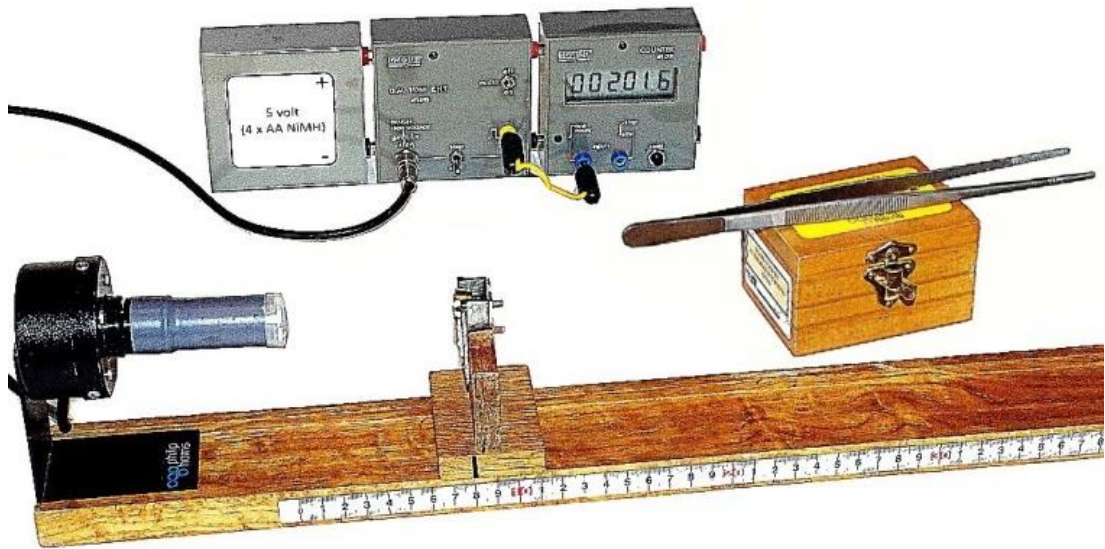


# L93 Managing Ionising Radiations and Radioactive Substances in Schools and Colleges

November 2016

Managing Ionising Radiations and Radioactive Substances in Schools and Colleges. L93 2016



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

This guide L93 is revised periodically to keep up-to-date with legislation and with improvements in radiological protection. Make sure you have the latest version, available from the CLEAPSS website. This publication updates the January 2013 guide.

**Acknowledgements:**

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

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

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

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# 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 handling radioactive substances in school science is very safe.**

This guide updates the 2013 edition. As with previous editions, it is written primarily for schools and colleges in England, Wales and Northern Ireland. The good practice it sets out is also relevant to Isle of Man, Jersey and Guernsey schools, although disposal arrangements are different. Scottish schools should refer to the guidance from SSERC.

The guide is divided into four main parts:

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

**Part B: Using radioactive sources.** Practical guidance for all 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 health and safety precautions for working with specific kinds of radioactive sources.

**Part C: Further Guidance.** Reference material and information for dealing with various incidents, disposing of and transporting sources. This section 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.

**Part D: Templates.** Forms, checklists, letter templates etc that you can copy and adapt.

### 1.1.1 Employers

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

## 1.2 Teaching about ionising radiations

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

Everyone is exposed to background radiation of varying levels, depending on where they live and what they do. Ionising radiations are not detectable by the senses and, partly for this reason, they either tend to be feared to an irrational degree or just ignored. Teaching about ionising radiations helps people to develop balanced

attitudes to the subject, neither blasé nor apprehensive. For many students, studying ionising radiations at school may be their only opportunity to achieve this.

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

### **1.2.1 Radiological protection**

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

There are three key principles of radiological protection:

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

These principles come from the International Commission on Radiological Protection<sup>1</sup> 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 way below legal dose limits. Handling the sources correctly, a teacher could carry out hundreds of demonstrations in a year before acquiring a dose as high as that from annual exposure to a typical background level. The doses students receive when observing demonstrations would be lower still.

## **1.3 Further help and guidance**

If you are unclear about any aspect of your work with radioactive sources, you can contact the CLEAPSS *Helpline* (as long as your school or college is a member – see [www.cleapss.org.uk/membership](http://www.cleapss.org.uk/membership) for more on this). You may also be able to contact your employer's Radiation Protection Adviser (RPA) for advice (or, in some 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 1999 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 types of equipment. CLEAPSS members can download these documents from our website – there are too many to list here, but the documents particularly relevant to L93 are set out in the next table.

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<sup>1</sup> International Commission on Radiological Protection, publication 103: ISBN 978-0-7020-3048-2.

Documents mentioned in L93	Notes
<p><b>PS46A Radiation Protection in School Science: Guidance for Employers – Information for local authorities</b></p> <p><b>PS46B Radiation Protection in School Science: Guidance for Employers – Information for independent schools &amp; colleges (including foundation &amp; voluntary-aided schools &amp; academies)</b></p>	These discuss options for Radiation Protection Adviser services.
<b>PS75 Should the RPS be a teacher or a technician?</b>	Explains why the RPS (Schools) should be a teacher.
<b>PS78 Radioactive Sources for School Use</b>	This lists radioactive sources that CLEAPSS has concluded conform to specification L256.
<b>PS79 Instrumentation for leak tests and contamination checks</b>	Discusses what equipment you need for leak tests, and how to make a test source.
<b>PS13 Pregnant, new &amp; breastfeeding mothers and school science</b>	Advice on the minimal risks to pregnant women posed by practical school science.
<b>L256 Specification of Radioactive Sources for School Use</b>	A specification written at the request of the DCSF (now DfE) intended for manufacturers, suppliers and employers.
<b>GL138 Choosing a Geiger-Muller tube and a counter or ratemeter</b>	Discusses equipment suitable for schools.
<b>GL220 Disposal of Waste Sealed Sources</b>	Guidance on grout/bin disposal route.
<b>GL221 Restoration or disposal of a lead-pot box for radioactive sources</b>	Guidance on repairing (or disposing of) the lead pot, wooden box, hasps and hinges.

## 2 The legal background

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

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

	Regulations	Notes
<b>Set 1</b>	<p><b>Using ionising radiations safely</b></p> <p>The Ionising Radiations Regulations 1999 – which relate to England, Scotland and Wales</p> <p>The Ionising Radiations (Northern Ireland) Regulations 2000</p>	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.
<b>Set 2</b>	<p><b>Environmental protection</b></p> <p>The Environmental Permitting (England and Wales) Regulations 2010, as amended</p> <p>The Radioactive Substances Act 1993 as amended, in Northern Ireland</p> <p>The Radioactive Substances Exemption (Northern Ireland) Order 2011</p>	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.

<b>Set 3</b>	<b>Transport regulations</b> 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 1 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.
<b>Set 4</b>	<b>Government control of education</b> The Education (Schools and Further and Higher Education) Regulations 1989, as amended The Education (Special Educational Needs) (Approval of Independent Schools) Regulations 1994, as amended The Education (Hazardous Equipment and Materials) (England) Regulations 2004	These laws require some schools and colleges to get approval from the relevant government department before using radioactive sources.  The laws are piecemeal, in that they do not apply to all types of schools, and they do not apply equally to all parts of the UK.

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

## 2.1 Schools and colleges in Northern Ireland

In this guide, if a reference is made to the Ionising Radiations Regulations 1999 – which relate to England, Scotland and Wales – the equivalent in Northern Ireland are the Ionising Radiations (Northern Ireland) Regulations 2000. Similarly, if this guide refers to the Environmental Permitting (England and Wales) Regulations 2010 as amended, the equivalent in Northern Ireland is the Radioactive Substances Act 1993 as amended and the Radioactive Substances Exemption (NI) Order 2011. But the legislation is essentially the same.

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

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

## 2.2 Schools and colleges in Wales

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

## 2.3 Schools and colleges in Scotland

Refer to the guidance from SSERC (Scottish Schools Education Research Centre). The environmental regulator is SEPA (Scottish Environment Protection Agency).

## Part A: Arrangements for keeping radioactive sources

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

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

### 3 Making the arrangements: the steps you need to follow

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

	Action	See section
Step 1	Make sure you have a good educational justification for acquiring the source(s).	3.1
Step 2	Decide who will be responsible for managing the radioactive source(s) and arrange training if needed.	3.2
Step 3	Check that the source is suitable for school science use. (Having to dispose of an unsuitable source, or obtain a permit, is expensive.)	3.3
Step 4	Obtain permission from your employer.	3.5.1
Step 5	The employer consults and appoints a Radiation Protection Adviser (RPA) if necessary.	3.4
Step 6	Obtain advice from your RPA on the source(s) you intend to acquire.	3.3 & 7.2
Step 7	Check if you need government education department approval for acquiring the source(s), and if so, apply for it.	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 notifies the HSE of their intention to use ionising radiations for the first time.	3.5.4
Step 11	Let the Fire and Rescue Service know where the store is, and the activity of the sources you have or are acquiring.	3.5.5
Step 12	Order the source from a reputable supplier.	3.6

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

This applies to all sources. You need to be able to justify why the school needs them. This is straightforward: it should be linked to the practical work for good teaching of the science curriculum. For example, it is justifiable to buy a set of standard cup-type sources, or a half-life demonstration source, if the school does not already have them; similarly, replacing a cobalt-60 source because its activity has become too low, or replacing sources that are at the end of their safe working life, is justified. Your employer may have its own requirements, but there is no formal requirement for you to supply a written justification. But you do need to be able to explain the justification. What isn't justified is acquiring sources – eg donations from industry or other schools – just because they are cheap or free. It would also be difficult for a school to justify acquiring a high-activity source that requires an environmental permit. Some schools have accepted unsuitable donations, only to find out later the considerable cost of disposal, sometimes running into thousands of pounds.

### **3.2 Decide who will be responsible for managing the radioactive sources**

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

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

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

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

#### **3.2.1 Training for the RPS (Schools)**

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

### **3.3 Choose sources that are suitable for school science use**

The types of source and quantities specified in the 'Standard School Holding' (see section 3.3.1) are suitable for school science use. When choosing a particular source, we strongly recommend that you follow the guidance in PS78, *Radioactive sources for*

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<sup>1</sup> CLEAPSS runs a suitable course in all parts of the country (except Scotland, where schools should contact SSERC).

*school use*, which lists specific radioactive sources aimed at schools and available in the UK. This indicates which sources CLEAPSS has concluded conform to a specification for suitable sources drawn up at the request of the Department for Children, Schools and Families (now DfE).

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

New sealed sources should meet a minimum specification of ISO 2919:2012 C23312. The older cup sources from Philip Harris, Griffin & George and Panax were not tested to this standard, but tests carried out by the National Radiological Protection Board (now Public Health England) and experience have shown that these sources are robust and can continue to be used if they are in good condition and checked yearly.

### 3.3.1 The Standard School Holding

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

#### Standard school holding

**Up to 1.2 MBq (~30 µCi) as sealed sources (but see section 3.3.2). That is six 185 kBq (5 µCi) sources. The nominal activity<sup>1</sup> of any source must not exceed 400 kBq (10 µCi). New sealed sources must meet ISO 2919:2012 C23312.**

**Up to 100 g of uranyl nitrate as a radiochemical; up to 100g of uranium compounds in total encapsulated in Becquerel plates and disc sources.**

**Protactinium generator for half-life experiments.<sup>2</sup>**

**Gas mantle radon-220 (thoron) generator for half-life experiments.<sup>2</sup>**

**Caesium-137/barium-137 elution source for half-life experiments, each up to 40 kBq.<sup>3</sup>**

**Low-activity cloud chamber sources, eg radium paint sources and thoriated tungsten welding electrodes (TIG electrodes).**

**Small specimens of naturally radioactive rocks.**

**Low-level radioactive consumer artefacts such as smoke alarms, gas mantles in a sealed bag, Vaseline glass, and Fiesta ware.**

### 3.3.2 Notes on the Standard School Holding

The 1.2 MBq limit for sealed sources is not a legal limit, but a limit established over decades as a sensible amount to meet the normal curriculum requirements. If you

<sup>1</sup> 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.

<sup>2</sup> No specific limit other than what is justified for curriculum use, up to the maximum holding for uranyl nitrate.

<sup>3</sup> 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.**

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

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

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

The Standard School Holding includes some consumer items that contain enough radioactive substances for the radiation to be detected by a Geiger-Müller (GM) tube. These include, for example, a smoke alarm and older radioluminescent watch or clock dials. It is essential that these consumer items are kept as intact sealed sources, usually in their original containers. Do not keep items where the protective glass face has been damaged or the dial has been removed from the timepiece. They must not be opened, adapted or mutilated. Sometimes radioluminescent paint becomes brittle with age – if there is any sign of this, the items may need to be disposed of safely (see section 12). You should not keep other radioluminescent items such as aircraft altimeters and compasses.

### **3.3.3 Containers for the sources**

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

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

### **3.3.4 Exempt material**

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

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

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

These are the conditions for exempt substances:

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

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

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

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

### **3.3.5 X-ray equipment**

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

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

## **3.4 The employer appoints a Radiation Protection Adviser (RPA)**

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

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

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

RPAs must hold a valid certificate of competence and be formally recognised as competent by the HSE, so it is very unlikely an adviser, teacher or technician can legally act as an RPA. (Until 2005, an RPA did not necessarily need to hold such a

certificate.) Note that the law also requires the RPA to be 'suitable', so the employer needs to check the RPA has adequate experience and expertise in managing small sources for teaching.

#### **3.4.1 The CLEAPSS RPA scheme for local authorities**

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

### **3.5 Sort out the permissions and notifications**

#### **3.5.1 Get permission from your employer**

Any employer who carries out work with ionising radiations is called a 'radiation employer'.<sup>1</sup>

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 the school starts working with radioactive sources, as they have to notify the Health and Safety Executive (HSE) first – see section 3.5.4. If your school changes status – eg changes from a local authority school to an academy – the employer may change too.

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 (2016), 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.

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<sup>1</sup> Under the Ionising Radiations Regulations 1999.

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*

In controlled schools, the Northern Ireland Education Authority is the employer.

In Catholic schools, the Catholic Council for Maintained Schools is normally the employer of the teaching staff. But the Education Authority is usually responsible for safety management, and normally employs the technicians. If you work in a Catholic school and you are unsure of your position, check with the Education Authority.

In voluntary grammar, integrated and independent schools, the employer is likely to be the governing body, corporation, trust or proprietor.

### **3.5.3 Get permission from the education department**

Some schools and colleges also need permission from their government department for education, as set out in the following table.

