RP COP004 – Protocol for determining the relative fractions of waste activity arising from experimental work with Unsealed Radioactive Materials

VERSION CONTROL	
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1. Introduction

Work using unsealed radioactive substances at the University is subject to the Environmental Authorisations (Scotland) Regulations 2018 (EASR). Depending on the complexity and risk of the work involved there are different levels of authorisation:

- General Binding Rules (GBR’s)
- Notification (not applicable to unsealed work at the University)
- Registration (not applicable to unsealed work at the University)
- Permit

General Binding Rules are a set of mandatory rules that cover specific low risk activities that are described in Schedule 9 of EASR; there are 11 GBRs although not all apply to the University’s work with radioactive substances. The GBRs largely replace the old activities that were exempted (Exemption Order) under the old Radioactive Substances Act 1993.

Due to most unsealed work at the University being “high risk” (environmentally) and involving disposal of radioactive waste to the sewer, work typically requires a Permit. A Permit has general “conditions” which must be met under EASR. In addition to this, there may also be “limits” to the amount of radioactivity which can be held and disposed of to a particular waste route under the Permit.

In order to ensure that these conditions and limits are not being exceeded, it is of course necessary to estimate how much radioactive waste is being generated per disposal route. This can only be done by estimating the waste disposed of per route and per use, and summating the estimates to determine an overall value per Permit. This Code of Practice outlines a protocol for *estimating* the amount of radioactivity disposed to each waste route from typical unsealed radioactive substance experiments. It is for use when it is not practicable to *measure* the activity of the waste prior to disposal.

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2. Responsibility

It is the responsibility of the individual user to ensure that an estimate of the waste fractions disposed of to each waste route is available for all of their work using radioactive substances. THE ESTIMATE MUST BE DONE BEFORE THE RADIOACTIVE MATERIAL IS USED, although it is recognised that on occasion an experiment might have to carried out to obtain the necessary results. This does not mean that each use requires a unique estimate; see below.

3. General Approach

In theory, the amount and relative fractions of radioactive waste will vary with each use. However, in practice, there are unlikely to be major differences for procedures that essentially follow the same process. Therefore, if the waste fractions have been determined for a representative procedure, those values may be used for many others. It is important however to ensure that the procedure is representative, and a different determination must be carried out when procedures are no longer sufficiently similar. Radiation users might be called upon by a SEPA inspector to justify their estimates and the assumptions or measurements used in making those estimates.

4. Model Used

The protocol is based on a model shown in the figure overleaf. If this model does not represent the general nature of the use of radioactive material, a more specific approach should be considered; contact the University RPA or RPU for advice as appropriate.

5. Waste Routes

The term *f* is used to describe the fractions of the original radioactivity in each waste route that needs to be estimated. Not all types of waste routes may arise in all procedures and only the relevant ones need to be considered.

The nature of the procedures will vary considerably, and the manipulation of material containing the radioactivity will vary correspondingly. The division of the source, manipulation of the samples, and sample analysis may contain one or many parts, each part giving rise to some waste. The total fraction to each waste route is the sum of the individual parts, viz. $f_{nal} = \Sigma(f_1,f_2,\ldots f_i)nal$, $f_{AL} = \Sigma(f_1,f_2,\ldots f_i)al$, $f_{nes} = \Sigma(f_1,f_2,\ldots f_i)nes$ and so on.

Each part must be considered, unless its contribution is clearly insignificant. It is clearly expedient wherever possible to estimate the activity in a waste route

