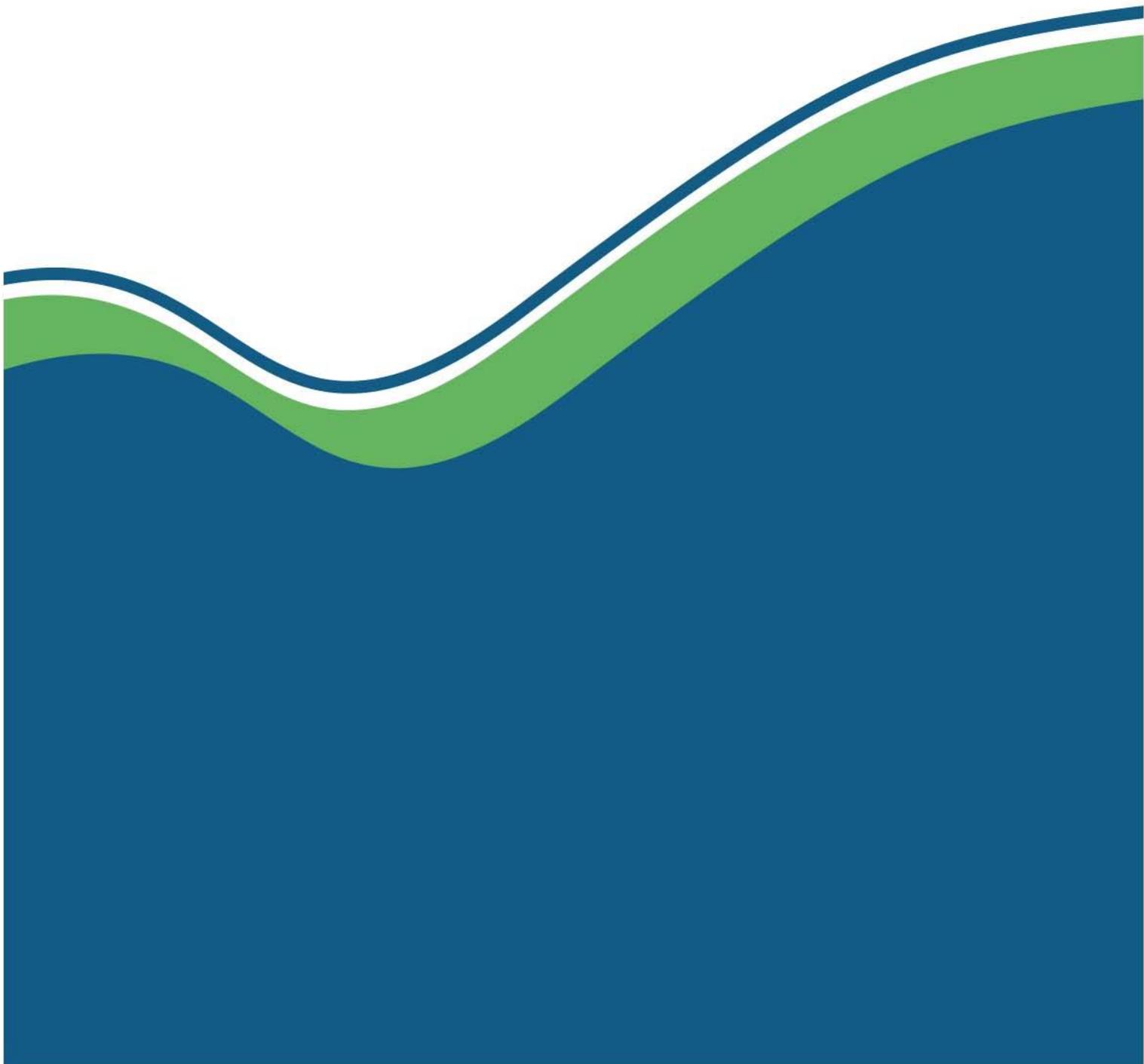




Scottish Pollutant Release Inventory Reporting

Scottish Release Inventory (SPRI) Operator Guidance on Release Estimation Techniques (RET)

2017



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1 Introduction

1.1 Introduction to the note

This Guidance Note provides information to assist you in preparing submissions to the Scottish Pollutant Release Inventory (SPRI). It has been developed through a process of consultation between industry stakeholders and ourselves. It is part of a range of non-statutory guidance and tools produced to assist in the completion of the annual SPRI return. Information on the range of guidance notes is available on the [SEPA website](#).

By providing a series of guidance notes, we seek to ease the burden on industry and to raise the quality of SPRI data. In addition, the increasing use of SPRI data in policy-making and for comparisons on a sector and national basis has led to a need for increased consistency in SPRI data and an improved understanding of uncertainty.

This Note provides information on RETs for reporting to the SPRI. The absence of a specific RET for a substance does not imply that an emission should not be reported to the SPRI. The obligation remains to report on all relevant emissions.

1.2 Release estimation techniques (RETs)

Where you believe a substance is released from your site to the environment, you will have to decide on the most appropriate release estimation technique (RET) to calculate the annual SPRI emission value. Some RETs will be specific to substances or to industry sectors. The absence of an RET for a substance does not imply that an emissions should not be reported to SPRI and the obligation remains to report on all relevant emissions.

In general, there are five types of RETs that may be used to evaluate emissions:

- Sampling or direct monitoring;
- Emission factors;
- Mass balance or other engineering calculations (such as fuel analysis);
- Indirect monitoring; and
- Engineering judgement.

Depending on the particular site, pollutant or process each of the techniques listed may be the most appropriate to use. You should choose the best RET which provides the most accurate emission data for your SPRI return. You should be able to demonstrate an understanding of the factors that lead you to the selection of the most appropriate RET for your activity and justify why the technique has been selected. You can record these details within your SPRI data return as part of the "Method Description". You should always select an RET based on the application for which it has been designed and the one which will give the best quality data.

There are cases where mandatory RETs exist, such as when reporting emissions European Union (EU) Directives or in accordance with authorisation or permit conditions, an example of this is the [EU Emission Trading System \(EU ETS\)](#) for greenhouse gases (GHGs). For consistency you should also consider extending the use of such mandatory methods to additional parts of the site that are not subject to the mandatory requirement, but that have SPRI reporting obligations. At a minimum the SPRI data should match other reporting obligations where there are common reportable substances, such as carbon dioxide emissions.

Mandatory, or industry, methodologies should be used where available and site specific data in the form of monitored emission concentrations, or mass balance techniques, should be used where appropriate. Measured emission concentrations should ideally be based on data obtained using appropriately certified equipment, and/or accredited services. Continuous monitoring data should normally be used in preference to periodically sampled data.

Where emissions factors are used, preference should be given to the use of site-specific emission factors over those developed from other representative plant. However, in order to develop a site-specific emission factor, it is necessary to relate the level of emissions to an activity within the process. This is normally obtained from sampling data, or can be obtained from the manufacturer's information, or by calculation. In the absence of such information, UK or international emissions factors can be used.

The RETs presented in this note relate principally to representative operating conditions. However, it is important to recognise that emissions resulting from significant operating deviations (e.g. failure of abatement plant) and/or accidental events (e.g. spills) also need to be estimated. In the case of air emissions from spillage events, it may be necessary to make an estimate of the amount of substances released as vapour. For all spills, the additional emission is the net emission; i.e. the quantity of the SPRI-reportable substance spilled, less the quantity recovered or consumed during clean-up operations.

1.3 Uncertainty

The level of uncertainty of a determination is important in judging whether a change in reported emissions is significant or not. For example, if the level of reported emissions from one year to the next increases by 10%, this may not be a real increase if the level of uncertainty in the measurement is 20%. In this case, two different values are reported but the actual emissions could be the same. The guidance given in this Note is aimed at reducing the variability and uncertainty in emission determination.

1.4 Limits of detection (LOD)

If the best available information indicates that a substance is not released from your process, report **N/A (not applicable)** for that substance. Where a substance may be released but at a release concentration that is below the LOD, you also need to report N/A unless an alternative RET, such as mass balance, produces an applicable result. By LOD we mean the lowest concentration which can be measured by the analytical method prescribed in the Permit, or such other method as we approve.

We recognise that there may be circumstances where some analyses in a series do not detect a substance but others do. Provided that no more than 5% of the readings show a positive value, and the values obtained are not more than 20% above the accepted LOD, you can treat them as if they were also reported as below the LOD. In any other case, use the values obtained and make the assumption that where the substance is reported as not detected it is present at 50% of the LOD. In these cases, you need to multiply each concentration (that is, those measured at above the LOD as measured and those measured at below the LOD as $\frac{1}{2}$ of the LOD) by the total flow during the period that the measurement relates to in order to determine the mass emission.

Sometimes we may agree a different methodology with you for a particular substance or process. If so, use this in place of the procedure above. If as a result of this methodology a positive result is obtained that is below the reporting threshold (BRT), it should be reported as BRT rather than N/A.

1.5 Access to further information

This Note does not provide detailed information on suggested measurement and monitoring techniques as this is dealt with extensively in other guidance documents that we publish. References to monitoring guidance and other sources of reference information are included in Section 5 of this document.

1.6 Disclosing information you provide

The General SPRI Guidance Note provides information relating to commercial confidentiality.