<b>Category of school or college</b>	<b>Government department from whom permission is required.</b>
<b>All schools and colleges in Northern Ireland</b>	No permission needed from the Northern Ireland Education Authority.
<b>All secondary schools (including academies) in England, but not sixth form colleges</b>	No permission needed from the DfE
<b>Sixth form colleges and further education colleges in England</b>	<p>No specific permission is required if the college agrees to keep within the Standard School Holding and follow L93.</p> <p>If a college wants to obtain and use sources of ionising radiation but does not agree to meet these conditions, their application to the Department for Business, Innovation and Skills (BIS) needs to be accompanied by a signed letter from their Radiation Protection Adviser. BIS will seek technical advice on whether to give approval. Application for this should be made to:</p> <p>Anthony Rodgers, FE Policy            Department for Business, Innovation and Skills            1 Victoria Street, London SW1H 0ET</p> <p>Tel: 020 7215 3173            E-mail: <a href="mailto:anthony.rodgers@bis.gsi.gov.uk">anthony.rodgers@bis.gsi.gov.uk</a></p>

<p><b>Secondary maintained schools, sixth form colleges and further education colleges in Wales</b></p> <p><b>Independent special schools in Wales that have been approved by the Secretary of State as special schools</b></p>	<p>Permission is required from:</p> <p>Schools Management and Effectiveness Division School Standards and Workforce Directorate Welsh Government Cathays Park, Cardiff CF10 3NQ</p> <p>Tel: 0300 060 3300 E-mail: smed2@wales.gsi.gov.uk</p>
<p><b>Other independent schools in Wales</b></p>	<p>No permission needed from the Welsh Government</p>

### 3.5.4 Check the HSE has been notified

Your employer has to notify the HSE (HSENI in NI) 28 days before the school first starts working with ionising radiation. This is a one-off notification: it isn't needed each time the school uses the sources, or when it acquires new but similar sources for the same purposes. Make sure you tell your employer of the sources you hold and check your school has been included in the notification.

A new notification will need to be made if there are any significant changes, for instance if the school moves to a new address or the employer changes (eg if the school becomes an academy). Let your employer know if you want to use a new kind of source for the first time, so that they can notify the HSE. You should also let your RPA know. If the notification is delegated to you, in England and Wales, all statutory radiation notifications are now processed online using form IRR6. Follow the relevant link at [www.hse.gov.uk/radiation/ionising/notification.htm](http://www.hse.gov.uk/radiation/ionising/notification.htm). For Northern Ireland schools, the notification is to HSENI, and is also done online. Follow the relevant link at [www.hseni.gov.uk/articles/ionising-radiation](http://www.hseni.gov.uk/articles/ionising-radiation).

### 3.5.5 Tell the Fire and Rescue Service

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

## 3.6 Order the radioactive source from a reputable supplier

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

### 3.6.1 Placing an order for a radioactive source

When placing an order for a radioactive source, you may need to confirm to the supplier that the school or college is allowed to hold that source and the employer has approved its acquisition, although this is rare now. We have provided a model letter to use if you wish (see section 16.9). If there is any difficulty over this, please contact us. Some suppliers may require a letter from your RPA.

Whenever a new radioactive source is purchased, the RPS (Schools) must keep copies of all the relevant paperwork (eg the delivery note, invoice, instructions and safety

data sheets). Schools have found these documents extremely useful, for example when the source eventually needs to be disposed of.

### **3.6.2 Delivery arrangements with the supplier**

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

## **3.7 Monitoring equipment**

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

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

## **4 Storage, labelling and security**

### **4.1 Plan where the sources will be stored**

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

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

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

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

The store room must be restricted to science staff only, using a good quality unique lock. A lockable science store room off a prep room or laboratory is ideal; a lockable cupboard in a prep room is acceptable. A store room used by the cleaners, or a general stationery cupboard used by school staff, or a boiler room are all examples of unsuitable store rooms.

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

#### **4.1.2 Locating the steel store cabinet in the store room**

The steel store 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 without needing to remove them from the cabinet.

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

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

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

#### **4.1.3 Other restrictions on the store room**

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

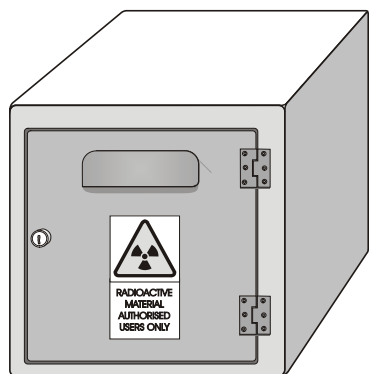
- No bulk stocks of highly flammable substances. The Fire and Rescue Service are unlikely to accept the risks arising from storing the sources near to flammable substances.
- No corrosive materials, to reduce the risk of damage to the sources.
- Only science department equipment. It is not acceptable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

#### **4.1.4 Construction of the steel store cabinet**

The cabinet must be:

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

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)



Radioactive material  
Authorised users only

Warning trefoil sign for the  
cabinet, with recommended text

#### 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.<sup>1</sup> 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. However, advertising the presence of radioactive sources may encourage vandalism or theft, or raise unnecessary concern. You should review these risks before labelling any doors.

#### 4.1.6 What to keep in the steel store cabinet

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

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

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

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

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<sup>1</sup> For example, Seton Ltd ([www.seton.co.uk](http://www.seton.co.uk)) and Safetyshop ([www.safetyshop.com](http://www.safetyshop.com)).

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.

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

## **4.3 Relocating the sources during school moves, refurbishments etc**

This is probably when there is the highest risk of losing the radioactive sources. During school moves to new buildings, closures, rebuilds and refurbishments, radioactive sources and cabinets have been misplaced, and in some cases lost entirely.

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

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

## Part B: Using radioactive sources

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

### 5 Authorised users

#### 5.1 School science staff

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

##### 5.1.1 Teacher qualifications

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

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

##### 5.1.2 Support staff qualifications

Technical support staff can have various qualifications and experience. It is important that technicians are confident and competent if they are to handle radioactive sources. The RPS (Schools) should decide what tasks (if any) they are given. This varies among schools. In some, technicians do not handle radioactive sources at all; teachers always collect sources and return them to the store. In others, technicians transfer sources to laboratories and carry out annual monitoring.

##### 5.1.3 Pregnant women and new mothers (staff or students)

It is important for a pregnant employee to let her employer know as soon as she is aware that she is pregnant, so that the employer can advise her of any special precautions or changes needed to working procedures.<sup>2</sup> 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 handling radioactive substances in schools will receive a dose anywhere near the limits specified by the regulations.

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

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<sup>1</sup> 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.

<sup>2</sup> See CLEAPSS leaflet PS13 *New & expectant mothers taking part in school science*.

contamination checks or work with unsealed sources (dealing with spills of radioactive substances, preparing protactinium generators, etc).

#### **5.1.4 Students under 16**

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

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

#### **5.1.5 Students aged 16 and over**

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

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

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

### **5.2 Staff training**

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

## **6 Working with radioactive sources**

### **6.1 Using the monitoring equipment**

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

### **6.2 Security**

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

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

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

### **6.2.1 Records for security: the use log**

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

Once the lesson is over and you put the source back in the store, complete the use log again. Give the date and time, sign it and add any comments (eg if the source was dropped). See section 16.3 for a use log template

## **6.3 Risk assessments**

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

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

- 1 A set of general safety precautions** that apply to working with all radioactive substances. These are called Standard Operating Procedures.<sup>1</sup> Model Standard Operating Procedures are set out in section 6.6, and can be downloaded from our website as a Microsoft Word-compatible document (DL93).
- 2 Specific risk assessments and useful information** for particular kinds of radioactive substances commonly used in schools. There is a specific risk assessment for each of the sources covered in this guide in section 6.7.

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

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

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

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<sup>1</sup> They are sometimes called 'local rules'. However, this term has a specific meaning in the Ionising Radiations Regulations that is not generally applicable to schools, so the term 'Standard Operating Procedures' is preferable here.

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

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

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

## **6.4 Standard school activities with ionising radiations**

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

Standard school activities with ionising radiations are practical investigations on:

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

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

## **6.5 Standard Operating Procedures for using radioactive sources**

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

## 6.6 Model Standard Operating Procedures

### Standard Operating Procedures: Contact information

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

### Standard Operating Procedures: Document locations

Document	Location
Radioactive source history	
Use log for radioactive sources	
Monthly simple check log book	
Annual detailed check of radioactive sources and store	
List of authorised users of radioactive sources	
List of radioactive sources held	

### Standard Operating Procedures to be used with the specific risk assessments

1.	The work with radioactive substances must have an educational benefit. Consider the maturity and behaviour of the pupils when planning to use radioactive sources in teaching.
2.	Practical work should be carried out in a laboratory and supervised by a qualified science teacher who has an adequate understanding of radioactivity hazards and basic radiological protection techniques.
3.	There must be suitable working detection equipment, eg GM tube and counter.
4.	The RPS (Schools) must be satisfied that the person carrying out the experiments is competent to do so safely.
5.	Anyone working with ionising radiation has a responsibility to restrict their personal exposure as far as reasonably practicable.

6.	If you are pregnant or breastfeeding, tell your RPS (Schools) before starting any work with ionising radiation.
7.	Never eat, drink or apply cosmetics when working with the ionising radiation.
8.	Wear any protective equipment indicated by the specific risk assessment. Before handling the radioactive substances, cover any wounds or skin damage with a suitable waterproof dressing.
9.	Keep a sensible distance from the source. Use a tool to handle sealed sources that don't have an integral handle. Keep your fingers away from the source – typically 100 mm away – eg by using long forceps. Some sources emit more radiation in a particular direction (collimated or non-isotropic sources) – keep these positioned so that the main radiation field is directed away from anyone. Keep any source at least 300 mm away from the rest of the body.
10.	Spend as little time as practicable near to the radioactive source.
11.	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.
12.	In addition to these Standard Operating Procedures, you must follow the specific risk assessments for particular sources in section 6.7 of the CLEAPSS guide, <i>L93 Managing Ionising Radiations and Radioactive Substances in Schools and Colleges</i> , as modified by the school.
13.	Students under the age of 16 should not use radioactive sources other than those in small cloud chambers (the source must remain inside the chamber during the lesson), and radioactive geological specimens (kept in suitable containers which are not easy to open). All other work with radioactive sources must only be demonstrated by the teacher or technician.
14.	Whenever students work with radioactive sources, you must give full training and, where appropriate, provide written instructions. Students must be closely supervised by a member of staff at all times.
15.	Responsible students aged 16 years and older may use sources within the Standard School Holding. Each student must understand these Standard Operating Procedures and the relevant specific risk assessment.
16.	A member of staff must check sources immediately after use by students. Report any suspected damage to your RPS (Schools), who will decide if further action or monitoring is required. Keep a record of any unusual incident involving a source with the appropriate source history and make a note in the use log.
17.	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. For radiochemicals, record the approximate mass used.
18.	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.
19.	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).

20.	In case of fire, follow the school's fire safety arrangements. If any radioactive sources were being used when the fire alarm started, tell the Fire and Rescue Service where they are, particularly if they are close to the fire. Tell the RPS (Schools) as soon as possible. You must not go back into the building until the Fire and Rescue Service advises it is safe to do so. In other incidents, tell the RPS (Schools) immediately and follow the contingency guidance in section 9 of the CLEAPSS guide, <i>L93 Managing Ionising Radiations and Radioactive Substances in Schools and Colleges</i> .
21.	If the source is dropped or spilt, follow the 'Spill or drop' guidance on the specific risk assessment for the source.
22.	<p>For contingencies, and in addition to the items in the normal CLEAPSS spill kit,<sup>1</sup> the following items should be available:</p> <ul style="list-style-type: none"> <li>• disposable gloves (preferably nitrile);</li> <li>• a pack of soft paper towels or tissues;</li> <li>• a pack of filter papers; and</li> <li>• a disposable FFP3 dust mask (used for spills of powders).</li> </ul>
23.	Wash your hands after you have finished using radioactive materials, even if only using sealed sources.

### Additional notes

End of the Standard Operating Procedures

Dated \_\_\_\_\_

<sup>1</sup> See CLEAPSS *Laboratory Handbook* section 7.7 for information about chemical spills, including details of spill kits.

## 6.7 Specific risk assessments for using radioactive sources

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

Note that there are some types of source, indicated in the list below with an asterisk, where our specific risk assessment recommends that they are taken out of use and disposed of.

CLEAPSS type number	Source
1	Radioactive rocks
2	Smoke alarm
3a	Luminous timepieces
3b	Spinthariscopes*
3c	Radioluminescent instruments that are not timepieces or spinthariscopes*
4a	Scintillation plate*
4b	Becquerel plate
5	Diffusion (Taylor) cloud chamber source
6	Expansion (Wilson) cloud chamber source
7	Perspex slide sources – Labgear*
8a	Cup sources
8b	Panax source S4
8c	Isotrak educational sources (recessed in aluminium rod)
9	Protactinium generator
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 (except uranyl nitrate)*
18	Uranium oxide encapsulated disc source

### 6.7.1 The specific risk assessments

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

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


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

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

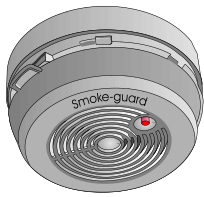
Most of the rows in the specific risk assessments are self-explanatory, but the following notes may be helpful.

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


## Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 1	Radioactive rocks		© CLEAPSS 2016
<b>Description</b>		<p>Supplied as a set, for example by Philip Harris or Griffin &amp; George. These usually contain thorium or uranium minerals. Typical radioactive minerals offered by educational suppliers are allanite, autunite, davidite, monazite, phosphuranylite, uraninite and torbenite.</p> <p>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.</p>	
<b>Use</b>	To demonstrate that natural rocks contain radioactive minerals. A rock should be regarded as radioactive if the count rate at the surface is more than 50% above the background count.		
<b>Original activity</b>	Varies, but can be up to 8.5 kBq g <sup>-1</sup> .		
<b>Radionuclide</b>	Thorium-232: 1.4 x 10 <sup>10</sup> years and/or uranium-238: 4.5 x 10 <sup>9</sup> years and decay chains. Uranium in rocks also comprises about 0.7% uranium-235.		
<b>Main radiations</b>	α, β, γ		
<b>Hazard</b>	<p>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.</p> <p>Thorium and uranium compounds are also toxic.</p>		
<b>Risk assessment</b>	The external dose rates and risks of loose material are significant, but the risks are low with the control measures in place.		
<b>Control measures</b>	Purchase radioactive rocks from educational suppliers. Only keep small samples – as a rough guide no more than 10 cm <sup>3</sup> each sample – and keep in a sealed plastic bag or other sealed transparent container when using them. Avoid much larger samples. Always follow the Standard Operating Procedures for the use of radioactive sources. Radioactive rocks should be treated in the same way as other radioactive sources.		
During use	The rocks should not be touched with the hands. They are best left in their transparent containers. Beware of loose contamination.		
Inspection	Annually or after use by students. A rock should be checked for damage and any chips or fragments disposed of. Forceps or disposable gloves should be used to handle rocks. Take care to avoid chipping the rock with the forceps. Handling time with gloves should be kept short.		
Leak test of source	Not required.		
Contamination check of container	Annually or if damage to the rock is suspected. The container should be cleaned if necessary.		
<b>Storage and labelling</b>	<p>Radioactive rocks are best stored in sturdy, transparent plastic bags or containers with secure lids. A plastic bag is better if the rock is friable (crumbly). The containers should be labelled with a radioactive warning sign and the name of the rock, and kept in the steel store cabinet or a locked display cupboard.</p> <p>If rocks are displayed, they must be kept in a locked cabinet at least 500 mm away from the person viewing them. The count rate at the viewing position must be similar to the background count rate.</p>		
<b>Spill or drop</b>	Wear a lab coat and disposable gloves. If a rock is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	Available from Philip Harris and other suppliers.		
<b>Standard School Holding</b>	No limit, other than what is justified for curriculum use.		