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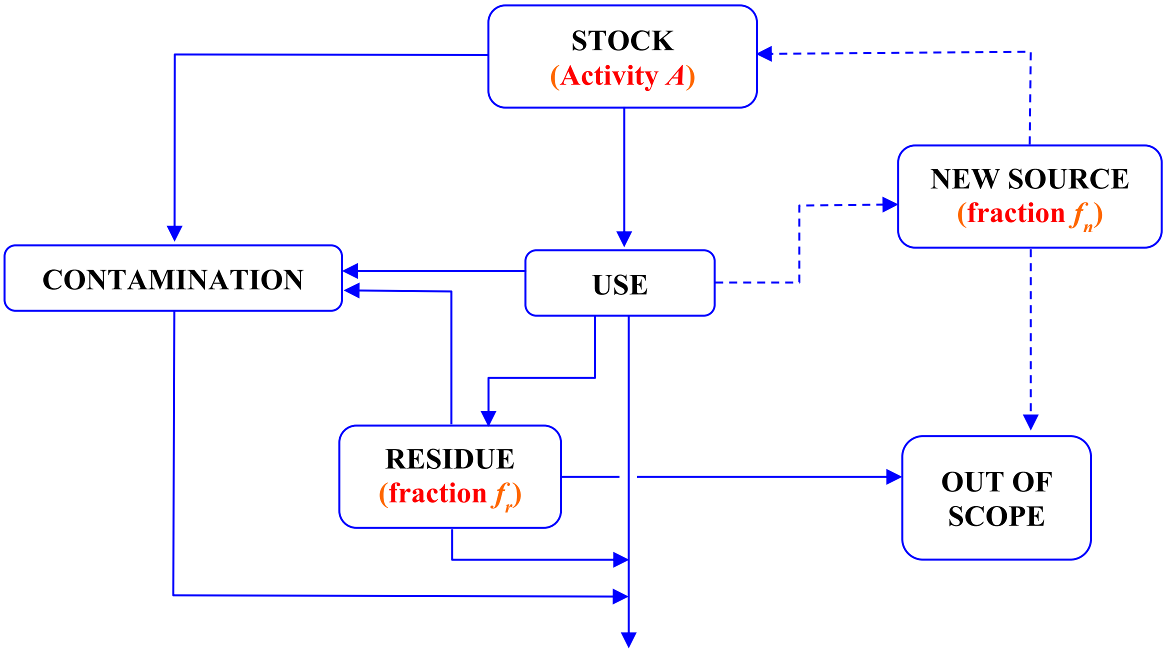
prior to disposal but after the waste from the individual parts has been reconsolidated.



WASTE ARISING				
Aqueous Liquid **(fraction f_{al})**	**Non-aqueous Liquid** **(fraction f_{nal})**	**Solid for Incineration** **(fraction f_s)**	**Solid to Normal Refuse (GBR)** **(fraction f_{snr})**	**Gaseous** **(fraction f_g)**

The sum of the fractions is equal to the original activity used in the experiment, i.e.

$$A = f_{al} + f_{nal} + f_s + f_{snr} + f_g\ (+ f_r)\ (+ f_n) \qquad (1)$$

The method of estimating each of these quantity fractions is described below:

Source/Aliquot (A)

The activity of the source at the beginning of the experiment must be known. In the case of aliquots removed from a stock solution, the activity should be estimated from the volume or mass removed compared to the volume or mass specific activity values provided by the supplier. In the case of material acquired specifically for the experiment the activity must have been provided by the supplier. Units must be in Becquerels (Bq) or multiples thereof.

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Aqueous Liquid (f_{AL})

This refers to all liquids that are disposed to the drains, including any non-aqueous waste that is disposed of by flushing into the sewers (if suitable for disposal to the sewer system). It is normally very difficult to determine the activity in this waste route, and it tends to be customary to estimate the activity by determining all other fractions. It might be possible to estimate likely activities making certain assumptions, based on past experience or knowledge of partition coefficients or a qualitative estimate of solubility's. Where one or more discrete quantities of liquid are collected, then it will probably be advantageous to determine the activity in this liquid by measuring a representative sample, thus allowing one of the other waste fractions to be estimated by subtraction. Units must be in Bq or, **provided that the same counting device is used throughout the experiment, in counts/unit time.**

Non-aqueous Liquid (f_{NAL})