1.7 Feedback

In order to improve the quality of our guidance, we would like to receive feedback from you on your experiences in using this Note. Such feedback will be taken into account in the preparation of other guidance notes in this series, and in the updating of this document.

Feedback should be submitted to the SPRI team by email. Email: SPRI.Administration@sepa.org.uk

1.8 How to contact the SEPA SPRI team for help

Enquiries about any aspect of the SPRI can be made to the following email address (note that there is no weekend cover available to any SPRI enquiries made): SPRI.Administration@sepa.org.uk

In all correspondence please quote your company's/organisations registered name and site address and your unique NIC (National Identity Code) number, this will help us deal more efficiently with your enquiry.

You can also contact your local SPRI Support Officer at the following office location:

SEPA Stirling Office
Strathallan House
The Castle Business Park
Stirling
FK9 4TZ

Tel No: 01786 457700
Fax No: 01786 446885

2 Emissions to air

2.1 Direct monitoring

Direct monitoring, also termed direct sampling, addresses a broad range of substances, or effects-based surrogates such as pH, if it is not possible to monitor for a specific chemical. In one sense, monitoring, which can be continuous or periodic, can be distinguished from all other methodologies. It is listed along with other techniques because, in many cases, a limited set of monitoring data is used to represent, or model, a broader range of releases. A distinction should be drawn in the case of continuous monitoring, for which (at least for the particular substance monitored and its source) no modelling should be required.

Continuous monitoring techniques are available for specific substances. Generally speaking, costs and difficulty increases for methods used to monitor specific substances. These factors often combine to make continuous monitoring an impractical option for most substances.

In contrast to continuous monitoring periodic monitoring is conducted less frequently. The frequency of periodic monitoring may range from daily to once or twice a year. In some cases, periodic modelling of certain substances can be used to represent other substances by applying average ratios, or by using some other condition related to the source.

Direct monitoring provides a good option for determining releases for some specific substances associated with a small number of well-defined sources. For example, SO₂ releases from large electricity generation plants, and other large industrial boilers using fossil fuels, can be monitored efficiently and accurately using existing, well established monitoring methods. In some industrial applications, releases are determined from these types of sources using continuous emission monitoring (CEM); such as 24 hour sampling of flue gasses. CEM refers to the collection of emission data using a monitor that is a permanently mounted collection system. It records releases over an extended and uninterrupted period. The sample streams of air are directed to the device and the data is recorded electronically.

Many of the sources that lend themselves to direct monitoring are those that are operated in a regular and consistent way. Releases from such sources do not vary much with time; therefore, direct monitoring at periodic intervals (statistical sampling) can be used to determine average releases over specified periods of time between monitoring cycles. Sources of this type include large steam boilers at industrial facilities, smelters, blast furnaces and ovens at steel production facilities, incineration plants and catalytic crackers at petroleum refineries.

2.2 Sampling

In order to use sampling data to estimate releases, information is required on both the flow rate and pollutant concentration. In order to accurately determine annual releases, sampling for SPRI reporting should be performed under conditions representative of annual operations, and ideally in accordance with methods or standards that SEPA has approved.

Care should be taken with relying on the results of one spot sample in order to report annual releases, unless you are certain that the process conditions are representative of annual average operations. Where a process has a number of steady state conditions, it may be necessary to take samples under each operating condition and average the result according to the length of time the process operates at each condition. Similarly, where process conditions at the time of the spot sampling are uncertain, it may be necessary to take several samples and to average the results in order to provide the final annual release estimate. Good engineering judgement should be used in order to select the most appropriate sampling time and data to use. You should be able to justify the sampling programme selected.

Sampling as part of an authorisation/permit condition may require that the monitoring be undertaken at maximum, or specified, load (i.e. higher than annual operating conditions) and this should be taken into account in the annual release estimates. When in doubt, the proposed sampling protocols should be confirmed by SEPA.

In order to estimate annual emissions from sampling data, the first step is to multiply the measured emission concentrations by the volumetric flow of the emission source at the time of the test. Assuming that representative sampling has been undertaken, these emission rates are then aggregated together for the annual operating period.

Care should be taken to ensure that the release concentration and flow rate are compatible; e.g. normalised release concentrations should be multiplied by normalised volumetric flow rates or similarly actual, measured release concentrations multiplied by actual, measured volumetric flow rates. Normalised release rates are quoted in terms of a standard oxygen concentration, and are usually dry gas, at a temperature of 273K and a pressure of 101.3 kPa. It is always good practice to confirm the basis of measured data. Formulae for conversion between normalised and actual emission concentrations are contained in Annex 1 to this Note.

Sampled release concentrations are also often reported in parts per million (ppm). In order to estimate annual releases, these need to be converted to mg/m³ at the release temperature at which the volumetric flow rate is measured. It is vital that concentrations and flow rates are on a consistent basis. Formulae for converting ppm to mg/m³ are contained in Annex 2 to this Note.

The following section shows how to calculate releases based on stack sampling data expressed in mg/m³. An example involving PM₁₀ releases is included, although the same general methodology is applicable for the majority of the pollutants listed in the SPRI.

Equation 1

$$E = C \times Q \times 0.0036 \times [\text{Op Hours}]$$

Where:	E	Emission rate of pollutant (kg/yr)
	C	Pollutant concentration (mg/m ³)
	Q	Volumetric flow rate of the emission (m ³ /s)
	0.0036	Conversion factor from mg/s to kg/hour
	Op Hours	Operating hours of the activity per year

Where the pollutant concentration is consistent over the averaging period (i.e. one year), Equation 1 can be rewritten as:

Equation 2

$$E = C \times M \times V \times 10^{-6}$$

Where:	E	Emission rate of pollutant (kg/yr)
	C	Average pollutant concentration (mg/m ³)
	M	Mass of fuel burnt/product/feedstock produced in one year (te dry fuel/product/feedstock)
	V	Standard volume of flue gas per tonne of fuel/product/feedstock (m ³ /te dry fuel/product/feedstock)

Example 1

The following example is for PM₁₀ emissions using Equation 1.

Operating hours	24 hours/day, 280 days/year
PM ₁₀ emission concentration	50mg/m ³ (normalised to 273K, dry, 3% oxygen)
Emission volumetric flow rate	10m ³ /s (normalised to 273K, dry, 3% oxygen)
E = C x Q 0.0036 x 24 x 280	
E = 50 x 10 x 0.0036 x 24 x 280	
E = 12,096 kg/yr	

The use of CEMS is considered in the next section, which in essence, follows the same principles as using spot sampling data.

2.3 CEMS sampling

Various Directives specify the individual requirements for CEMS depending on the activity being carried out and these must be considered when reporting (e.g. the Industrial Emissions Directive (IED) – requires installation of CEMS for the measurement of SO₂, NO_x and PM emissions).

In general, you should use CEMS data that are from appropriately calibrated instrumentation operating within stated tolerances (according to CEN standards where available or ISO/national standards where they are not). Although CEMS can report real-time releases over a variety of time periods automatically, it may be necessary to manually determine annual releases from such data, especially for periods where data may be out of tolerance. In any case, where annual releases are calculated within the software of a CEMS, it is good practice to manually check the data in order to ensure that the automatic calculations are accurate. To use CEMS data, knowledge of the corresponding volumetric flow rates is required in order to determine mass releases.

The IED requires subtraction of confidence intervals (as specified in the appropriate Directive) from CEM average values, to provide “validated” averages that are compared against the given ELVs for compliance purposes. This is acceptable for relatively short-term average periods, but not long-term periods (such as whole year and SPRI returns) when positive and negative errors (random errors) would be increasingly expected to cancel each other out. Therefore, confidence intervals must not be subtracted from the average values generated from the raw emissions data, prior to calculation of annual mass emissions (unless part of an over-riding written agreement with SEPA).

Prior to using CEMS to determine releases, it is preferable to agree the methodology for collecting and averaging the data with SEPA.

The basic equation for determining releases is Equation 1, adjusted for the appropriate time period of the measurement. It must be applied for each time period for which release measurements are available in the year. Normally, the measurement time periods are the same, such that it is possible to simply multiply the average release rate by the operating time per year to obtain the annual release. However, it may be that the measurement time periods vary, and then Equation 3 should be used.

Equation 3

$$E = \sum_{i=1}^n (E_i \times t)$$

Where:	E	Emission rate of pollutant (kg/yr)
	E _i	Emission rate of pollutant over time period t
	t	Time period for emission measurement
	n	Number of time periods in the year

Example 2

This example shows how SO₂ emissions can be calculated using Equation 3 based on the average CEMS data for 6 days of a week. In the case of the example, it is assumed that the process operates for 24 hours per day, 48 weeks per year and that the CEMS data is representative of annual operations.

E ₁ = 13.2 kg/hr	E ₄ = 12.2 kg/hr
E ₂ = 12.6 kg/hr	E ₅ = 14.0 kg/hr
E ₃ = 11.2 kg/hr	E ₆ = 13.4 kg/hr
E = [(13.2 x 24) + (12.6 x 24) + (11.2 x 24) + (12.2 x 24) + (14 x 24) + (13.4 x 24)] x 48	
E = 88,243 kg/yr	

2.4 Emission factors

2.4.1 General emission factors

Emission factors can be used to estimate releases to the environment. An emission factor is a representative value that attempts to quantify the release of a pollutant to the environment. General emission factors have been developed from a variety of sources, but this guidance draws upon UK information in particular.