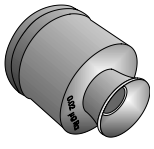
## Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 2	Smoke alarm		© CLEAPSS 2016
<b>Description</b>		<p>Most domestic smoke alarms use an ionisation chamber smoke detector. This is a small metal chamber containing a radioactive source. If smoke enters the chamber, the level of ionisation reduces, decreasing the flow of electric current in a circuit and triggering a siren.</p>	
<b>Use</b>	<p>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.</p>		
<b>Original activity</b>	<p>Typically 37 kBq (1 <math>\mu</math>Ci).</p>		
<b>Radionuclide and half-life</b>	<p>Americium-241: 458 years.</p>		
<b>Main radiations</b>	<p><math>\alpha</math>, <math>\gamma</math>. The <math>\alpha</math> radiation is not normally detectable because of shielding by the ionisation chamber wall.</p>		
<b>Hazard</b>	<p>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.</p>		
<b>Risk assessment</b>	<p>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.</p>		
<b>Control measures</b>	<p>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.</p>		
During use	<p>The plastic cover of the smoke alarm may be opened for observation, to detect ionising radiation and to insert the battery. Under no circumstances should the metal ionisation chamber be opened. The test button or smoke can be used to trigger the alarm.</p>		
Inspection	<p>Annually and after use by students. Check that the ionisation chamber is undamaged.</p>		
Leak test of source	<p>Annually or if damage is suspected. The accessible surfaces of the ionisation chamber should be tested.</p>		
Contamination check of container	<p>Not required unless leakage is suspected.</p>		
<b>Storage and labelling</b>	<p>A smoke alarm should be put in a strong, self-sealing 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.</p>		
<b>Spill or drop</b>	<p>Wear a lab coat and disposable gloves. If a smoke alarm is dropped, it is most unlikely that any radioactive spill will occur. If it is damaged, sweep the fragments into a strong plastic bag and tie it up. Check the area for contamination, and decontaminate it if necessary. See section 9.2.</p>		
<b>Availability</b>	<p>Sold by hardware stores.</p>		
<b>Standard School Holding</b>	<p>Up to five 40 kBq Am-241 smoke detectors. Some older detectors are Ra-226, and some are above 40 kBq – do not acquire these.</p>		


## Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 3a	Luminous timepieces		© CLEAPSS 2016
<b>Description</b>		Radium-based paint was in regular use in the first half of the 20th century to make various objects self-luminous in the dark.	
<b>Use</b>	To demonstrate that old timepieces once used radioactive substances to make a substance (usually zinc sulfide) glow. Note that although the radioluminescence gradually decreases over the years as the paint deteriorates, to the point where it barely glows in the dark, the radioactivity remains almost unchanged. These timepieces are of questionable use now.		
<b>Original activity</b>	Luminous dials: there is little information available. Timepieces have been reported at 5 to 50 kBq.		
<b>Radionuclide and half-life</b>	Usually radium-226 (promethium-147 and tritium have also been used). Ra-226: 1602 years; Pm-147: 2.6 years; tritium: 12.6 years.		
<b>Main radiations</b>	Radium-226 and decay chain: $\alpha$ , $\beta$ , $\gamma$ . Promethium and tritium: low-energy $\beta$ .		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	The items are at least 50 years old and the radioluminescent paint is frequently brittle with age and flaking off. The metal dial and hands can be corroded. These items should be checked carefully for damage. They should be disposed of if there are any signs of paint or metal deterioration.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
Physical design	The radioactive dial and hands must be securely encased in the timepiece with the front glass intact, effectively making it a sealed source. Most luminous watches provide satisfactory protection. An old alarm clock usually has holes that the controls pass through, and sometimes a loose-fitting face; these should be sealed with epoxy resin (eg Araldite).		
During use	Demonstrations should be limited to using a GM tube to show that the device is radioactive, and viewing items in the dark.		
Inspection	Check that the visible luminous paint is not crumbling, the glass is intact, and the luminous paint is completely enclosed.		
Leak test of source	Annually or if damage is suspected. The complete outer casing should be tested.		
Contamination check of container	Not required unless leakage is suspected.		
<b>Storage and labelling</b>	Keep the timepieces in a sealed, transparent plastic bag. Label the bag and keep it in the steel store cabinet.		
<b>Spill or drop</b>	Wear a lab coat, dust mask (FFP3) and disposable gloves. If a timepiece is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	Second hand only. Any items you have that are within the exemption limit can be used until the end of their safe working lives. Replacement is not recommended.		
<b>Standard School Holding</b>	The total activity of Ra-226 in all materials that cannot be classed as sealed must be no more than 10 kBq.		


Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 3b</b>	<b>Not recommended – dispose</b> <b>Spinthariscopes</b>		© CLEAPSS 2016
<b>Description</b>		A device used to view scintillations from a low-activity radioactive source, often a spot of radium paint, with a screen that scintillates.	
<b>Original use</b>	To demonstrate radioluminescence.		
<b>Original activity</b>	The Philip Harris spinthariscopes were 740 Bq (0.02 µCi). The Griffin types are of similar activity.		
<b>Radionuclide and half-life</b>	Usually radium-226: 1602 years.		
<b>Main radiations</b>	α, β, γ including emissions from the decay chain.		
<b>Reason for withdrawal from use</b>	These are old and there is no straightforward way of checking the condition of the actual source inside.		
<b>Hazard</b>	Internal irradiation of the body due to flakes of self-luminous paint being inhaled, absorbed through the skin or through wounds, or swallowed.		
<b>Risk assessment</b>	The source could have deteriorated inside but there is no easy way of checking.		
<b>Storage and labelling</b>	The items 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.		
<b>Spill or drop</b>	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.		
<b>Disposal</b>	See section 12.		

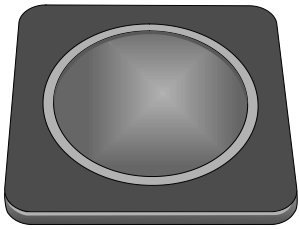

Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 3c</b>	<p>Not recommended – dispose</p> <p><b>Radioluminescent instruments that are not timepieces</b></p>		© CLEAPSS 2016
<b>Description</b>		<p>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.</p>	
<b>Original use</b>	To demonstrate radioluminescence.		
<b>Original activity</b>	There is little information available. Marine compasses can be up to 400 MBq.		
<b>Radionuclide and half-life</b>	<p>Usually radium-226 (promethium-147 and tritium have also been used).</p> <p>Ra-226: 1602 years; Pm-147: 2.6 years; tritium: 12.6 years.</p>		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chain.		
<b>Reason for withdrawal from use</b>	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 flakes of radium paint can come loose.		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	<p>This type of instrument can present a greater risk than other sources commonly used in schools.</p> <p>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.</p>		
<b>Storage and labelling</b>	The items 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.		
<b>Spill or drop</b>	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.		
<b>Disposal</b>	See section 12.		

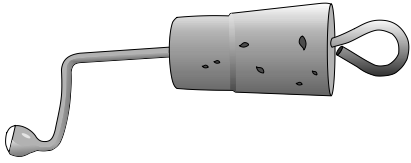
Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 4a</b>	Not recommended – dispose Scintillation plate		© CLEAPSS 2016
<b>Description</b>			<p>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.</p> <p>The picture left shows a Panax plate and the boxed set it was taken from.</p>
<b>Typical dimensions</b>	Varies. Panax type scintillation plates are length 65 mm, width 25 mm, thickness ~ 2 mm.		
<b>Original use</b>	To observe radioluminescence, and individual scintillations with a magnifier.		
<b>Original activity</b>	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.		
<b>Radionuclide and half-life</b>	Usually radium-226, 1602 years.		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chain.		
<b>Reason for withdrawal from use</b>	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 nuisance contamination inside the storage cardboard box and on nearby surfaces.		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	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.		
<b>Storage and labelling</b>	Wear disposable gloves and lab coat and put the items or boxed set directly into a sealed bag and labelled 'DO NOT USE'. If you need to handle the plates, do it by the edges and avoid touching or knocking the paint spots. Place this in a plastic bottle with a sealable lid, store it in the steel store cabinet and make prompt arrangements to dispose of them.		
<b>Spill or drop</b>	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.		
<b>Disposal</b>	See section 12.		

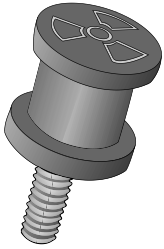
Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 4b	Becquerel plate		© CLEAPSS 2016
<b>Description</b>	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.	
<b>Typical dimensions</b>	Length 38 mm, width 38 mm, thickness 4 mm.	Length 85 mm, width 30 mm, thickness 4 mm	
<b>Use</b>	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.		
<b>Original activity</b>	Depends on type, but uranium types are usually less than 100 kBq.		
<b>Radionuclide and half-life</b>	<p>Uranium oxide paint or encapsulated uranium oxide powder. Panax types also have dummies with manganese oxide. Some Panax plates are yellow in colour. These contain uranyl nitrate, and some are dummies with sulfur.</p> <p>Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: <math>4.5 \times 10^9</math> years.</p>		
<b>Main radiations</b>	$\alpha$ , $\beta$ including emissions from the decay chain.		
<b>Hazard</b>	<p>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.</p> <p><i>The Panax-type case seals are known to fail, the uranyl nitrate absorbs water and the compound leaks out, causing contamination. Keep them under review. Look for a tell-tale line as water moves along the uranyl nitrate. If you see this, dispose of them promptly.</i></p>		
<b>Risk assessment</b>	The residual risk is low with the control measures in place.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
During use	These sources should be handled by the edges. Handle the Panax cases with disposable gloves.		
Inspection	Annually and after use by students. Check for crumbling of the active material and any damage to the plate or its cover. For the yellow Panax cases, look for a tell-tale line as water moves along the uranyl nitrate, indicating the seal has failed. .		
Leak test of source	Annually or if damage is suspected. The outer surfaces and edges of the plate should be tested.		
Contamination check of container	Not required unless leakage is suspected.		
<b>Storage and labelling</b>	These sources should be kept in sturdy sealable leak-proof container, labelled with a radioactive warning sign and kept in the steel store cabinet.		
<b>Spill or drop</b>	Wear a lab coat and disposable gloves. If a source is dropped, check the area for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	These sources have not been available for many years. Replacement is not recommended.		
<b>Standard School Holding</b>	No specific limit, other than what is justified for curriculum use. The total mass of uranium should not exceed 100 g.		

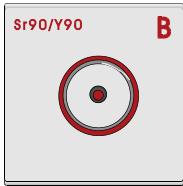
Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 5	Diffusion (Taylor) cloud chamber radium paint source		© CLEAPSS 2016
<b>Description</b>		<p>This source is part of a diffusion (Taylor) cloud chamber from Griffin &amp; 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.</p> <p>See specific risk assessment 15, <i>Thoriated tungsten welding electrode</i> for an alternative.</p>	
<b>Typical dimensions</b>	Length 70 mm, height 25 mm, diameter of cup 5 mm. Some have a plain end.		
<b>Use</b>	Observation of tracks produced by ionisation due to alpha particles.		
<b>Original activity</b>	Typically 0.74 kBq (0.02 µCi).		
<b>Radionuclide and half-life</b>	Radium-226: 1602 years.		
<b>Main radiations</b>	α, β, γ including emissions from the decay chain.		
<b>Hazard</b>	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. The paint can become loose and contaminate the surroundings, particularly in the plain-ended type (as opposed to the bell-ended type shown). The wire plating can show deterioration with the risk of the radium paint flaking away.		
<b>Risk assessment</b>	The residual risk is low with the control measures in place.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
During use	The radioactive end of the source should not be touched. The source should be kept in the cloud chamber.		
Inspection	Annually and after use by students. Check the sources for damage, but keep them well away from your eyes – a mirror is useful for closer inspection. The radium-based paint should not be crumbling or cracked. The metal plating should not be corroded or peeling off.		
Leak test of source	Not applicable.		
Contamination check of container	Not required, unless leakage is suspected. The amount of radium in this source is small that and contamination due to radon will be insignificant.		
<b>Storage and labelling</b>	The source should be removed from the cloud chamber by gently pulling out the cork and the wire mounting. Handle it by the wire loop or the cork; do not touch the radioactive end. Several sources may be kept together in a closed container in such a way that the radioactive ends can't be knocked about... The container should be labelled with a radioactive warning sign and kept in the steel store cabinet		
<b>Spill or drop</b>	Wear a lab coat and disposable gloves. If a source is dropped, check the area for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	These sources have not been available for many years. When you need to replace one, consider the thoriated tungsten welding electrode instead.		
<b>Standard School Holding</b>	The total activity of Ra-226 in all materials that cannot be classed as sealed must be no more than 10 kBq. This would be 13 of the 0.74 kBq sources.		

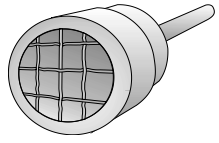
Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 6</b>	<b>Expansion (Wilson) cloud chamber radium source</b>		© CLEAPSS 2016
<b>Description</b>		This source is part of an expansion (Wilson) cloud chamber. It consists of a metal foil radium source shaped into a cylinder around the centre of a brass assembly that screws into the chamber. Supplied by Philip Harris as part of an expansion cloud chamber apparatus.	
<b>Typical dimensions</b>	Diameter 7 mm, height 8 mm (excluding threaded shaft).		
<b>Use</b>	Observation of tracks produced by ionisation due to alpha particles.		
<b>Original activity</b>	Typically 37 kBq (1 µCi).		
<b>Radionuclide and half-life</b>	Radium-226: 1602 years.		
<b>Main radiations</b>	α, β, γ including emissions from the decay chain.		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	The residual risk is low with the control measures in place.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
During use	This source should be kept in its cloud chamber. It should not be touched.		
Inspection	Annually and after use by students. Check the source (left in the cloud chamber) remotely for damage, eg with an inexpensive USB endoscope (snake scope).		
Leak test of source	Annually or if damage is suspected. The outer surfaces should be tested.		
Contamination check of container	Due to the very small amounts of radon gas emitted from radium sources, the inside of the cloud chamber should be checked annually and decontaminated if necessary. This is also required if leakage is suspected.		
<b>Storage and labelling</b>	It is usually best not to try to remove the source from this type of cloud chamber because the thread can be tight and removal may damage the source. Therefore the whole chamber should be labelled with a radioactive warning sign and stored in a labelled, locked cupboard, preferably near to the main store cabinet. It is normally best not to keep the whole cloud chamber in the steel store cabinet itself, because it would be difficult to clean if contaminated by other sources. It may also be too large to fit in the cabinet.		
<b>Spill or drop</b>	Wear a lab coat and disposable gloves. If a cloud chamber source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	These sources have not been available for many years. When you need to replace one, consider the diffusion cloud chamber instead.		
<b>Standard School Holding</b>	The total activity of all sealed sources should not exceed 1.2 MBq, and no single sealed source should be above 400 kBq. If practicable, choose sources no greater than 200 kBq.		


Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 7</b>	No longer recommended – dispose Perspex slide sources – Labgear					© CLEAPSS 2016
<b>Description</b>			<p>The active substance or foil source is held in a plastic slide with epoxy resin.</p> <p>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.</p> <p>Some slides have a protective wire mesh.</p>			
<b>Typical dimensions</b>	Length 50 mm, width 50 mm, thickness 3.5 mm.					
<b>Original use</b>	To investigate the basic properties of ionising radiations.					
<b>Original supplier</b>	These sources have not been available for many years. The supplier was Labgear Ltd. The foils were from Nycomed Amersham.					
<b>Radionuclide and half-life (years)</b>	<b>Co-60</b> 5.26	<b>Sr-90</b> 28.1		<b>Am-241</b> 458	<b>Ra-226</b> 1602	<b>Th-232</b> $1.4 \times 10^{10}$
<b>Main radiations</b>	$\gamma, \beta$	$\beta$		$\alpha, \gamma$	$\alpha, \beta, \gamma$	$\beta, \gamma (\alpha)$
<b>Original activity kBq (<math>\mu\text{Ci}</math>)</b>	37 (1) 185 (5)	37 (1)	185 (5)	3.7 (0.1) 185 (5)	185 (5)	37 (1)
<b>Labgear code</b>	C	B	E	A	D	F
<b>Reason for withdrawal from use</b>	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.					
<b>Risk assessment</b>	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.					
<b>Storage and labelling</b>	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'. Dispose of them.					
<b>Spill or drop</b>	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.					
<b>Disposal</b>	See section 12.					


## Specific Risk Assessments for radioactive sources, use, spill &amp; storage

Type number 8a		Cup sources				© CLEAPSS 2016
Description						This is the most common type of sealed source used in schools and colleges, originally supplied by Philip Harris, Griffin, Panax and others. The radioactive substance is sintered into a metal foil and secured at the base of a metal cup by a circlip. In some newer designs of foils, the radioactive material is anodised into the foil surface. The open end of the cup is covered with wire mesh. It has a stem for handling and mounting. Details of the radionuclide and original activity are usually stamped on the back of the cup, next to the stem. A serial number may be engraved there too. Cup sources are supplied in a small lead pot with a lead lid, inside a suitably labelled wooden container.
Typical dimensions	Length 22 mm, diameter 13 mm, stem diameter 4 mm.					
Use	To investigate the basic properties of ionising radiations.					
Original activity	3.7 kBq (0.1 µCi) to 370 kBq (10 µCi), depending on type. Most commonly 185 kBq (5 µCi).					
Radionuclide and half-life (years)	<b>cobalt-60</b> 5.26	<b>strontium-90</b> 28.1	<b>americium-241</b> 458	<b>plutonium-239</b> $2.44 \times 10^4$	<b>radium-226</b> 1602	
Main radiations	$\gamma$ ( $\beta$ )	$\beta$	$\alpha$ , $\gamma$	$\alpha$	$\alpha$ , $\beta$ , $\gamma$	
Colour code (if present)	Green	Yellow	Brown	Blue	Red	
Hazard	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.					
Risk assessment	The residual risk is low with the control measures in place.					
Control measures	Always follow the Standard Operating Procedures for the use of radioactive sources.					
During use	This type of source should be manipulated by the stem and kept at least 100 mm from the hand – long forceps are ideal. Only one source should be used at a time. Between investigations, the source should be returned to its container.					
Inspection	Annually and after use by students. Check the whole source for signs of damage. View the active foil surface using a plane mirror on the bench, or remotely with a digital camera. Never point the foil surface towards your eyes. Keep a record of any blemishes, particularly to the foil surface.					
Leak test of source	Annually or if damage is suspected. The outer surface should be tested.					
Contamination check of container	Not required unless leakage is suspected. For radium sources, small amounts of radon gas can be emitted, so an annual check should be made on the containers of these sources, and they should be cleaned if necessary.					
Storage and labelling	The source should be stored in its lead-lined container, labelled with a radioactive warning sign and kept in the steel store cabinet.					
Spill or drop	Wear a lab coat and disposable gloves. If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.					
Availability	Currently sold by Edu-lab, Philip Harris, SciChem and Timstar.					
Standard School Holding	The total activity of all sealed sources should not exceed 1.2 MBq. No single sealed source should be above 400 kBq. If practicable, choose sources no greater than 200 kBq.					


Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 8b	Panax source S4		© CLEAPSS 2016
<b>Description</b>		<p>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.</p> <p>The activity will be lower than when new owing to the 28 year half-life.</p>	
<b>Typical dimensions</b>	Length 50 mm, width 45 mm, depth 25 mm (including collimator and metal storage cap).		
<b>Use</b>	To investigate deflection of beta radiation by a magnetic field.		
<b>Original activity</b>	330 kBq (9 $\mu$ Ci).		
<b>Radionuclide and half-life</b>	Strontium-90: 28.1 years.		
<b>Main radiations</b>	$\beta$ .		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	The residual risk is low with the control measures in place.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
During use	This type of source should be held by the plastic edges. The aluminium cap should be removed with plastic forceps, making sure your hand is not placed in front of the source slit. The aluminium cap should be replaced immediately after you have finished the investigation using the source.		
Inspection	Annually and after use by students. Check the whole source for signs of damage. There is no point in remotely looking into the source slit because little of the foil can be seen.		
Leak test of source	Annually or if damage is suspected. The outer surface should be tested.		
Contamination check of container	Not required unless leakage is suspected.		
<b>Storage and labelling</b>	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.		
<b>Spill or drop</b>	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.		
<b>Availability</b>	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.		
<b>Standard School Holding</b>	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.		

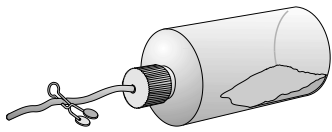
## Specific Risk Assessments for radioactive sources, use, spill &amp; storage

Type number 8c	Isotrak educational sources					© CLEAPSS 2016
<b>Description</b>			The source assembly is made up of a source (a sealed stainless steel capsule or a metal foil or disc), housed in a recess in an aluminium rod. The rods are supplied in a metal cylinder, which can hold one (as shown in the illustration) or more rods in a 'well'.  The radioactive end of the rod is stored downwards into the metal cylinder well.			
<b>Typical dimensions</b>	Length 85 mm, diameter 12 mm. The source is recessed 8 into the end of the rod.					
<b>Use</b>	To investigate the basic properties of ionising radiations.					
<b>Original activity</b>	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.					
<b>Radionuclide and half-life (years)</b>	<b>cobalt-60</b> 5.26	<b>strontium-90</b> 28.1	<b>americium-241</b> 458	<b>sodium-22</b> 2.62	<b>caesium-137</b> 30	
<b>Main radiations</b>	$\gamma$ ( $\beta$ )	$\beta$	$\alpha$ , $\gamma$	$\beta^+$	$\gamma$ , $\beta$	
<b>Hazard</b>	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.					
<b>Risk assessment</b>	The residual risk is low with the control measures in place.					
<b>Control measures</b>	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. <i>Make sure you know which is the source end.</i> Only one source should be used at a time. Between investigations, the source should be returned to its container, the source end of the rod goes into the metal cylinder well.					
Inspection	Annually and after use by students. Check the whole source for signs of damage. View the recessed surface using a plane mirror on the bench or remotely with a digital camera. Never point the foil surface towards your eyes. Keep a record of any blemishes, particularly to the source surface.					
Leak test of source	Annually or if damage is suspected. The outer surface should be tested, but avoid contact with the actual active surface of the source.					
Contamination check of container	Not required unless leakage is suspected.					
<b>Storage and labelling</b>	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.					
<b>Spill or drop</b>	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.					
<b>Availability</b>	Currently supplied by SciChem.					
<b>Standard School Holding</b>	The total activity of all sealed sources should not exceed 1.2 MBq. No single sealed source should be above 400 kBq,					

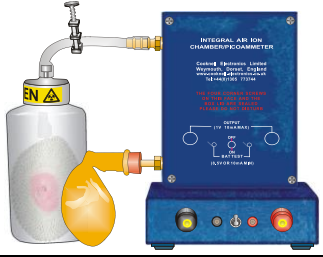
## Specific Risk Assessments for radioactive sources, use, spill &amp; storage

Type number 9	Protactinium generator		© CLEAPSS 2016
<b>Description</b>		Good quality ones are sealed, thin-walled fluoropolymer bottles containing an aqueous solution of acidified uranyl(VI) nitrate beneath an organic solvent. The acid is moderately concentrated hydrochloric acid. The generators that use pentyl ethanoate tend not to give good results after many years, probably due to a gradual deterioration of the organic solvent. The solvent in some designs becomes a thick goo over time, and ceases to work, and makes disposal difficult.	
<b>Use</b>	When the bottle is shaken, only 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.		
<b>Original activity</b>	Old Philip Harris version: 45 kBq (1.2 µCi). Sciencescope and new Philip Harris version: 20 kBq (0.5 µCi). CLEAPSS design: 10 kBq (0.3 µCi).		
<b>Radionuclide and half-life</b>	Uranium-238: $4.5 \times 10^9$ years, decay chain thorium-234: 24 days and protactinium-234m: 72 s. Uranium comprises also up to 0.7% uranium-235.		
<b>Main radiations</b>	$\beta$ , ( $\alpha$ blocked by the bottle wall)		
<b>Hazard</b>	Concentrated hydrochloric acid is corrosive. Organic solvent, depending on design (eg pentyl ethanoate (amyl acetate)), is harmful and flammable. See CLEAPSS <i>Hazcards</i> for specific information on chemical hazards. Uranyl(VI) nitrate is toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.		
<b>Risk assessment</b>	The external radiation is low. The greatest risk is from contamination if the bottle leaks or if the cap is removed. The residual risk is low with the control measures in place. <i>Many home-made versions are prone to leaking, particularly ones made from non-fluoropolymer bottles. CLEAPSS generally advises schools to buy a generator rather than make one because of the difficulty ensuring it remains leak-proof over time.</i> If a school does decide to make their own, follow guide GL119 carefully, including the bottle type. We advise that you dispose of home-made generators not constructed to GL119 standard.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
During use	Never remove the top from a generator bottle. Wear disposable gloves, goggles and lab coat when handling 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. Between investigations, the bottle should be returned upright into its secondary outer container. An appropriate spills kit should be readily available. If there is a spill, report it immediately.		
Inspection	Annually, as well as before and after any use. Check for any signs of damage or deterioration. If the cap is accessible on home-made generators, check that it remains secure and the bottle has not deteriorated.		
Leak test of source	Annually or if damage is suspected. Wipe around the cap and any suspect areas but do not open the bottle.		
Contamination check of outer container	Annually or if leakage is suspected. Check the container the bottle stands in and clean if necessary. If you find contamination, the bottle or the cap seal is probably failing.		
<b>Storage and labelling</b>	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.		
<b>Spill or drop</b>	Wear a lab coat, goggles and disposable gloves. Spills of a few cm <sup>3</sup> can be mopped up with a tissue. Contain larger spills with a mineral absorbent and scoop it into a bucket with sodium carbonate and water. Check the surface where the spill occurred for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	Versions currently sold by Edu-Lab, Philip Harris, SciChem and Timstar.		
<b>Standard School Holding</b>	No specific limit, other than what is justified for curriculum use. The total mass of uranium held as a radiochemical should not exceed 100 g.		


Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 10</b>	No longer recommended – dispose <b>Radon-220 (thoron) generator (powder version)</b>		© CLEAPSS 2016
<b>Description</b>		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.	
<b>Typical dimensions</b>	No standard bottle size, but usually less than 50 mm diameter and less than 150 mm length.		
<b>Original use</b>	Generating radon-220 for demonstrating and measuring the half-life of a radioactive material.		
<b>Original supplier</b>	Panax, Philip Harris, Griffin.		
<b>Radionuclide and half-life</b>	Thorium-232 and decay chain. Thorium-232: $1.4 \times 10^{10}$ years.		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chain.		
<b>Reason for withdrawal from use</b>	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.		
<b>Risk assessment</b>	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.		
<b>Storage and labelling</b>	<i>The bottle must not be opened.</i> Place the radon generator in a sealed bag and label it 'DO NOT USE'. Keep it in the steel store cabinet while arrangements are made to dispose of it.		
<b>Spill or drop</b>	Wear a lab coat, disposable gloves and dust mask (FFP3). If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Disposal</b>	See section 12.		

