Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

STANDARDISED REPORTING OF RADIOACTIVE DISCHARGES FROM NUCLEAR SITES IN SCOTLAND

Radiological Monitoring Technical Guidance Note 1

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About this technical guidance note

This guidance note was originally published jointly by the Environment Agency and Scottish Environment Protection Agency. It was been developed by the Radiological Monitoring Standards Working Group (RMSWG). The RMSWG has representatives from the Environment Agency, Scottish Environment Protection Agency, Nuclear Decommissioning Authority, Food Standards Agency, nuclear industry and experts. The RMSWG is a sub-group of the Nuclear Industry Liaison Group.

The guidance was reviewed following changes to legislation in Scotland and this version only applies in Scotland.

1 Introduction

1.1 The Scottish Environment Protection Agency (SEPA) has responsibility for regulating discharges of radioactive waste to the environment from the nuclear industry (on nuclear licensed sites) under the Environmental Authorisations (Scotland) Regulations 2018 (EASR).

1.2 Discharges of radioactive waste to the environment are strictly controlled through authorisations granted to nuclear operators. Granting of an authorisation is subject to a number of requirements being met. One requirement on nuclear licensed sites is that Best Practicable Means (BPM) are used for monitoring discharges.

2 Purpose

2.1 This document provides good practice guidance to nuclear operators on how they should assess discharges for reporting to SEPA. This guidance will help nuclear operators comply with the requirements to use BPM. The benefits of this guidance are:

- Most appropriate method selected for assessing radioactive discharges (i.e. monitoring, calculation, or estimation) – Operators will be able to select a more cost effective method if it delivers an appropriate level of quality for assessing discharges.
- More realistic discharges – Current approaches for assessing discharges from nuclear sites lead to over-reporting of discharges, where there is a high proportion of results below the detection limit. This guidance will lead to more realistic assessments of discharges and doses and hence a more appropriate level of regulatory attention. In addition, it will provide a better evaluation of compliance with the UK Discharge Strategy [Ref 1].
- Consistent regulatory approach – The guidance provides a consistent regulatory approach for reporting of discharges from nuclear sites and ensures that discharges from different nuclear sites can be compared.

2.2 The guidance is not mandatory, but SEPA expects it to be followed (subject to an agreed reasonable timetable) in the following situations:

- New facilities or new discharge reporting systems.
- There is a net benefit (e.g. costs to implement a new discharge reporting system are less than cost savings from introducing new assessment methods).
- The costs are not significant or are broadly similar to the benefits.

2.3 The guidance is also designed to support practicable implementation in the UK of parts of the European Commission's (EC) recommendation (2004/2/Euratom) [Ref 2] on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation. Hence, this document provides guidance on what discharge information SEPA should report to the Scottish Government for onward reporting to the EC. Discharges from defence sites are excluded from reporting to the EC.

2.4 A summary of the requirements of the EC Recommendation and how this guidance meets them are shown in Appendix 1. The purpose of the EC Recommendation is to allow radioactive discharges

reported by member states to be comparable on an EC wide basis and to provide more realistic discharge data for dose assessments.

3 Scope

3.1 This guidance applies to all nuclear sites, whether in normal operation or decommissioning in Scotland. It applies to discharges assessed by routine monitoring, calculation or estimation.

3.2 This guidance does not currently apply to non-nuclear premises. The benefits of the application of this guidance to the non-nuclear sector are not considered to be sufficiently large, since discharges are generally calculated or estimated rather than routinely monitored and the radionuclides discharged generally have short radioactive half-lives. We will be reviewing this situation, particularly for the oil and gas sector.

4 Process for assessing and reporting discharges

4.1 The following flow chart summarises the key steps of who should do what.

Step	Who does what	Guidance
1	***Nuclear operators*** Identify radionuclide reporting requirements	• Nuclear operators should identify all the radionuclide reporting requirements in their EASR authorisation (e.g. reporting against authorisation limits, pollution inventory). The requirements may include reporting radionuclides with different chemical forms.
2	***Nuclear operators*** Radionuclides for routine monitoring or discharge calculation/ estimation	• Nuclear operators should review which radionuclides in each waste stream are to have discharges assessed by routine monitoring, which by routine calculation/estimation and those for which a standard reporting value will be defined. See Section 6 for standard reporting values. • Routine monitoring should be undertaken where it is technically feasible and where it provides a more appropriate assessment of the discharge than a calculation method. Routine monitoring should be carried out at a point where results above the decision threshold can be achieved (i.e. prior to dilution from other waste streams). • Calculated/estimated discharges will be acceptable in these circumstances: o more accurate than measurements (e.g. Ar-41, Kr-85); o as accurate as measurement, but more cost effective; o measurement system has failed; o planned outage of a routine discharge monitoring system; o minor or other discharge route (as defined in the EPR 10 permit or RSA 93 authorisation).