An empirical model is one in which the modeller develops a mathematical relationship between one or more process-related characteristics (input variables) and a set of release estimates (output variables). An example would be air releases of SO₂ from the recovery of air-dried unbleached pulp using multicyclone and venturi scrubbers and magnesium oxide as base. In this situation the input variable, expressed as 1000 kgs of air-dried unbleached pulp recovered, is known and is directly related to the output variable, expressed as the kgs of SO₂ emitted. The model itself would simply consist of a ratio: being the kgs of SO₂ emitted per 1000 kgs of air-dried unbleached pulp recovered. Such a ratio is often referred to as a release factor. The release factor in this scenario is 4.5 kgs of SO₂ emitted per 1000 kilograms of air-dried unbleached pulp recovered. Such release factors probably represent the most widely used method of estimating air releases.

Some release sources cannot be easily represented by a linear function between one operating parameter and the resulting release rate. Emission factors for these types of processes may require more than one input variable, and as such become slightly more complex than the simple linear model.

Another advantage of emission factors is that they can sometimes be used to generate default release factors for non-measurable substances by applying specific knowledge of the process characteristics.

Emission factors can be expressed in almost any units, allowing a great deal of flexibility in deciding on the most appropriate measure to use as the basis for the release factor. Typically, emission factors can be based on a reactant or process input (e.g. tonnes of coal or tonnes of ore processed, litres of solvent used) or a product or process output (e.g. m² of paper produced, kilowatts of energy produced). Where making use of emission factors the units should be noted and converted if necessary.

2.4.2 Air emission factors

Emission factors are usually expressed as the weight of a substance emitted, multiplied by the unit mass, volume, distance, or duration of the activity emitting the substance. In some cases, and particularly in the case of SO₂, the release factor is based on fuel analysis data because of the direct relationship to the fuel's sulphur content. Most emission factors are developed by taking the average measured release rate during a representative time interval and relating that to some other measure of the operating rate of the activity.

The primary limitation associated with the use of emission factors is that not all sources are designed or operated in the same way. For a large number of sources, however, some of the errors in the techniques would be associated with different operating conditions, and will very likely, average out. Another, more serious limitation of emission factors is that they are developed for a particular source type, and are at times applied to sources that are inherently different (this often happens when a better method cannot be found). These limitations should be considered in all analyses that rely on emission factors, as there can be large differences in such factors where facilities in a particular sector in one country may have significantly different features than those of the same sector in a different country.

Emission factors are widely used to estimate air releases in environmental management programmes of all kinds. While there is considerable information available on air release factors, a large portion of these documented release factors assess criteria substances such as volatile organic carbon (VOCs) or particulate matter, or very common compounds such as SO₂, lead or NH₃, and there are few release factor compilations for other specific substances, such as benzene, mercury and specific dioxins.

Emission factors are used to estimate a facility's substances releases by the general equation listed as Equation 4 (It is important to note that EF is the release factor for the pollutant after the release has been abated):

Equation 4

$$E = [A \times \text{Op Hours}] \times EF$$

Where:	E	Emission rate of pollutant (kg/yr)
	A	Activity rate of process (te/hr or m ³ /hr)
	Op Hours	Operating hours per year of activity (hr/yr)
	EF	Controlled emission factor of pollutant per activity (kg/te kg/m ³)

Depending on the availability of information, Equation 4 can be rewritten as:

$$E = M \times EF$$

Where:	E	Emission rate of pollutant (kg/yr)
	M	Activity rate in terms of mass of fuel burnt/product produced/feedstock in the year (te/yr)
	EF	Controlled emission factor of pollutant per activity (kg/te kg/m ³)

The following example shows how to estimate annual emissions using Equation 4.

Example 3

Estimating carbon monoxide (CO) emissions from light fuel oil combustion serves as an example of the simplest use of emission factors. Consider an industrial boiler that burns 4,000 litres of oil per hour and operate for 300 days per year. The CO emission factor given is assumed to be 0.6 kg of CO per 1000 litres of oil burned.

A	4,000 litres per hour (4m ³ /hr)
Op Hours	24 hours per day, 300 days per year
EF	0.6 kg/m ³
E = 4 x 24 x 300 x 0.6	
E = 17.280 kg/yr	

Where no mandatory or sector specific release factor exists it is encouraged that the emission factor used is calculated for the actual process using the equations provided above.

Provided that unit operations remain consistent, representative monitoring data can be used to generate site-specific release factors. The release factor will be the ratio of the measured or calculated release to the process activity (e.g. fuel flow rate). Site-specific release factors should be periodically verified to ensure their continued validity, especially where fuel quality varies throughout the year. Where different fuels are used, the release when using each fuel separately should be determined, and the results added together.

Where release factors are used for the estimation of the annual mass releases from a process you should first consider the use of any mandatory, or sector specific, factors developed for your industry; e.g. Emission factors for the Electricity Supply Industry (ESI). This will promote a consistent approach to calculating the annual mass releases within the same industry sectors across different sites.

Where an emission factor or RET is not available for a particular substance then you may review published information or use emission factors listed in the SPRI guidance. Care needs to be taken in selecting appropriate emission factors to ensure that the conditions under which the release factor has been determined are representative of the sites' operations. Preference should be given to using UK or European release factors over release factors from other sources.

Emission factors developed from measurements for a specific location can sometimes be used to estimate releases at other sites provided that the processes are comparable in size and operation. As previously mentioned, it is advisable to have a release factor reviewed and approved by us prior to its use for SPRI submissions.

In the case of new or modified processes, initial release factors can be obtained from manufacturers' data with sampling undertaken during commissioning to confirm the assumed values.

2.4.3 Carbon dioxide (CO₂) factors

The European Commission (EC) has published guidance on the monitoring and reporting of GHGs pursuant to [Directive 2003/87/EC establishing the EU ETS](#). The EC guidance sets out the approved methodology for estimating CO₂ emissions based on emissions from regular operations and abnormal events, including start-up and shut-down and emergency situations over the reporting period.

Under the EU ETS guidelines, the EC has put monitoring and reporting into a European-level Regulation, to bring harmonisation across Europe. The Monitoring and Reporting Regulation (MRR) is defined within [EC Regulation 601/2012](#). Further information on CO₂ reporting can be found on the [EC's website](#).

2.4.4 Other source factors

Other source factor for activities such as combustion, refineries and incineration can be found in the sector specific SPRI guidance documents relating to the activity in question.

2.4.5 Fuel/feedstock analysis and process stream data

The use of fuel/feedstock/raw material analysis and process stream data to determine emissions is similar to the use of emission factors. The basic equation used in fuel/feedstock analysis emission calculations is show in Equation 5, below;

Equation 5

$$E = Q_f \times [\text{Op Hours}] \times (\text{PC}_f/100) \times (\text{MW}_p/\text{EW}_f)$$

Where:	E	Emission rate of pollutant (kg/yr)
	Q _f	Fuel/feedstock/raw material use (kg/hr)
	PC _f	Pollutant concentration in the fuel/feedstock/raw material (%)
	Op Hours	Operating hours per year (hr/yr)
	MW _p	Molecular weight of pollutant as emitted after combustion/processing
	EW _f	Elemental weight of pollutant as present in fuel/feedstock/raw material

Where the pollutant concentration in the fuel/feedstock/raw material is consistent over the averaging period (i.e. one year), Equation 5 can be rewritten as:

$$E = M \times [\text{PC}_f/100] \times (\text{MW}_p/\text{EW}_f)$$

Where:	E	Emission rate of pollutant (kg/yr)
	M	Mass of fuel/feedstock/raw material used in one year (kg/hr)
	PC _f	Pollutant concentration in the fuel/feedstock/raw material (%)
	MW _p	Molecular weight of pollutant as emitted after combustion/processing
	EW _f	Elemental weight of pollutant as present in fuel/feedstock/raw material

The following example shows how to estimate annual emissions using Equation 5.

Example 4

This example shows how SO₂ emissions can be calculated from oil combustion, based on fuel analysis results and fuel flow information. It is assumed that the facility operates using oil for 150 hours per year and that abatement of SO₂ does not occur.

Q _f	2000 kg/yr
PC _f	1.17%
MW _p	64
EW _f	32
Op Hours	1500 hr/yr
E = Q _f x PC _f x (MW _p /EW _f) x [Op Hours]	
E = [(2000) x (1.17/100) x (64/32) x 150] kg/yr	
E = 7.02 x 10 ³ kg/yr	

Equation 5 can also be used for volatile elements such as fluorine and chlorine as well as trace metallic pollutants, although some of these species are retained in the plant, either in the ash or in the abatement equipment and appropriate retention factors applied.

When using Equation 5 you should be aware that the amount of pollutants present in the fuel/feedstock/raw material or process stream can vary significantly.

2.4.6 Fugitive emissions

Methodologies and factors used to calculate fugitive emissions are contained within the sector specific SPRI guidance documents relating to the activity in question.