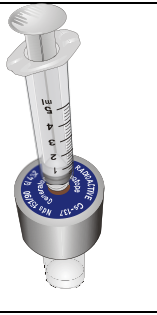
Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 11	Radon-220 generator (gas mantle version)		© CLEAPSS 2016
<b>Description</b>			<p>A polythene squeeze bottle containing thoriated gas mantles (mantles impregnated with thorium oxide). Very small quantities of radon-220 (thoron) gas are produced by the radioactive decay series of thorium. When the generator is not in use, a Mohr clip on a single rubber tube prevents gas escaping. In the version manufactured by Cooknell, the radon generator is connected to an ionisation chamber and an integral picoammeter.</p>
<b>Use</b>	<p>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 must be made gas-tight, eg by fitting a small party balloon over the port and tying it tightly. Unsealed systems should not be used.</p>		
<b>Original activity</b>	<p>Typically 6 kBq (0.16 µCi) (four gas mantles).</p>		
<b>Radionuclide and half-life</b>	<p>Thorium-232: 1.4 x 10<sup>10</sup> years, and decay chain, including radon-220: 56 seconds.</p>		
<b>Main radiations</b>	<p>α, β, γ including emissions from the decay chain.</p>		
<b>Hazard</b>	<p>Thorium compounds are toxic and radioactive. Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.</p>		
<b>Risk assessment</b>	<p>The thorium is impregnated into the gas mantle fabric, so the release of any significant thorium dust will be unlikely. Radon gas should not escape if the apparatus is used carefully – even if it did, the concentration in the air would be extremely low. Caution is needed if the bottle splits or the top needs to be removed, as there can be fragments of mantle which could be released. The residual risk is low with the control measures in place.</p>		
<b>Control measures</b>	<p>Always follow the Standard Operating Procedures for the use of radioactive sources. Gas mantles are regarded as low-level radioactive artefacts.</p>		
<b>During use</b>	<p>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.</p>		
<b>Inspection</b>	<p>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.</p>		
<b>Leak test of source</b>	<p>Annually or if damage is suspected. Do not open the bottle. The outer surfaces and the cap should be leak tested.</p>		
<b>Contamination check of container</b>	<p>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.</p>		
<b>Storage and labelling</b>	<p>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.</p>		
<b>Spill or drop</b>	<p>If the bottle breaks, the gas mantles may release a few fragments, so care is needed. Wear a lab coat, dust mask (FFP3) and disposable plastic gloves. Carefully pick up the bottle and gas mantles with a tissue and place them in a bag. Dab the bench area with sticky tape to pick up any fragments. Wear a lab coat and disposable gloves. Check the area for contamination, and decontaminate it if necessary. See section 9.2</p>		
<b>Availability</b>	<p>Currently sold by Cooknell Electronics Ltd (Weymouth) and Timstar.</p>		
<b>Standard School Holding</b>	<p>No specific limit, other than what is justified for curriculum use.</p>		



Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 12	Gas mantles (thoriated)		© CLEAPSS 2016
<b>Description</b>		<p>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.</p> <p>These are becoming difficult to obtain as most brands now no longer use thorium.</p>	
<b>Use</b>	To show that 'domestic' objects may be naturally radioactive. Also useful as a simple check source to test detection equipment is functioning.		
<b>Original activity</b>	Of one mantle, typically 1 kBq (0.03 µCi).		
<b>Radionuclide and half-life</b>	Thorium-232: $1.4 \times 10^{10}$ years, and decay chain.		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chain.		
<b>Hazard</b>	<p>Thorium compounds are very toxic and radioactive.</p> <p>Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.</p>		
<b>Risk assessment</b>	<p>Gas mantles are available to the general public. The concentration of radon in the air would be extremely low. And certainly before the mantle is burnt, there is little risk of inhalation of thorium dust, because the thorium is impregnated into the fabric of the mantle.</p> <p>The residual risk is low with the control measures in place.</p>		
<b>Control measures</b>	<p>Always follow the Standard Operating Procedures for the use of radioactive sources.</p> <p>Gas mantles are regarded as low-level radioactive artefacts.</p> <p>Do not use burnt gas mantles because the fine ash easily causes contamination</p>		
During use	Keep the unused gas mantle, including the plastic or cellophane envelope in which it is supplied, into a small sealable plastic bag.		
Inspection	Check that the mantle is in good condition and not fraying.		
Leak test of source	Not applicable.		
Contamination check of container	Not required unless it is suspected fragments of mantle may have escaped from the bag.		
<b>Storage and labelling</b>	Gas mantles should be put in a strong, sealable plastic bag, labelled with a radioactive warning sign and kept in the steel store cabinet.		
<b>Spill or drop</b>	Wear a lab coat and disposable gloves. If a gas mantle is dropped, it is unlikely that any radioactive spill will occur. Check the area for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	Camping shops, hardware stores. Many stockists only supply non-radioactive gas mantles, and this is usually stated on the packaging.		
<b>Standard School Holding</b>	No limit, other than what is justified for curriculum use.		

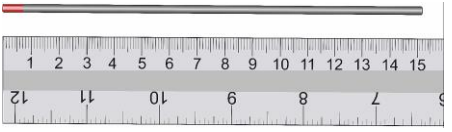
Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 13	Caesium-137/barium-137 elution source		© CLEAPSS 2016
<b>Description</b>		<p>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.</p>	
<b>Typical dimensions</b>	Diameter 40 mm, length 60 mm (including two plastic storage caps).		
<b>Use</b>	The generator will yield up to 1000 small liquid samples containing the barium-137m isotope. The short half-life of this can be easily measured.		
<b>Original activity</b>	Typically 33 kBq (0.9 µCi).		
<b>Radionuclide and half-life</b>	Caesium-137: 30 years; barium-137m: 2.6 minutes.		
<b>Main radiations</b>	γ (β)		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	<p>The dose rate near the surface is low, so in the short time the generator and eluate are handled, the equivalent dose on the hands will be negligible. There is a risk arising from undesirable release of caesium-137 into the eluate. Data from the supplier shows that the bleed-through using the eluent provided with the generator is very low: less than 50 Bq cm<sup>-3</sup>.</p> <p>The residual risk is low with the control measures in place.</p>		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources. Only staff who have been trained in using this source should handle it.		
During use	Wear disposable gloves, a lab coat and eye protection. Work over a drip tray lined with absorbent material such as paper. Check that the correct eluent (ie, as supplied with the source) is used. Do not attempt to make your own eluent, it could ruin the source..		
After use	<p>After at least 30 minutes, the eluate can be poured down the drain and flushed with several litres of water. The disposable gloves and paper liner can be placed in a plastic bag, tied off (do not label the plastic bag) and placed in the normal refuse.</p> <p>Monitor the area immediately around where the source was used to check there is no contamination.</p>		
Records	On the use log, record, list the name(s) of anyone who handled the source and note the volume eluted.		
Inspection	Annually, as well as before and after each use. Check for any signs of damage or deterioration.		
Leak test of source	Annually or if damage is suspected.		
Contamination check of container	Annually or if leakage is suspected. It is sufficient to check the container the source is kept in. Clean if necessary. If you find contamination, the source may be leaking so further investigation is required.		
<b>Storage and labelling</b>	The source should be stored in its original container, labelled with a radioactive warning sign and kept in the steel store cabinet.		
<b>Spill or drop</b>	Wear a lab coat, disposable gloves and eye protection. If a source is dropped, or the eluate is spilt, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	Supplied by HTSL and others.		
<b>Standard School Holding</b>	No individual source may exceed 40 kBq. You can hold up to 10 of these sources if you can justify it. Note: the versions of this source above 40 kBq are not exempt from EPR permitting.		


Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 14</b>	<b>Uranium-coloured domestic glassware and ceramic items</b>		© CLEAPSS 2016
<b>Description</b>			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.
<b>Typical dimensions</b>	Not applicable.		
<b>Use</b>	To show that some domestic items are radioactive. Using a GM tube close to the item, an increased count is demonstrated, compared with background radiation. Vaseline glass may also be shown to fluoresce under ultraviolet radiation (see other CLEAPSS guidance on the safe use of ultraviolet).		
<b>Original activity</b>	Vaseline glass is typically less than 2% uranium by mass. The glaze used on radioactive Fiestaware is typically less than 15% uranium by mass. The count rate by a GM detector can be surprisingly high.		
<b>Radionuclide and half-life</b>	Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: $4.5 \times 10^9$ years.		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chain of uranium-238 and uranium-235.		
<b>Hazard</b>	External irradiation of the body, including possibly more sensitive organs such as the eyes. Internal irradiations of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed. Uranium compounds are also very toxic.		
<b>Risk assessment</b>	The residual risk is low with the control measures in place.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources. Do not handle items more than is needed for the demonstration. Be wary of acquiring items that give high surface count rates – above 100 counts per second with a ZP1481 almost touching the glass or ceramic surface with the GM end cap removed.		
During use	Use in a tray, to contain fragments in the event of damage. This also allows direct handling time to be kept to a minimum.		
Inspection	Annually, as well as before and after any use. Items which are chipped or cracked should be disposed of.		
Leak test of source	Annually or if damage is suspected. The outer surfaces of the item should be tested.		
Contamination check of container	Not required unless leakage is suspected.		
<b>Storage and labelling</b>	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'.		
<b>Spill or drop</b>	If one of these glass or ceramic items is dropped and breaks, the greater hazard will be from sharp edges. However, care must also be taken to avoid contamination from the low amounts of radioactive material present. Wear a lab coat, dust mask (FFP3) and disposable gloves. Use forceps to transfer larger broken fragments onto several layers of newspaper. Carefully sweep up the remainder with a dustpan and soft brush and put it onto the newspaper. Wrap the fragments and dust in the newspaper and bind it with sticky tape. Put it into a sturdy plastic bag and tie it off.  Check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Availability</b>	Available through second-hand and antiques dealers.		
<b>Standard School Holding</b>	No limit, other than what is justified for curriculum use.		

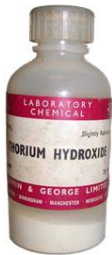
Specific Risk Assessments for radioactive sources, use, spill & storage


Type number 15	Thoriated tungsten welding electrode		© CLEAPSS 2016
<b>Description</b>		<p>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.</p>	
<b>Typical dimensions</b>	Diameter 3 mm, length 150 mm. Other diameters are available.		
<b>Use</b>	Can be used in a diffusion (Taylor) cloud chamber in place of the small radium paint sources, which are no longer available. The cloud chamber may need to be modified by having an additional 3.5 mm hole drilled 7 mm above the chamber floor. The electrode is held in place by inserting it into a bung or cork at each end.		
<b>Original activity</b>	Red-tipped (2%) rods are about 3.2 kBq.		
<b>Radionuclide and half-life</b>	Thorium-232: $1.4 \times 10^{10}$ years, and decay chain.		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chain.		
<b>Hazard</b>	<p>Thorium compounds are very toxic and radioactive.</p> <p>Internal irradiation of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed.</p>		
<b>Risk assessment</b>	<p>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.)</p> <p>The residual risk is low with the control measures in place.</p>		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources. Thoriated tungsten electrodes are regarded as low-level radioactive artefacts. Use electrodes that conform to BS EN ISO 26848:2004		
Inspection	Check that the electrode surface is clean and free from obvious defects.		
Leak test of source	Annually, carry out a simple wipe test (using dry filter paper).		
Contamination check of container	Not required.		
<b>Storage and labelling</b>	Remove from the cloud chamber and put them back in the plastic storage case in which they are normally supplied. Keep with other radioactive sources in the steel store cabinet.		
<b>Spill or drop</b>	Due to the design, it is almost inconceivable that thorium oxide would be released even if the electrode were broken. See section 9.2.		
<b>Availability</b>	SWP brand, type WT20 supplied through welding supplies shops.		
<b>Standard School Holding</b>	No limit, other than what is justified for curriculum use.		

Specific Risk Assessments for radioactive sources, use, spill & storage

Type number 16	Uranyl(VI) nitrate-6-water (uranyl nitrate)		© CLEAPSS 2016
<b>Description</b>		Uranyl nitrate is a yellow crystalline compound. It is deliquescent, so store in a sealed container.	
<b>Typical dimensions</b>	Not applicable.		
<b>Use</b>	To prepare protactinium generators. It is also used as a stain in microscopy (but not in school-level work).		
<b>Original activity</b>	Specific activity is $5.8 \text{ kBq g}^{-1}$ for uranium-238. Owing to decay chain and traces of U-235, the actual specific activity is always greater.		
<b>Radionuclide and half-life</b>	Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: $4.5 \times 10^9$ years.		
<b>Main radiations</b>	$\alpha$ , $\beta$ including emissions from the decay chain of uranium-238 and uranium-235.		
<b>Hazard</b>	Mainly internal irradiations of the body due to substances being inhaled, absorbed through the skin or through wounds, or swallowed. Uranium compounds are also very toxic.		
<b>Risk assessment</b>	The residual risk is low with the control measures in place.		
<b>Control measures</b>	Always follow the Standard Operating Procedures for the use of radioactive sources.		
During use	Use over a tray to contain the compound if it is spilt.		
Inspection	Annually, to check the container remains in good condition.		
Leak test of source	Not applicable.		
Contamination check of container	Not required unless leakage is suspected.		
<b>Storage and labelling</b>	Keep in the air-tight reagent bottle, clearly labelled.		
<b>Spill or drop</b>	Wear a lab coat, dust mask (FFP3) and disposable gloves. The crystals can be brushed carefully onto a sheet of paper using a dry tissue, and returned to an appropriate container. Check the area where the item was dropped with a GM tube, to make sure it is free of contamination, cleaning with moist towels or tissue as necessary. See section 9.2.		
<b>Availability</b>	Available through specialist suppliers, eg TAAB Laboratories Equipment Ltd.		
<b>Standard School Holding</b>	100 g.		

Specific Risk Assessments for radioactive sources, use, spill & storage

<b>Type number 17</b>	No longer recommended – dispose Uranium and thorium compounds as radiochemicals (excluding uranyl nitrate)		© CLEAPSS 2016
<b>Description</b>		<p>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.</p> <p>One of the Panax kits has sachets of uranium and thorium compounds to show their radioactivity.</p>	
<b>Typical dimensions</b>	Not applicable.		
<b>Original use</b>	Various.		
<b>Original supplier</b>	Various.		
<b>Radionuclide and half-life</b>	<p>Uranium - mainly uranium-238 with up to 0.7% uranium-235 - and decay chains. Uranium-238: <math>4.5 \times 10^9</math> years.</p> <p>Thorium-232 and decay chain. Thorium-232: <math>1.4 \times 10^{10}</math> years.</p>		
<b>Main radiations</b>	$\alpha$ , $\beta$ , $\gamma$ including emissions from the decay chains.		
<b>Reason for withdrawal from use</b>	No relevance to the current science curriculum.		
<b>Risk assessment</b>	The risk cannot be justified because the radioactive substances are redundant in schools.		
<b>Storage and labelling</b>	Place each bottle or sachet individually in a sealed bag and label it 'DO NOT USE'. Keep them in the steel store cabinet while arrangements are made to dispose of them.		
<b>Spill or drop</b>	Wear a lab coat and disposable gloves and dust mask (FFP3). If a source is dropped, check the area where it fell for contamination, and decontaminate it if necessary. See section 9.2.		
<b>Disposal</b>	See section 12.		

Type number 18	Uranium oxide encapsulated disc source		© CLEAPSS 2016
<b>Description</b>			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.
<b>Typical dimensions</b>	Diameter 20 mm, thickness ~2 mm.		
<b>Use</b>	Used as a check source, mainly a beta emitter from the Pa-234m in the decay chain.		
<b>Original activity</b>	JMB version is 1.1 kBq (0.03 μCi).		
<b>Radionuclide and half-life</b>	Uranium oxide. Uranium is mainly uranium-238 with up to 0.7% uranium-235 and decay chains. Uranium-238: $4.5 \times 10^9$ years.		
<b>Main radiations</b>	$\alpha$ , and $\beta$ emissions from the decay chain. $\alpha$ emissions blocked by the aluminium envelope.		
<b>Hazard</b>	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.		
<b>Risk assessment</b>	The residual risk is very low with the control measures in place.		
<b>Control measures</b>	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.		
<b>Storage and labelling</b>	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.		
<b>Spill or drop</b>	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.		
<b>Availability</b>	These sources have not been available for many years. Replacement home-made sources are not recommended.		
<b>Standard School Holding</b>	No specific limit, other than what is justified for curriculum use. The total mass of uranium should not exceed 100 g.		