3	***Nuclear operators*** Define 'good practice' discharge assessment methods	• Nuclear operators should define and document their 'good practice' routine monitoring and calculation/estimation methods for assessing discharges of each radionuclide. This should include method specific 'good practice' decision thresholds and detection limits (see Section 5 and Appendix 2). • Nuclear operators should refer to the standard detection limits in column 3 of Annex 1 of the EC Recommendation [Ref 2] to help define 'good practice' detection limits. These detection limits provide an indicator of likely future performance standards. They should be considered to represent 'good practice' for new facilities. It may be necessary to derive activity per sample (e.g. Bq per filter) detection limits from the detection limits in the EC Recommendation, by for example, taking account of the effluent flow.
4	***Nuclear operators*** Submit discharge assessment methods	• Nuclear operators should submit, to SEPA, the proposed discharge assessment methods (routine monitoring or calculation). This will include decision thresholds and detection limits for each radionuclide, and if appropriate, each waste stream. • This may be provided as part of the submission for the EASR authorisation application, variation or review.
5	***SEPA*** Review discharge assessment methods and determine acceptability	• SEPA should review acceptability of proposed methods, including decision thresholds and detection limits. • SEPA to discuss methods with nuclear operators until they reach an acceptable standard.
6	***Nuclear operators*** Assess discharges to air and water for reporting period	• Nuclear operators should assess the discharge of each radionuclide to air and to water for the reporting period using monitoring or estimated/calculated data. • Nuclear operators should refer to section 5 of this guidance on assessing discharges.
7	***Nuclear operators*** Report assessed site discharges to SEPA	• Nuclear operators should submit assessed discharges to water and air for the reporting period to the relevant environment agency. These are usually monthly discharge returns and an annual pollution inventory report.

8	***SEPA*** Report discharge information to Scottish Government	• SEPA should report total nuclear site discharges to air and water for the calendar year to Scottish Government, by 25 September of the year following the calendar year reporting period. • Onward submission to the EC, will exclude discharges from defence sites.
9	***SEPA*** Report sampling methods to Scottish Government	• SEPA should report sampling methods used by operators when requested by EC during an Article 35 verification visit.
10	***Nuclear operators*** Review discharge assessment methods	Nuclear operators should review, and if necessary revise, discharge assessment methods, method specific decision thresholds and detection limits and standard reporting values at an appropriate frequency agreed with SEPA. This will normally be no more frequent than annually and no less frequent than every 3 years.

5 Guidance on assessing radioactive discharges

5.1 Where routine monitoring is used to assess discharges, air or water concentration monitoring results of a radionuclide for a particular waste stream are multiplied by the volume of air or water flowing or discharged, to determine the discharge from that waste stream for that monitoring period. These discharges are summed for each waste stream for discharges to air or water to provide an assessment of the site discharge to air and water over a reporting period. For such routine monitoring, operators should use the following guidance for the appropriate reporting period when there is one (or more) result below the result specific or method specific decision threshold:

Situation	Reporting guidance
There is a justifiable operational reason why a radionuclide is not expected to be present (e.g. planned shutdown, diversion of discharges).	Treat results as zero. Provide information on the operational reason to the relevant environment agency.
All results below the result specific or method specific 'good practice' decision threshold for a particular radionuclide and waste stream in the reporting period.	Treat all results as 50% of decision threshold. Report as an actual discharge value (i.e. report as X Bq and not < X Bq). Review whether a standard reporting value could be calculated, rather than assessing discharges based on routine monitoring (see Section 6)

Some results are above and below the result or method specific 'good practice' decision threshold over the reporting period for a particular radionuclide and waste stream.	Treat results below decision threshold as 50% of decision threshold. Report as an actual discharge value (i.e. report as X Bq and not < X Bq).
All results are above the result or method specific 'good practice' decision threshold over the reporting period for a particular radionuclide and waste stream.	Treat all results as actual result and report as actual discharge value.