2.4.7 Substances reported 'as'

Certain substances on the SPRI return are required to be reported as the main constituent; e.g. 'Nitrogen oxides, NO and NO₂ as NO₂'. When a conversion needs to be made, the emission concentration, or emission rate, should be multiplied by the molecular weight of the main constituent and divided by the molecular weight of the substance. This is shown in Example 5. Further guidance on reporting emission of specific compounds is given in the SPRI General Guidance Note.

Example 5

Assume a discharge concentration of NO is 50 mg/m³. Using the molecular weights of NO and NO₂, the equivalent discharge concentration of NO₂ can be determined.

Relative atomic mass of NO	30
Relative atomic mass of NO ₂	46
Concentration of NO as NO ₂ = 50 x 46 / 30	
= 76.7 mg/m ³	
The mass of NO ₂ released can then be calculated in accordance with Equation 1.	

2.4.8 If no emission factors or RETs are available

If an emission factor or other RET is not available then please contact us.

2.4.9 Units

In completing the SPRI return, care should be taken with the units of the substances reported. A checklist of unit prefixes is included in Annex 3 to help you with this process.

3 Wastewater and water releases

3.1 Introduction

Emissions of substances to water can be recorded as either, direct to the water environment, where it is directly discharged via a sewer to groundwater, rivers, lochs, estuaries or coastal waters or pollutants may be transferred in waste water to an off-site urban wastewater treatment plant (UWWTP) by sewer pipe. Such data should be recorded at a pollutant level within Section C of your SPRI form.

If your wastewater is treated at an independently-operated wastewater treatment plant (IOWWTP) covered by Section 5 of the Pollution Prevention and Control (Scotland) Regulations 2012 (as amended), then this waste stream should be recorded as a transfer in tonnes/year within Section D – Waste Transfers. Any transfers of liquid waste from the SPRI-reporting site by road tanker or other liquid container should also be reported within Section D – Waste Transfers.

Guidance on what constitutes an emission or a transfer is contained in the General SPRI Guidance document.

3.2 Releases to water

There is less choice in the techniques to use for the determination of emissions to water than for emissions to air. The most appropriate method is to use direct measurement; however you may use other RETs, particularly mass balances or site specific emission factors where appropriate. Mass balances can often be used where emissions to water are very complex and difficult to quantify with other approaches. However, a mass balance calculation is still likely to require direct measurement of emissions from some of the water pathways in order to verify the calculations. Site specific emission factors are determined from the ratio of the measured or calculated pollutants emission to the water flow rate.

3.3 Sampling

Releases into wastewater and water are generally confined to a pipe or some other conveyance system. Frequently, flow meters are placed at critical locations in the conveyance system in order to monitor conditions that would indicate a breach, a constriction, or a process upset. Releases can be estimated by measuring the concentrations of target substances in wastewater flows. T

The concentration of the substance in wastewater can be expressed in units of mass/volume multiplied by the flow rate in units of volume/time, yielding a direct release rate expressed in units of mass/time. In order to estimate the mass release to water, the appropriate concentration is then multiplied by the flow rate for that particular discharge point. These representative discharge rates are then aggregated together based on the time for which the water is discharged at that rate. The estimated mass releases from all discharge points to either sewer or controlled water should then be summed for each individual for each reporting medium.

Using a direct measurement technique requires information on both the flow rate and pollutant concentration. Measurement of flows and pollutant concentrations should be undertaken at the same time during representative operating conditions. Particular care should be taken when relying on results of one spot sample in order to report annual emissions unless you can be certain that operating conditions are representative. Where a process has a number of operating conditions, it may be necessary to take samples at each condition and average the result according to the length of time the process operates at each condition. Similarly, where process conditions at the time of the spot sampling are uncertain, then it may be necessary to take several samples and the results averaged in order to provide the final annual emission estimate.

An approximation of continuous monitoring of water substances is often accomplished by collecting composite samples of wastewater. Composite samples, collected over a set period of time, are then analysed for a variety of different parameters. One approach based on volume proportional sampling has been shown to be nearly as accurate as continuous monitoring; however when a process has instabilities, or otherwise varies over time, the operator should be aware that composite samples may obscure temporal patterns.

For those processes that have wastewater releases that are consistent over time, periodic monitoring of the concentration, along with the standard and continuous monitoring of flow, will provide accurate and representative estimates of the releases.

Sample acquisition, stabilisation, and handling are all relatively straightforward procedures. Furthermore the analytical methods for many common water substances are automated and the analysis costs are typically lower relative to the operating costs of modern industrial facilities. For these reasons, periodic direct monitoring approaches are a primary method for making estimates of releases from confined industrial wastewater flows.

The frequency of sampling will depend on the variability of the data. Initially, it may be necessary to take several samples and average the results to yield an annual result. If, however, the results indicate that a concentration and flow are reasonably constant, then the frequency of sampling may be reduced to a practical minimum of once per year. You should be able to justify the sampling regime selected and this may be supported by a history of previous measurements. The sampling requirements will usually be set out in your permit and it is important to note that no additional sampling and monitoring is required solely for the purposes of reporting to the SPRI.

The background load of a reportable substance in water may also need to be taken into account. For example, if water is collected at the site of the installation from a neighbouring river, lake or sea for use as process, or cooling, water which is afterwards released from the site of the facility into the same river, lake or sea, the “release” caused by the background load of that substance can be subtracted from the total release of the installation. The measurements of pollutants in collected inlet water and in released outlet water must be carried out in such a way that ensures that they are representative of the conditions occurring over the reporting period. If the additional load results from the use of extracted groundwater, or drinking water, it should not be subtracted since it increases the load of the pollutant in the river, lake or sea.

It may also be necessary to take account of the fact that evaporation of water from the process will lead to an increase in the concentration. This can be done by using Equation 6:

Equation 6

$$PC = (OC - [IC \times VF])$$

Where:	PC	The pollutant emission concentration due to the process (mg/l)
	OC	The measured pollutant concentration in the discharge (mg/l)
	IC	The measured pollutant concentration in the feed water (mg/l)
	VF	The ratio of volume of water extracted to volume of water discharged

In order to estimate the mass emission to water, the appropriate pollutant concentration is then multiplied by the flow rate for that particular discharge point. These representative discharge rates are then aggregated together based on the time for which the water is discharged at this rate. The estimated mass emissions from all discharge points to either the water environment, or in wastewater transfers, should then be summed for each individual pollutant for each reporting medium.

For emission points fitted with continuous monitors, calculation of mass emissions from a particular discharge point can be made automatically. However, for cooling water it may also be necessary to adjust the measured data to take account of input pollutant concentration as described previously, and it is good practice to manually check automatic calculations to ensure that they are accurate.

Example 6 shows how to estimate annual mass flow of a substance from cooling water discharges taking into account water evaporation in the plant.

Example 6

The chromium concentration $[OC_{cr}]$ and annual volume flows from 3 separate discharge points is:	
$[OC_{cr}]_1 = 2.2 \times 10^{-3} \text{ mg/m}^3$	$V_1 = 4.2 \times 10^6 \text{ m}^3$
$[OC_{cr}]_2 = 1.2 \times 10^{-3} \text{ mg/m}^3$	$V_2 = 36 \times 10^6 \text{ m}^3$
$[OC_{cr}]_3 = 4.5 \times 10^{-3} \text{ mg/m}^3$	$V_3 = 21 \times 10^6 \text{ m}^3$
Chromium inlet concentration $[ICcr]$	$= 0.12 \times 10^{-3} \text{ mg/m}^3$
Volume of water extracted during testing period	$= 15,000 \text{ m}^3$
Volume of water discharged during testing period	$= 14,300 \text{ m}^3$
Volume factor	$15,000/14,300 = 1.05$
From Equation 6, the following average process concentrations are as follows:	
$[PC]_1 = \{2.2 \times 10^{-3} - [0.12 \times 10^{-3} \times 1.05]\} = 2.07 \times 10^{-3} \text{ mg/m}^3$	
$[PC]_2 = \{1.2 \times 10^{-3} - [0.12 \times 10^{-3} \times 1.05]\} = 1.07 \times 10^{-3} \text{ mg/m}^3$	
$[PC]_3 = \{4.5 \times 10^{-3} - [0.12 \times 10^{-3} \times 1.05]\} = 4.37 \times 10^{-3} \text{ mg/m}^3$	
Total annual chromium mass emission $= \{[PC]_1 \times V_1\} + \{[PC]_2 \times V_2\} + \{[PC]_3 \times V_3\}$	
$= \{2.07 \times 10^{-3} \times 4.2 \times 10^6\} + \{1.07 \times 10^{-3} \times 36 \times 10^6\} + \{4.37 \times 10^{-3} \times 21 \times 10^6\}$	
$= 139 \text{ g (below the reporting threshold)}$	

3.4 Water emission factors

When monitoring data is not available, emission factors can be used to quantify pollutant releases to water from point sources. Emission factors are most useful for well-defined and regulated processes, such as chemical processing activities in continuous operation. As is the case for emission factors used to predict releases of air pollutants, emission factors for water pollutants will provide greater accuracy for aggregate estimates that represent large numbers of similar sources and for long averaging times. Individual source variability, and variability in the effluent characteristics over time, is generally not well represented by average emission factors. Many emission factors for water pollutants address classes of pollutants, such as total nitrates, soluble organic matter, or silt in water, as opposed to specific compounds such as mercury or chlorine.