## Part C: Further guidance

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

### 7 Roles and responsibilities

#### 7.1 The role of the RPS (Schools)

##### 7.1.1 Working with radioactive sources

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

You need to:

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

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

##### 7.1.2 Training of other members of staff

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

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

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

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

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

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

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

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

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

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

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

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

### **7.1.5 Security and monitoring**

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

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

You must be confident that each time after radioactive sources have been used, they have all been put back in the store, and that the use log has been completed. If a source becomes lost, it is helpful to know when it was last seen. So, once a month,

and at the start and end of the summer vacation, you should arrange a simple visual check of the steel store cabinet just to see that the containers of the sources are inside and the sources are in their containers. For example, for the sealed sources housed in lead pots in wooden boxes, open the box lid, then lift the inner lead lid just a little with long forceps to check there is a source in the pot. It is not necessary to actually take the source out of its immediate container. Make a simple record of the check in a log book (see section 16.3 for a template). This task could be done by a technician. It doesn't count as a 'use' and doesn't need to be logged in the use log.

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

#### **7.1.6 Making sure leak tests are undertaken**

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

## **7.2 The role of the Radiation Protection Adviser (RPA)**

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

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

- appropriate risk assessments for each activity involving work with ionising radiation;<sup>2</sup>
- 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 RPA is appointed to an individual school or college, he or she (or a competent representative) will usually want to visit the school occasionally (perhaps every two

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

<sup>2</sup> Specific risk assessments for the radioactive sources used in schools are provided in section 6.6.

or three years) to monitor what is going on, although there is no legal requirement for this. If an RPA is appointed to a local authority, he or she may visit a small sample of the authority's schools each year. However, if the authority uses the CLEAPSS RPA scheme, a trained officer from the local authority, usually the RPO, will visit instead.

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

### **7.3 The role of the Radiation Protection Officer (RPO)**

This role applies to local authorities that subscribe to the CLEAPSS local authority RPA service (see section 3.4.1). In this scheme, a local authority appoints one of its officers as a Radiation Protection Officer (RPO). (This is not a legal term, just a convenient description of their role.) The RPO is the link between the schools and the RPA. The schools in the scheme will not normally need to contact the RPA directly, except perhaps in an emergency. CLEAPSS provides training for RPOs in the scheme. In the scheme, the RPA does not normally visit the schools. Instead, the RPO will visit each school periodically to monitor whether they are managing the radioactive sources properly, and reassure their employer that the arrangements for radiation protection are working.

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

## **8 The records that are required**

The school must have an appropriate record-keeping system to account for the radioactive substances and show they are being managed correctly. Keep the records securely so the information can't be used maliciously. Records can be kept electronically but make sure you have backups and that the records are secure. If the record requires a signature, print a copy periodically and sign it, and discard the previous printed copy.

In case the records are lost or damaged, it is good practice to keep backup copies securely in another building (for instance in the school office).

Suggested formats for the documents required are shown in section 16.

### **8.1 Records of history, maintenance and disposal of the sources**

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

- unique name or reference number;
- radionuclide (and chemical name for radiochemicals);
- original activity of the parent nuclide (or mass of radiochemical); and
- delivery date and supplier.

See section 16.4 for a template. Keep results of inspections and leak tests on these individual records. If you no longer have the source, the history should include details of its disposal. If it was not disposed of through the normal refuse collection

or sewerage system, the record should include written confirmation from the organisation accepting responsibility for it (including the name and address).

Keep a copy of the approval letter from the government education department (if the school or college is still required to have one). See section 3.5.3.

## **8.2 Use log**

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

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

See section 16.5 for a template.

## **8.3 Inventory records, and store-check records**

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

## **8.4 Retention of records**

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

Records that are no longer of any use may still hold sensitive information. Follow your employer's guidance on data retention, including how to discard information. However, your employer's guidance will probably not mention records relating to radioactive sources specifically, in which case the following may be helpful.

You must keep the records on source acquisition (when you obtained it, the supplier and information from the supplier) and the source characteristics (principal radionuclide, original activity and serial number if the source has one) securely for as long as the source is kept. This is part of the conditions for exemption from needing a permit for the source. You should discard these records when you come to discard the disposal record for that source.

The Ionising Radiation Regulations require leak test results to be kept for only two years or until the next leak test. However, we recommend keeping previous results for the life of the source so you can check there is no trend of rising contamination, particularly from radium sources which can lead to small amounts of radon.

Keep use log records for 10 years – older records can be discarded. Store check records must be kept for two years, so we recommend you discard records dating two years before the latest entry in the record.

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

See section 10.2 for retention of transport records.

#### **8.4.1 Investigation reports**

Investigation reports arising from an unauthorised dispersal, or wrongful disposal, or loss, or theft of radioactive material need to be retained for two years, and in some cases for 50 years. Contact CLEAPSS or your RPA before discarding such reports.

#### **8.4.2 Records of disposal**

You do not need to keep records of disposal of very low level waste (eg used gloves, wipes etc) that goes in black bags directly into the dustbin with normal waste.

Records for disposal of consumer items that can be purchased in shops (eg smoke detectors and thoriated TIG welding rods) that are disposed of with normal waste need only be kept for the current school year plus one further year.

For other radioactive waste, including sealed sources, thorium and uranium waste (solid or liquid) we recommend you keep these records for at least 10 years; for sources that were originally part of a kit or equipment, we recommend you keep all the records relating to the disposal for ten years and longer until you dispose of the rest of the kit or equipment. Otherwise, someone in the future, not knowing what has happened to the sources, may start an unnecessary investigation which might lead to reporting to the regulators. See section 16.12 for a template.

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. When you dispose of a source, it is essential to update your inventory to reflect the change.

#### **8.4.3 School closure**

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

## 9 Contingency plans for incidents involving radioactivity

This section provides contingency plans suitable for schools working with the Standard School Holding.

Radiation incidents are highly unlikely in schools. The incidents that CLEAPSS hears about tend to relate to loss of the sources rather than anything else. Incidents which cause significant contamination are rare. Nevertheless, it is good practice to keep a durable copy of all your contingency plans – you can do this by printing this section (amended with any further 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.

In emergencies, it would also be advisable for the RPS (Schools) to contact CLEAPSS or your RPA (or RPO).

### 9.1 Urgent medical treatment

Where people need urgent medical attention, call the emergency services and explain fully the nature of the incident, including details of any contamination. (If significant radioactive material has entered a person's body, you need to call the emergency services, even if there are no other injuries, because the person must be given urgent medical attention.)

The ambulance or paramedic service will give advice and will decide where the medical treatment should be given. You should inform your RPA,<sup>1</sup> who may liaise with the emergency services on matters such as monitoring.

Follow your school or college's normal procedures for injury incidents. Treatment of the injured is the first priority, but take reasonable steps you can to reduce any contamination spreading. If there has been significant radioactive contamination, the first aider should wear appropriate personal protective equipment – see section 9.2.1.

### 9.2 Spills and contamination

Contamination can be caused by spilling an unsealed source, or damage to a sealed source. You should distinguish minor spills, which are cleaned up easily with minimal risk, from larger or widespread spills, from which there is a significant risk of exposure or environmental damage. Report any contamination involving radioactive material to the RPS (Schools) as soon as possible. If the RPS (Schools) is available, it may be appropriate for him or her to oversee the clear-up if it is not minor. The RPS (Schools) should report any non-minor spills to the RPA as soon as possible.

If a spill is large or widespread, you may need to take containment measures (see section 9.2.2), restrict access to the area, and contact CLEAPSS or the RPA<sup>1</sup> immediately. If there is a spill of a fine powder, close the windows, lock the room and consult CLEAPSS or your RPA, so that the situation can be assessed before proceeding.

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<sup>1</sup> For local authorities who subscribe to the CLEAPSS local authority RPA service, the RPA is contacted via the Radiation Protection Officer (RPO).

### 9.2.1 Personal protective equipment

Wherever there are unsealed radioactive substances present, it is essential to wear a lab coat and disposable gloves. If items containing fine powders are involved, such as from an old radon generator, you will also need to wear a suitable FFP3 disposable dust mask. And if a protactinium generator containing hydrochloric acid is spilt, you will also need eye protection (goggles).

### 9.2.2 Dealing with the contamination

#### *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 (eg, do not use a dustpan and brush on fine powders).

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

*Small amounts of crystalline materials* (eg uranyl nitrate): these can be swept carefully onto filter paper using a dry tissue, and returned to an appropriate container.

*Spilt liquids*: cover the spilt liquid with a mineral absorbent (or tissues for very small quantities).

*Spilt powders* (eg thorium powders used in old radon generators): cover the powder and the surrounding area with damp tissues or paper towels. Keep air disturbance to a minimum. Use a tool such as a wide flat spatula to carefully remove most of the damp powder into a suitable container. Remaining traces can be removed with damp tissues.

### 9.2.3 If a person is contaminated

Decontaminate external contamination as soon as possible.

- Remove contaminated clothing and place it in a strong plastic bag, to be washed separately or disposed of.
- If the skin is contaminated, decontaminate it by washing with warm water, soap and soft tissues. Avoid spreading the water onto uncontaminated parts of the body. Cleanse gently to avoid skin damage.
- If the eyes are contaminated, irrigate them continuously for at least 10 minutes with gently flowing clean water – eg, using a rubber tube fitted to a cold water tap, just as you would for any other chemical in the eye.

If possible, do any 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.

If the person is also injured, you can decontaminate them as long as it does not aggravate their injuries or interfere with the first aid treatment.

### 9.2.4 Checking a source after possible damage

If a radioactive source is dropped – or after any other event that may have damaged its integrity – it must be carefully inspected. Test it for leaks if you suspect it has been damaged. If you need to look at the foil, use a plane mirror or digital camera to view it indirectly. See section 11.3.1 of L93.

### 9.2.5 Final monitoring, and disposal

After a spill has been cleared up, the affected area will need to be given a 'clearance check' to make sure there is no remaining contamination.

Contamination may not be visible, so you need to check for radioactivity. Scan the area with a GM tube, keeping the end window within 5 mm of the affected surface but not touching it. The GM tube could be supported close to the surface using a clamp and stand (with the base on an uncontaminated surface). Investigate any places where the count rate seems to be higher than the background rate. If a 100 second count of the activity in a suspect area shows more than 1.5 times background, clean the area again using tissues and a detergent solution. Do this until further readings show the suspect area is at the background rate.

If the RPS (Schools) has any doubts about the success of the clean-up, the area must be protected, access to it must be restricted and appropriate warning notices put up. Contact CLEAPSS or your RPA<sup>1</sup> for further advice. For example, you may need more sensitive instruments for monitoring contamination than are normally available in the school.

Make a record in the use log (see section 8.2 of L93) of any significant events; include the date, area etc of any spill.

Double-bag the contaminated waste using strong plastic bags. See section 12 of L93 for guidance on disposal.

### 9.2.6 Reporting an unintended release of radioactive material

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

## 9.3 If a source is misplaced, lost or stolen

If a source is discovered to be missing, first check carefully that it has not been:

- placed in the wrong store after use;
- left inside the piece of equipment where it was last used;
- temporarily moved to another area; or
- placed with waste for disposal.

Use a torch to check in dark corners of drawers and cupboards. Completely empty the store cabinet. If necessary, members may consult CLEAPSS for suggestions. We emphasise the importance of double-checking.

If the search fails to locate the source, someone in the school, usually the RPS (Schools), must tell the RPA.<sup>1</sup> If the total amount lost, including any other losses of the same radioactive material in the last 12 months, exceeds specified limits, you must report it to the Environment Agency and the HSE (HSENI and NIEA in

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<sup>1</sup> For local authorities who subscribe to the CLEAPSS local authority RPA service, the RPA is contacted via the Radiation Protection Officer (RPO).

Northern Ireland) and the radiation employer will probably be required to conduct a formal investigation. The specified limits (which are much lower than those for unintended releases) for common school sources are given in the following table. If different types of radionuclides have been lost, there is a 'summation' rule in the regulations that determines whether or not it is a reportable loss. It would be a good idea to contact your RPA on this. The enforcement agencies may prosecute if you lose a source.

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

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

For other radionuclides, the reporting threshold is 10 times the column 2 value in table 5 of The Environmental Permitting (England and Wales) (Amendment) Regulations 2011 (the values are the same for all of the UK).

### 9.3.1 Suspected theft

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

## 9.4 Fire

Follow the school or college's fire safety instructions. If any radioactive sources are being used when the fire alarm starts, if there is time, return the sources to their containers. Do not take the sources outside of the lab – it is too easy to misplace them in the emergency. Tell the Fire and Rescue Service where they are, particularly if they are close to the fire. Also tell the RPS (Schools) as soon as possible. You must not go back into the building until the Fire and Rescue Service advises it is safe to do so.

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 go to the laboratory and make the sources secure before the students return.

If you suspect the sources may have been damaged by the fire, contact your RPA<sup>1</sup> promptly for advice. Do not go into the area where the sources are located until you are sure that radioactive material has not been released into the environment.

<sup>1</sup> For local authorities who subscribe to the CLEAPSS RPA service, the RPA is contacted via the Radiation Protection Officer (RPO).

## 10 Transporting radioactive sources

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

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

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

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

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

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

### 10.1 Driver awareness training

If radioactive material is transported as excepted packages, no special driver training is required. However, drivers should have awareness training, which should include what to do in the event of an accident. This condition could be met if the driver is a member of the science staff who is familiar with handling the sources. He or she could be given a briefing note along the following lines.

Before leaving, you must:

- Check that there is a completed consignor's certificate (transport document – see section 16.10 of L93) with the package(s), and that the number of packages tallies with the certificate.
- Check that the package(s) is/are in good condition for road transport.
- Put the package(s) securely in the car, as far away as possible from the occupants, preferably locked in the boot if there is one.
- Plan to take the most direct route.
- Have arrangements in place for backup transport in case the vehicle breaks down (eg membership of the AA, RAC or similar).
- Carry a mobile phone so you can communicate any problems promptly.

You must be aware that:

- The vehicle must not be left unattended without reasonable cause, and must be locked if unattended.
- In the event of a breakdown or minor accident in which no one is injured and the radioactive packages are undamaged, you should let the consignor know that there will be a delay and if necessary use the backup transport arrangements.
- If there is a more serious incident (eg theft, loss or likely damage to the package), you should tell the local police immediately, giving them details but taking care to avoid overreaction. You should also report the incident to your employer and make notes of the incident as soon as possible, as this could be useful in assessing exposure.

## 10.2 Packaging for excepted packages

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

- **Strontium-90, plutonium-239 and americium-241 cup sources**, in their normal containers, can be transported in any reasonably-stout cardboard box.
- **Radium-226 and cobalt-60 sources** will require special packaging (unless the cobalt-60 is old and has decayed to a low level) to bring the surface dose rate below the specified limits. You can do this by using a large cardboard box, packed with smaller boxes, so that the wooden source box is at least 150 mm from any surface of the outer box.
- A **uranium or thorium compound** (in an appropriate container) must be carried inside a robust container, usually metal (eg a tool box), so that it is extremely unlikely to be damaged in a road accident.
- Transporting **radioactive material in solution** should be restricted to a 30 cm<sup>3</sup> protactinium generator. This should be kept upright and surrounded by a mineral absorbent (eg cat litter), sufficient to absorb twice the volume of liquid in the container, in a sturdy, water-tight outer container, all inside a strong plastic bag. The bag should be tied and then securely packed in a robust container, usually metal (eg a tool box), so that it is extremely unlikely to be damaged in a road accident.

