedures and specific-source risk assessment guidance assume that the practical work you are carrying out will be 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 of:

- 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

[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.

- the inverse square law for uncollimated gamma radiation
- how to determine the half-life
- observing tracks in a cloud chamber using thoriated TIG rods
- 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 Model Standard Operating Procedures

Sections A, B and D need to be completed by the RPS(Schools). In section D, if no additions are needed, record 'none needed'. You need to keep the Standard Operating Procedures up-to-date.

The model Standard Operating Procedures are for science teachers and technicians, and for post-16 students using sources under the supervision of an authorised teacher or technician. They come from the careful consideration of the hazards from internal and external ionising radiations exposure from sources in the standard school holding, and the people who may be affected.

The Standard Operating Procedures are the general safety precautions and safety information that you need to follow to minimise the risks of these hazards to you and to others such as students observing demonstrations, and people in the vicinity of the sources.

A. Standard Operating Procedures: Contact information	
School or college name	
Employer (see section 3.5.2)	
Radiation Protection Supervisor (Schools) (RPS (Schools))	Name .... Internal telephone .... E-mail ....
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 yes/no (circle the correct answer)	RPA: Telephone .... E-mail .... RPO: Name .... Telephone .... E-mail ....
Contact for advice: CLEAPSS	+44 (0)1895 251496

B. Standard Operating Procedures: Document locations	
Document	**Location**
Radioactive source history	
Use log for radioactive sources	
Monthly check log book	
List of authorised users of radioactive sources	
Inventory of radioactive sources held, and annual check	

C: Standard Operating Procedures to be used with the risk assessment guidance for specific-sources	
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. The risk assessments assume the students are suitably mature and well-behaved. If there are serious behaviour problems in a particular class, the use of radioactive sources may be inappropriate.
2	In addition to these Standard Operating Procedures, you must follow the specific-source risk assessment guidance in section 6.6 of the CLEAPSS guide, or exceptionally, one provided by CLEAPSS in liaison with your employer.
3	You must be authorised by your RPS(Schools) to work with the sources.
4	If you are pregnant or breastfeeding, tell your RPS (Schools) before starting work with ionising radiation.
5	Practical work with students should be carried out in a laboratory and supervised by a qualified science teacher who has adequate training and understanding of radioactivity hazards and basic radiological protection techniques.
6	The sources must be in good and serviceable condition.
7	You must not subject sources to harsh handling or conditions, or temperatures outside of the ambient temperature (except for cloud chamber sources) or used in ways that could damage their integrity.
8	There must be suitable working monitoring equipment, easily and readily available.
9	Anyone working with ionising radiation has a responsibility to restrict their personal exposure as far as reasonably practicable.
10	While alpha radiation causes little exposure outside the body, it is far more dangerous should the alpha-emitting material enter the body, eg by swallowing or inhaling alpha-emitting radioactive material.
11	The Control of Substances Hazardous to Health regulations mean you must not eat, drink or apply cosmetics when working in the laboratory, including when working with ionising radiation.
12	Wear protective equipment indicated by the specific-source risk assessment guidance. Before working with radioactive substances, cover any wounds or skin damage with a suitable waterproof dressing. Protective equipment must be the right size for you, and you must know how to fit it and wear it correctly.
13	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, including when positioning absorbers in front of sources. Some sources emit more radiation in a particular direction (collimated or non-isotropic sources). Position these 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.
14	Spend as little time as practicable near the radioactive source.
15	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.
16	Students under the age of 16 (at the start of their current school year) should not use radioactive sources other than low-activity sources in small diffusion 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). You must give adequate information and guidance to the students. Record on the use log that adequate information has been given to the teaching group. All other work with radioactive sources must be demonstrated by the teacher only.
17	For demonstration practical work, arrange the students so they are at least 2 m away from the sources.
18	Responsible students aged 16 years and older (at the start of their current school year) in Y12 (Y13 in NI) and above may use sources within the Standard School Holding. Each student must understand these Standard Operating Procedures and the relevant risk assessment guidance.

19	Whenever students in Y12 (Y13 in NI) and above work with radioactive sources, you must give suitable training and, where appropriate, provide written instructions. (If the student has support staff to help with medical or other needs, you must also give the support staff suitable training and, where appropriate, written instructions. The students must be closely supervised. Record on the use log the students' names and that adequate information has been given to the students, and if relevant, support staff.
20	A member of staff must check sources 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.
21	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.
22	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. Do not leave them unattended ready for a lesson.
23	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).
24	If the fire alarm sounds, follow the school's fire safety procedure. The 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.
25	If the source is dropped or spilt, follow the 'Spill or drop' guidance on the specific-source risk assessment guidance, and section 9, Managing incidents involving radioactivity. For any drop or spill, inform the RPS(Schools) promptly.
26	Wash your hands after you have finished using radioactive materials, even if only using sealed sources.

D. Standard Operating Procedures: Additional notes

End of the Standard Operating Procedures Dated ________________

6.6 Risk assessment guidance for using specific radioactive sources

The following pages provide specific-source risk assessment guidance. It is the additional information and precautions that you must follow for specific radioactive sources and used along with the Standard Operating Procedures. It is for science staff and students using radioactive sources in the Standard School Holding. This arises from the risk assessment process carried out by CLEAPSS in consultation with school employers (see section 15). The risk assessment process considered the source radionuclide, its form, design, use, and likely dose rates.

Your RPS (Schools) in agreement with your employer and your employer's RPA, may have adapted the specific-source risk assessment guidance for special circumstances in your school. If so, you should follow any extra conditions and guidance they have added.

Note that there are some sources, indicated in the list below with an asterisk, where our risk assessment guidance advises that they are taken out of use and disposed of. Our risk assessment conclusion 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 - but not radium
8a	Cup source – radium
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

6.6.1 The risk assessment guidance for specific radioactive sources

There is a colour-coded frame around each risk assessment guidance page, 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 reputable suppliers. They are old and near to the end of their safe working lives. Their continued use should be reviewed carefully. 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-source risk assessment approved by the school's RPA justifies continuing to use it.

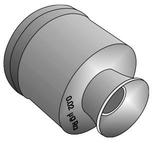
Most of the rows in the risk assessment guidance pages are self-explanatory, but note the following.

- The type number in the top left of each risk assessment guidance is the CLEAPSS type number, which is used for reference in other CLEAPSS documents.
- An *Availability* row gives a note on current suppliers if the sources are available.
- The *Use* row gives the uses that were assumed when the risk assessment was undertaken. If you intend to use the source for something different, the risk assessment guidance is unlikely to be suitable. See sections 6.4 and 7.1.1
- The 'Guidance reviewed by' bottom row should be completed by the RPS(Schools) after carefully checking the guidance is suitable. See section 7.1.1. Only one signed-off risk assessment is needed for each *type* of source you hold, not each source (because the all the hazards and necessary control measures are identified on the risk assessment for that type).
- The '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's 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 principal radiations are given for each source. The radiations in brackets are radiation types normally shielded by the source construction, deliberately or otherwise. These may need to be taken into account when planning investigations about the properties of the different radiations.
- The row on equivalent dose rates gives indicative dose rates at 10 cm and contact, but you should also refer to section 15 for details of dose rates of individual sources at other distances.
- 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).

Type number 1	**Radioactive rocks**	**© CLEAPSS 2024**
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. A rock is treated as radioactive if the count rate at the surface is more than 50% above the background count.
Use	Observation only in containers, to demonstrate that natural rocks contain radioactive minerals	
Original activity	Varies, but can be up to 8.5 kBq g-1.	
Radionuclide & half-life	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 from the thorium or uranium, and the decay chain.	
Equivalent dose rates	Typically, less than 100 µSv/h at 10 cm. See section 15 for other distances.	
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	Always follow the Standard Operating Procedures for the use of radioactive sources. Purchase radioactive rocks from educational suppliers. Only keep small samples (as a rough guide no more than 10 cm^3 each sample) and keep them in a sealed plastic bag or other sealed transparent container when using them to avoid the spread of contamination. Avoid much larger samples. 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 must be left in their transparent containers for observation. Hold the container by the edges. 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 when changing the container. 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	Check annually or if damage to the rock is suspected. The container should be cleaned if necessary.	
Storage and labelling	The rocks are best stored in sturdy, transparent plastic bags or containers with secure lids. A plastic bag is better if the rock is crumbly. The containers should be labelled with a radioactive warning sign and the name of the rock, and kept in the steel store cabinet. The rocks may be put on temporary display, but they must be kept in a locked display cabinet at least 500 mm away from the people 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. Check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details.	
Availability	Available from Philip Harris and other suppliers.	
Holding limit	No limit, other than what is justified for curriculum use.	
Guidance reviewed by	Name	Date

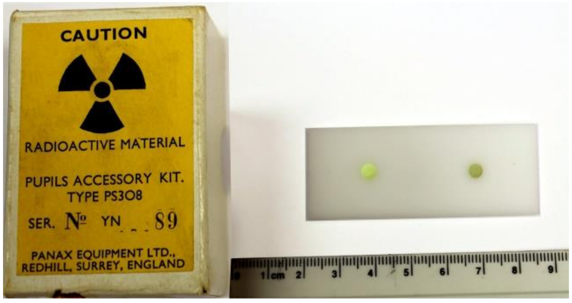
Type number 2	**Smoke alarm**	**© CLEAPSS 2024**
Description		Many domestic smoke alarms use an ionisation chamber smoke detector. This is a small metal chamber containing a radioactive source. If smoke enters the chamber, the level of ionisation reduces, decreasing the flow of electric current in a 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. The ionisation chamber is not to be opened.	
Original activity	Typically, 37 kBq (1 µCi).	
Radionuclide & 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.	
Equivalent dose rate	Typically, less than 0.022 µSv/h at 10 cm. See section 15 for other distances.	
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 actual 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	If a smoke alarm is dropped, it is most unlikely that any radioactive spill will occur. If it dropped onto the floor, wear a lab coat and disposable gloves, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details.	
Availability	Sold by hardware stores.	
Holding limit	Up to five 40 kBq Am-241 smoke alarms. Some older detectors are Ra-226, and some are above 40 kBq. Do not acquire these.	
Guidance reviewed by	Name	Date

Type number 3a	**Not recommended – dispose** **Radioluminescent (radium-painted) timepieces (including dials removed from them)**	**© CLEAPSS 2024**
Description		Clocks and watches with radium paint so they radioluminesce (glow in the dark). Note that over a long time the radioactivity remains almost unchanged, although the radioluminescence gradually decreases over the years as the paint deteriorates, to the point where it barely glows in the dark.
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 & 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.	
Equivalent dose rate	On average around 3 μSv/h in front of the glass if the cover glass is in place. If the cover glass is missing, the dose rate will be much higher. The actual dose rates will depend on the activity of the radium and the dial dimensions. See GL173.	
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.	
Disposal	See section 12.	

Type number 3b	**Not recommended – dispose** **Spinthariscopes**	**© CLEAPSS 2024**
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 & half-life	Usually radium-226: 1600 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Equivalent dose rate	Very low, less than 1 µSv/h at 10 cm.	
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.	
Disposal	See section 12.	

Type number 3c	**Not recommended – dispose** **Radioluminescent instruments that are not timepieces**	**© CLEAPSS 2024**
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 & 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.	
Equivalent dose rate	If the glass is in place, the dose rates for high activity dials can reach the order of 100 μSv/h at the glass face. At 10 cm, it drops to the order of 10 μSv/h. The dose rates will be much higher if the glass is missing. The actual dose rates will depend on the activity of the radium and the dial dimensions. See GL173.	
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	
Disposal	See section 12.	

<table>
<tr><th>Type number 4a</th><th colspan="2">Not recommended – dispose

Scintillation plate</th><th>© CLEAPSS 2024</th></tr>
<tr><td>Description</td><td colspan="2">


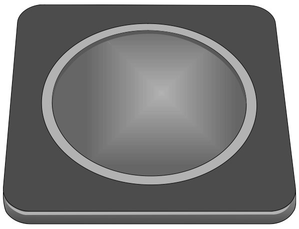
</td><td>Various designs featuring spots of radium paint on a plate. The Panax design has two radium paint spots; one is much weaker than the other. The Panax plates are in boxes of 20 labelled PS-308.

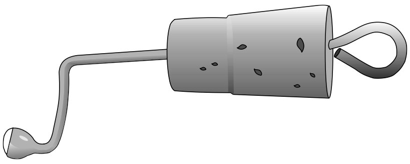
The picture left shows a Panax plate and the boxed set it was taken from.</td></tr>
<tr><td>Typical dimensions</td><td colspan="3">Varies. Panax type scintillation plates are length 65 mm, width 25 mm, thickness ~ 2 mm.</td></tr>
<tr><td>Original use</td><td colspan="3">To observe radioluminescence, and individual scintillations with a magnifier.</td></tr>
<tr><td>Original activity</td><td colspan="3">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.</td></tr>
<tr><td>Radionuclide & half-life</td><td colspan="3">Radium-226, 1600 years.

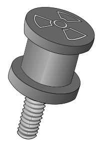
.</td></tr>
<tr><td>Main radiations</td><td colspan="3">α, β, γ including emissions from the decay chain.</td></tr>
<tr><td>Equivalent dose rate</td><td colspan="3">About 10 µSv/h at 10 cm. About 20 mSv/h actually touching the old paint.</td></tr>
<tr><td>Reason for withdrawal from use</td><td colspan="3">The 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.</td></tr>
<tr><td>Hazard</td><td colspan="3">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.</td></tr>
<tr><td>Risk assessment</td><td colspan="3">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.</td></tr>
<tr><td>Storage and labelling</td><td colspan="3">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.</td></tr>
<tr><td>Spill or drop</td><td colspan="3">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.</td></tr>
<tr><td>Disposal</td><td colspan="3">See section 12.</td></tr>
</table>

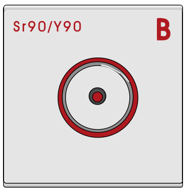
`Type number 4b	**Not recommended – dispose** **Becquerel plate**	**© CLEAPSS 2024**
Description	A radioactive substance lines a recess in a plastic plate, normally protected by a transparent cover or case. Most were originally supplied by Griffin & George, Philip Harris and Panax.	
		
	Becquerel plate	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 & half-life	Uranium oxide paint or encapsulated uranium oxide powder. Panax types also have dummies with manganese oxide. Some Panax plates are yellow. 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.	
Equivalent dose rate	About 120 µSv/h if held	
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 the 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.	
Disposal	See section 12.	