This actually refers to all liquids that are not aqueously immiscible and those that are not permitted to be disposed of to the drains because of toxic or environmental reasons. Since this material must be collected, the activity can be determined by measuring a representative sample. Units must be in Bq or, **provided that the same counting device is used throughout the experiment, in counts/unit time.**

Solid for Incineration and Solid to Normal Refuse (f_S and f_{SNR})

The activity of solid waste is often difficult to determine, and if it is possible to determine f_{al}, it is advisable to do so in preference. It might be possible to put a piece of the solid in liquid scintillant, or count directly using a contamination meter. Work might have been done and published elsewhere that gives an indication. It may also be the case than an arbitrary percentage of the total activity is assigned to any solid waste generated from an experiment. Units must be in Bq or, **provided that the same counting device is used throughout the experiment, in counts/unit time**.

Gaseous (f_G)

In all but the most unusual cases, the route for disposal of radioactive gas is to the atmosphere, usually discharged via a fume cupboard. If f_g is significant, then there is a significant risk of inhalation of radioactive material. Such a risk must have been recognised in the generic or specific risk assessment, and might have included measurements of the concentration in air. These values can be used to calculate back to the amount of initial activity being lost to the atmosphere. Measurements might not be taken when the method of use eliminates any potential exposure to airborne radioactivity. However, in this case sufficient data must be available to estimate the quantity of gas by other means. (This might be necessary to ensure compliance with the conditions of the Permit.) This may require calculation based on perhaps knowledge of

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transfer coefficients, dilution rates, or previous studies, or broad assumptions may have to be made. Due to the method of estimation, this fraction must be described in units of Bq or multiples thereof.

Residue (f_R)

This fraction refers to one of the following situations:

- A sample or samples is/are being kept, perhaps for a long time, and hence will not arise within the waste within the immediate future.
- The material is being sent outwith the University, so is no longer subject to the University's Permit(s)

The fraction in the material, object or animal should normally be measured by appropriate counting. Work might have been done and published elsewhere that gives an indication of the residual activity. Units must be in Bq or, **provided that the same counting device is used throughout the experiment, in counts/unit time**.

New Source (f_N)

Sometimes the radioactivity is manipulated to manufacture a source for further use. In this case, there is an additional fraction. The activity of this should be determined by measurement. Units must be in Bq or, **provided that the same counting device is used throughout the experiment, in counts/unit time**.

6. Short Half-life Material

Some parts of the University use short half-life (t½) material. A substance is **<u>not</u>** radioactive material or radioactive waste where none of the radionuclides which it contains or which it consists of has a half-life exceeding 100 seconds. It should be noted that decay is **<u>not</u>** a disposal route. Therefore, some value of activity must always be placed against the material when it is being disposed of, even if that material has decayed to insignificant levels. It is probably best to allocate a nominal less-than value, such as "< 1 kBq".

7. Contamination

It is of course assumed that all contamination is considered as waste. Although it is included in the model, the amount of contamination arising under normal circumstances should be very small compared to the other sources of waste, and activity values should not need to be included in the estimate. Nevertheless, contaminated - or assumed contaminated - articles must be disposed of as radioactive waste. Where there is an accident resulting in a significant spillage, then waste arising from the contamination clean up might be a significant fraction of the waste and a specific incident estimate might need to be made.

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If necessary, surface contamination can be estimated by either direct measurement on a representative object, or wiping a known area of surface, counting the wipe and assuming an even spread of contamination. In the latter case, it is necessary to make an assumption of the amount of contamination wiped off. Custom and practice has given rise to the assumption of 10% wiped off, but this is most likely to be a considerable underestimate for laboratory work. It is therefore advisable to rewipe and monitor the same area. If the second wipe shows little or no activity and there is no or little activity detected by a monitor of the wiped surface, assume a wipe removal efficiency of 90%. If the second wipe shows more activity, or no activity but a monitor shows significant residual activity on the wiped surface, assume 10% removal efficiency. In the case of tritium or any surfaces that cannot be reached by a monitor, assume a removal efficiency of 10%.