6 Standard reporting values

6.1 Nuclear operators may define a standard reporting value for minor discharges of radionuclides. This value may be defined on the basis of a period of monitoring results or be calculated / estimated. Where there is evidence that monitoring results are below the decision threshold over a 12 month reporting period and there is no better means of calculating a standard reporting value, this standard reporting value may be defined as zero. Where there are monitoring results above and below the decision threshold, the standard reporting value may be calculated from the actual results above the decision threshold and 50% of the decision threshold for the results below the decision threshold.

6.2 Nuclear operators may monitor waste streams, to check for unusual discharges, where the normal method for reporting discharges is to use a standard reporting value. Where there is a result above the decision threshold during a reporting period and there is a valid operational reason for this result, then the monitoring result should be used as part of the discharge assessment for that reporting period.

7 Definitions

Decision threshold – defined in an ISO standard [Ref 3] as the "the fixed value of the decision quantity (random variable for the decision whether the physical effect to be measured is present or not) by which, when exceeded by the result of an actual measurement of a measurand quantifying a physical effect, it is decided that the physical effect is present". Further guidance on the decision threshold is provided in Appendix 2.

Decommissioning operations – activities relating to the dismantling phase of decommissioning. It excludes post-operational clean out, containment and surveillance operations and care and maintenance operations.

Detection limit – defined in an ISO standard [Ref 3] as the "smallest true value of the measurand that is detectable, with a given probability of error, by the measuring method". Further guidance on the detection limit is provided in Appendix 2.

Non-nuclear premises – A premises with an EASR authorisation which is not a nuclear site (e.g. university, hospital, pharmaceutical company).

Nuclear site – A site that has a nuclear site license as defined in section 26 of the Nuclear Installations Act 1965. Also included are tenants on nuclear licensed sites and those sites which would be nuclear licensed sites if EASR regulation 78 did not apply.

Nuclear operator – operator of a nuclear site.

Normal operations – normal activities relating to the operation of a nuclear site, including commissioning, operations, post-operational clean out, containment and surveillance operations and care and maintenance operations. It excludes the dismantling phase of decommissioning.

Routine monitoring – monitoring of effluent at point of discharge to assess discharges over reporting period. Monitoring will either be direct monitoring during discharge or analysis of representative sampling collected during discharge or from a tank prior to discharge.

Reporting period – The period in the permit or authorisation for which discharge reports must be made. These could be reports of monthly discharges, 12 month rolling discharges or calendar year for the pollution inventory. The reporting period in the EC Recommendation is the calendar year.

Standard reporting value – A discharge value defined for a particular radionuclide and waste stream which is reported each reporting period.

8 References

1. Welsh Assembly Government, Department of the Environment Northern Ireland, The Scottish Government, Department of Energy & Climate Change (2009). UK Strategy for Radioactive Discharges.

2. Commission Recommendation of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation, 2004/2/Euratom

3. International Standards Organisation. Determination of the detection limit and decision threshold for ionizing radiation measurements — Part 7: Fundamentals and general applications. ISO/FDIS11929-7.

Appendix 1 How EC recommendation is addressed in the UK

Para ref	EC Recommendation requirement	How addressed in the UK
1	This Recommendation defines information selected for monitoring and reporting to the European Commission on radionuclides discharged or liable to be discharged from nuclear power reactors and reprocessing plants in normal operation.	Included in scope and definitions of this guidance.
2	For the purpose of this Recommendation, the following definition apply: (a) 'normal operation': normal activities relating to the operation of a nuclear power reactor or reprocessing plant, including the decommissioning phase (shutdown and containment and surveillance operations), but not the dismantling phase; (b) 'key nuclide': suitable measurement sensitivity indicator, selected for each radionuclide category; (c) 'detection limit': smallest true value of the measurand that is detectable, with a given probability of error, by the measuring method; (d) 'decision threshold': the fixed value of the decision quantity (random variable for the decision whether the physical effect to be measured is present or not) by which, when exceeded by the result of an actual measurement of a measurand quantifying a physical effect, it is decided that the physical effect is present.	Included in scope and definitions of this guidance as appropriate.