Type number 5	**Not recommended – dispose** **Diffusion (Taylor) cloud chamber radium paint source**		**© CLEAPSS 2024**
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 risk assessment guidance 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 are 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 & half-life	Radium-226: 1600 years.		
Main radiations	α, β, γ including emissions from the decay chain.		
Equivalent dose rate	About 3 mSv/h in direct contact, 2 μSv/h at 10 cm.		
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.		
Disposal	See section 12.		

Type number 6	**Not recommended – dispose** **Expansion (Wilson) cloud chamber radium source**	**© CLEAPSS 2024**
Description	 	This source is part of an expansion (Wilson) cloud chamber. It consists of a metal foil radium source (picture on the immediate left) shaped into a cylinder around the centre of a brass assembly. This screws into the chamber (picture far left) There were various designs, supplied by Philip Harris, MLI and others as part of an expansion cloud chamber apparatus.
Typical dimensions	The source diameter is 7 mm, height 8 mm (excluding the threaded shaft).	
Use	Observation of tracks produced by ionisation due to alpha particles.	
Original activity	Typically, 37 kBq (1 µCi).	
Radionuclide & half-life	Radium-226: 1600 years.	
Main radiations	α, β, γ including emissions from the decay chain.	
Equivalent dose rate	Assuming the glass cover is intact, around 0.8 µSv/h close to the glass. See section 15 for other distances.	
Reason for withdrawal from use	The foils have degraded over time, and all the ones we have seen show significant discolouring. The foil surface integrity is now questionable. The source is difficult to inspect closely and leak test around the immediate area of the foil without dismantling the apparatus. The TIG rod diffusion cloud chamber is a safer alternative.	
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. The seal is now questionable and a risk assessment does not support extending their service life.	
Storage and labelling	Label it ‘DO NOT USE’. Store the whole chamber in a locked cupboard, preferably near to the main store cabinet ready for disposal.	
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.	
Disposal	See section 12. CLEAPSS has a guide for dismantling and disposing of this source and equipment.	

<table>
<tr><td>Type number 7</td><td colspan="5">Not recommended – dispose

Perspex slide sources – Labgear

Do not confuse these sources with the potassium-40 check source. The Labgear sources all have a distinctive red circle. The check source doesn’t</td><td>© CLEAPSS 2024</td></tr>
<tr><td>Description</td><td colspan="2">
</td><td colspan="4">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.

DO NOT CONFUSE THESE LABGEAR SOURCES WITH THE POTASSIUM-40 CHECK SOURCE. The check source has no red circle.</td></tr>
<tr><td>Typical dimensions</td><td colspan="6">Length 50 mm, width 50 mm, thickness 3.5 mm.</td></tr>
<tr><td>Original use</td><td colspan="6">To investigate the basic properties of ionising radiations.</td></tr>
<tr><td>Original supplier</td><td colspan="6">These sources have not been available for many years. The supplier was Labgear Ltd. The foils were from Nycomed Amersham.</td></tr>
<tr><td>Radionuclide & half-life (years)</td><td>Co-60
5.27</td><td colspan="2">Sr-90
28.8</td><td>Am-241
432.6</td><td>Ra-226
1600</td><td>Th-232
1.4 x 10^{10}</td></tr>
<tr><td>Main radiations</td><td>γ, β</td><td colspan="2">Β</td><td>α, γ</td><td>α, β, γ</td><td>β, γ (α)</td></tr>
<tr><td>Original activity kBq (µCi)</td><td>37 (1)

185 (5)</td><td>37 (1)</td><td>185 (5)</td><td>3.7 (0.1)

185 (5)</td><td>185 (5)</td><td>37 (1)</td></tr>
<tr><td>Labgear code</td><td>C</td><td>B</td><td>E</td><td>A</td><td>D</td><td>F</td></tr>
<tr><td>Equivalent dose rates</td><td colspan="6">The dose rates will be similar to the cup sources. See section 15. The equivalent dose rates for a Labgear source that is lower activity than the corresponding cup source can be calculated by simple proportionality.</td></tr>
<tr><td>Reason for withdrawal from use</td><td colspan="6">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.</td></tr>
<tr><td>Risk assessment</td><td colspan="6">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.</td></tr>
<tr><td>Storage and labelling</td><td colspan="6">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.</td></tr>
<tr><td>Spill or drop</td><td colspan="6">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.</td></tr>
<tr><td>Disposal</td><td colspan="6">See section 12.</td></tr>
</table>

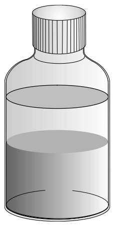
Type number 8a	**Cup sources – <u>but not radium-226</u>**			**© CLEAPSS 2024**
Description		This is the most common type of sealed source used in schools and colleges, a style and construction meeting CLEAPSS L256 specification and originally supplied by Philip Harris, Griffin, Panax, Nicolson and others. 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. The open end of the cup is covered with wire mesh or gauze. It has a 4 mm diameter 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 box container.		
Typical dimensions	Length 22 mm, diameter 13 mm, stem diameter 4 mm.			
Use	To show the basic properties of ionising radiations: ionisation, absorption, inverse square law, beta deflection, backscatter, randomness of disintegrations, and ranges of emissions.			
Original activity	3.7 kBq (0.1 µCi) to 185 kBq (5 µCi), depending on type. Most commonly 185 kBq (5 µCi).			
Radionuclide & half-life	cobalt-60 5.27	strontium-90 28.8	americium-241 432.6	plutonium-239 2.41×10^4
Main radiations	γ (β)	Β	α, γ	α
Equivalent dose rates	It depends on the radionuclide, activity and distance. See section 15.			
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 source for damage. View the foil surface using a plane mirror on the bench, or remotely with a camera. Never point the source open end towards your eyes. The Panax source has a close weave mesh that can obstruct inspection. 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			
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	Pick it up with the handling tool, cup open end facing away from the body. If it dropped onto the floor, wear a lab coat and disposable gloves, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details.			
Availability	Currently sold by Edu-lab, Philip Harris, SciChem and Timstar.			
Holding limit	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.			
Guidance reviewed by	Name		Date	

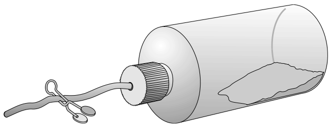
Type number 8a	**Cup sources – radium-226 only**	**© CLEAPSS 2024**
Description		The radium foil cup design is the same as the other cup sources. The radioactive part is a metal foil behind the mesh. Materials from within the radioactive foil can diffuse into the foil surface, causing it to change from a mirror-like surface to a red-brown colour, eventually becoming deep brown. **If you see any sign of this, the foil is no longer as designed, and the source should be disposed of.**
Typical dimensions	Length 22 mm, diameter 13 mm, stem diameter 4 mm.	
Use	To show the basic properties of ionising radiations: ionisation, absorption, inverse square law, beta deflection, backscatter, randomness of disintegrations, and ranges of emissions.	
Original activity	185 kBq (5 µCi)	
Radionuclide & half-life	radium-226; 1600 y	
Main radiations	α, β, γ from radium and its decay chain.	
Equivalent dose rates.	500 µSv/h at 10 cm from a 185 kBq source. See section 15 for other distances	
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. Owing to the decay chain, there are several high-energy beta emitters, so the beta field in front of the source can be relatively high. The decay chain includes radon-222 which can escape from the foil and cause nuisance low-level contamination on the external surfaces. Also, the foil seal may be compromised by diffusion of materials from within the foil into the face layer that degrade it. See CLEAPSS guide GL066	
Risk assessment	If the foil is in good condition and passes leak tests and inspections, the risk is low. If the foil shows any sign of discolouring, it should be taken out of use and disposed of.	
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 source for damage. View the foil surface using a plane mirror on the bench, or remotely with a camera. Never point the source open end towards your eyes. The Panax source has a close weave mesh that can obstruct inspection. **If there is any sign of the foil discolouring, or the foil cannot be inspected through the mesh, dispose of the source.**	
Leak test of source	Annually or if damage is suspected. The outer surface should be tested.	
Contamination check of container	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	Pick it up with the handling tool, cup open end facing away from the body. If it dropped onto the floor, wear a lab coat and disposable gloves, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details.	
Availability	Not sold as a cup source since ~1998	
Holding limit	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.	
Guidance reviewed by	Name	Date

Type number 8b	**Panax source S4**	**© CLEAPSS 2024**
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 demonstrate the basic properties of beta radiation: ionisation, absorption, beta deflection, backscatter, randomness of disintegrations, and ranges of beta emissions.	
Original activity	330 kBq (9 μCi).	
Radionuclide & half-life	Strontium-90: 28.8 years.	
Main radiations	β.	
Equivalent dose rate	When new, 260 μSv/h at 10 cm. See section 15 for other distances	
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 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	Pick it up by the edges with the slit open end facing away from the body. If it dropped onto the floor, wear a lab coat and disposable gloves, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details.	
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.	
Holding limit	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.	
Guidance reviewed by	Name	Date

Type number 8c	**Isotrak educational sources**				**© CLEAPSS 2024**
Description		The source assembly is made up of a source (in an ion exchange resin, or a metal foil), housed in a recess in an aluminium rod. The rods are supplied in a metal cylinder shield, 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 well. The metal cylinder shield has a grub screw in the side. When supplied, this is screwed in to lock the rod in the well for transport. The screw should be undone a few turns so the rod clicks in and out of the well nicely. **Note: this risk assessment guidance is unsuitable for the Frederiksen / Hevesy Laboratory rod sources.**			
Typical dimensions	Length 85 mm, diameter 12 mm. The source is recessed about 4 mm into the end of the rod.				
Use	To show the basic properties of ionising radiations: ionisation, absorption, inverse square law, beta deflection, backscatter, randomness of disintegrations, and ranges of emissions.				
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 & half-life	cobalt-60 5.27 y	strontium-90 28.8 y	americium-241 432.6 y	sodium-22 2.6 y	caesium-137 30.1 y
Main radiations	γ (β)	β	α, γ	β^+	γ (β)
Equivalent dose rate	It depends on the radionuclide, activity and distance. See section 15.				
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*. It is the end that is recessed. 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 damage. View the recessed surface using a plane mirror on the bench or remotely with a camera. Never point the recessed end 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. Alternatively, it can be stored be stored in its metal cylinder shield, upright in a clean plain plastic screw-top bottle, roughly 250 ml volume.				
Spill or drop	Pick it up by the non-source end. If it dropped onto the floor, wear a lab coat and disposable gloves, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details				
Availability	Currently supplied by SciChem.				
Holding limit	The total activity of all sealed sources should not exceed 1.2 MBq. No single sealed source should be above 400 kBq,				
Guidance reviewed by	Name		Date		

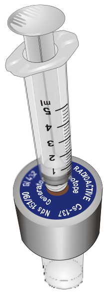
Type number 9a	**Protactinium generator (Philip Harris). (NOT DIY versions. See Type 9b)**	**© CLEAPSS 2024**
Description		A thin-walled fluoropolymer bottle containing an aqueous solution of acidified uranyl(VI) nitrate beneath an organic solvent. The cap is sealed onto the bottle, and there is usually 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. 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. **Keep in mind the limited service life and the cost of disposal. Disposal must be by registered waste carrier, and the costs are many £100s, and higher for parts of the UK.**
Use	To show the half-life of Pa-234m.	
Original activity	Current Philip Harris version: 7.5 kBq (head of chain)	
Radionuclide & half-life	Uranium-238: 4.5 x 10^9 years and its immediate decay chain. Uranium also comprises up to 0.7% uranium-235.	
Main radiations	Mainly β, (α blocked by the bottle wall)	
Equivalent dose rate	14 µSv/h to the skin when holding it. See section 15 for other distances	
Hazard	Concentrated hydrochloric acid is corrosive. Organic solvent, depending on design (eg pentyl ethanoate (amyl acetate)), is harmful and flammable. See CLEAPSS Hazcards for 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 handling or storage. The residual risk is low with the control measures in place**. The recommended working life of these generators is 8 years, so they should be disposed of after this time. However, the life can be extended no more than a further two years if the generator is giving good results, and a thorough inspection shows the bottle and seal are in good condition.**	
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 a 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. Take particular care not to drop the source. 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 you suspect damage. Dry wipe around the cap and any suspect areas. Do not open the bottle.	
Contamination check of the outer container	Annually or if leakage is suspected. Check the container the bottle stands in and clean it if necessary. If you find contamination, the bottle or the cap seal is probably failing.	
Storage and labelling	The lower half of the bottle should be labelled that it is a radioactive protactinium generator. There should also be a label on the cap stating that it must not be opened. 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, then decontaminate the affected area. For spills on the skin, wash the affected area with soap and water. See section 9 for details.	
Availability	Supplied by Philip Harris	
Holding limit	No specific limit other than what is justified. The total mass of uranium should not exceed 100 g.	
Guidance reviewed by	Name	Date

Type number 9b	**Not recommended – dispose** **Protactinium generator (DIY versions)** **Do not make protactinium generators. School-made generators should be disposed of. Replace it with a type 9a, 11 or 13 source.**	**© CLEAPSS 2024**
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. 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 use	To show the half-life of Pa-234m.	
Original activity	It depends on the formulation.	
Radionuclide & 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)	
Equivalent dose rate	14 μSv/h to the skin when holding it. See section 15 for other distances	
Reasons for withdrawal from use	The plastic bottles deteriorate with age and leak, particularly the seal around the cap. Concentrated hydrochloric acid is corrosive and is contaminated by uranium. The failure rate of these DIY generators is relatively common and the damage and consequent clean up caused by the leak can run into the thousands of pounds. There have been many cases of serious contamination and damage caused by failed bottles.	
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. The risk assessment does not support the continuation of this source.	
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.	
Disposal	See section 12	

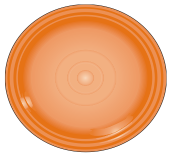
Type number 10	**Not recommended – dispose** **Radon-220 (thoron) generator (powder version)**	**© CLEAPSS 2024**
Description		Originally called a thoron generator, but more correctly termed a radon-220 gas generator. It is a plastic squeeze bottle containing about 20 g of a thorium compound in powder 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 for demonstrating and measuring the half-life of Ra-220.	
Original supplier	Panax, Philip Harris, Griffin.	
Radionuclide & half-life	Thorium-232 and decay chain. Thorium-232: 1.4 x 10^{10} years.	
Main radiations	Α, β, γ including emissions from the decay chain.	
Equivalent dose rate	Around 100 μSv/h to the skin when holding it.	
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	Seek specialist advice from your RPA.	
Disposal	See section 12.	