3.5 Substances reported 'as'

Certain substances on the SPRI return are required to be reported as the main constituent; e.g. 'Chlorides – total as Cl'. For instances when a conversion needs to be made, the emission concentration should be multiplied by the molecular weight of the main constituent and divided by the total molecular weight of the substance. This is shown in Example 7. Further guidance on reporting emission of specific compounds is given in the SPRI General Guidance Note.

Example 7

The measured concentration of sodium chloride is 50 mg/l and the total volume released is 1,000 m³.

Relative atomic mass of sodium	23
Relative atomic mass of chlorine	35
Molecular weight of sodium chloride	58
Concentration of sodium chloride as chloride $= 50 \times 35 / 58$	
$= 30.2 \text{ mg/l which} = 30.2 \text{ g/m}^3$	
The mass of chloride release is $(30.2 \times 10^{-3}) \times 1000 = 30.2 \text{ kg}$, and is below the reporting threshold.	

3.6 If no emission factors or RETs are available

If an emission factor or other RET is not available then please contact us

3.7 Units

In completing the SPRI return, care should be taken with the units of the substances reported. A checklist of unit prefixes is included in Annex 3 to help you with this process.

4 Off-site waste transfers

4.1 Introduction

You are asked to report waste or tankered liquid waste removed from the site. All sites are likely to produce some waste and should address this issue.

You are required to report waste transfers from your site where the reporting thresholds of **2 tonnes/yr for hazardous waste** and/or **2,000 tonnes/yr for non-hazardous waste** are exceeded.

Any transfer of waste off-site to a third party is covered by the Duty of Care provisions of the Environmental Protection Act 1990. This includes the requirement to describe the waste and record the quantity. You should therefore use data generated in compliance with Duty of Care requirements to complete the SPRI return.

If tankered waste is to be further processed, such as, dewatering of oily waste by a specialist waste contractor, it should be recorded within this Section. However, where tankered waste is destined to be treated at an Urban Waste Water Treatment Plant (UWWTP) outwith your site it should be recorded with **Section C** "Waste Water".

4.2 Transboundary shipments of hazardous waste

For transboundary movements of hazardous waste (outwith the UK), the name and address of the recoverer or the disposer of the waste and the actual recovery or disposal site have to be reported.

5 Other forms of RET

5.1 Mass balance

The mass balance technique is the simplest conceptual form of release estimation not involving direct monitoring, although in practice it can be the most complex to develop. These models rely on the fundamental fact that what goes in must:

- Either come out in the form of a product or as an release, or
- Be chemically changed to some other compound.

A release can therefore be modelled from any system by knowing the amount of pollutant going into the system and the amount that is created or destroyed within the system. Any positive difference between inputs and net destruction (destruction – creation) in the system must therefore represent a release.

Equation 7

Output = Input - Consumption + Generation

In practice, because most systems have multiple releases, one generally deals with a set of known outputs (for example the amount of the pollutant incorporated into the product and the amount in known wastes) in order to model an unknown output (for example air releases).

For more complex systems, the conceptual simplicity of this approach is offset by intensive data requirements that will usually require direct monitoring of the other processes. Care should be taken to apply the mass balance approach to the media and combinations that have the lowest uncertainty or the most benign potential effects. Moreover, the margin of error resulting from mass balance applications should be taken into account when considering this technique.

It is also possible to apply an overall mass balance estimate to check the validity of the individual estimates of releases to the various media.

A mass balance check may be particularly useful for source and combinations that have relied on differing estimation techniques and that have uncertainties that are either unknown or cannot be easily calculated. It is a relatively simple procedure to add up all of the release estimates for the individual media and compare the results to the known amounts of the pollutant that is input to the process. The results will help to establish a measure of how reasonable the individual estimates are.

Mass balance methods may or may not account for release controls, depending on the system, process or operation to which the mass balance is applied. Care should be taken to ensure that pollution control equipment is taken into account when performing mass balance calculations.

5.1.1 Air releases and mass balance

There are certain forms of mass balance that can be used to estimate releases from specific industrial applications. The amount of a solvent used as a raw material in any defined time period is almost always known. If the process adds a specific amount of the solvent to the product, and the amount emitted as water and/or if the chemicals in the waste are known, the air release can be inferred by subtraction. These approaches can be used in complex operations for non-point source releases that result from many potential release points such as pumps, valves, flanges or monitoring ports.

5.1.2 Water and wastewater releases and mass balance

Releases to water and wastewater are often estimated by a mass balance approach. This technique is well suited to situations where releases to water are very complex and difficult to quantify with other approaches. The approach is similar to that used to quantify releases of solvents to air using mass balances.

This technique may be especially well suited for facilities involved in chemical synthesis that wish to quantify their solvent releases to water, but do not have any direct monitoring or release factors. For example, releases to water from a chemical facility may come from numerous discharge points that are not easily sampled or identified. In this case, performing a mass balance calculation for a specific solvent, or, can be the most efficient means of estimating representative releases to water.

5.2 Engineering calculations

An alternative approach to modelling that can be somewhat less data intensive than mass balance modelling is to consider the detailed relationships that exist within an identified system. A process specific model, in effect, replaces knowledge of what the inputs and outputs of a system are with knowledge of what is likely to happen to an input or an output, inside the modelled system. For example, while a mass balance model of a storage tank is likely to consider inflow and outflow to estimate breathing losses, a process specific model might focus on pressures inside the tank, vapour pressure of the liquid in the tank, and the operating parameters of relief valves. There is an infinite range of possible models between (what is commonly referred to as) the pure black box model (mass balance model) and the completely transparent process model (process specific model). The more information known about the inputs and outputs, the less knowledge is needed about internal processes, and vice versa.

5.2.1 Air releases and engineering calculations

Calculations using models can be applied to sources that have releases related to an activity, and that are also influenced by some other external factor that is not related to the activity. For example, some sources of volatile organic substances are affected by temperature in addition to the amount of activity. In circumstances where it is easier to measure the operating parameters of a process than to directly assess releases, the calculation model can be described as indirect monitoring. Some examples of sources where releases reflect both a primary measure of activity and an additional process condition are listed in Table 1.

Table 1 – Examples of source/activity for which calculation models are used

Source	Factors	Dependent Parameters
Tank (vapour evaporation)	Quantity of liquid stored	Temperature, turnover rate
Surface impoundment (evaporation)	Mass loading rate	Temperature, wind speed, pH

A key weakness associated with calculation models is similar to the weakness associated with release factors. These methods are sometimes inappropriately applied to sources that are operated differently from the sources that were used to develop the model. In other cases, these methods may require some specific types of information that may not be readily available to the developer.

5.3 Indirect monitoring

In some cases, it is possible to infer information about releases by monitoring other process parameters. This is known as indirect monitoring and can be very useful for sources that have release signatures that are dependent on standard operational conditions, such as temperature, pressure or moisture/water content. In most situations, however, indirect monitoring is used to obtain enough data to adequately represent average conditions related to the desired spatial and temporal scales. In some cases, periodic monitoring of certain pollutants can be used to represent other pollutants by applying average ratios, or by using some other known conditions related to the source.

Consider a process for which the release depends directly on the temperature and pressure within a reactor. In many cases, the product yield and/or product quality may also depend on those parameters. The parameters may be routinely monitored as a part of the production process. Those same parameters can then be used to estimate releases. For a process that has been very well characterised, indirect monitoring methods can be used to develop release estimates that are nearly as accurate as direct monitoring for selected sources at a fraction of the cost.

5.3.1 Water and wastewater releases and indirect monitoring

Indirect monitoring (calculation models with some parameters monitored in real time) can be applied in many cases for estimating water contaminants from industrial point source releases to water and wastewater. The amount and nature of water substances emitted from industrial facilities are often directly related to one or more process related parameters, and estimates of releases to water and wastewater can often be determined to a high degree of accuracy from measurements of these parameters.

Often, wastewater streams are not analysed for target pollutants but for more general parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen concentrations or total organic carbon (TOC). These measurements provide a relatively inexpensive and easy test of the pollutant load in wastewater, but not of the specific pollutants. Knowledge of the potential pollutants in the wastewater may make these general tests more cost effective than analysing water for specific levels of individual pollutants.

5.4 Engineering judgement

All of the approaches previously discussed are typically described as explicit models. That is, the parameters and assumptions used to make the prediction of a release can be stated unambiguously. Frequently, however, releases are estimated using methods that are more intuitive. Such implicit models take advantage of the experience and professional knowledge of the estimator, using knowledge of the chemical and physical properties involved, the design features of the source and an understanding of the applicable physical and chemical laws.

Over time these approaches have been discussed collectively as methods based on engineering judgement. While it has been recognised that the use of engineering judgement methods has the potential for errors and inconsistencies, the practical advantage of their role in developing release estimates quickly and inexpensively should not be unduly minimised.

Often, engineering judgement methods are used initially to provide estimates in the first year or two of reporting. The analysis and interpretation of these results then frequently lead to the use or development of more sophisticated methods that can improve the accuracy, specificity and uses of the data.