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

## 10.3 Labelling for transport

No external signs are required on the vehicle.

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

The UN number is:

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

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

## 10.4 Transport document

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

## 11 Maintenance of sealed sources and detection equipment

### 11.1 Checking the monitoring equipment works effectively

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<sup>-2</sup>) of at least 15 mm diameter is needed, such as the ZP1481 GM tube (previously MX168) used for many years in schools.<sup>1</sup>



You first need to check that this equipment is working effectively. For a simple test, check that the background count is what you expect, then check you get a significant count rate from a cup source such as strontium-90.

Before starting the leak tests, you need to run a basic efficiency check using a test source. A test source using naturally radioactive potassium compound can be purchased from IPC Electronics, Holker School, Cark-in-Cartmel, Grange-over-Sands, Cumbria LA11 7PQ (website: [www.ipcel.co.uk](http://www.ipcel.co.uk)). Alternatively, you can make one (see CLEAPSS guide PS79 *Radioactivity: Instrumentation for leak tests and contamination checks*). Use the check source to make sure the detection equipment responds as you would expect. See guide PS79 for checking with the CLEAPSS-designed test source.

Formal calibration of the monitoring equipment used for leak tests and contamination checks by someone with United Kingdom Accreditation Service approval is expensive and unnecessary in normal circumstances for schools working with the Standard School Holding. If really necessary, the RPA may be able to lend a calibrated instrument to the school. However, this would usually involve the cost of an RPA visiting the school.

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

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<sup>1</sup> A suitable alternative is the LND 72233, which is also found in some schools. There is more on this in CLEAPSS guide PS79 *Radioactivity: Instrumentation for leak tests and contamination checks*.

require this information. This might require more sophisticated monitoring equipment – contact CLEAPSS or your RPA for advice.

## 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 of its container. It is rare for sealed radioactive sources used in schools and colleges to be damaged, or to fail. However, the sources need to be checked to make sure they are in good condition. We recommend that these checks are done annually.<sup>1</sup>

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

Radium sources can emit small amounts of radon gas, and the radon decay products can cause low levels of contamination of the container surfaces – see section 11.4.1.

## 11.3 Carrying out inspections and leak tests

All sources should be inspected, but leak tests do not apply to all sources. Leak tests should be carried out on sealed sources (there is no exemption activity below which a leak test is not required on a sealed source), and some others as detailed in the specific risk assessments in section 6.7. Follow the Standard Operating Procedures (see section 6.5). Wear a lab coat and disposable gloves (and a disposable dust mask if unsealed items containing powders are involved). Carry out the work over a large tray.

### 11.3.1 Physical inspection

Specific details for each type of source are given in the specific risk assessments in section 6.7.

Choose a place in good lighting. Never look directly into a sealed source or try to modify a source to look into it. Use a mirror held in the other hand to view the most active areas (eg foils) for a short time, tilting it so it faces away from the eyes. A digital camera with a macro facility and remote shutter release, or a USB snake scope, is another way of remotely examining the surface of a sealed source. However, some sources, such as the Panax type, have fine meshes that make it difficult to examine the internal foil.

Check for any damage or deterioration, particularly to foils, plastic bottles and seals, which might result in the enclosed radioactive substance escaping from the source. If a source has any small blemishes, scratches etc which will not affect its safe use, it is

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<sup>1</sup> The *HSE Approved Code of Practice* states that the interval between leak tests should not be more than two years. We recommend annual testing because sealed sources are often used beyond their nominal recommended working life.

useful to make a note of these on the radioactive source history sheet (a sketch may be helpful). This can help in future inspections, allowing fresh damage or deterioration to be detected more easily.

### 11.3.2 How to carry out a leak test

Wear a lab coat and disposable gloves. Work over a shallow tray. You need a GM tube with suitable detection efficiency, such as a ZP1481; the small-window tubes (less than 15 mm diameter) often used for data-logging are not suitable.

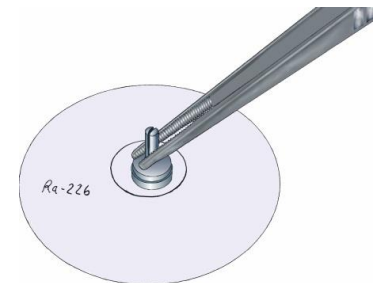
Check the equipment is detecting satisfactorily – see section 11.1.

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 to, but not touching, a piece of filter paper beneath. 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; if necessary, use a few turns of PVC insulating tape around the circumference of the GM tube and holder to make sure it is securely in held.



With all radioactive sources at least 2 m away, 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.

Place a fresh piece of the same filter paper on the tray. For cup sources, use forceps to take the source out of its container, and gently wipe the open end of the source over an area of the filter paper about the size of the GM tube window. For other 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 (if appropriate), and move it back to where it was when the background count was taken (at least 2 m away from the GM tube).

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

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

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

### 11.3.3 Results of inspection and leak tests

For each source, record the actual count made above background, 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 (but see section 11.4.1 on radium-226). Any suspect source should be kept inside its normal container and placed in a strong plastic bag. This should be sealed, labelled 'Do not use' and kept in the usual store. Consult CLEAPSS or the RPA<sup>1</sup> for advice – 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 Contamination checks

The precautions and procedures for contamination checks are similar to those described for leak tests. Carry out a contamination check on any containers, or on the steel store cabinet if you suspect that radioactive substances may have contaminated the surfaces, by the 'wipe and count' method described in 11.3. 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 water. 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.

### 11.4.1 Radium sources

When leak testing the sources, test any radium sources last. The slight emission of radon-222 gas by radium-226 sources, which is normal, may 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 you do have a radium source that fails initially, clean the outside of the source using a clean filter paper, held by forceps, dampened with water. Clean the source container pot, and retest the source in a month. If the source fails repeatedly, it may need to be disposed of; contact CLEAPSS or your RPA for advice.

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.

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<sup>1</sup> For local authorities who subscribe to the CLEAPSS local authority RPA service, the RPA is contacted via the Radiation Protection Officer (RPO).

## 12 Disposal of radioactive sources

### 12.1 Reasons for disposal

You may need to dispose of a radioactive source because:

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

#### 12.1.1 Unacceptable reasons for disposing of radioactive sources

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

- *We have nowhere satisfactory to store the sources*  
The minimum storage requirement is normally easy to achieve (see section 4). If there are difficulties, consult CLEAPSS or the RPA.
- *We have security problems and are not happy to store sources at our school*  
If there are security problems, there are plenty of other items in the science department which pose risks at least as great as the theft of radioactive sources. The security problems need to be addressed.
- *None of our teachers know what to do with the sources*  
All qualified science teachers who teach about radioactivity should be confident in handling radioactive sources and carrying out basic demonstrations. Appropriate training should be given (see section 7.1.2).
- *We don't think radioactive sources are safe to use, and prefer to describe the demonstrations, show videos of them or use a computer simulation*  
The standard educational radioactive sources are very safe when used following the guidance from CLEAPSS. Pictures, videos and computer simulations may complement practical work in science, but they are no substitute for it.
- *We don't teach about radioactivity any more*  
Radioactivity is included in the various national curricula, and is an important part of advanced-level work in science (see section 1.2).
- *We can detect radiation from the source outside its container*  
This is perfectly normal for sources that emit gamma radiation (eg cobalt-60 and radium-226). Gamma radiation is the most penetrating, and will pass through all substances, including lead. A raised count rate around the container is expected.
- *The radium source is contaminating its pot*  
Radium sources emit small amounts of radon gas which can deposit radioactive decay products in the lead container. This is quite normal and is dealt with by routine decontamination (see section 11.4.1).

- *The sources are not working and need to be replaced*  
Often, when schools report a non-emitting source, we find that the measuring equipment is faulty or being used incorrectly, although cobalt-60 sources have too low an activity once they are several decades old.
- *We do not have any detection equipment to carry out investigations*  
The equipment needed is a GM tube and counter to check for leakage and contamination if radioactive substances are stored (whether they are used or not). Occasionally, the equipment needed may be found at the back of a cupboard.  
  
Many science departments already have data-logging equipment, and you may only need to buy a GM tube to go with it. Money from an ICT budget could be used for this purpose. Note, however, that some of the probes supplied with data-logging equipment may not be suitable for leak testing and contamination checks.

## 12.2 Legal responsibilities for disposing of waste

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

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

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

- 1 The Environmental Permitting Regulations (EPR) mean that generally you need a permit to dispose of radioactive waste; the permit sets conditions on the disposal. Fortunately, most school sources are conditionally exempt from needing permits.
- 2 If the radioactive waste is exempt from an EPR permit but it has other hazardous properties – it may be toxic or corrosive – the disposal still needs to meet the regulations on hazardous waste.<sup>1</sup>
- 3 The transport of radioactive sources on public roads is controlled by the transport regulations, which place duties on both the ‘consignor’ and ‘consignee’. However, radioactive material below certain activity thresholds is exempt from the transport regulations. If a registered waste contractor agrees to dispose of the waste for you, they 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

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

authorisation) to accumulate or dispose of radioactive waste. Schools do not need permits (or authorisations) if they are within the Standard School Holding.

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

### **12.3 Keeping radioactive waste**

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

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

### **12.4 How to dispose of radioactive waste**

To find out how to dispose of your radioactive waste, go through the following table, starting at the first row and moving down row by row to see the first that applies. When you find the correct row, make sure you read and understand the more 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
<b>Radioactive rocks</b> (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.
<b>Domestic smoke detectors</b> (CLEAPSS source type 2)	Consider recycling as smoke detectors if they are in good condition and not past their recommended working life. Smoke detectors that have a sealed source of americium-241 with an activity of no more than 40 kBq can be disposed of as waste electrical and electronic equipment (WEEE). They must not be disposed of by the dustbin route. Refer to your premises manager for the school's procedures for disposing of WEEE. Remove the battery and dispose of it separately at a battery recycling point.	There is an annual limit of 10 MBq on the disposal of sealed sources. For electrical and electronic equipment bought after July 2007, distributors must allow consumers to return the waste equipment without charge.
<b>Consumer items: gas mantles, thoriated TIG electrodes, Fiestaware china, Vaseline glass</b> (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.
<b>Very low-level solid waste (not uranium or thorium compounds)</b>	This is waste such as used gloves, masks, wipes, washed bottles with no visible residues etc that may be contaminated by minor amounts of radioactive material, and if it were not for the radioactive contamination, would be classed as non-hazardous. Dispose of it by the dustbin route. See section 12.4.2.	The limit for any one dustbin disposal is 400 kBq per 0.1 m <sup>3</sup> of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.
<b>Powder radon generators</b> (CLEAPSS source type 10)	The powder is usually thorium hydroxide or carbonate. Despite what some textbooks say, these compounds are extremely hard to dissolve. It must be disposed of as hazardous waste by a registered waste carrier, who will remove the waste to an appropriately permitted disposal site. See section 12.4.4	The plastic bottles are known to become brittle and split. The thorium powder is fine and can create a dust. Put the generator into a sealed bag before disposal.

Source	Disposal routes	Notes
<b>Protactinium generators</b> (CLEAPSS source type 9)	In many cases the organic solvent has become a thick goo which will be contaminated with uranium. This is 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	If the organic solvent is still liquid, and the bottle can be opened without difficulty, protactinium generators can be disposed of by an experienced chemist as aqueous waste through the sewerage system. Telephone CLEAPSS for advice.
<b>Mineral absorbent contaminated by clearing spill from a generator</b>	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 <sup>3</sup> , or other spills, contact CLEAPSS for advice in disposal.
<b>Aqueous uranium and thorium solutions</b> (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 <sup>1</sup> , 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.
<b>Liquid non-aqueous thorium or uranium waste</b> (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.

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

Source	Disposal routes	Notes
<p><b>Solid uranium and thorium compounds (including insoluble compounds)</b> (CLEAPSS source types 4b, 16, 17 and 18)</p>	<p>It is possible that solid uranyl nitrate, uranyl zinc acetate and uranyl magnesium acetate radiochemicals can be taken for re-use if they are in their original bottles in reasonable quantities and in good condition. Contact CLEAPSS for further information. If it is taken by this route arranged by CLEAPSS, don't expect to sell it to the person collecting it.</p> <p>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.</p> <p>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</p>	<p>Up to 500 g of solid uranium or thorium compounds can be disposed of per week.</p> <p>Small amounts of some compounds can be dissolved in acid by an experienced chemist and disposed of as aqueous waste. This is hazardous and requires a special risk assessment. Telephone CLEAPSS for advice.</p> <p>For thorium powder radon generators, see the row that specifically applies.</p> <p>This row does not apply to small quantities of consumer items.</p>
<p><b>Caesium-137 elution source</b> (CLEAPSS source type 13)</p>	<p>A caesium-137 elution source not exceeding 40 kBq can be disposed of by the grout/dustbin route. See section 12.4.2</p>	<p>The limit for any one disposal is 400 kBq per 0.1 m<sup>3</sup> of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.</p>
<p><b>Radium paint diffusion cloud chamber sources, spinthariscopic and scintillation plates</b> (CLEAPSS source types 3b, 4a, and 5)</p>	<p>Radium paint cloud chamber sources, typically 740 Bq (0.02 µCi), can be disposed of by the grout/dustbin route. See 12.4.2</p> <p>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</p>	<p>The limit for any one disposal is 400 kBq per 0.1 m<sup>3</sup> of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.</p>

Source	Disposal routes	Notes
<p><b>Radium paint timepieces and instruments (but not spinthariscopes)</b> (CLEAPSS source type 3a and 3c)</p>	<p>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</p> <p>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.</p> <p>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, who will remove it to an appropriately permitted site. See section 12.4.4</p>	<p>For the grout/ dustbin route, the limit for any one disposal is 400 kBq per 0.1 m<sup>3</sup> of normal waste and no item above 40 kBq. The annual limit for this category of disposal is 200 MBq in total.</p>
<p><b>Sealed sources</b> (CLEAPSS source types 6, 7, 8a, 8b, 8c)</p>	<p>Waste sealed sources up to 200 kBq can conditionally be disposed of by the grout/ dustbin route. See section 12.4.1.</p> <p>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, who will remove it to an appropriately permitted site.</p>	<p>CLEAPSS guide GL220, available on request, explains how to do the disposal. It is important to follow this guidance because there are several conditions that must be met. The annual limit for disposal of this category of waste is 10 MBq.</p>
<p><b>Other sources not described above</b></p>	<p>Members should contact CLEAPSS for advice.</p> <p>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, who will remove it to an appropriately permitted site.</p>	<p>Note that you cannot legally dispose of a source if you do not know what it is. Contact CLEAPSS, preferably by emailing a good quality sharply-focused picture. There is little point sending us fuzzy pictures, or pictures of something wrapped in lead foil.</p>

#### 12.4.1 Notes on disposing of sealed sources by the dustbin route<sup>1</sup>

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

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

#### 12.4.2 Notes on disposing of very low level solid waste by the dustbin route<sup>1</sup>

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

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

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

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

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

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

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

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

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

wash the absorbent thoroughly. Wear heavier-duty protective gloves and eye protection (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 less than 50 cm<sup>3</sup>, sodium carbonate should not be needed at this stage and most of the organic solvent is likely to have evaporated after the spill.) Carefully pour off the resulting liquid and dispose of it as aqueous waste down a fast-flowing prep room sink. Fill the sink and empty it at least once to make sure none of the radioactive substance collects in the traps. Clean the work surface areas. Allow the damp washed mineral absorbent to dry in the bucket, then double-bag it and dispose of it as very low level waste. Wash the bucket after and return it to normal use.