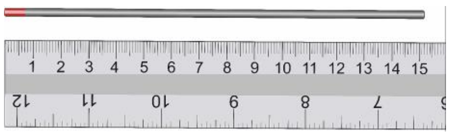
Type number 11	**Radon-220 generator and picoammeter (Cooknell gas mantle version)**	**© CLEAPSS 2024**
Description		A polythene squeeze bottle containing thoriated gas mantles (mantles impregnated with thorium oxide). Very small quantities of radon-220 (thoron) gas are produced by the radioactive decay series of thorium. When the 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 has a small party balloon over it. When the generator is not in use, a clip on the tube prevents gas from escaping.
Use	To show and measure the half-life of Rn-220.	
Original activity	Typically, 6 kBq (0.16 µCi) (four gas mantles).	
Radionuclide & 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.	
Equivalent dose rate	10 µSv/h to the skin when holding it. See section 15 for other distances	
Hazard	Thorium compounds are radioactive and generally toxic. 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. However, be cautious 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. Refit the tube clip at the end of the demonstration.	
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	In the highly unlikely event the bottle has broken, the gas mantles may release a few fragments. The risk from this is small. Allow any fragments to settle. Carefully pick up the bottle and gas mantles with a tissue and place them in a bag, then decontaminate the area. See section 9.2.2 for details.	
Availability	Currently sold by Cooknell Electronics Ltd (Weymouth) and Timstar.	
Holding limit	No specific limit, other than what is justified for curriculum use.	
Guidance reviewed by	Name	Date

Type number 12	**Gas mantles (thoriated)**	**© CLEAPSS 2024**
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 that detection equipment is functioning.	
Original activity	Of one mantle, typically 1 kBq (0.03 µCi).	
Radionuclide & half-life	Thorium-232: 1.4×10^{10} years, and decay chain.	
Main radiations	α, β, γ including emissions from the decay chain.	
Equivalent dose rate	20 µSv/h to the skin when holding it. See section 15 for other distances	
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. Before the mantle is burnt, there is certainly 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, in 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	In the highly unlikely event the bag breaks, the gas mantles may release a few fragments. The risk from this is small. Allow any fragments to settle. Carefully pick up the gas mantles with a tissue and place it in a bag, then decontaminate the area. See section 9.2.2 for details.	
Availability	Camping shops, hardware stores. Many stockists only supply non-radioactive gas mantles, and this is usually stated on the packaging.	
Holding limit	No limit, other than what is justified for curriculum use.	
Guidance reviewed by	Name	Date

<table>
<tr><th>Type number 13</th><th colspan="2">Isotrak caesium-137/barium-137 elution source</th><th>© CLEAPSS 2024</th></tr>
<tr><td>Description</td><td></td><td colspan="2">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.

The generator will yield up to 1000 small liquid samples containing the barium-137m isotope.</td></tr>
<tr><td>Typical dimensions</td><td colspan="3">Diameter 40 mm, length 60 mm (including two plastic storage caps).</td></tr>
<tr><td>Use</td><td colspan="3">For showing and measuring the half-life of Ba-137m.</td></tr>
<tr><td>Original activity</td><td colspan="3">Typically, 33 kBq (0.9 μCi).</td></tr>
<tr><td>Radionuclide & half-life</td><td colspan="3">Caesium-137: 30.1 years; barium-137m: 2.6 minutes.</td></tr>
<tr><td>Main radiations</td><td colspan="3">γ (β)</td></tr>
<tr><td>Equivalent dose rate</td><td colspan="3">16 μSv/h to the skin when holding it. See section 15 for other distances, and dose rate from the eluate</td></tr>
<tr><td>Hazard</td><td colspan="3">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.</td></tr>
<tr><td>Risk assessment</td><td colspan="3">The dose rate near the surface is low, so in the short time the generator and eluate are handled, the dose on the hands will be negligible. There is a risk arising from undesirable release of Cs-137 into the eluate. The supplier's data states 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.</td></tr>
<tr><td>Control measures</td><td colspan="3">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.</td></tr>
<tr><td>During use</td><td colspan="3">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.</td></tr>
<tr><td>After use</td><td colspan="3">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 black plastic bag, tied off (do not label the plastic bag) and placed in the normal black-bag refuse. Monitor the area immediately around where the source was used to check there is no contamination. On the use log, record, the volume eluted.</td></tr>
<tr><td>Inspection</td><td colspan="3">Annually, as well as before and after each use. Check for any signs of damage or deterioration.</td></tr>
<tr><td>Leak test of source</td><td colspan="3">Annually or if damage is suspected, by dry wipe of the plastic body.</td></tr>
<tr><td>Contamination check of container</td><td colspan="3">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.</td></tr>
<tr><td>Storage and labelling</td><td colspan="3">The source should be stored in its original container, labelled with a radioactive warning sign and kept in the steel store cabinet.</td></tr>
<tr><td>Spill or drop</td><td colspan="3">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. For spills on the skin, wash the affected area with soap and water. See section 9.2.</td></tr>
<tr><td>Availability</td><td colspan="3">Supplied by HTSL and others.</td></tr>
<tr><td>Holding limit</td><td colspan="3">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 will require EPR permitting.</td></tr>
<tr><td>Guidance reviewed by</td><td colspan="2">Name</td><td>Date</td></tr>
</table>

Type number 14	**Uranium-coloured domestic glassware and ceramic items**	**© CLEAPSS 2024**
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. 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.
Typical dimensions	Not applicable.	
Use	To show that some older domestic items are radioactive.	
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 GM detector count rate can be surprisingly high.	
Radionuclide & half-life	Uranium-238: 4.5 x 109 years, decay chain thorium-234: 24 days and protactinium-234m: 72 s. Uranium also comprises up to 0.7% uranium-235.	
Main radiations	α, β, γ including emissions from the decay chain of uranium-238 and uranium-235.	
Equivalent dose rate	Very low, but it depends on the item. See section 15	
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. Note that 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. Test the outer surfaces of the item with a simple wipe test (using dry filter paper).	
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'. Keep them with other radioactive sources in the steel store cabinet.	
Spill or drop	If one of these glass or ceramic items is dropped and breaks, beware of sharp edges. Care must also be taken to avoid contamination from the low amounts of radioactive material present. Wear a lab coat and disposable gloves. Carefully clear up the breakage, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2 for details.	
Availability	Available through second-hand and antiques dealers.	
Holding limit	No limit, other than what is justified for curriculum use.	
Guidance reviewed by	Name	Date

Type number 15	**Thoriated tungsten welding electrode**	**© CLEAPSS 2024**
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. Shorter lengths may be fitted in commercial cloud chambers.	
Use	Used in a diffusion (Taylor) cloud chamber in place of the small radium paint sources, which are no longer recommended. (The cloud chamber may need to be modified by having an additional 3.5 mm hole drilled 7 mm above the chamber floor. It can also be used as a check source.	
Original activity	Red-tipped (2%) rods are about 3.2 kBq.	
Radionuclide & half-life	Thorium-232: 1.4 x 10^{10} years, and decay chain.	
Main radiations	α, β, γ including emissions from the decay chain.	
Equivalent dose rates	12 µSv/h to the skin when holding it. See section 15 for other distances	
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. Do not attempt to cut or grind the rods. Thoriated tungsten electrodes are regarded as low-level radioactive artefacts. Use electrodes that conform to BS EN ISO 6848:2015	
During use	The teacher, not the students, should insert the rod into the chamber. The organic solvent for producing cloud tracks is highly flammable, make sure there are no sources of ignition nearby. The electrode is held in place by inserting it into a bung or cork at each end. Ensure all the TIG rods are present at the end of the lesson.	
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 them from the cloud chambers 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 for details.	
Availability	SWP brand, type WT20 supplied through welding supplies shops.	
Holding limit	No limit, other than what is justified for curriculum use.	
Guidance reviewed by	Name	Date

Type number 16 **Type number 17**	**Not recommended – dispose** **Uranium and thorium compounds as radiochemicals (including uranyl nitrate)**	**© CLEAPSS 2024**
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 & half-life	Uranium - mainly uranium-238 with up to 0.7% uranium-235 - and decay chains. Uranium-238: 4.5 x 10^9 years. Thorium-232 and decay chain. Thorium-232: 1.4 x 10^{10} years.	
Main radiations	α, β, γ including emissions from the decay chains.	
Equivalent dose rate	Depends on the radionuclide and quantity, but unlikely to be more than 200 μSv/h to the skin when holding the bottle.	
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	Seek specialist advice from your RPA	
Disposal	See section 12.	

Type number 18	**Uranium oxide encapsulated disc source**	**© CLEAPSS 2024**
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. Can be used as a low-level beta source to demonstrate basic properties of beta radiation.	
Original activity	JMB version is 1.1 kBq (0.03 µCi).	
Radionuclide & 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 are blocked by the aluminium envelope.	
Equivalent dose rate	50 µSv/h to the skin when holding it. See section 15 for other distances	
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 for details.	
Availability	These sources have not been available for many years. Replacement school-made sources are not recommended.	
Holding limit	No specific limit, other than what is justified for curriculum use. The total mass of uranium should not exceed 100 g.	
Guidance reviewed by	Name	Date

Part C: Further guidance

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

7 Roles and responsibilities

7.1 The role of the RPS (Schools)

Your employer retains the ultimate legal responsibility for the health and safety of staff and students at the school or college, but responsibilities are delegated to managers and supervisors. As the RPS(Schools), you have the delegated 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 the precautions in the risk assessment guidance. You should be based at the school, but you don't have to be on-site every time for the routine authorised use of the sources. If you know the sources are going to be used when you are off-site, make arrangements so you can be contacted if necessary.

You need to:

- be directly involved with work using ionising radiations, including practical teaching
- understand the Standard Operating Procedures and risk assessment guidance for the sources used at your school
- be able to exercise the authority to ensure that all work with radioactive sources follows the school's Standard Operating Procedures and risk assessment guidance
- 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 accident or incident (see section 9).

The head of science, not the RPS(Schools), has the main responsibility for monitoring that teaching is effective and safe. Tell the head of science if you become aware of unsafe practices in teaching practical radioactivity.

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. Training is important for newly qualified or newly recruited staff too. Don't assume any prior knowledge, and recognise that equipment often differs among schools.

You should keep an up-to-date list of the science staff who are authorised to handle the radioactive sources, the training they have received and when they received it (see section 16.6 for a template).

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 use each type of radioactive source safely by following the specific-source risk assessment guidance
- 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
- dealing with radiation incidents, and contingency plans for radiation accidents, and
- when to seek help and advice from the RPS (Schools).

7.1.1 Make sure the *Standard Operating Procedures* and the *specific-source risk assessment guidance* are suitable for your sources and your intended use

You need to complete the *Standard Operating Procedures* (section 6.5) and check that they are suitable for your school's circumstances. Make any additional notes to the procedures, eg, if the storage cabinet is in a store room that opens into a busy corridor, then avoid lesson changeover when collecting the sources. If you conclude no additions are needed, record this in the additional notes.

You need to review the *Standard Operating Procedures* guidance periodically. We recommend you do this each year by using the checklist in section 16.1, or if you have a reason to suspect they are no longer sufficient. If you complete and date the checklist, that will record that you carried out this review.

Second, for each of the sources you hold, you need to confirm that there is a *specific-source risk assessment guidance* (section 6.6) that matches exactly your source, and that the *Use* row is correct for how your school intends to use the source. Confirm this by writing your name and date in the bottom row of the guidance. If you believe that the guidance does not match your source or is not suitable for your intended use, do not modify the guidance. Any use that is not covered by the *Use* row and section 6.4 would need to be discussed in advance with your employer's RPA to adapt the risk assessment guidance in agreement with your employer. Do not allow any radioactive source to be used without a suitable risk assessment. When a major revision of L93 is issued, you need to repeat this process.

You should review the specific-source risk assessment guidance periodically to make sure the *Use* row is still suitable. We recommend this is done annually by using the checklist in section 16.1. If you complete and date the checklist, that will record that you carried out this review.

7.1.2 Make sure the contingency plans are suitable for your school

Complete the table in section 9. Review the plans to make sure they are suitable for your school. As necessary, add any additional notes to the end of section 9. The contingency plans need to be reviewed periodically. We recommend a routine review each year by using the checklist in section 16.1. If you complete and date the checklist, that will record that you have reviewed the contingency plans. If your review indicates that the contingency plans are unsuitable in some ways for your school, contact CLEAPSS or your RPA for specialist advice.

7.1.3 Make sure authorised users have ready access to the Standard Operating Procedures, the specific-source risk assessment guidance, and contingency plans

You need to put a copy of the completed Standard Operating Procedures for your school or college (from the model in section 6.5), specific-source risk assessment guidance, and contingency plans (see section 9) where they are easily available to the authorised teachers and technicians.

7.1.4 Add information to the point-of-use texts for lesson planning

We recommend that you signpost L93 in the schemes of work that are used for lesson planning in the department. Signpost part B and the Standard Operating Procedures. Make it clear that only authorised users are allowed to use the sources. This helps new or early career teachers to know they must not access the sources without training and being authorised by you.

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 inspected, and sealed sources leak tested, annually (see section 11); and
- all records required are accurate, up-to-date and kept in a secure place. See section 8.

You must be confident that every time the radioactive sources have been used, they are put back in the store and 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 holiday, 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 that 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). The record should indicate each source has been checked, not just that the cupboard has been opened. This task could be done by a technician. It doesn't count as use and doesn't need to be logged in the use log.

A more detailed inventory check is needed annually. 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 on the inventory (see section 16.2). This counts as a 'use' of the sources and so should 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[1].

7.1.6 Making sure leak tests and inspections are undertaken

Once a year, arrange for the sources to be inspected, and 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. CLEAPSS is an HSE-recognised RPA Body and is qualified to give you this advice. There are various statutory matters on which an employer must consult an RPA, but many of these would not normally apply to schools. The relevant matters are:

- Helping the employer to make suitable and sufficient radiation risk assessments
- 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 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 accident or incident does happen, the RPA can be expected to give advice. However, the RPA is not responsible for dealing with the accident or incident, clearing away any contamination or disposing of unwanted or damaged sources. These are all the responsibility of the employer, and are led initially by the RPS (Schools).