Engineering judgement refers to approaches that are based on informed assessments and direct experience. These approaches are primarily used in cases where none of the more explicit estimation methods are judged to be applicable for a particular source or category of sources. Frequently, engineering judgement is applied to make estimates of one component by assuming that the release rate is proportional to another component for which a more accurate method was used. For example, releases of a particular type of reactive organic solvent used in a process may be routinely estimated as part of another specific environmental media programme. The reagent used in the process may include an additive that acts as a preservative. The additive, which would be present in a small concentration and not be involved in the process, would not be of as much interest as the reactive organic compound. The releases of the additive could be estimated in proportion to the releases estimate for the reactive organic compound. This type of estimate would be considered engineering judgement.

The reliability of these estimates depends on the complexity of the process and the level of understanding of its physical and chemical properties. To apply an engineering assessment method, there are four basic principles, which should be followed:

- Review all data pertaining to the specific source and to the industrial sector in general;
- Use this data to provide gross approximations and refine these using sound engineering principles as data becomes available to provide more accurate estimations;
- Whenever possible, alternative methods of calculation should be conducted to cross-check each level of approximation;
- Employ good record keeping by documenting all related information for further release refinement when more accurate data become available.

There are many possible engineering judgement methods that could be developed depending on the particulars of specific processes and sources. It is not possible to mention all of them here, but similar engineering judgement methods are likely to be obvious in particular circumstances as they arise. There is no ready way of characterising the application of engineering judgements to different release media.

6 Pollutant-specific reporting conventions for releases to air

For all pollutants the total mass of the specified pollutant should be reported unless otherwise specified. Within this section, specific guidance is provided for these pollutant groups.

6.1 Metals and compounds

For metals and compounds the mass of each relevant compound should be converted to its mass of metal equivalent (by dividing by its relative molecular mass and multiplying by the relative atomic mass of the metal). The total mass reported should be the sum of these figures for a given metal and its compounds.

6.2 Brominated diphenylethers

The total mass of all compounds of this type should be reported expressed as the equivalent mass of bromine (Br). If data is available on a number of compounds of this type divide the mass of each by its relative molecular mass then multiply by 80 to give the equivalent mass of bromine, and then sum these figures to give the total mass to be reported.

6.3 Chlorine and total inorganic chlorine compounds

The mass of each inorganic chlorine compound and chlorine should be converted to the equivalent mass of hydrogen chloride (HCl) (by dividing by relative molecular mass and multiplying by 36.5) then these figures summed to give the total mass to be reported as the total HCl equivalent.

6.4 Fluorine and total inorganic fluorine compounds

The mass of each inorganic fluorine compound and fluorine should be converted to the equivalent mass of hydrogen fluoride (HF) (by dividing by relative molecular masses, multiply by 20) then these figures summed to give the total mass to be reported as the total HF equivalent.

6.5 Halogenated fluorocarbons

There are six groups of halogenated fluorocarbons which you should consider reporting to the SPRI. In each case the total mass should be reported. These are summarised below in Table 2.

Table 2 – Types of halogenated fluorocarbons

Acronym	Name	Composition	Description
CFC	Chlorofluorocarbons	Chlorine + fluorine + carbon only	A general class of halogenated organic compounds based on methane and ethane, in which all of the hydrogen atoms have been fully substituted with chlorine and fluorine atoms.
	Halons	Fluorine +/- chlorine + carbon + one other halogen	For the purposes of SPRI reporting halons are a general class of halogenated organic compounds based on methane and ethane, in which all of the hydrogen atoms have been substituted with chlorine and/or fluorine and at least one other halogen species. In practice this definition means that a halon will contain bromine atoms in addition to chlorine and/or fluorine atoms.
HCFC	Hydrochlorofluorocarbons	Hydrogen + chlorine + fluorine + carbon only	A general class of halogenated organic compounds based on methane and ethane in which some of the hydrogen atoms have been substituted with chlorine and fluorine atoms.
HFC	Hydrofluorocarbons	Hydrogen + fluorine + carbon only	A general class of halogenated organic compounds based on methane and ethane in which some of the hydrogen atoms have been substituted with fluorine atoms.
PFC	Perfluorocarbons	Fluorine + carbon only	A general class of halogenated organic carbons based on methane and ethane in which all of the hydrogen atoms have been substituted with fluorine atoms.

6.6 Dioxins and furans

Dioxins and furans are a family of compounds known chemically as polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Each compound is made up of two benzene rings interconnected by oxygen atoms. Each individual PCDD or PCDF is termed a congener (there are 210 congeners in total).

In reporting dioxin and furan releases to the SPRI, only the mass of PCDD and PCDF with chlorine atoms in the 2, 3, 7 and 8 benzene ring positions (which are of particular environmental concern) should be included. The 17 relevant PCDD and PCDF congeners are listed in Table 4 (see below) and an annual mass release based on WHO-TEQ values for the sum of the 17 pollutants listed should be reported.

There are various ways of reporting dioxin releases in terms of their toxicity. The two schemes to be used in reporting to the SPRI are those of International Toxicity Equivalents (I-TEQ) and World Health Organisation Toxicity Equivalents (WHO-TEQ). Both methods should be used to report dioxin releases within your SPRI return.

Under these schemes each dioxin congener is assigned a toxic equivalency factor (I-TEF for the International scheme and WHO-TEF for the WHO scheme). The 2,3,7,8-TCDD isomer is the most toxic, and by convention is assigned a TEF of 1.0. The remaining 2,3,7,8 - positional congeners are then assigned lower TEFs, relative to that of 2,3,7,8-TCDD.

The toxicity mass of a particular substance relative to 2,3,7,8-TCDD, can then be expressed by multiplying the mass of those 2,3,7,8- positional congeners present in the mixture by their respective TEFs. The resulting toxic equivalents (TEQs) are expressed in terms identical to those in which the individual congeners are expressed, which for SPRI purposes is mass. You must give the total quantity of dioxins and furans in terms of their I-TEQ and WHO-TEQ values.

TEFs for each of the 17 relevant 2,3,7,8- positional congeners of PCDDs and PCDFs are presented in Table 3. All other congeners that may be present in a sample are assigned a TEF value of 0.0 and so are not reportable to the SPRI.

If releases monitoring data representative of annual releases are available, the TEQ of the mixture is obtained by summing the individual TEQs using the following approach:

Step 1	Calculate the TEQ for each congener emitted	Multiply the concentration (per m ³) of each emitted congener by its TEF and then by the total volume emitted in that year (in m ³) to provide the TEQ.
Step 2	Calculate the total TEQ emitted	Add together the TEQs of all the congeners emitted.
Step 3	Repeat steps for TEFs	Carry out steps 1 and 2 for both sets of TEFs.

Table 3 – Dioxin congeners to be considered when calculating total releases and associated International and WHO toxic equivalency factors

Congener	WHO-TEF*	I-TEF†
PCDDs		
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	1	0.5
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD*	0.0003	0.001
PCDFs		
2,3,7,8-TCDF	0.1	0.1
2,3,4,7,8-PeCDF *	0.3	0.5
1,2,3,7,8-PeCDF*	0.03	0.05
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF*	0.0003	0.001
WHO-TEF: World Health Organisation Toxic Equivalency Factor. I-TEF: International Toxic Equivalency Factor (T = tetrachloro, Pe = pentachloro, Hx = hexachloro, Hp = heptachloro, O = octachloro)		
*Van den Berg et al., 1998. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environmental Health Perspectives, 106 (12), 775-792.		
NATO/CCMS. (1988) Scientific basis for the development of the International Toxicity Equivalency Factor (I- TEF) method of risk assessment for complex mixtures of dioxins and related compounds. Report No. 178 Dec 1988.		
The 2005 World Health Organization re-evaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds.		

6.7 Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are a group of 209 chlorinated organic compounds. The UK Committee on Toxicity (CoT) has recommended 13 PCB congeners as a priority, which may have a dioxin-like effect, and these are listed Table 4 below.

For releases to air (the requirement is different for water) an annual mass release based on WHO-TEQ values for the sum of the 12 pollutants listed in Table 4 should be reported. Other PCBs are assumed to have a TEF of zero and so are not considered reportable for the purposes of the SPRI. Where monitoring has been carried out, calculating TEQ values requires the same approach as for dioxins and is outlined in the following steps:

Step 1	Calculate the WHO-TEQ for each PCB emitted	Multiply the concentration (per m ³) of each emitted PCB by its WHO-TEF and then by the total volume emitted in that year (in m ³) to provide the WHO-TEQ.
Step 2	Calculate the total WHO-TEQ emitted	Add together the WHO-TEQs of all the congeners emitted.

Table 4 - PCBs and their toxic equivalency factors (WHO-TEF)

PCB	IUPAC number	WHO-TEF*
non-ortho		
3,3',4,4'-TCB	77	0.0001
3,4,4,5'-TCB	81	0.0003
3,3,4,4',5-PeCB	126	0.1
3,3',4,4',5,5'-HxCB	169	0.03
mono-ortho		
2,3,3',4,4'-PeCB [#]	105	0.0003
2,3,4,4',5-PeCB [#]	114	0.0003
2,3',4,4',5-PeCB [#]	118	0.0003
2',3,4,4',5-PeCB [#]	123	0.0003
2',3,3',4,4',5-HxCB [#]	156	0.0003
2,3,3',4,4',5'-HxCB [#]	157	0.0003
2,3',4,4',5,5'-HxCB [#]	167	0.0003
2,3,3',4,4',5,5'-HpCB [#]	189	0.0003

6.8 Polycyclic aromatic hydrocarbons (PAHs)

The total mass figure for individual PAHs should be reported separately where possible and all other PAH releases should be summed and reported as a single total mass value. Where appropriate you should report the polycyclic aromatic hydrocarbons (PAHs) (four indicator compounds of LRTAP), listed in Table 5. Additional PAHs of concern listed in Table 6 should also be reported individually.