Para ref	EC Recommendation requirement	How addressed in the UK
3	For airborne and liquid discharges from nuclear power reactors and reprocessing plants, Member States should assess the discharged activity of all radionuclides considered in column 1 of Annex I.	The Scottish Government, in conjunction with other government departments and devolved administrations, has agreed that it is only reasonably practicable to provide standardised information on discharges to the EC where this information is already provided to SEPA as a requirement of EASR authorisations. A consultative process with the nuclear and non-nuclear industries will be followed, if significant changes to the Pollution Inventory reporting requirements (e.g. new radionuclide) are required. Hence reporting of discharge information will not be required against the full list of radionuclides in Annex 1 of the Recommendation.
4	In situations where measured values are below detection limits, for key nuclides identified in column 2 of Annex I, the detection limits achieved should not exceed the corresponding requirements defined in column 3 of Annex I.	Covered by this guidance. The detection limits are included in the guidance as performance standards for new facilities and modifications which should be taken into consideration when determining whether 'good practice' has been used to set detection limits.
5	In situations where a similar accuracy can be achieved by the calculation of discharges for specific radionuclides on the basis of operational data, or on the basis of measurement results for other radionuclides, such calculated discharge values may be used as a substitute for direct measurements.	The guidance to nuclear operators in this document covers this.
6	The determination of detection limits, decision thresholds, and the expression of results should comply with international standard ISO/IS 11929-7.	Covered by this guidance.
7	Where measurement outcomes are below the decision threshold, these outcomes should conservatively be substituted by one half of the decision threshold. However, if repeated measurement outcomes in the period considered are all below the decision threshold, then it is reasonable to assume that the true value is zero, i.e. that the radionuclide is not present in the discharge.	Covered by this guidance.

Para ref	EC Recommendation requirement	How addressed in the UK
8a	Member States should report the following information on radioactive discharges to the Commission in the format of the compilation sheets outlined in Annex II: (a) annual discharge values for each radionuclide listed in column 1 of Annex I for which there is at least one measurement outcome above the decision threshold in the period considered, or for which a calculated assessment has been made in the same period;	Covered by this guidance. All discharges reported to SEPA as required by the EASR authorisation, including reporting against the pollution inventory should be used to produce the discharge report.
8b	(b) for each key nuclide, the highest value of the detection limit that has been obtained among all the measurements for the period considered;	This is currently not required by EASR authorisations and will not be reported.
8c	(c) estimates of radionuclide discharges based on calculation, as a substitute for measurement, when measurement is technically not feasible; Estimated values as referred to in (c) should be identified as such in a commentary together with an indication of the method used and, where appropriate, any relevant detection limit.	Covered by this guidance. Estimates based on calculation are currently reported to SEPA and will be reported to the Scottish Government. The operator documents the methods for calculation in order to demonstrate fulfilment of the requirements of the permit or authorisation.
8d	(d) as far as available, the chemical/physical form of tritium, carbon-14 and iodine discharges to the atmosphere; The information referred to in (d) should be provided in the commentaries.	This is currently not being required or reported. Guidance does not cover this.
8e	(e) the time basis for the reported values, and where appropriate information on the summation method used, including the substitutes for values below decision threshold, which have been used in estimating summation results; The information referred to in (e) should be provided in the commentaries.	This is currently not being required or reported. Guidance does not cover this.
8f	(f) the sampling method for the effluent streams. The information referred to in (f) should be provided in the commentaries.	Covered by this guidance. For SEPA the operator documents the methods for sampling in order to demonstrate fulfilment of the requirements of the authorisation. This information is currently not being reported annually, but is made available to the EC during Article 35 verification visits. This guidance does not cover this.

Para ref	EC Recommendation requirement	How addressed in the UK
9	The period of reporting information on radioactive discharges should be one calendar year. Information on radioactive discharges should be submitted no later than 30 September of the following year.	Covered by guidance to ensure report can be provided to the deadline.
10	This Recommendation is addressed to the Member States.	N/A

Appendix 2 Decision threshold and detection limit for radiometric methods

Definitions and differences

The decision threshold and detection limit are defined by ISO in Reference A2.1 for radiometric methods (see definitions in Section 7). The decision threshold is equivalent to the critical level as defined by Currie [Ref A2.2]. There are many formulations of the decision threshold and detection limit in use for measuring radioactivity, in particular. Key points leading to differences are:

- The decision threshold and detection limit should be based on the uncertainty in the measurement of a 'blank' sample (or no sample), commonly referred to as the background. Background counts may be undertaken, for different time durations than the sample count time and this complicates the formulation of the uncertainty. The continuum on a gamma spectrum is affected by the activity of the sample. Hence, it is necessary to calculate the counts in the continuum over the region where the peak is located and assign this as the background counts. Strictly, the continuum counts and the net backgrounds counts when a blank sample is present should be used to derive the total background. Methods which use the uncertainty in the gross or net sample counts to derive the detection limit should be avoided.