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

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.

The RPO should review the arrangements for the sources at each school at least once every two years to monitor whether they are managing the radioactive sources properly, and reassure the employer that the arrangements for radiation protection are working. If a school in the CLEAPSS RPA scheme has not received a visit, the RPS(Schools) should report this to CLEAPSS. The RPO should issue an inspection report to the school, and a copy also sent to the allocated RPA (not CLEAPSS). Any shortcomings identified in the report need to be resolved by the head of science. It is not for the RPA to chase up.

8 The records that are required

The school must have a good record-keeping system to account for the radioactive substances and to 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 it, sign it, and destroy the previous printed copy.

8.1 Records of history, maintenance and disposal of the sources

Keep an individual record for each source. See section 16.4 for a template and what details you need to record. 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.

Keep the 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, for aqueous liquids, the 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. The sources used should be identified individually, don't write 'All' or other generic terms. See section 16.5 for a template and what details you need to record. 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 and what details you need to record. Keep records of the monthly store checks and the annual inventory check. See sections 16.2 and 16.3 for templates. The inventory must indicate the location of the store(s).

If your source inventory is a paper record only, 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 Appointment of an RPA

The appointment must be in writing (it can be an email). The employer should keep a copy of the appointment. See section 3.4

8.5 HSE registration

The employer should keep a copy of the registration. See section 3.5.4

8.6 Authorised users and training

Keep a list of authorised users and brief details of the training and refresher training they have received. The list needs to record that the training included contingency plans. See section 16.6 for a template.

8.7 Retention and disposal of records

This applies to sources that are (or were) within the Standard School Holding. See section 10.2 for the retention of transport records. 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 from 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 cover 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 until the next leak test, or two years after disposal. 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 are 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. Retain the up-to-date list and discard any that are out-of-date. There is no requirement to keep a record of previous authorised users.

8.7.1 Investigation reports

Investigation reports arising from an unauthorised dispersal, wrongful disposal, 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.

8.7.2 Records of disposal

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.

For other radioactive waste, 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 may unwittingly 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.

8.7.3 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 Ltd., https://irms.org.uk.

9 Managing radiation incidents and accidents

This needs to be completed by the RPS(Schools), including section 9.5

Educational Establishment to which this applies	
Name of RPS(Schools) who leads on this	
Location of personal protective equipment	
Additional notes added (yes/not needed)	
Date these plans were last reviewed by the RPS(Schools)	

Complete the table above, and review the plans in section 9 to make sure they are suitable for your school. Add any additional notes to the end of this section. If none, state 'none'.

Tick the checkbox of 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.2.5 and 9.3.2 where these apply to your school.

Section 9 provides procedures for radiation incidents, and contingency plans for radiation accidents, for schools working with sources in the Standard School Holding.

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

Radiation accidents are rare in schools. The ones that CLEAPSS hears about mostly relate to the loss of the sources rather than anything else. Nevertheless, you should read through all of 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 all radiation incidents and accidents should be reported promptly to you, the RPS(Schools)

The RPS(Schools) has the role, initially, of leading in managing a radiation accident. In emergencies, contact CLEAPSS or your RPA (or RPO). If the emergency services need to be called, this should be done following the school procedures, with information supplied by you. Where emergency services become involved, they will take over the lead but you will likely be required to liaise with them.

9.1.1 Personal protective equipment for people dealing with an incident or accident

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. The protective equipment must be suitable for the task. Staff using protective equipment must be given training on how to fit it correctly.

9.1.2 Investigating and reporting of radiation incidents and accidents

After an incident or accident 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. 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 Radiation incidents

The following incidents do not need a contingency plan. They can be dealt with by normal laboratory procedures. These incidents need to be covered in training and refresher training.

- a standard school holding source (other than a protactinium generator) dropped onto the floor
- a small spill of radioactive liquid, easily cleared up
- a fire drill or false fire alarm causing an evacuation of a lab (as part of a whole-school evacuation) during the use of the sources
- a source is misplaced, but located soon after it was mislaid and has caused no exposure of any concern
- trace contamination on the hand or lab coat, of low activity, unlikely to cause skin damage, noticed immediately and easily removed

If the drop of the source, other than a protactinium generator, ceramic or glassware item, is only a few centimetres from the bench, then continue with the use. It is almost unimaginable that these sources, in good condition, would release material from a short drop.

After dropping a source onto the floor, or after any other event that may have damaged its integrity, where the source appears undamaged, arrange for a visual inspection and leak test (where relevant) soon after the lesson, following section 11.3.1. If the source is undamaged and passes its leak test, it can be returned to use. Make a note on the source leak-test record.

If a dropped source has caused contamination, it will probably have to be disposed of. Contact CLEAPSS or your RPA for advice

9.2.1 A cup-style source, Panax S4 source, Isotrak rod source, TIG rod, uranium disc source, or smoke detector, dropped onto the floor ☐ [Tick here if this applies to your school]

Pick it up. For a cup source, use the handling tool, with the cup open end facing away from the body; for an Isotrak rod source, pick it up by hand at the opposite end of the rod to the radioactive component. Hold the S4 source by the plastic edges and the slit open-end facing away from the body.

It is highly unlikely the drop would cause the dispersal of radioactive material, but as a precaution, take the source out of service immediately. Cordon off the affected area (you can use stools or similar). While there is no immediate urgency, check the floor area with a GM detector to confirm there has been no loss of radioactive material.

In the remote event there is some release of active material, clean the area carefully using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Then follow section 9.4.

9.2.2 A Cooknell bottle or gas mantle dropped onto the floor ☐ [Tick here if this applies to your school]

If the bottle or gas mantle bag is intact, pick it up. In the highly unlikely event the bottle or gas mantle bag breaks, the gas mantle(s) may release a few fragments. Wear a lab coat and disposable gloves. Carefully pick up the bottle and gas mantles with a tissue and place them in a bag. Clean the area carefully using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Then follow section 9.4.

9.2.3 A dropped ceramic or glassware item, or rock ☐ [Tick here if this applies to your school]

Check if the item has broken. The greater hazard could be from sharp fragments. Care must still be taken to avoid contamination from the low amounts of radioactive material present. Wear a lab coat 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, for disposal. When all observable material has been removed, clean the area carefully using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Then follow section 9.4.

9.2.4 A dropped elution source onto the floor ☐ [Tick here if this applies to your school]

Pick it up by gloved hand and put it back on the tray. Cordon off the affected area (you can use stools or similar). While there is no immediate urgency, check the floor area with a GM detector to confirm there has been no loss of radioactive material.

In the remote event there is some release of active material onto the floor, Clean the area carefully using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Then follow section 9.4.

Carry out an elution and check the eluate decays to background within 20 minutes. If it doesn't, it indicates the ion exchange resin has been damaged and the source must be disposed of.

9.2.5 A small amount of spilt liquid ☐ [Tick here if this applies to your school]

For example, a spill of eluate, or a slight leak from a failing protactinium generator seal. Wear disposable gloves, lab coat and eye protection. Wipe up the spill using tissues held in tongs. Then clean the area carefully using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Then follow section 9.4. If a protactinium generator has leaked, dispose of it.

9.2.6 Fire alarm while the sources are in use

Follow the school or college's fire safety procedure. The 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. 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

9.2.7 If a source is misplaced

If a source is missing, arrange a prompt search to be carried out by authorised users. 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 is not found quickly, cannot be found, or probably stolen, this is more serious and classed as a radiation accident – see section 9.3

If a source is misplaced, first check carefully that it has not been:

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

9.2.8 Trace contamination on the hand or lab coat

This relates to low-consequence contamination easily removed. If the contamination is on the lab coat, remove the lab coat promptly and carefully so as not to spread the contamination, and bag it for separate washing. For contamination on hands (or forearms) and noticed immediately, place the skin promptly under a gently-running tap and wash off the contamination, avoiding splashing. 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

9.3 Contingency plans for radiation accidents

A radiation accident is a type of accident where it is likely a person has received or could receive a significantly greater dose than would be expected from the routine use of the radioactive sources[1]. For example:

- contamination to a person that required removal of contaminated clothing other than a lab coat, repeated washing of the skin (particularly if over an area greater than 10 cm^2) or medical treatment was required
- a spill of uranium or thorium compound from a legacy source that caused dust that could have been inhaled
- a protactinium generator dropped onto the floor
- a loss or theft of sources, or
- a major fire affecting the sources.

These need a written contingency plan (which is the rest of this section) because they need immediate actions to prevent or reduce harm to people. These are more serious events that are not dealt with by normal laboratory procedures. If you are concerned that an accident could have caused a dose greater than would be expected from the routine use of the radioactive sources, or anything else you are unsure of, contact CLEAPSS (or your RPA) to get help in assessing the likely dose.

It is inappropriate to physically rehearse these contingency plans. But they should link to your science department's other contingency plans, and you must go over the plans in detail with the authorised users as part of the initial and refresher training. This is called a desktop rehearsal. You must keep a record that this has been done.

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 Serious (or suspected serious) contamination on a person

Decontaminate external contamination as soon as possible. Seek advice from CLEAPSS or your RPA, but do not delay the decontamination

- 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 it with cool water, soap and soft tissues. Avoid spreading the water onto uncontaminated parts of the body. Extensive skin contamination may need to be removed 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 20 minutes with gently flowing clean water. For example, using a rubber tube fitted to a cold water tap, just as you would for any other chemical in the eye. Make sure there is a clean rubber tube readily available, and that fits easily onto the tap.

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. See section 9.4.

[1] Quantitatively, In terms of dose, this would be an effective dose exceeding 50 µSv arising from the incident.

9.3.2 Dropped protactinium generator onto the floor ☐ [Tick here if this applies to your school]

Wear a lab coat, splash proof goggles and disposable gloves. Check carefully for any signs of liquid spill. Spills of a few cm^3 can be mopped up with a tissue held in tongs. Contain larger spills with a mineral absorbent and scoop it into a bucket with sodium carbonate and water. Do not overlook the hazards of mopping up moderately concentrated hydrochloric acid. Follow the procedure for '*Spilt liquids'* in 9.3.3.

9.3.3 Larger spills and contamination

This should not happen because schools should not hold significant quantities of unsealed sources. Should there be exceptional circumstances where this does happen, evacuate all people from the area who do not need to be there, provided they are uncontaminated.

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: if there is a risk of the liquid spreading further, place mineral absorbent, or towels, around the spill to stop it from 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. When most of the spill has been retrieved, carefully clean the area using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Then follow section 9.4. See 12.4.2 for treating and disposing of the absorbent.

Spilt powders (eg thorium powders used in old radon generators): move everyone out of the area until the dust has settled. When it has settled, wear a lab coat and disposable gloves, and 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 the special risk assessment and procedure, SPRA132, for dealing with powder spills. In some cases, the specialist advice may include the use of respiratory protective equipment.

9.3.4 Urgent medical attention is also required

If 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.

Follow your school or college's normal procedures for injury incidents. Treatment of the injured is the 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.

9.3.5 If a source is lost or stolen (including during a lesson)

If you have good grounds to suspect a student has taken the source, immediately inform the school senior leadership team. Any screening or searching of students must follow your school policy.

If other cases of loss, and straightforward checks have been made and the source has not been found, you need to organise a thorough search, by authorised users, 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. Empty the store cabinet. 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 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 to cause injury or alarm in the community.

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

Radionuclide	Reporting threshold
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).

9.3.6 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.

9.4 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 twice the background rate, wearing disposable gloves, carefully clean the area again using paper towels moistened with detergent, or general-purpose surfactant wipes, held in tongs. Do this until further readings show the suspect area is less than twice the background count rate. Put contaminated wipes and used gloves into a black bag and dispose of it following section 12.4.2

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 than are available in the school for monitoring contamination.

9.4.1 Reporting an unintended release of radioactive material

When any radioactive material has been released into the environment (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 a release is reportable.

9.5 Additional notes.

If none, state ‘none’. Add sheets for additional notes.

10 Transporting radioactive sources by road

Do not transport radioactive sources by public transport.

Avoid transporting sources if reasonably practicable. For example, if the sources are used in laboratories on different sites, it is better to have a separate store and set of sources at each location. Under these circumstances, the Standard School Holding may be exceeded for the whole school, as long as the sources at each site are within the Standard School Holding. However, occasionally a school may need to organise transport of their sources, for example if the school is moving site, or the science department is being refurbished and the sources are being moved to a different site temporarily for safe-keeping.

Transporting radioactive materials by road is regulated by the Ionising Radiations Regulations 2017 (IRR17), and the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (CDG) which incorporates the Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR). The terms commonly used in transporting are: a *consignment* that is a package for transport sent from a *consignor* to a *consignee*, by a *carrier,* an organisation undertaking the carriage.

When packed correctly, the sources within the Standard School Holding can be sent as ‘excepted packages’. This reduces the extent of the CDG regulations and ADR. However, excepted does not mean exempt, and transporting excepted packages of radioactive material is far from straightforward. Transporting the package by private car or school minibus is not a realistic option.

The consignor has legal duties when it comes to consigning the package, the outcome of which is that the consignor must have a contingency plan for accidents that could happen during the transport of the radioactive material. Additionally, the CDG requires consignors and carriers to have a radiation emergency plan where their risk assessment shows there is a possibility of an accident causing a dose above 1 mSv to anyone. However, it is highly unlikely an excepted package of school sources could cause a dose above 1 mSv in a transport accident, so an emergency plan is not needed (see sections 15.3 and 17.3). This is just as well because an emergency plan places specific legal duties on the consignor, the carrier and the driver in a transport radiation emergency and it would be impractical for a school to meet many of these.

Considering the above, there are two realistic choices for transporting the sources:

10.1 Option A.

Use a commercial parcel carrier registered for Class 7 dangerous goods to consign and carry the sources. You then have no transport duties as the consignor or carrier (although you still must meet IRR17). This is the most straightforward option, but likely to be more expensive than option B.

10.2 Option B

Act as the consignor, package the sources as an excepted package and use a commercial parcel carrier registered for Class 7 dangerous goods whose risk assessment shows they do not need a CDG emergency plan to collect the package and deliver it to the consignee. But both you and the carrier must have your own contingency plans for a possible transport incident, and the two plans must dovetail.

Check the carrier’s contingency plan and make sure you can meet their expectations of you. For example, if the carrier’s contingency plan requires that you can be contacted for information on your package, that is achievable. But if the expectation is that someone from your school travels to the incident scene with detection equipment, that is not realistic and you should not engage this carrier.