#### **12.4.3 Notes on disposing of aqueous radioactive solutions via the sewerage system**

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

For solid radiochemicals, the following method only applies to uranyl nitrate and thorium nitrate because they dissolve easily in water. Many uranium and thorium compounds are difficult to dissolve, and some such as uranyl acetate do not dissolve completely in water. For an experienced chemist it may be possible to dissolve some of these compounds in acid. Telephone CLEAPSS for advice.

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 acid, as tests by CLEAPSS have confirmed.

##### *Setting up*

- Do this during a quiet time, eg an in-service training day, when interruptions are unlikely and corridors and toilets are clear.
- Wear a lab coat, disposable gloves and eye protection. Wear a disposable dust mask (FFP3) when handling unsealed fine powders.
- Work in a draught-free environment, eg a fume cupboard with the fan switched off, and over a tray to contain any spills.
- You will need a plastic reagent bottle with a good sealable screw top, between say 150 ml and 250 ml. Test the plastic bottle using water to make sure it seals securely with no leaks.
- You will need two large clean plastic buckets. We'll call them an orange bucket and a black bucket. (The bucket colour is irrelevant. It is only so we can make the following explanation clear.) A jug may be useful too.
- You will need a pack of fresh 'multi-action' kitchen surface wipes.

##### *Preparing an aqueous solution for disposal*

If the waste is already in solution form, pour the solution into a plastic bottle and screw on the top securely. Put the sealed bottle into the orange bucket.

##### *Preparing water-soluble solid uranium and thorium compounds for disposal*

- Working over a tray, put no more than ten grams of the compound into a 250 ml conical flask, carefully add 100 ml of distilled water and gently swirl it until it has all dissolved.

- Pour the solution into the plastic bottle and screw on the top securely. Put the sealed bottle into the orange bucket.

*Disposal of the aqueous waste to the sewerage system*

- The disposal should be done with the help of an assistant. Both you and the assistant should wear lab coats, eye protection and disposable gloves.
- Take the plastic bottle, with the top screwed firmly closed, in the orange bucket, to a toilet. The assistant should bring the black bucket, a jug and the kitchen surface wipes. The assistant should open the doors and check the way is clear.
- Flush the toilet to check it is working satisfactorily with no blockages.
- Roughly two-thirds fill the black bucket with tap water – a jug may be useful.
- Lift the toilet seat. Take the bottle from the orange bucket. Then, holding the bottle well inside the toilet pan, remove the bottle top and carefully pour the waste solution into the centre of the toilet, avoiding splashing.
- Screw the top back on the empty bottle and return it to the orange bucket.
- Stand back and the assistant can then flush the toilet. If the toilet is dual flush, make sure you use the full flush.
- Carefully pour the water from the black bucket down the toilet, and then flush the toilet again.
- As a precautionary measure, the assistant should wipe down the flush handle, the top of the toilet and the toilet seat with a few fresh 'multi-action' kitchen surface wipes. Don't flush the wipes, but put them in the orange bucket.
- Take the buckets, jug, empty bottle and wipes back to the prep room. Thoroughly wash out all containers in the prep room sink with a fast-flowing waste outlet.
- Fill the sink and empty it at least once to make sure traces of the radioactive substance do not collect in traps. Clean the work surface areas.
- Double-bag the used wipes and the empty washed plastic bottle and dispose of it as very low level waste in the school dustbins, following section 12.4.2.
- Wash your hands with soap and warm water.
- Use a GM tube and counter to verify there is no contamination on the work surface where you did the dissolving and pouring into the bottle.

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

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

When you arrange for someone to collect and dispose of your waste, you must make sure they are a registered waste carrier – so you can 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 across all the UK. They will want enough details to characterise your waste before finalising and arranging collection – you may need advice from CLEAPSS in some cases to make sure you give the correct information.

Waste contractor	Address	Comments
<b>Active Collection Bureau Ltd</b>	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.
<b>Eckert &amp; Ziegler Environmental Services Ltd</b>	3A Churchward Didcot Oxfordshire OX11 7HB Tel: 01235 514 310 E-mail: enquiries@ezag.com Website: www.ezag.com/eze	All types of radioactive waste, including sealed sources.
<b>Grundon Waste Management Ltd</b>	Thames House Oxford Road, Benson Oxfordshire OX10 6LX Tel: 01491 834340 E-mail: radsales@grundon.com Website: www.grundon.com	Disposal of thorium and uranium compounds and protactinium generators. Sealed sources up to 200 kBq. Other radioactive waste from unsealed sources also possible – enquire by e-mail.
<b>Tradebe</b>	Fawley Thermal Treatment Centre Charleston Road Hardley, Hythe Southampton SO45 3NX Tel: 02380 883018 E-mail: nicki.hatch@tradebe.com chris.macey@tradebe.com Website: www.tradebe.co.uk	Disposal of thorium and uranium compounds and protactinium generators. Other radioactive waste from unsealed sources also possible – enquire by e-mail.

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

## 12.5 Records of disposal

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

## 13 Exemption limits

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

### 13.1 Exempt quantities

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

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

Radioactive sources conditionally exempt	Acquisition and keeping quantity limits	Disposal quantity limits
<b>Sealed sources</b>	Individual sources not exceeding 4 MBq, to a total of 200 MBq	200 kBq source per 0.1 m <sup>3</sup> of normal waste, to a maximum of 10 MBq per year
<b>Uranium and thorium compounds</b>	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
<b>Thoriated welding rods (not more than 4% thorium)</b>	No limit	No limit
<b>Gas mantles (including gas mantle radon generators)</b>	As for thorium compounds	As for thorium compounds
<b>Protactinium generators</b>	As for uranium compounds	As for uranium compounds
<b>Naturally radioactive rock specimens</b>	No limit	No limit
<b>Caesium-137/barium-137 elution sources</b>	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 <sup>3</sup> of inert waste, no single item exceeding 40 kBq, to a maximum of all very low level waste of 200 MBq per year

<b>Smoke detectors</b>	Each detector not exceeding 4 MBq No limit on number of detectors (strictly they should be affixed to the premises)	As for sealed sources
<b>Radioluminised watches and clocks not exceeding specified activities of promethium or tritium (but not radium)</b>	Each item not exceeding 80 MBq of Pm-147 or 4 GBq of tritium, total not exceeding 40 GBq of Pm-147 or 200 GBq of tritium	80 MBq of Pm-147 per 0.1 m <sup>3</sup> of normal waste 4 GBq of tritium per 0.1 m <sup>3</sup> of normal waste
<b>Radium-226 (radioluminised clocks and watches, cloud chamber sources)</b>	10 kBq in total of unsealed sources (but a timepiece with intact face glass can be considered sealed)	400 kBq for the total waste per 0.1 m <sup>3</sup> of inert waste, no single item exceeding 40 kBq, to a maximum of all very low level waste of 200 MBq per year

## 14 X-ray equipment

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

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

### 14.1 Monitoring

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

### 14.2 Permissions and notifications

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

## 15 Doses of radiation

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

- *Absorbed dose*: The absorbed dose is the quantity of energy given by ionising radiation to a unit mass of matter (such as living tissue), and is measured in gray (Gy). One

gray is the amount of ionising radiation which delivers one joule of energy to a kilogram of absorbing material.

- *Equivalent dose*: Different ionising radiations have different biological effects, and this is taken into account by multiplying the absorbed dose by a radiation weighting factor. This leads to a term known as 'equivalent dose', measured in sievert (Sv), where:

$$\text{equivalent dose} = \text{radiation weighting factor} \times \text{absorbed dose}$$

- *Tissue-weighting factor*: Some organs and tissues are more susceptible to harm from radiation than others. Another weighting, a tissue-weighting factor, is used to take this into account.
- *Effective dose*: Effective dose is a quantity based on the consequences of whole body exposure to radiation. It is the tissue-weighted sum of the equivalent doses in all the tissues and organs of the body, and it gives a broad indication of the detriment to health. It is intended for use as a protection quantity. Effective dose is usually calculated using a sensitive dose meter and the dose is modelled to individual tissues by means of empirical formulae. Effective dose is also measured in sievert (Sv).

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

### 15.1 Dose from background compared to a school radioactive source

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

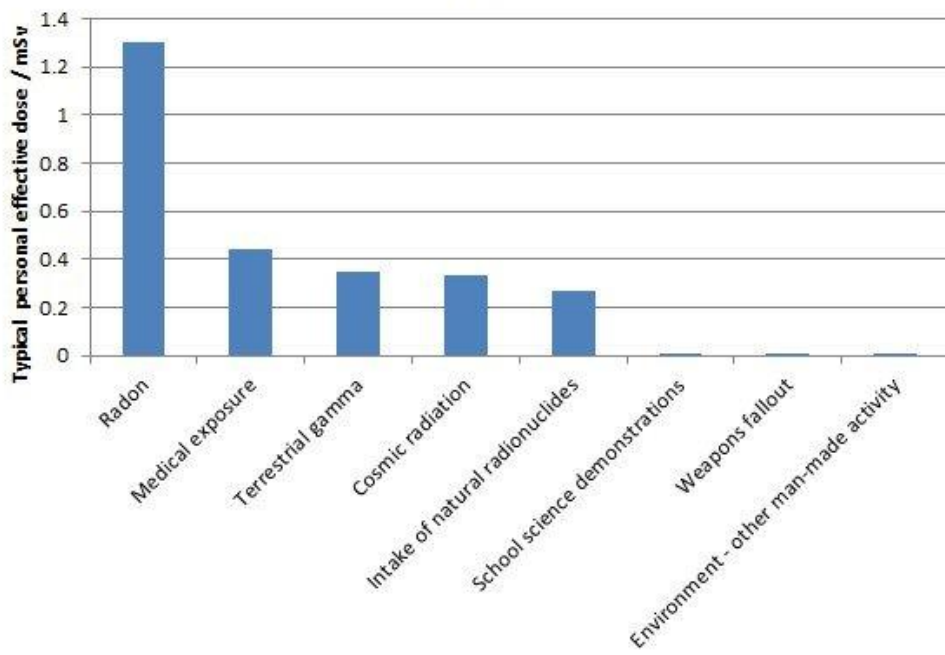
The legal maximum annual effective dose for an employee over the age of 18 is 20 mSv and for an employee under the age of 18 it is 6 mSv.

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

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<sup>1</sup> Public Health England, *Ionising radiation exposure of the UK population: 2010 review*.  
[www.gov.uk/government/publications/ionising-radiation-exposure-of-the-uk-population-2010-review](http://www.gov.uk/government/publications/ionising-radiation-exposure-of-the-uk-population-2010-review)

## Average exposure of a UK person to sources of ionising radiation



## Part D: Templates

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

### 16 Useful checklists, record sheets, letters etc

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

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

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

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





## 16.4 Radioactive source history

Unique name / reference number of source	
Radionuclide / chemical name	
Either the original activity (37 kBq = 1 $\mu$ Ci)	kBq                      uCi
Or, for a radiochemical, the original mass (or volume) and specific activity	g (or cm <sup>3</sup> )                      kBq g <sup>-1</sup>
Delivery date (attach original paperwork if possible)	
Supplier	
Supplier catalogue number	
Source serial number (sealed sources only)	
Source manufacturer	
Disposal date	
For a radiochemical, mass used up or disposed of	
Disposal route and details (Attach disposal record sheet and any paperwork from the waste contractor)	

<p>Sealed sources: indicate significant blemishes, scratches etc, with dates when these were noted</p> <p>A sketch, or attach photograph of, the source. (Inspect foils with a mirror or digital camera)</p>	
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Inspection and leak tests (usually annual)  
 Include comments on any action taken: eg decontamination of a radium source and its container, referral to RPA if a source appears to be damaged or leaking

Date	Background reading (if relevant)	Inspection and leak test reading (if relevant)	Inspection and leak test (if relevant) passed (yes or no)	Test carried out by	Comment (if any)







## 16.9 Sample letter to supplier when purchasing radioactive sources

This letter should be adapted as appropriate and copied onto school headed stationery.

Dear

### **Purchase of radioactive sources**

Please supply the following radioactive source(s)

The employer of staff in this school/college requires that we purchase only sources that comply with the recommendations in the document *Design and Specification of Radioactive Sources for School Use* (CLEAPSS guide L256), and we believe that the above source(s) comply. If there is doubt on this, could you please contact us before supplying the source(s).

### **[Delete A or B]**

- A. Only maintained schools in Wales need a specific letter of approval from the government department to buy radioactive sources, so no letter is attached.
- B. This school/college requires a letter of approval from the relevant government department to buy radioactive sources. A letter of approval is attached.

No permit or authorisation is required from the environmental regulator because exemptions to the environmental regulations on radioactive material allow schools to use up to 200 MBq of sealed sources, with no individual source exceeding 4 MBq. This order is well within the specified limits.

### **[Complete the { } brackets as appropriate]**

The {Radiation Protection Adviser /Radiation Protection Officer} for our school/college has agreed to this purchase. A copy of their confirmation is attached. If there are any enquiries about this order, please contact {school or college contact name} on {contact tel. number}.

If you require clarification on the legal position on supplying radioactive material to schools, the specification of sealed sources, or the current position on government Letters of Approval, please contact CLEAPSS on 01895 251496 or e-mail [science@cleapss.org.uk](mailto:science@cleapss.org.uk).

Yours sincerely

## 16.10 Transport document

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

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

## 16.11 Suitable labels for excepted packages

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

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

## 16.12 Example of a disposal record sheet

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

# Glossary and definitions

## Glossary

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

## Definitions

Many of these definitions appear in the Ionising Radiations Regulations 1999.

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

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

Old units of radioactivity / $\mu\text{Ci}$	SI units of radioactivity / kBq
0.1	3.7
0.125	4.6
5.0	185
9.0	333

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

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

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

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

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

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

**Radiochemical:** An unsealed radioactive substance used as a chemical.

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

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

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

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

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