- Radiometric spectrums are normally assumed to follow a Poisson distribution, due to the integer nature of the measurement process (ISO now uses Bayesian statistics). However, at low counts, the distribution tends to diverge from a Poisson distribution. Although, revised methods are available to take account of this [Ref A2.3], the correction provided is less than 10% where there are ten background counts or more. For less than ten background counts, deciding how many counts are in the background is likely to provide the greatest source of error. Hence, for simplicity, it is recommended that the same method is used to derive decision thresholds and detections limits, whatever the number of background counts.

- The probability of error used in the formulation of the decision threshold and detection limit varies between methods. A common assumption is to use a confidence level of 95%. This gives a so called 'coverage' or 'k' factor of 1.96 for a two-tailed distribution and 1.645 for a one-tailed distribution.

- Analytical or monitoring instruments may have embedded software for calculating decision thresholds and detection limits. However, these quantities are often given different names and are derived in different ways. The best fit to the formulations below will need to be selected. Where there is no option to select the decision threshold, the decision threshold may be taken to be half the detection limit. Some embedded software will have algorithms for accepting and rejecting peaks. If a peak is rejected by such an algorithm then the counts of the rejected peak should be included with the continuum background counts when calculating decision thresholds or detection limits.

Parameter definitions

k =	coverage factor (at defined confidence level)
b =	background count rate (counts/s) (includes continuum when sample present and background when no sample present)
t_s =	sample count time (s)
t_0 =	background count time (s)
w =	1 / (e *V f)* or 1 / (*e M f)*
e =	detector efficiency (0-1), including branching ratio for radionuclide where appropriate
V =	volume (litre)
M =	mass (kg)
f =	other factors (e.g. quench correction, recovery, density correction)
$u_{rel}(w)$ =	total relative standard uncertainties for all the factors making up w

Generic formulae

The generic formulae for the decision threshold and detection limit where the coverage factor (k) is the same for the decision threshold and detection limit are:

Decision threshold (L_c) (activity concentration/Bq/l or Bq/kg) =

$$k\,w\sqrt{\frac{b}{t_s}+\frac{b}{t_0}}$$

Detection limit (L_d) (activity concentration / Bq/l or Bq/kg) =

$$\frac{2L_c+\frac{k^2 w}{t_s}}{1-k^2\,u_{rel}^2(w)} = \frac{\frac{k^2 w}{t_s}+2k\,w\sqrt{\frac{b}{t_s}+\frac{b}{t_0}}}{1-k^2\,u_{rel}^2(w)}$$

Simplified formulae

The generic formulae can be simplified by setting a value for the coverage factor (usually chosen to be 1.645 for 95% probability); assuming that the count time (t_s) is the same as or shorter than the background count time (t_0); and that there is negligible relative error in w $(u_{rel}(w))$:

$$\text{Decision threshold } (L_c) \text{ (activity concentration / Bq/l or Bq/kg)} = 2.3\, w \sqrt{\frac{b}{t_s}}$$

$$\text{Detection limit } (L_d) \text{ (activity concentration / Bq/l or Bq/kg)} = \frac{2.7w}{t_s} + 4.7\, w \sqrt{\frac{b}{t_s}}$$

These simplified formulae may be used under the following conditions:

- The sample count time is the same as or shorter than the background count time. If the sample count time is longer than the background count time, then the background count time should be used in the formulae.
- The relative error in $(u_{rel}(w))$ is less than 10% at one standard deviation (coverage factor =1).

Appendix 2 references

A2.1. International Standards Organisation. Determination of the detection limit and decision threshold for ionizing radiation measurements — Part 7: Fundamentals and general applications. ISO/FDIS11929-7.

A2.2. L A Currie, limits for Qualitative Detection and Quantitative Determination. Analytical Chemistry, 40, 586-593, 1968

A2.3. C Hurtgen, S Jerome and M Woods (2000). Revisiting Currie – How low can you go? Applied Radiation and Isotopes, Volume 53(1), 45-50.