If you choose option B, you must:

1 Let your employer know they must register the practice of transport with the HSE, even if you are only packing the sources. Transport includes packing for transport.

2 Complete the transport risk assessment guidance as the consignor of an excepted package of school sources and share it with the carrier.

3 Raise a suitable consignment note, give it to the carrier and keep a copy for 3 months.
4 Have written confirmation (an email is acceptable) that the head of the organisation to which you are consigning the package will accept the sources, and they are legally allowed to have the sources.
5 Check the sources are in good condition, and leak-tested within the week before the transport.
6 Use a package that meets the general package requirements of ADR and be able to demonstrate this if required.
7 Label the excepted package correctly.
8 Have a contingency plan that dovetails neatly with the carrier's contingency plan.

Why restrict the carrier to one who does not need a CDG emergency plan?

A carrier may be transporting more radioactive material than just yours and their radiation risk assessment may conclude a transport radiation emergency plan is required. Should there be a radiation emergency, it doesn't matter that yours is an excepted package. The driver, carrier and all the consignors have legal duties in a transport radiation emergency and it is unlikely a school could meet the consignor's duties.

10.2.1 Model transport risk assessment guidance for the consignor of an excepted package of school sources for transport by a carrier

Model transport risk assessment guidance for the consignor of an excepted package of school sources for transport by a commercial carrier registered for Class 7 dangerous goods who does not need a CDG emergency plan. The RPS(Schools) should complete rows a to g, add any notes at row 9, then sign and date it at row 10 to say they have followed rows 1-9 and checked this covers all the circumstances at their school. Make this plan available to the carrier.	
a. The name of the organisation consigning the package	
b. Date of transport	
c. Name of the RPS(Schools) and telephone number at the consignor's site	
d. Name and telephone number of the contact person at the consignee's site	
e. Address of the parcel destination	
f. The commercial carrier	
g. The radionuclides and activities of the sealed sources being transported, and form. These must only be sources within the standard school holding, no more than 1.2 MBq in total.	
Scope of the risk assessment guidance	This risks from packaging and unpackaging an excepted package of school sealed sources, and the carriage by a commercial parcel carrier.
The nature of the risk	The hazard is exposure (internal and external) to ionising radiations. Exposure to ionising radiations is a known carcinogenic hazard. The emissions of concern during routine transport are gamma.
How do the risks of this arise	The main risks from this arise from incorrect handling during packing and unpacking, the loss or theft of the sources (including vehicle theft), poor security at delivery, and the release of radioactive material following a vehicle accident.
Who could be harmed	The person packing the sources, the carrier, the person receiving the sources, any emergency responders and members of the public in

	the event of a road traffic accident, someone stealing the sources or vehicle, or the person unpacking the sources.
Likely dose rates and doses during routine packing and transport	The upper bound dose rate to the hand packing and unpacking is 70 µSv/h. The dose rate from the package is no more than 5 µSv/h. Assuming the package is at least one metre from the driver during transport, the dose from up to ten excepted packages would be insignificant.

The radiation risk assessment, by considering paragraph 70 of the L121 ACoP to the 2017 Ionising Radiations Regulations, determines the following control measures. This risk will then be low.

1. The person packing the sources must be a member of the science department staff trained and authorised to work with the sources and understands they must follow the Standard Operating Procedures and Specific Risk Assessment Guidance in section 6 of L93. Make sure the consignee understands the parcel must be unpacked by a person trained and authorised to work with the sources.
2. The headteacher/principal of the site receiving the sources must give you an agreement in writing (which can be by email) that they will accept the sources, and as the recipient of the sources they are legally allowed to have them (check that the recipient's employer school has registered with the HSE and has appointed an RPA).
3. The sources must be in good condition and passed leak-tests within the week before the date of transport.
4. The packing must adhere to section 10.2.2 in L93. You must give the carrier a consignment note that details, among other things, the exact sources in the package. See 16.10 for a template
5. Engage a suitable commercial parcel carrier registered for Class 7 dangerous goods. The risk of loss, theft or damage during transport is much lower than school staff transporting the package by private car.
6. Check the consignee knows when the package is arriving, and explain they need to have arrangements for a responsible person to take the package promptly to a secure store in the science department.
7. The RPS(Schools) must go through the school's transport contingency plan and the carrier's contingency plan to make sure there are no mismatches.
8. Important notes

- The RPS(Schools) should monitor the packing operations.
- No PPE is necessary for the packing/unpacking of the excepted package.
- A suspected equivalent dose arising from the packing or unpacking of more than 50 µSv should be investigated by the RPS(Schools) with advice from the employer's Radiation Protection Adviser.
- A dose constraint is not appropriate because individual doses from a single type of radiation source will be a small fraction of a millisievert and far below legal dose limits.
- There is no radiological reason why a pregnant or breastfeeding employee should not be the person packing or unpacking if she is content to do so.
- No person needs to be classified because the likely effective doses are well below 6 mSv, or 150 mSv to the hand. Similarly, no area needs to be designated supervised or controlled.

9. Any other notes. (If none, state 'None'.)

10. **Signature of the RPS(Schools), and date.**

10.2.1 Contingency plan

This does not need to be complex; a contingency plan does not need the same detail as a CDG emergency plan. As the RPS(Schools), you are the contact in case of a transport incident. You need to consider what to do if your parcel is returned to you in a damaged state.

Model transport contingency plan for transport of an excepted package of school teaching sources. (Attach a copy of the consignment note to this document.) You need to obtain a copy of the carrier's contingency plan and check there are no clashes with this plan. Complete rows a-g. Go through the actions listed in rows 1-10; some you need to do before consigning the package.		
a.	The school consigning the excepted package.	
b.	The consignor's employer.	
c.	The contact details of the employer's RPA.	
d.	Date of the transport.	
e.	Name of the carrier.	
f.	Contact details of the carrier.	
g.	The person responsible for putting the school's contingency plan into effect. (This would normally be the RPS(Schools).	
	Required content item in the plan	**Action. (Additional notes in italics)**
1	what immediate actions for assessing the seriousness of the situation are necessary (this needs reference to the carrier's contingency plan);	If the carrier contacts you, ascertain the type of incident. Does the incident warrant attendance by the emergency services, and have they been called? *Determine if it is fire, loss, theft, or road traffic accident, and the initial assessment of the severity and condition of the package.*
2	what immediate mitigating actions are needed, for instance in clearing the accident area and establishing temporary means of preventing access to that area;	Check that the carrier's contingency plan covers this adequately. *Immediate mitigating actions will be principally the responsibility of the carrier because it is highly unlikely anyone from the school could get to the scene of the incident quickly.*
3	what emergency equipment is required to deal with identified accidents and where this can be found;	Check that the carrier's plan covers this adequately. *Emergency equipment will be principally the responsibility of the carrier because it is highly unlikely anyone from the school could get to the scene of the incident quickly.*
4	other sources of information and guidance, such as equipment manufacturers and contact details	You should have the exact details of the sources, including their form, to give to the carrier if you are contacted.

5	what PPE is needed and where it can be found;	The carrier's contingency plan should not involve someone from the school attending the scene to repackage the sources. A lab coat and disposable gloves are needed when inspecting the sources for damage if the package is returned.
6	what personal dosimetry requirements there are for people involved in controlling the accident;	School staff should not be involved in controlling the accident as they are highly unlikely to be able to get to the scene of the incident in prompt time.
7	what training is required for employees;	The person liaising with the carrier should have completed a course for RPS(Schools) that included contingency planning and handling potentially damaged sources.
8	how to obtain radiation protection expertise so that proper judgements can be made about the seriousness of the situation and the measures necessary to recover from it;	Contact the school's appointed RPA for advice. *Transport incidents can happen outside of office hours. Check the carrier's contingency plan to make sure there are arrangements for this that match yours.*
9	under what circumstances to contact the emergency services and who is responsible for doing this;	This will be principally the responsibility of the driver because it is highly unlikely anyone from the school could get to the scene of the incident quickly to assess whether the emergency services are needed. This should be in the carrier's contingency plan.
10	what dosimetry follow-up is needed so that the people affected by the accident are identified and provision is made for their dose assessment.	No one from the school should attend the scene of the incident, so no dosimetry is needed.

10.2.2 Packing excepted packages

For packing the sources, follow the Standard Operating Procedures and Specific Risk Assessment Guidance in section 6. These consider the risks and go into enough detail about handling the sealed sources safely.

The excepted package must be able to hold its contents securely under any conditions likely to arise during routine transport, and meet the general requirements of ADR 6.4.2. Use a fibreboard carton that is UN-approved 4GV. These are available from packaging suppliers and are not particularly expensive. You must retain the receipt so you have evidence, if requested, that the carton you used achieved the general requirements of ADR. You also need to obtain packing material for packing the sources into the carton to keep the source containers in place.

Make sure each of your source containers, ie the lead-lined wood box or aluminium cylindrical shield, has a radioactive warning sign on it. For additional security of the wood boxes, put cable ties around the box to prevent the lid opening should the catch fail. For Isotrak rod sources, screw in the grub screw in the aluminium cylinder shield to lock in the rod. Carefully tug the rod to check it is in the locked position. Then put each source container into a sealable plastic bag.

The dose rate at any point on the external surface of the excepted package must not exceed 5 µSv/h. This can be achieved by packing the source(s) appropriately into the UN-approved 4GV carton as follows:

- Strontium-90, americium-241 and plutonium-239 CLEAPSS type 8a, 8b and 8c sources, in their supplied containers and shielding, have no significant gamma radiation. Put no more than four of these into the carton. Use a 4GV carton at least a 200 mm cube size so that the source container(s) will be at least 75 mm from any side of the carton. Put each source container in its sealed plastic bag into the carton and surround it with packing material, for example shredded cardboard or tightly-scrunched newspaper.

- Radium-226, cobalt-60 and caesium-137 CLEAPSS type 8a and 8c sources have gamma emissions and require particular packing to bring the surface dose rate below 5 µSv/h. Put no more than one of these sources into the carton. Use a 4GV carton at least a 300 mm cube size. Half-fill the carton with packing material, for example shredded cardboard or tightly-scrunched newspaper, place the source container in the centre so the actual source is at least 150 mm from any surface of the carton, and complete the filling.

When opened, it must be obvious the carton contains radioactive material. Put the word 'Radioactive' and the warning symbol on the inside of the carton lid. Put an A4 sheet inside the box with a radioactive trefoil, the words 'Radioactive materials', your address and telephone number, and how many sources are in the package. Then close and seal the boxes with 50 mm wide cross-fibre adhesive packing tape. See the next section for external labels.

10.2.3 Consignment note

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 give the contact number of the consignor, sign and date the document and give an accurate description of the contents of the package. There is a template in section 16.10. The carrier must be clear on the consignee. It should be a specific person or department that can sign for the package on delivery and take it directly to a secure store.

10.2.4 Labelling for transport

The outside of the carton must be durably and clearly labelled with the relevant United Nations (UN) number and the name and address of the consignor and consignee. See section 16.11 for label templates. The UN number is UN2910 for sealed sources. Write 'Open this end' on the top of the carton.

10.3 Choosing a commercial parcel carrier

Take reasonable steps to select a suitable one. We advise that you use a well-established carrier and use a service that tracks your parcel. The carrier will probably have appointed a dangerous goods safety adviser, although this is 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. The driver must have received training for transporting Class 7 dangerous goods– you should ask for evidence that this has been done. You must tell the carrier exactly what is in your package by providing an accurate consignment note.

Additionally, if you are packing and consigning the package, check that the carrier does not need a CDG emergency plan. However, they will need a contingency plan. You must check you can meet its expectations. See 10.2.1. You need to share your contingency plan with the carrier.

10.4 Gas mantles and thoriated TIG welding rods

Gas mantles and thoriated TIG welding rods are individually out of scope of the transport regulations, but check the terms and conditions of the carrier. Small quantities (no more than 10 kBq) do not need to be sent as an excepted package. They still need to be packaged properly.

10.5 Protactinium generators and elution sources

We recommend that you do not transport these. If you have a good reason to, contact CLEAPSS.

10.6 Retention of transport documents

Transport documents for excepted packages must be retained for at least 3 months following completion of the journey.

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 necessary, the RPA may 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-source risk assessments in section 6.6.

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.

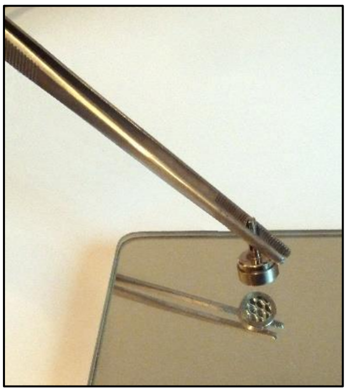
11.4 Carrying out inspections and leak tests

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 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-source risk assessment guidance in section 6.6. Wear a lab coat and disposable gloves, 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-source risk assessments in section 6.6 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. Glue is visible on the foil edge, and there are some foil scratches from when the foil was manufactured

3. Poor condition. The foil is 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 before 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.

[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.

- 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.

- Position the GM-tube vertically so the end window is pointing uppermost. If clamping is needed, clamp the tube holder, not the tube.
- 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.
- If the GM voltage on the counter is adjustable, set it to 450 volts.
- 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.
- Note the count, t, over 1000 s, in the Test Record.
- 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 of 200 to 500, even 700 counts in high granite areas.

- Replace the protective cap on the tube.
- 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 1000 seconds with the test source, on new GM tubes)

Second, check the alpha response

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

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.

The GM tube comparative beta efficiency can exceed 100% due to variations in tube manufacture, tolerances in constructing the test source, and the randomness of radioactivity. Additionally, in tests at CLEAPSS, the LND72233 type GM tube had a higher comparative beta efficiency, around 130%. But regard with some suspicion efficiencies over 150% for the ZP1481, or 175% for the LND72233. These are 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 x 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 that it is not somehow contaminated.

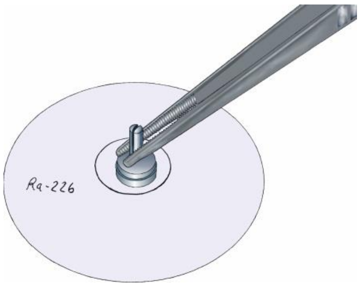
11.4.3 Carrying out the dry-wipe leak-test procedure

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, 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.