Table 5 – PAHs to be considered when calculating total releases

	CAS no.	Molecular mass (g)
Benzo(a)pyrene	50-32-8	252.32
Benzo(k)fluoranthene	207-08-9	252.32
Indeno(1,2,3-cd)pyrene	193-39-5	276.34
Benzo(b)fluoranthene	205-99-2	252.32

Table 6 – Individual PAHs to be reported to SPRI

	CAS no.	Molecular mass (g)
Anthracene	120-12-7	178.23
Chrysene	218-01-9	228.29
Fluoranthene	206-44-0	202.26
Napthalene	91-20-3	128.17

6.9 Oxides of nitrogen and sulphur

The releases of oxides of sulphur, expressed as the mass equivalent of sulphur dioxide, should be reported. In practice this means converting any sulphur trioxide releases to the equivalent mass of sulphur dioxide (by multiplying by 0.8) and adding to the mass of sulphur dioxide emitted.

Oxides of nitrogen releases are defined as the sum of nitrogen dioxide and nitric oxide releases reported as the NO₂ equivalent. The nitric oxide releases should be converted to their nitrogen dioxide mass equivalent (by multiplying by 1.5) before being added to the mass of nitrogen dioxide emitted.

6.10 Non-methane volatile organic compounds (NMVOCs)

The mass of a number of specific organic compounds (VOCs) and total mass of non-methane VOCs (NMVOCs) must be reported in Section C of the form. The term VOC covers a wide range of pollutants with different environmental impacts. They are principal components in atmospheric reactions that form ozone and other photochemical oxidants. For the purpose of this guidance, and when completing the SPRI reporting form, VOCs are defined as:

'Any organic compound emitted to the atmosphere from the operator's facility or process, but excluding releases of naturally produced (i.e. not man made) volatile organic compounds from within the plant boundary and methane (which is a non-reactive compound and is therefore not classified as a VOC)'.

This definition is derived from the definition of VOCs in the UNECE VOC Protocol concerning the control of releases of volatile organic compounds and their transboundary fluxes (Protocol to the UNECE Convention on long-range transboundary air pollution).

Organic compounds with no photochemical reactivity may also be excluded from this classification. If you believe your process emits a VOC that is not photochemically reactive, you should discuss and reach agreement on this with us before excluding it from the SPRI return.

6.11 Particulate matter (PM) to air

Where particulate matter (PM) is released as part of your company's process you should report separately the total mass of particulate matter emitted (termed 'Particulate matter – total') and the masses of the smaller fractions, PM₁₀ and PM_{2.5} where required.

6.12 Carbon dioxide (CO₂) to air (biomass percentage)

Within Section C (Releases to Air) you are able to record the percentage (%) biomass from any non-fossil fuel combustion processes from your SPRI process. This is the percentage of the total CO₂ emissions attributable to biomass fuels. Where you record "BRT" you can still enter a percentage figure within the "Biomass Percentage" box. If you calculate you are above the reporting threshold enter the total CO₂ figure, which should include both fossil fuel emissions as well as biomass derived releases. Within your "Method Description" you should enter full details of how this biomass percentage figure was calculated, this should quote the figures in kg/yr for both non fossil fuel derived CO₂ (biomass) as well as fossil fuel CO₂.

7 Pollutant-specific reporting conventions for releases to water

For all pollutants the total mass of the specified pollutant should be reported unless otherwise specified. Specific guidance is provided below for these pollutant groups. As in the case for releases to air certain substances on the SPRI return are required to be reported as the main polluting constituent.

7.1 Metals and compounds

For 'Metals and compounds' the mass of each relevant compound should be converted to its mass of metal equivalent (by dividing by its relative molecular mass and multiplying by the relative atomic mass of the metal) and the total mass reported should be the sum of these figures for a given metal and its compounds.

7.2 Brominated diphenylethers

The total mass of all compounds of this type should be reported expressed as the equivalent mass of bromine (Br). If data is available on a number of compounds of this type divide the mass of each by its relative molecular mass then multiply by 80 to give the equivalent mass of bromine and then sum these figures to give the total mass to be reported.

7.3 Chlorides, fluorides and cyanides

For each of these classes of compounds, convert the mass of individual inorganic species where known to the equivalent mass of chloride, fluoride or cyanide and report the sum in each class.

7.4 Halogenated organic compounds

The mass of the fraction of adsorbable organohalogenated compounds, adsorbable organic halogens (AOX) should be reported. This measurement indicates the overall level of the halogens; fluorine, chlorine, bromine and iodine.

7.5 Nitrogen

Convert the mass of individual inorganic nitrogen-containing species (e.g. nitrate, nitrite, etc.) where known to the equivalent mass of nitrogen (N) and report the sum.

7.6 Phenols

Convert the mass of individual phenols to the equivalent mass of carbon and report the sum.

7.7 Phosphorus

Convert the mass of individual inorganic phosphorus-containing species (phosphate, etc.) where known to the equivalent mass of phosphorus (P) and report the sum.

7.8 Ammonia

Convert the mass of individual inorganic ammonical species (e.g. NH_3 , NH_4^+ , etc.) where known to the equivalent mass of ammonia (NH_3) and report the sum

7.9 Polychlorinated biphenyls (PCBs)

Report the total mass of all PCBs emitted from your SPRI site.

7.10 Polycyclic aromatic hydrocarbons (PAHs)

The reporting requirements for substances to consider are the same as for air, stated in Table 5 above, however separate reporting of benzo(a)pyrene is not required.

7.11 Total organic carbon (TOC)

Report the TOC annual load. In the absence of this data the value can be taken as one third of the annual chemical oxygen demand (COD) load.

8 Appendix 1 – Normalisation of emission concentrations

In many cases, pollutant emission concentrations to air are reported as normalised concentrations, the actual measured emission concentration having been adjusted to a normalised temperature (273K), oxygen, pressure and/or water vapour concentration. In calculating mass emissions to air, it is important that either the actual release concentration is multiplied by the actual volumetric flow rate, or the normalised concentration is multiplied by the normalised volumetric flow rate. In many cases, emission concentrations and volumetric flow rate are quoted in different ways, and you should ensure that the measurements are multiplied together on a consistent basis.

The following equations can be used to correct measured concentrations and flow rate for temperature, oxygen, pressure and water vapour content. It should be noted that the equations for correcting concentrations and volumetric flow rate are simple inversions of each other.

Concentrations

To correct for moisture concentration to dry (0% oxygen)

$$C_d = C_m \times (100/(100 - \%H_2O))$$

Where C_d is the dry concentration
 C_m is the measured concentration
 $\%H_2O$ is the measured water vapour percentage

To correct the % oxygen to dry basis (if required – may already be measured dry)

$$O_{2(dry)} = O_{2m} \times (100/(100 - \%H_2O))$$

Where $O_{2(dry)}$ is the dry oxygen percentage
 O_{2m} is the measured oxygen percentage

To correct to normalised oxygen concentration

$$C_{corr} = C_d \times (20.9 - O_{2norm})/(20.9 - O_{2(dry)})$$

Where C_{corr} is the corrected concentration for oxygen concentration
 O_{2norm} is the stated normalised oxygen percentage

To correct for temperature

$$C_{normT} = C_{corr} \times ((273 + T_m)/273)$$

Where C_{normT} is the normalised concentration for temperature
 T_m is the measured temperature in degrees centigrade

To correct for pressure

$$C_{norm} = C_{normT} \times (101.3/P_m)$$

Where C_{norm} is the normalised concentration
 P_m is the measured pressure in kPa

Volumetric flow rates

To correct for moisture concentration to dry (0% oxygen)

$$Q_d = Q_m \times ((100 - \%H_2O))/100$$

Where Q_d is the dry volumetric flow rate
 Q_m is the measured volumetric flow rate
 $\%H_2O$ is the measured water vapour percentage

To correct the % oxygen to dry basis (if required – may already be measured dry)

$$O_{2(dry)} = O_{2m} \times (100/(100 - \%H_2O))$$

Where $O_{2(dry)}$ is the dry oxygen percentage
 O_{2m} is the measured oxygen percentage

To correct to normalised oxygen concentration

$$Q_{corr} = Q_d \times (20.9 - O_{2(dry)})/(20.9 - O_{2norm})$$

Where Q_{corr} is the corrected volumetric flow rate for oxygen concentration
 O_{2norm} is the stated normalised oxygen percentage

To correct for temperature

$$Q_{normT} = Q_{corr} \times (273/(273 + T_m))$$

Where Q_{normT} is the normalised volumetric flow rate for temperature
 T_m is the measured temperature in degrees centigrade

To correct for pressure

$$C_{norm} = C_{normT} \times (P_m / 101.3)$$

Where C_{norm} is the normalised volumetric flow rate
 P_m is the measured pressure in kPa

9 Appendix 2 – Conversion factors

ppm to mg/m³ – air

The conversion between ppm and mg/m³ is dependent on both the molecular weight of the substance and the temperature at which the conversion is made. The assumption is that the pollutant behaves as an ideal gas and as such, 1 mole of the substance occupies 22.4 litres at standard temperature (273K) and pressure (101.3 kPa). This is consistent with normalised concentrations, and it is therefore not normally necessary to take account of the temperature or pressure difference in the conversion. However, when converting ppm to mg/m³ at actual discharge conditions, it is important to take account of the necessary factors.