8. Estimation

Equation (1) shows the summation of the individual waste fractions to equal the initial activity used in the experiment. Since the initial activity A is known, this allows us to determine one of the fractions by summating the others. It is commonly the aqueous liquid waste (f_{al}) that is not determined, and this is shown in the following equation, but it could be applied to any one of the waste fractions as appropriate to the particular experiment. Hence:

$$f_{al} = A - (f_{nal} + f_s + f_{snr} + f_g\ (+ f_r)\ (+ f_n)) \qquad (2)$$

If the same counting technique is used for each of the measurements, then the activity in Bq in each of the waste routes can be calculated from the fraction of the original activity. This saves having to establish counting efficiencies for each sample (although this technique does assume that there is no significant alteration in the counting efficiencies in between samples, which might arise in liquid scintillation counting). Thus if f_{counts} is the counts measured from a sample of any of the waste routes, and A_{counts} is the counts measured from the same counter of the initial source activity:

$$f \text{ in Bq} = \frac{f_{counts} \times A \text{ in Bq}}{A_{counts}} \qquad (3)$$

It is important to note that equation (3) cannot be applied if different types of counter are used for any of the measurements.

9. Accuracy

Although the protocol described above gives the impression of accuracy, this is not the case. When estimating the activity fractions to the various waste routes, it is not necessary to attempt a high degree of accuracy, which inevitably would not be possible due to all sorts of systematic errors in the measurement or assessment techniques, and how representative the sample is of the procedure to follow. Measurements may not always be necessary, and assumptions can be made. However it is important that these

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assumptions can be justified; for example, it is not acceptable to simply guess percentages for the various fractions and apply that to all radioassay work that might follow.

10. Recording

The estimate of the waste fractions must be carried out at an early stage of developing the use to which the radioactive material will be put. The results must be recorded, and kept for as long as the experiment or experiments is/are carried out. The record should contain the following information:

- identification of department;
- identification of the type or group of experiments to which this estimate applies;
- name of the person undertaking the estimate;
- date of the estimate;
- relative fractions; and
- Method of estimation e.g. measurement, calculation using known parameters, observation and estimate, calculation based on other known fractions etc.

A suggested design is attached in the Appendix. A template can be downloaded from the forms area of the RPU website at:

https://www.ed.ac.uk/health-safety/radiation-protection/radiation-protection-management/forms-and-checklists

Copies of the estimates should be held together in a laboratory file, where they can be seen by all experimenters and are readily available for inspection if required. They should not be kept, for example, in an individual's lab. book; remember an Enforcing Authority inspector might ask to see it.

For advice on any of the above topics please contact the Radiation Protection Unit, radiation@ed.ac.uk.

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Appendix 1: Waste Fraction Determination Template

DISPOSAL OF RADIOACTIVE WASTE

Estimation of Fraction of Activity Disposed to Each Waste Route

RADIATION APPLICATION:	
School and Division:	
Radiation Application:	
Location:	
Activity Used (A):	

WASTE ROUTES	USED?	BRIEF DESCRIPTION OF WASTE
Aqueous Liquid (f_{al}):	☐	
Non-aqueous Liquid (f_{nal}):	☐	
Solid for Incineration (f_s):	☐	
Solid to Normal Refuse (f_{snr}):	☐	
Gaseous (f_g):	☐	
Residue (f_r):	☐	
New Source (f_n):	☐	
Routine Contamination	✓	

ESTIMATION AND RATIONALE:	
Aqueous Liquid (f_{al}):	
Non-aqueous Liquid (f_{nal}):	
Solid for Incineration (f_s):	
Solid to Normal Refuse (f_{snr}):	
Gaseous (f_g):	
Residue (f_r):	

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ESTIMATION AND RATIONALE:	
New Source (f_n):	
Routine Contamination	

ORIGINATOR	
Name:	
Position:	
Signature:	
Date:	Click or tap to enter a date.

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