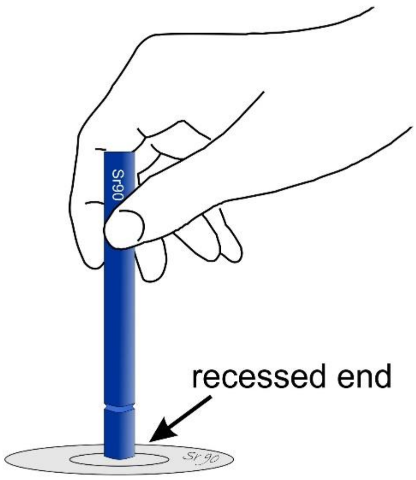
(If exceptionally, the count over 1000 s exceeds 700, contact CLEAPSS because you will need to use longer counting times.)

Place a fresh piece of the same filter paper flat on the tray. Draw a circle 20 mm in diameter (eg draw around a penny). Write on the outside of the filter paper the source that is going to be tested.



For cup sources, use forceps to take the source out of its container. Still using forceps, gently wipe the cup source open end on the filter paper, keeping it within the area of the 20 mm circle. Do not press hard. 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.



For Isotrak rod sources, hold the rod by the correct end, the end furthest from the machined groove, so that the recessed end is downwards. Keep the rod upright and wipe the rod end gently across the flat filter paper, keeping it within the area of the 20 mm circle. Do not press hard.

Do not attempt to wipe inside the recessed end of the rod.

There must be no debris on the paper or rod that could get into the rod recess and damage the radioactive component.

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

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 gently wipe it over the surfaces of the source. For a protactinium generator, wipe around the bottle seal. 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 are completed, place all the used wipes and anything that may have very low-level contamination in a strong black plastic bag, then 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 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, and 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 a radium source where the foil surface looks discoloured, or it fails its first leak test by a high count, say more than three times the background, the source should be disposed of.

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 6.6
- 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)
- 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 that 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 6.5 and the additional information in section 12.4 and its subsections, but you may need to add to them to suit your circumstances.

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

- The Environmental Permitting Regulations (EPR) mean that generally, you need a permit to dispose of radioactive waste. The permit sets conditions for the disposal. Fortunately, most school sources are conditionally exempt from needing permits.
- 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]
- 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 discover that the school has an unsuitable source that 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

[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's 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.

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.

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 alarms (CLEAPSS source type 2)	Consider recycling as smoke alarms if they are in good condition and not past their recommended working life. Smoke alarms 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 and 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 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 on 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. Members can 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 such as gas mantles.
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 explains how to do the disposal. It is important to follow this guidance because several conditions 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 in 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.

12.4.2 Notes on disposing of very low-level solid waste by the dustbin route[18]

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 the contractor who collects the normal refuse specifically of this waste. Such waste should be unlabelled when it goes into the bin avoid causing 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 of 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
- 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 black-bag 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. 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 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 goggles. 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 of 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 twice 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.

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

12.4.3 Notes on disposing of aqueous solutions of thorium or uranium via the sewer

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 the 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 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.co.uk	All types of radioactive waste, including sealed sources.
Grundon Waste Management Ltd	Thames House Oxford Road, Benson Oxfordshire, OX10 6LX	Disposal of thorium and uranium compounds and protactinium generators. Sealed sources up to 200

	Tel: 01491 834340 E-mail: radsales@grundon.com Website: www.grundon.com	kBq. Other radioactive waste from unsealed sources is 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 is also possible – enquire by e-mail.
Tradebe - Labwaste	23 Jacknell Rd, Hinckley, LE10 3BS Tel: 01455 616673 E-mail: UKTAD@tradebe.com Website:www.tradebe.co.uk	Disposal of thorium and uranium compounds and protactinium generators. Other radioactive waste from unsealed sources is 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 alarms	Each smoke alarm not exceeding 4 MBq No limit on the number of detectors	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 devices will require different operating procedures and contingency plans to those for 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 suitable radiation monitor capable of detecting adventitious X-rays over the spectrum emitted. This would need advice from your RPA.

14.2 Permissions and registration

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. Your employer will need to register with the HSE to work with X-rays unless the X-ray apparatus operates at 30 kV or less, and in normal use the dose rate is no more than 1 $\mu Sv\ h^{-1}$ at 0.1 m from any accessible surface.

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 using empirical formulae. Effective dose is also measured in sievert (Sv).*

In rudimentary terms, we use effective dose to gauge the risk of harm to the whole body from a radiation exposure. Equivalent dose relates just to one organ or tissue, such as would happen with beta radiation to the skin, and is used to set legal limits to individual parts of the body.

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

Dose rates in table 15.1

The table in 15.1 gives estimated equivalent dose rates. For sources that are principally beta, or beta and gamma (indicated by β, or β,γ) the dose rate is to the skin (and also to the hand for dose estimates where the source is near to the hand.) The skin equivalent dose is weighted by a factor of 0.01 to calculate its contribution to the effective dose.

For sources that are principally gamma, the effective dose can be estimated by selecting the distance from the source to the front of the trunk of the body, and taking the equivalent dose rate as the effective dose rate. This assumes the body is uniformly irradiated, so the estimated effective dose rate will be over-estimated, but will give a reasonable indication for regulatory purposes.

15.1 Dose rates from school sources used in practical activities

Tick the rows that are relevant to the sources you hold

Equivalent dose rates at selected distances with sources identified in L93. (Note that the column 'contact' is mSv/h, not µSv/h). Dose rates were calculated using Varskin+1.2, and Peplow (2020)

Source	Tick all relevant	original activity (kBq), or mass	emissions considered	estimated equivalent dose rate at distances:				
				10 cm µSv/h	40 cm µSv/h	1 m µSv/h	2 m µSv/h	contact **mSv/h**
Co-60 cup source		185	γ	5.7	0.35	0.057	0.014	0.53
Am-241 cup source		185	γ	0.11	0.0070	0.0011	0.00028	0.31
Am-241 cup source		4.7	γ	0.0028	0.00018	<0.0001	<0.0001	0.008
Pu-239 cup source		185	γ	0.0042	0.00026	<0.0001	<0.0001	0.047
Pu-239 cup source		3.7	γ	<0.0001	<0.0001	<0.0001	<0.0001	0.0010
Ra-226 cup source		185	γ	4.0	0.25	0.040	0.010	1.0
Ra-226 cup source		185	β,γ	500	31	5.0	1.3	110
Sr-90 cup source		185	β	310	20	3.1	0.79	67
Sr-90 cup source		37	β	63	3.9	0.63	0.16	13
Sr-90 cup source		4.7	β	8.0	0.50	0.080	0.020	1.7
Sr-90 Panax S4		333	β	260	16	2.6	0.65	48
Sr-90 Isotrak		74	β	130	7.9	1.3	0.31	20
Isotrak mixed source Am-241, Sr-90, Cs-137		4.4, 4.4 333	β,γ	10	0.64	0.10	0.026	2.6
Na-22 Isotrak		74	γ	1.1	0.072	0.011	0.0028	0.70
Co-60 Isotrak		74	γ	2.3	0.14	0.023	0.0057	0.16
Am-241 Isotrak		74	γ	0.045	0.0028	0.00045	0.00011	0.16
Cs-137 Isotrak		370	γ	3.0	0.19	0.030	0.0076	0.22
Cs-137 Isotrak		74	γ	0.61	0.038	0.0061	0.0015	0.044
Elution source Isotrak		33	γ	0.27	0.017	0.0027	0.00068	0.016
Eluate initial dose rate		33	γ	0.27	0.017	0.0027	0.00068	0.051
Wilson cloud chamber		37	γ	0.79	0.049	0.0079	0.0020	0.020
Smoke detector		37	γ	0.022	0.0014	0.00022	< 0.0001	0.0050
TIG rod		3.2	β,γ	0.040	0.0025	0.0004	0.0001	0.012
Boxed Co-60		185	γ	4.1	0.26	0.041	0.010	0.033
Boxed Ra-226		185	γ	3.1	0.20	0.031	0.0078	0.023
Boxed Am-241		185	γ	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cs-137 Isotrak in shield		370	γ	2.2	0.14	0.022	0.0055	0.070
Cs-137 Isotrak in shield		74	γ	0.44	0.028	0.0044	0.0011	0.017
Gas mantle		1.5	β,γ	5.0	0.40	0.050	0.013	0.020
Uranium oxide disc		1.1	β,γ	0.47	0.029	0.0047	0.0012	0.050
Cooknell Rn generator		6	β,γ	20	1.3	0.20	0.050	0.010
Protactinium generator		1.25 g	β,γ	25	1.6	0.25	0.063	0.014
Philip Harris rock set		< 8.5kBq/g	β,γ	20	2.0	0.20	0.050	0.10
Fiestaware 15 cm saucer		~15% U w/w	β,γ	20	2.0	0.20	0.050	0.030
Vaseline 10 cm glass dish		~2% U w/w	β,γ	2	<<1	<<1	<<1	0.0020

Notes

a. The dose rate from a beta source assumes the part of the body exposed is in front of the source. If the person is behind a cup or Isotrak source, take the dose rate as zero for Sr-90 sources, and use the gamma-only table entry for Ra-226 sources.

b. The beta dose rates are over-estimates because no account is taken of self- or air-attenuation.

c. Be cautious of the significance of the high numerical values of contact dose rate from some of the cup and Isotrak rod sources. No account was taken of the mesh or retaining circlip. Actual dose rates are likely to be much less, but the values can be used for worst-case estimates.

d. The Co-60 cup source, the Isotrak Cs-137 and the Isotrak Na-22 source have integral filters that block most of the beta emissions, so the estimates are based mainly on the gamma emissions.

e. All the sources are assumed to be new except Ra-226 and Panax S4, which were taken as at least 30 years old because these have not been available since the late 1980s. The Panax S4 dose rates will be an overestimate given the collimation.

f. Larger Fiestaware items such as thick-glazed dinner plates can give higher contact dose rates, up to 0.24 mSv/h

For distances other than those listed in the table, an approximate dose rate can be calculated by using the distance at 1 m and applying the inverse square law.

15.2 Dose rates (where relevant) and dose estimates from internal and external reasonably foreseeable contamination from sources.

The assessment does not include the chemical toxicity of any compounds being used.

Dose rate and estimate of a leak from a faulty protactinium generator while shaking it

Assumptions
The person is not wearing gloves. A leak of 1 cm^3 leaks onto the hand over an area of 10 cm^2 and goes unnoticed for five minutes. The protactinium generator has 5 g of uranyl nitrate dissolved in 20 cm^3 of 8M hydrochloric acid and 5 cm^3 of pentyl ethanoate. Assume all the protactinium is dissolved into the organic solvent after shaking.

Dose rate and dose estimate
The head-of-chain specific activity for uranium-238 is 5.86 kBq g^{-1}. In 5 g of uranyl nitrate, there will be 29.3 kBq of Pa-234m in 5 cm^3 of organic solvent. If 1 cm^3 of this leaks onto the hand, it will be 5.86 kBq of Pa-234m onto the hand. Using Varskin+v1.2, the estimated initial equivalent dose rate to the hand is 1.03 mSv/h, but the dose rate will fall quite quickly owing to the short half-life. The decay-corrected dose will be 28 µSv

Estimate of dose from ingestion and inhalation of uranyl nitrate from a protactinium leak

The radioactive contents of a protactinium generator are, at most, 5 g of uranyl nitrate in solution.

Assumptions
A person's hand is contaminated, the person then eats food, transferring 10% of the contamination into themselves. Assume a complete spillage (ie 5 g of uranyl nitrate solution spilled and 5% of total spill left after decontamination). This is 0.250 g remaining. 10% of this is ingested.

Dose estimate.
The radionuclides in the uranium decay chain have been addressed in the ICRP derivation of the dose coefficients for the uranium parent. Taking the ICRP137 dose coefficients for soluble compounds for the uranium radioisotopes, if 25 mg of uranyl nitrate is ingested, the estimated effective dose from ingestion is roughly 6 µSv

Dose estimate from inhalation of radon-220 from failed Cooknell CP3-IC apparatus bottle

Radon-220 from four thoriated gas mantles collects in a plastic bottle. The radon is puffed into a sealed-system ionisation chamber to enable the ionisation current to be demonstrated. If the bottle failed while being squeezed, radon would escape into the room.

Assumptions
All the radon-enriched air escapes the bottle into the breathing zone of the demonstrator. 25% of the radon escapes from the gas mantle surface (Nuclear Regulatory Commission, NUREG1717). The demonstrator sits 0.5 m from the ionisation chamber, and the chamber is on a bench with a wall behind it. The dose rate by inhalation is 40 nSv h^{-1} Bq^{-1} m^{-3} for equilibrium equivalent concentrations of radon-220 (UNSCEAR 2000).

Dose estimate
The air in the bottle will be diluted into a quarter sphere volume, with its centre at the ionisation chamber and radius to the experimenter's mouth. Assume the experimenter breathes that concentration for ten minutes. Finally, since the quantities of radon-220 progeny cannot be determined, take the equilibrium equivalent concentration as the concentration of radon-220. This will give an overestimate of the effective dose.

1.0 kBq of radon-220 will be distributed into 0.131 m^3 of air, giving an average concentration of 7.6 kBq m^{-3}. Assuming this is an equilibrium equivalent concentration, the effective dose in ten minutes will be 40 x 0.167 x 7600 nSv, i.e. 50 µSv.

Dose estimate from inhalation of gas mantle fragment from failed Cooknell CP3-IC apparatus bottle

Mantle fragments could be released if the bottle or filter failed. These could be inhaled or ingested.

Assumptions
Thoriated gas mantles are typically 1 to 1.5kBq of Th-232 and Th-228 when new. In estimates of thorium dust (Huyskens, Hemelaar and Kicken, 1985), 0.1% is taken for the fraction released when changing a brittle, used, mantle on a lamp. The dust from a new gas mantle will be much less, no more than 0.01 per cent. Assume the person inhales all the dust released. This is an inhalation of 0.01% of 6 kBq of Th-232, and similarly 0.01 per cent of 6 kBq of Th-228 (assuming relatively new mantles). Although thorium-232 and Th-228 have decay chains, these have been considered in the dose coefficients. Assume the internal radiation risk is entirely from inhalation because the ICRP137 dose coefficients for ingestion of thorium are much less.