To convert from ppm to mg/m³, the following formula should be used:

$$\text{mg/m}^3 = \text{ppm} \times (\text{MW}/22.4) \times (273/\text{T}) \times (\text{P}/101.3)$$

Where MW is the molecular weight of the substance (in grams)
 T is the temperature at which the conversion is to be made (degrees Kelvin)
 P is the pressure at which the conversion is to be made (kPa)

To convert from mg/m³ to ppm, the following formulae should be used:

$$\text{ppm} = \text{mg/m}^3 \times (22.4/\text{MW}) \times (\text{T}/273) \times (101.3/\text{P})$$

ppm to mg/l – Water

The conversion between ppm and mg/l for water is straightforward in that it is normally assumed that water has a density of 1000 kg/m³. On this basis, 1 ppm = 1 mg/l = 1 g/m³ = 1 mg/kg.

Metric prefixes

The following prefixes are given for the metric system as an easy reference guide.

Factor by which unit is multiplied	Prefix	Symbol
10 ²⁴	yotta	Y
10 ²¹	zetta	Z
10 ¹⁸	exa	E
10 ¹⁵	peta	P
10 ¹²	tera	T
10 ⁹	giga	G
10 ⁶	mega	M
10 ³	kilo	k
10 ²	hecto	h
10	deca	da
10 ⁻¹	deci	d
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p
10 ⁻¹⁵	femto	f
10 ⁻¹⁸	atto	a
10 ⁻²¹	zepto	z
10 ⁻²⁴	yocto	y

10 Appendix 3 – Glossary

ACI	Animal Carcass Incineration
ALT	Alternative (measurement method)
AOX	Adsorbable Organic Halogens
APC	Air Pollution Control
ART	Above Reporting Threshold
As	Arsenic
BaP	Benzo(a)pyrene
BAT	Best Available Techniques
BCA	British Cement Association
BDEs	Brominated Diphenylethers
BOS	Basic Oxygen Steelmaking
BRT	Below Reporting Threshold
BS	British Standard
BSI	British Standards Institute
BTX	Benzene, Toluene, Xylene
CAR	Water Environment (Controlled Activities) (Scotland) Regulations 2011
CCGT	Combined Cycle Gas Turbine
CCU	Catalytic Cracking Unit
CEMS	Continuous Emission Monitoring System
CEN	European Committee for Standardisation
Cd	Cadmium
CF	Conversion Factor
CFCs	Chlorofluorocarbons
CH ₄	Methane
CHP	Combined Heat and Power
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
COD	Chemical Oxygen Demand
CoT	Committee on Toxicity
CN	Cyanide
Cr	Chromium
CRM	Certified Reference material
Cu	Copper
CWI	Clinical Waste Incineration
D&R	Disposal and Recovery
DI	Drum Incineration
EAF	Electric Arc Furnace
EC	European Commission
EEA	European Environment Agency
EF	Emission Factor
EGR	Exhaust Gas Recirculation
EIA	Environmental Impact Assessment
ELV	Emission Limit Value
EPER	European Pollutant Emission Register
ESI	Electricity Supply Industry
ESP	Electrostatic Precipitator
ETP	Effluent Treatment Plant
EU	European Union
EU ETS	European Union Emissions Trading System
E-PRTR	European Pollutant Release and Transfer Register
ESP	Electrostatic Precipitator
EWC	European Waste Catalogue
FCCU	Fluidised Catalytic Cracking Unit
FGD	Flue Gas Desulphurisation

FGR	Flue Gas Recirculation
FSF	Fully Slatted Floor
GCV	Gross Calorific Value
FID	Flame Ionisation Detector
GHG	Greenhouse Gas
HCFCs	Hydrochlorofluorocarbons
HCl	Hydrogen Chloride
HCN	Hydrogen Cyanide
HF	Hydrogen Fluoride
HFCs	Hydrofluorocarbons
HFO	Heavy Fuel Oil
Hg	Mercury
H ₂ S	Hydrogen Sulphide
HW	Hazardous Waste
HWI	Hazardous Waste Incineration
IBC	Intermediate Bulk Container
IED	Industrial Emissions Directive
INT	Internationally Approved (measurement standard)
IOWWTP	Independently-operated Wastewater Treatment Plant
IPC	Integrated Pollution Control
IPPC	Integrated Pollution Prevention and Control
I-TEF	International Toxicity Equivalency Factor
I-TEQ	International Toxicity Equivalents of Dioxins
JEP	Joint Environment Programme
K	Kelvin (unit of temperature)
LOD	Limit of Detection
LPG	Liquefied Petroleum Gas
LRTAP	Long-range transboundary air pollution (convention)
LVOC	Large Volume Organic Chemicals
MAB	Mass Balance Method
MBq	Mega Becquerel
MCERTS	(Environment Agency's) Monitoring Certification Scheme
Mg(OH) ₂	Magnesium Hydroxide
Mn	Manganese
MRR	Monitoring and Reporting Requirements
MSW	Municipal Solid Waste
MWI	Municipal Waste Incineration
NAEI	National Atmospheric Emissions Inventory
NCV	Net Calori fic Value
Ni	Nickel
NH ₃	Ammonia
NIC	National Identity Code
NLA	No Longer Applicable
NO _x	Oxides of nitrogen (mixture of NO and NO ₂)
NO ₂	Nitrogen Dioxide
NO	Nitric Oxide
N ₂ O	Nitrous Oxide
NRB	National or Regional Binding (measurement method)
OCC	Opencast Coal
OTH	Other (measurement method)
NMVOCs	Non-methane Volatile Organic Compounds
PAHs	Polycyclic Aromatic Hydrocarbons
Pas	Publically Available Standard

Pb	Lead
PCBs	Polychlorinated Biphenyls
PCDDs	Polychlorinated Dibenzodioxins PCDF
	Polychlorinated Dibenzofurans
PER	Measurement method already prescribed by the competent authority (SEPA) in a license or permit for that facility
PF	Pulverised Fuel
PFBC	Pulverised Fuel Bed Combustion
PFCs	Polyfluorinated Hydrocarbons
PI	Pollution Inventory
PM	Particulate Matter
PM _{2.5}	Particulate Matter (<2.5µm aerodynamic diameter)
PM ₁₀	Particulate Matter (<10µm aerodynamic diameter)
PPC	Pollution Prevention and Control (Scotland) Regulations 2012 (as amended)
Ppm	Parts per million
Ppmv	Parts per Million by Volume
PSF	Partially Slatted Floor
PVC	Polyvinyl Chloride
RCF	Recycled Fibre
RET	Release Estimation Technique
RS	Radioactive Substances
Sb	Antimony
SCR	Selective Catalytic Reduction
SIC	Standard Industry Classification
SLF	Substitute Liquid Fuel
Sn	Tin
SNCR	Selective Non-catalytic Reduction
SO _x	Oxides of Sulphur (mixture of SO ₂ and SO ₃)
SO ₂	Sulphur Dioxide
SO ₃	Sulphur Trioxide
SRU	Sulphur Recovery Unit
SSC	Sector Specific Calculation
SSI	Sewage Sludge Incineration
SWS	Sour Water Scrubber
SPRI	Scottish Pollutant Release Inventory
TOC	Total Organic Carbon
TPM	Total Particulate Matter
TSS	Total Suspended Solids
UKSIC	United Kingdom Standard Industry Classification
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
UWWTP	Urban Wastewater Treatment Plant
V	Vanadium
VC	Vinyl Chloride
VDU	Vacuum Distillation Unit
VOCs	Volatile Organic Compounds
WESP	Wet Electrostatic Precipitator
WEWS	Water Environment and Water Services (Scotland) Act 2003
WHO	World Health Organisation
WHO-TEF	WHO Toxicity Equivalency Factor
WHO-TEQ	Toxicity Equivalents of Dioxins
WML	Waste Management Licence
WID	Waste Incineration Directive
WWTP	Wastewater Treatment Plant
Zn	Zinc

11 Appendix 4 – Useful references

1. [Scottish Pollutant Release Inventory website](#)
2. [The Pollution Prevention and Control \(Scotland\) Regulations 2012 \(as amended\) SSI 2012 No. 360](#)
3. [SEPA. Scottish Pollutant Release Inventory General Guidance Document](#)
4. [Scottish Pollutant Release Inventory \(SPRI\) Operator Guidance on Release Estimation Techniques](#)
5. [Scottish Pollutant Release Inventory Sector Guidance](#)
6. [UK-PRTR website](#)
7. [E-PRTR website](#)
8. [Industrial Emissions Directive \(2010/75/EU\)](#)
9. [European Union Emissions Trading System \(EU ETS\) Directive](#)
10. [EU Emissions Trading System guidelines for the monitoring and reporting of greenhouse gas emissions](#)
11. [European Commission](#)

End of SPRI RET Guidance Document.