Dose estimate
Using the most restrictive ICRP137 dose coefficient for a low solubility thorium compound, an inhalation of 0.01 per cent each of 6 kBq of Th-232 and Th-228 gives an effective dose of 46 µSv.

Dose estimate from a spill of eluate onto the hand from a caesium elution source

The eluate is in an unsealed source that could plausibly spill from the bottle onto the skin.

Assumptions
The eluate is 2 ml of saline containing 33 kBq of Ba-137m that gets onto the hand over 4 cm^2 area, and goes unnoticed. The activity has decayed to background before the skin is washed (about 15 minutes). The eluate is inside the glove.

Dose estimate
Using Varskin+v1.2, the equivalent dose to the skin is 2.8 µSv.

15.3 Dose and dose rate calculations from a transport accident

The modelling is directly from the research of PHE (now UKHSA) as detailed in their report CRCE-EA-5-2013 2013. You should refer to that document if you need further detailed information on the modelling. The model assumes the release of radionuclide from a car accident and subsequent fire in which all the sources are ruptured in the accident. The effective dose to both the driver of the vehicle and members of the public from inhalation of radionuclide in the sealed sources, D_i is calculated using:

$$D_i = C_{air} T_{exp} R_{inh} DC_{inh}$$

Where C_{air} is the activity concentration in the air during the accident (Bq m^{-3}); T_{exp} is the exposure time, assumed to be $0.25\ \text{h}$ for workers and $0.5\ \text{h}$ for members of the public; R_{inh} is the inhalation rate $(1.2\ \text{m}^3\ \text{h}^{-1}$ for workers and $0.92\ \text{m}^3\ \text{h}^{-1}$ for members of the public and DC_{inh} is the dose coefficient for inhalation for members of the public (Sv Bq^{-1}). For members of the public C_{air} was calculated by:

$$C_{\text{air}} = \frac{A_{\text{load}}\, TIAC_{\text{af}}\, RF}{T_{\text{exp}}}$$

where A_{air} is the activity that is being transported; $TIAC_{af}$ is the time integrated concentration in air for a 30 minute release at ground level at a distance of $100\ \text{m}$ for category F $(6\ \text{x}10^{-3}\ \text{Bq s m}^{-3}$, RF is the release fraction from fire, assumed to be 1 for gases, $1\text{x}\ 10^{-3}$ for solid and sealed sources and T_{exp} is the exposure time (0.5 h). The equation used to calculate C_{ar} for workers was:

$$C_{\text{air}} = \frac{A_{\text{load}} RF}{V k_{\text{af}} T_{\text{exp}}} \left(1 - e^{-k_{\text{af}}\, T_{\text{exp}}}\right)$$

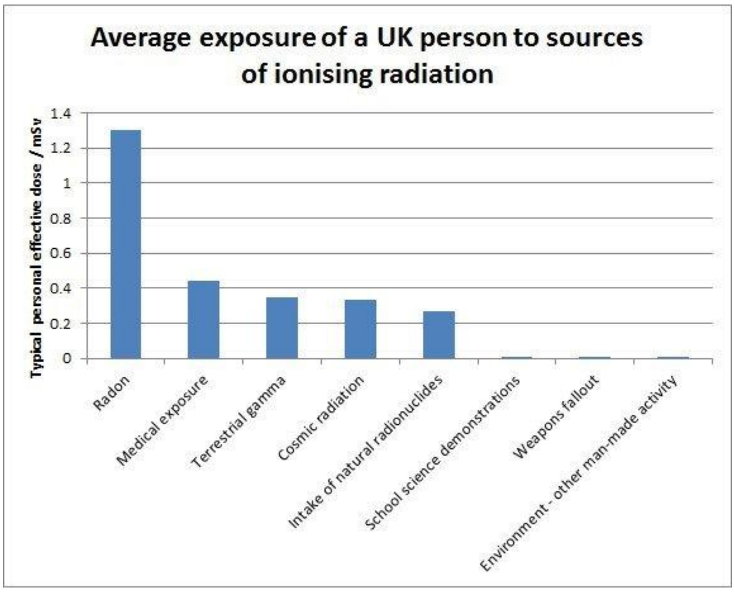
A_{load} is the activity that is being transported; V is the volume of the lorry/cab, assumed to be 7 m^3; k_{af} is the rate of air changes in a lorry $(5\ \text{h}^{-1})$ and T_{exp} is the exposure time $(0.25\ \text{h})$ and RF is the release fraction from fire.

The activities used in the calculations assumed a set of six sealed sources, one of each type in the standard school holding (Am-241, Co-60, Sr-90, Ra-226, Pu-239 all 185 kBq, and Cs-137 370 kBq). The dose from each was calculated separately and then summed. The dose coefficients were the most pessimistic values from the ICRP Occupational Intake of Radionuclides series (2015 -2022). For drivers, the estimated dose was 0.2 mSv, and for members of the public, 0.04 mSv.

If someone handles a packet item directly, taking the worst case of an Isotrak Cs-137 370 kBq sealed source locked into its shield, the hand is separated from the source by 16 mm of aluminium and roughly 1 mm of stainless steel. The HVL of aluminium for Cs-137 is taken as 34.5 mm and for stainless steel 16 mm. The specific gamma ray constant was from Peplow (2020). From this, the dose rate to the hand is estimated at 70 µSv/h.

15.4 Dose from background compared

The chart, based on data from Public Health England (now the UK Health Security Agency) indicates 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.



Part D: Templates, etc

16 Templates

Modify these templates for checklists, record sheets, letters and forms as necessary to suit your needs. These are available in DL093, in Word format, from our website.

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	Annual checklist for the RPS(Schools) to complete
16.2	Inventory of radioactive sources held
16.3	Monthly 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 secondary container
16.8	Withdrawn. (Now subsumed in the checklist in Part C)
16.9	Withdrawn (Sample letter to the 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 Annual checklist for the RPS(Schools) to complete

	Item	yes/no
1	You have checked your employer has appointed a suitable Radiation Protection Adviser (RPA)	
2	You have checked your employer has registered the science department's use of radioactive sources.	
3	There is a record (ideally in the department H&S policy) you have been appointed as the RPS(Schools)	
4	You have attended a suitable training course, and refresher training thereafter at least every five years	
5	There is an up-to-date list of staff authorised to handle the sources.	
6	Authorised staff have received suitable training (which you can give), refreshed at least every five years.	
7	There is an up-to-date record of all the training given, including yours, and when it was given.	
8	The Standard Operating Procedures (SoP) have been completed by you, and you have checked the SoP remain suitable for the circumstances at your school.	
9	You have checked that each source has suitable specific-source risk assessment guidance available, and you have completed the bottom row of each guidance.	
10	You have checked that the *Use* row on the specific-source risk assessment guidance remains suitable for the sources you have and how they are used.	
11	You have completed and checked the contingency plans are suitable for your school, and additional notes added as necessary.	
12	The radioactive substances held are all within the Standard School Holding.	
13	The relevant rows in section 15 table on dose rates have been ticked.	
14	There is an up-to-date accurate source inventory (this can be digital), checked within the last year.	
15	Appropriate, working monitoring equipment is easily available.	
16	There are suitable signposts to the L93 in the point-of-use schemes of work.	
17	The *use log* is completed whenever sources are used, including a column to record that information has been given to students.	
18	There is suitable internal storage of the radioactive sources, including *correct* signage on the cabinet door.	
19	The cabinet store room is lockable and accessed only by science staff.	
20	The cabinet is fixed to the bench or fabric of the building.	
21	The cabinet is at least 2 m from any regularly-used workstation.	
22	There are no bulk flammables or corrosive materials in the vicinity of the cabinet.	
23	Only radioactive sources and their immediate containers are stored in the cabinet.	
24	There is a *monthly store-check* record, and it is up-to-date.	
25	Within the last year, all the sources have been inspected and all the sealed sources leak tested.	
26	A *radioactive source history* exists for each source, including the latest results of inspections and leak tests.	
27	There are suitable arrangements for the security of cabinet keys, combination codes, etc.	
28	A spare cabinet key is located securely offsite or in a different building.	
29	Any waste source has arrangements for prompt disposal.	
30	The location of the store cabinet is identified on the school's fire risk assessment.	
	Name of the person carrying out these checks: Date:	

16.2 Inventory of radioactive sources held

Location of the store that this inventory applies to:			
Name /reference no of source	Radionuclide	Original activity (in kBq)	CLEAPSS specific-source risk assessment type number[1]

Annual inventory check

Date of check		Name of person who checked it	

[1] Type number that appears on the specific-source risk assessment guidance in section 6.6 of CLEAPSS guide, L93 *Managing Ionising Radiations and Radioactive Substances in Schools and Colleges* (2024).

16.3 Monthly store check

List each source individually. Do not simply state ‘all present’, etc.

Location of the store			
Date of check	Source (including identifier)	Comment (if any)	Name of the person who checked

16.4 Radioactive source history

Unique name / reference number of source	
Radionuclide (for decay chains, the head of chain)	
The original activity (units Bq or kBq)	
Delivery date. Attach original paperwork if possible.	
Supplier	
Supplier catalogue number (if known)	
Source serial number (where relevant)	
Storage location	
Disposal date	
Disposal route and details. Attach the disposal record sheet and any paperwork from the registered waste carrier if used	

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

Inspection and leak tests by dry wipe, following L93 procedure. Give comments on any action taken: eg decontamination of a radium source and its container, referral to CLEAPSS if a source appears to be damaged or leaking. (Leak test fail is where the total count from the wipe exceeds 2 x background)

Date	Average background count in 100 s	Leak test count inc. background in 100 s	Inspection, (& leak test where relevant) passed (yes or no)	Test carried out by: (name)	Reason for test (eg, routine annual, after drop) and comments (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. State radionuclide, activity and identifier.	Date and time removed from store Name of the person who checked all source(s) are in their containers	Member of staff supervising the source(s)	Teaching group Include names of any post-16 students using the source(s).	Date and time returned to store Name of the person who checked all source(s) are back in their containers	Write 'Yes' in this column to state suitable safety information was given to the student(s) and support staff. This record is a legal requirement. Also add any other comment if relevant.

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) Note that refresher training is required at least once every five years, or if there has been a major change to L93. See L93 section 7.			
Name	Date authorised	Training courses, briefings etc. Indicate if it included contingency plans.	Date of course etc

16.7 Labels for protactinium generator secondary containers

For the protactinium generator secondary container. See specific-source risk assessment guidance 9b (section 6.6).

<table>
<tr><td></td><td></td><td rowspan="3">PROTACTINIUM GENERATOR

DO NOT OPEN THE GENERATOR BOTTLE

Follow the 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</td></tr>
<tr><td colspan="2">Corrosive (skin, eyes). Irritant (respiratory)</td></tr>
<tr><td colspan="2">
Radioactive</td></tr>
</table>

16.10 Transport document (consignment note)

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

Transport document (consignment note)	
The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009	
Consignor (sender) (Name and address of school sending the package)	Consignee (recipient) (Name and address of the person receiving the package)
Contact phone number	Contact phone number
Contact name:	Contact name
United Nations number	UN 2910
Description of radioactive substances. Include radionuclides, activities and form (sealed, solid)	
Signed	
Date of commencement of journey	

16.11 Suitable label for excepted packages

Name of sender Address package sent from Contact number:	Name of recipient Address for delivery
Excepted package, UN Class 7 UN Number: UN 2910	

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 the 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:**

17 How L93 meets the Ionising Radiations Regulation 8

The Ionising Radiations Regulations (IRR17) directs employers (through an HSE Approved Code of Practice L121, paragraphs 70 and 71) in what they must consider when undertaking a risk assessment for using radioactive materials, and the decisions on the subsequent guidance for using the materials safely.

This section gives details of how CLEAPSS considered the regulations on behalf of school employers, and the subsequent decisions made in liaison with school employers who use L93.

17.1 How L121 paragraph 70 was considered in the risk assessment from using sources in science teaching

Approved Code of Practice L121 Paragraph 70	How this was considered in L93	CLEAPSS reference, where relevant
a) the nature of the sources of ionising radiation to be used, or likely to be present, including accumulation of radon in the working environment;	The sources are sealed, and described in L93, the Standard School Holding. The nature and risks of environmental radon are covered in the separate CLEAPSS document GL406.	L93 p7
b) estimated radiation dose rates to which anyone can be exposed;	The estimated dose rates during the routine use of the sources, along with examples of estimated doses from the use, are detailed in Appendix 1. Similarly, the estimated dose rates that arise from incidents we identified that could happen in schools, along with estimated doses, are detailed in Appendix 2. Note that from the estimates of dose rate, the effective dose from a single sealed source used in a demonstration, or by a 16+ student, is unlikely to exceed 10 µSv if the procedures in L93 are followed.	L93 p79
c) the likelihood of contamination arising and being spread;	The risk of contamination is highly unlikely with the standard cup and Isotrak sources, which conform to ISO 2919:C23312 (2012). Leak tests are carried out to check this. The more likely risk of contamination is from a failing protactinium generator. For this reason, DIY versions are not included in the standard school holding.	L93 section 6.6
d) the results of any previous personal dosimetry or area monitoring relevant to the proposed work;	Dosimetry is not appropriate for using small teaching sources, listed as current in L93. Interestingly, whole body and finger doses were carried out using what was the NRPB dosimetry service, and the doses from carrying out a series of typical school science demonstrations were below the minimum detectable by the film badges.	
e) advice from the manufacturer or supplier of equipment about its safe use and maintenance;	The advice supplied by the manufacturer on handling, storage, inspection and testing has been incorporated into L93.	L93 section 6.6 incorporates the manufacturer's advice.
f) engineering control measures and design features already in place, or planned;	Engineering controls are not appropriate for the small teaching sources listed as current in L93. The school sources in L93 are restricted to those of a well-tested design and high reliability. Where sources show signs of age-related degradation, L93 states they should be taken out of service and disposed of.	L93 section 6.6 and 'double red border' sources
g) any planned systems of work;	The planned systems of work are explained in the Standard Operating Procedures in L93, coupled with the specific-source risk assessment guidance for the type of source, and the periodic maintenance. These	L93 section 6, and section 11.

	are based on standard good laboratory practice to minimise exposure.	
h) estimated levels of airborne and surface contamination likely to be encountered;	Small surface contamination can arise from some radium sources. This is monitored and cleaned by annual checks. More significant contamination can arise from failures of radon gas generators, protactinium generators and caesium elution sources. The risks of these are mitigated by good design, regular visual checks and annual leak tests. Section 15.2 details estimated doses from such incidents.	L93 section 6 L93 section 15.2
i) the effectiveness and the suitability of PPE to be provided;	Special PPE is not required for cup and Isotrak sealed sources. If using protactinium generators or caesium elution sources, suitable PPE is the standard for school science laboratories: lab coat, nitrile gloves and safety spectacles.	L93 section 6.6
j) the extent of unrestricted access to working areas where dose rates or contamination levels are likely to be significant;	Students observing a demonstration should be at least 2 m away from the sources. Stores have restricted access and are at least 2 m away from any permanent workstation.	L93 section 4.1 and 6.6
k) possible accident situations, their likelihood and potential severity;	These are listed in L93, section 9.	L93 section 9
l) the consequences of possible failures of control measures – such as electrical interlocks, ventilation systems and warning devices – or systems of work;	Electrical interlocks, ventilation systems and warning devices are inappropriate for small teaching sources.	
m) steps to prevent identified accidents, or limit their consequences.	The foreseeable accidents are listed in L93 section 9. The most likely accident is the loss of the sources. This is covered in L93	L93 section 9

17.2 How L121 paragraph 71 led to the following decisions for controlling the risks from using sources in science teaching

Approved Code of Practice L121 paragraph 71	Decision
a) the action needed to make sure the radiation exposure of all people is kept as low as reasonably practicable (regulation 9(1))	Employers are advised to adopt the procedures in the current version of L93.
b) the steps necessary to achieve this control of exposure by the use of engineering controls, design features, safety devices and warning devices (regulation 9(2)(a)) and, in addition, to develop systems of work (regulation 9(2)(b));	Engineering controls and safety devices are inappropriate. The specification of ISO2919:C23312 and safe systems of work in L93 are adequate to mitigate the risks as far as is reasonably practicable.
c) whether it is appropriate to provide PPE and if so, what type is adequate and suitable (regulation 9(2)(c));	School-standard lab coat, nitrile gloves and safety spectacles are appropriate for the sources in L93, where these are specified.
d) whether it is appropriate to establish any dose constraints for planning or design purposes and if so, what values will be used (regulation 9(4));	The Approved Code of Practice p157 states that dose constraints are not likely to be appropriate for occupational exposures resulting from teaching and most research activities.
e) the need to alter the working conditions of any employee who declares they are pregnant or breastfeeding (regulation 9(6));	There is no reason why a pregnant woman should not continue to demonstrate the sources if she wishes to, but we advise employers to follow the guidance in L93 section 5

f) an appropriate investigation level to check that exposures are being restricted as far as reasonably practicable (regulation 9(8));	The effective dose from a single demonstration listed in section 6.4 of L93 should not exceed 10 µSv based on good practice and on what can be reasonably achieved. So, any event in which a person has received an estimated effective dose above 50 µSv from one practical activity, or above an estimated equivalent dose of 50 µSv to the hand, should be investigated in consultation with the RPA. L93 section 9.3 covers the exceptional circumstances that could likely cause a dose above 50 µSv
g) the maintenance and testing schedules required for the control measures selected (regulation 11);	Leak testing and inspection are yearly. This is explained in L93 section 11.
h) what contingency plans are necessary to address reasonably foreseeable accidents (regulation 13);	L93 section 9 has been written to give details on foreseeable radiation accidents and the contingency plans for them.
i) the training needs of classified and non-classified employees (regulation 15);	The training needs identified are explained in L93 section 7.
j) the need to designate specific areas as controlled or supervised areas and to specify local rules (regulations 17 and 18);	None is required. There are no special procedures required other than standard laboratory procedures that are used with, for example, hazardous chemicals, microbiological hazards or high temperature equipment. With the control measures of L93 in place, no person is likely to receive an effective dose greater than 1 mSv a year or an equivalent dose greater than 5 mSv a year for the lens of the eye or greater than 50 mSv a year for the skin or the extremities. External dose rates do not exceed 7.5 µSv/h when averaged over the working day. The hands of an employee are very unlikely to enter an area where the 8-hour, time-average dose rate exceeds 75 µSv/h. Employees untrained in radiation protection are highly unlikely to go into an area that exceeds 7.5 µSv/h averaged over one minute. The practical work is unlikely to spread significant contamination outside the working area, and it is not necessary to prevent, or closely supervise, access to the area by employees who are unconnected with the work.
k) the actions needed to make sure access is restricted and other specific measures are put in place in controlled or supervised areas (regulation 19);	Designated areas are not required.
l) the need to designate certain employees as classified persons (regulation 21);	Classified workers are not appropriate. The likely doses to teachers and technicians do not warrant it.
m) the content of a suitable programme of dose assessment for employees designated as classified persons and for others who enter controlled areas (regulations 19 and 22);	No programme is required as there are no controlled areas.
n) the requirements for the leak testing of radioactive sources (regulation 28);	These are detailed in L93 section 11. The period is yearly, or more frequently.
o) the responsibilities of managers and workers (including outside workers) for ensuring compliance with these regulations;	An explanation is given in the CLEAPSS guidance leaflet PS46, and in L93.
p) an appropriate programme of monitoring or auditing of arrangements to check the requirements of these regulations are being met.	An appropriate programme is explained in detail in the CLEAPSS guidance leaflet RPA002. See also L93, section 7.3

17.3 How L121, paragraph 70 was considered in the risk assessment of transport

The nature of the risk	The hazard is exposure (internal and external) to ionising radiations. Exposure to ionising radiations is a known carcinogenic hazard. The main risks from this arise from poor practice during packing and unpacking, the loss or theft of the sources (including vehicle theft), or release of radioactive material following a vehicle accident.
Who could be harmed	The person packing the sources, the carrier, the person receiving the sources, any emergency responders and members of the public in the event of a road traffic accident, or to someone stealing the sources or vehicle.
The nature of sources of ionising radiation to be used, or likely to be present, including accumulation of radon in the working environment.	The standard school holding This is no more than six sealed sources restricted to any of: Sr-90, (beta) no more than 185 kBq Am-241 (alpha, gamma) no more than 185 kBq Cs-137 (beta, gamma) no more than 370 kBq Co-60 (beta, gamma) no more than 185 kBq Ra-226 (alpha, beta, gamma) no more than 185 kBq Pu-239 (alpha) no more than 185 kBq (excluded fissile c.f. ADR 2.2.7.7.1.7) Trace levels of radon-222 can arise from radium sealed sources, but this will not accumulate to any significant quantities.
Estimated radiation dose rates to which anyone can be exposed.	The sources will be in their shielded containers. The dose rates handling the shielded sources are: Sr-90, no more than 185 kBq: none Am-241, no more than 185 kBq: none Cs-137, no more than 370 kBq: 70 µSv/h Co-60 (beta, gamma) no more than 185 kBq: 33 µSv/h Ra-226 (alpha, beta, gamma) no more than 185 kBq: 23 µSv/h Pu-239 (alpha) no more than 185 kBq: none The maximum dose rate while handling the shielded containers is less than 70 µSv/h (the 370 kBq Cs-137 source). The shielded container will be taken from the store into a tray, and carried to the bench where the packing takes place. The direct handling of each source will be under one a minute, and similarly for unpacking. An upper bound of equivalent dose to the hand packaging is 14 µSv The effective dose rate from the package is no more than 5 µSv. Assuming the maximum 6 packages are carried from the building to the vehicle in no more than 15 minutes, and similarly at the destination, the upper bound to the effective dose is 15 µSv. There is no reason for any other person to be within 1 metre of the excepted packages, so the dose to any other person from that package will be below significance.
The likelihood of contamination arising and being spread.	The sealed sources are of a design that meets ISO2919:C23312 and designed to contain the radionuclides under harsh conditions (NRPB research R92). This design will not release significant contamination in foreseeable damage conditions, not even in fires. The risk of contamination is very low.
The results of any previous personal dosimetry or area monitoring relevant to the proposed work.	Test dosimetry using an EPD showed no significant doses received.
Advice from the manufacture or supplier of equipment about its safe use and maintenance.	The sources are kept securely in their shielded containers. The Isotrak sources have locking screws which are engaged for transport. The sources are within the interval for inspection and leak-testing
Engineering control measures and design features already in place or planned.	The standard school sources are supplied with shielded container, either a lead-lined wood box or aluminium cylindrical shield. The sources must be transported in their supplied containers. The sources do not have any other engineering controls.

Any planned systems of work.	The transport is by excepted package that is UN-approved 4GV. The package should be loaded at quiet times when no students are around.
Estimated levels of airborne and surface contamination likely to be encountered.	For normal transport operations, surface contamination levels will be zero. The sealed sources have a very high level of integrity.
The effectiveness and suitability of PPE to be provided.	There are no practical personal protective equipment options for the transport of sealed sources within the standard school holding.
The extent of unrestricted access to working areas where dose rates or contamination levels are likely to be significant.	There areas where packaging is undertaken should be restricted to a laboratory prep room where there will be no students or unauthorised people. Similarly, the unpacking and checking should take place in the laboratory prep room at the destination.
Possible accident situations, their likelihood and potential severity.	The estimated dose is low, less than 1 mSv. The modelling used by Public Health England (now UKHSA) was used to estimate the doses to the driver and to members of the public following a road accident and fire by a car used to transport a set of six school sealed sources. The assessment included external and internal doses. The dose was below 1 mSv y^{-1} from the excepted package. If the package is stolen, or an attempt made to steal the contents, the thief may not realise from the outside of the package that it contains radioactive material. It is foreseeable the thief could take out a boxed cup source, or a shielded Isotrak source, before realising it is radioactive. The worst-case equivalent dose rate would be ~ 70 µSv/h to the hand, so it is not foreseeable the thief would handle the source long enough to obtain an effective dose of 1 mSv unless harm was intended.
The consequences of possible failures of control measures – such as electrical interlocks, ventilation systems and warning devices – or systems of work.	A source could come out of its shielded container. The shielding is mainly for alpha and beta emissions, not gamma radiation. The plastic bag in the packing material should stop the source migrating close to the side of the box. The fibreboard box and packing material will shield the alpha and beta so that the surface dose rate from the beta is insignificant.
Steps to prevent identified accidents, or limit their consequences.	The only sources transported are restricted to the relatively low-activity small sealed teaching sources that are of a robust design. The carriage is by a commercial parcel carrier registered for Class 7 dangerous goods, and will have more experience, training and resources than transport by school staff by private car.

17.4 How L121 paragraph 71 led to the following decisions for controlling the risks from transport

Approved Code of Practice L121 paragraph 71	Decision
a) the action needed to make sure the radiation exposure of all people is kept as low as reasonably practicable (regulation 9(1))	Employers are advised to adopt the operating procedures in the current version of L93. The transport is restricted to sources within the standard school holding. The person undertaking the packing must be a member of science department staff who is trained and authorised to work with the sources. Similarly, make sure the consignee understands the parcel must be opened only by a member of science department staff who is trained and authorised to work with the sources. Use a commercial parcel carrier and carry out reasonable checks that the drivers are trained and the carrier has a contingency plan that can dovetail with yours.
b) the steps necessary to achieve this control of exposure by the use of engineering controls, design features, safety devices and warning devices (regulation 9(2)(a)) and, in addition, to develop systems of work (regulation 9(2)(b)).	To reduce the risk of a source coming out of its shield, the cup source boxes must have cable ties or equivalent to ensure the lid dos not open. The Isotrak sources must be in the locked position using the grub screw, and the rod tugged to check it is in the locked position.

	The cup and Isotrak sealed sources are a design that meet ISO2919:C23312.
c) whether it is appropriate to provide PPE and if so, what type is adequate and suitable (regulation 9(2)(c)).	PPE is not required by the person packing or unpacking.
d) whether it is appropriate to establish any dose constraints for planning or design purposes and if so, what values will be used (regulation 9(4)).	A dose constraint for packing and unpacking is not appropriate. It is only likely to be appropriate where individual doses from a single type of radiation source will be a significant fraction of the legal dose limits. The carrier may have a dose constraint for their driver.
e) the need to alter the working conditions of any employee who declares they are pregnant or breastfeeding (regulation 9(6)).	There is no reason why a pregnant woman should not package sources as an excepted package, if she wishes to, but we advise employers to follow the guidance in L93 section 5
f) an appropriate investigation level to check that exposures are being restricted as far as reasonably practicable (regulation 9(8)).	A suspected dose arising from the packing or unpacking of more than 50 µSv should be investigated by the RPS(Schools) with advice from the employer's Radiation Protection Adviser.
g) the maintenance and testing schedules required for the control measures selected (regulation 11).	Leak testing and inspection are yearly. This is explained in L93 section 11. The sources for transport must have been leak-tested within the week.
h) what contingency plans are necessary to address reasonably foreseeable accidents (regulation 13).	A contingency plan is necessary. The consignor must check that it fits with the carrier's own plan. The contingency plan must comply with IRR17 regulation 13. See section 10.2.1
i) the training needs of classified and non-classified employees (regulation 15).	The training needs identified are explained in L93 section 7. The training must include the safe handling of the sources in their containers.
j) the need to designate specific areas as controlled or supervised areas and to specify local rules (regulations 17 and 18).	None is required. There are no special procedures required. With the control measures in place, no person is likely to receive an effective dose greater than 1 mSv a year or an equivalent dose greater than 5 mSv a year for the lens of the eye or greater than 50 mSv a year for the skin or the extremities. External dose rates do not exceed 7.5 µSv/h when averaged over the working day.
k) actions needed to make sure access is restricted and other specific measures are put in place in controlled or supervised areas (regulation 19).	Designated areas are not required.
l) the need to designate certain employees as classified persons (regulation 21).	Classified workers are not appropriate. The likely doses to the people packing and unpacking do not warrant it.
m) the content of a suitable programme of dose assessment for employees designated as classified persons and for others who enter controlled areas (regulations 19 and 22).	No programme is required as there are no controlled areas.
n) the requirements for the leak testing of radioactive sources (regulation 28).	The sources for transport must have been leak-tested within the week before transporting them.
o) the responsibilities of managers and workers (including outside workers) for ensuring compliance with these regulations.	For transport, the RPS(Schools) has the main responsibility for ensuring correct packaging and procedures for contracting and liaising with a suitable carrier.
p) an appropriate programme of monitoring or auditing of arrangements to check the requirements of these regulations are being met.	The transport is one-off for non-routine circumstances so a programme of monitoring is not possible.