Release Estimation Techniques for Pollutant Release and Transfer Register Data

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I. Background

The purpose of the factsheet is to expand on the information in the video module on Release Estimation Techniques for Pollutant Release and Transfer Registers (PRTRs) available at http://prtr.unitar.org/site/unique/1372.

In this paper:

- ✓ Identifying where releases occur
- ✓ How to select the most appropriate estimation technique
- ✓ Examples that show how to apply each estimation technique
- ✓ Where to find guidance on release estimation for specific industries or chemicals

This document presents information on release estimation techniques (RETs) that is summarized from UNITAR, OECD and individual PRTR program's guidance documents. PRTRs around the world have provided guidance on release estimation techniques to meet the following goals:

Data Quality: At the core of every PRTR are the data collected on releases. Providing clear guidance on how to estimate releases is essential to obtain high quality data. In turn, high quality data are necessary for a PRTR to achieve the goal of providing reliable information to the public, governments, and other stakeholders.

Comparability: Guidance on release estimation techniques also leads to consistency in the data collected. With consistent data, comparisons are more accurate - such as, across individual facilities in the same industry, across geographic regions or countries, and to prepare aggregated national inventories for the international conventions.

Burden Reduction: With clear guidance on release estimation techniques, facilities understand the most appropriate methods to use with available information to calculate releases. Such guidance can minimize the time facilities invest in preparing their PRTR data.

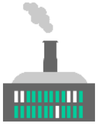
Transparency: Given the broad spectrum of operations covered by most PRTRs, there is likewise a wide range in the accuracy of the values reported, based on the type of RET used. By publishing both the RET method and numeric release values, PRTR data users can better incorporate uncertainty into their analyses, perform more accurate analyses, and make more informed decisions.

With PRTRs now implemented in so many countries, the resources are available and ready to be adopted or to be customized as needed to meet national circumstances.

Section VIII. Resources of this document provides instructions on where to find the RET guidance documents.

II. Sources Covered by the PRTR

For PRTRs, Release Estimation Techniques can cover a range of sources; which sources are applicable to a particular PRTR depends of the scope of the PRTR. The most common types of sources are:



Point sources: Point sources are stationary, identifiable sources, such as manufacturing plants, electric and wastewater utilities, and mines.

Non-point sources: Also referred to as “diffuse” sources, this category includes sources that are not point sources such as motor vehicles, agricultural land, biogenic sources (e.g., microbial activity), geogenic sources (e.g., volcanos), and small point sources (e.g., residential heating) that are grouped together and considered an “area” source.

Transfers: Transfers are off-site shipments of a waste containing one or more listed chemicals. Release estimation techniques used to estimate amounts transferred are similar to those used for on-site releases.

Products: Some countries identify, classify, and quantify releases from the use of retail and commercial products.

A PRTR may cover a combination of these sources. The focus of this document is point sources, as every PRTR covers it.

For guidance on estimating releases from non-point sources, transfers, and products, see these resources:

OECD developed a Resource Compendium of PRTR Release Estimation Techniques which is made up of four parts. Part 1 covers techniques used to quantify releases from point sources. The remaining parts of the Compendium cover the other types of sources:

- Non-point sources: Part 2 describes RETs suitable for estimating the amount of chemicals released from diffuse sources: Resource Compendium of PRTR Release Estimation Techniques Part 2 : Summary of Diffuse Source Techniques
- Transfers: Part 3 summarises RETs suitable for estimating the amount of chemicals in transfers: Resource Compendium of PRTR Part 3: Summary of Techniques for Estimating Quantities Transferred, Released or Disposed
- Products: Part 4 summaries information on RETs used to estimate releases of chemicals contained in products: Resource Compendium of PRTR Part 4: Summary of Techniques for Estimating Releases of Chemicals from Products

In addition, UNITAR publishes Guidance on Estimating Non-Point Source Emissions

III. Identifying Releases

Before selecting a RET, the facility must first identify where releases and transfers of reportable chemicals are occurring at the facility. This is accomplished by conducting a systematic assessment. The general process to identify where releases occur starts with a plant walk-through and developing (or updating) a flow chart of operations. The assessment should include:

- In the **walk-though**, look at each piece of equipment, identify where input streams come from, where output streams go, and what materials they process or handle
  - Consult with facility personnel who operate the equipment and processes on inputs and outputs for standard operations as well as for intermittent operations (e.g., changes to batch production or cleaning)

- Identify **where listed chemicals are used** or formed in the facility
  - Consider both chemicals that are part of the process, and those that are used in or formed through ancillary activities.
  - For each process, consider PRTR-listed chemicals in:
    - Raw material inputs
    - Products and mixtures used in the process
    - Chemicals formed during the process, such as through chemical reactions or as by-products
  - For ancillary activities, consider PRTR-listed chemicals in:
    - Products used for cleaning and maintenance
    - Products used in waste treatment or formed during waste treatment processes
    - Fuels and chemicals formed as combustion by-products
  - Do not overlook one-time releases, such as those associated with equipment malfunctions or spills

- Identify **where all releases occur**, and if it is a release to air, water, land, or is a transfer to an off-site location
  - Collect data that can be used to estimate release quantities, such as:
    - Production/throughout data
    - Monitoring data
    - SDS (Safety Data Sheets)
    - Waste shipment manifests
    - Purchasing and inventory records
    - Vendor specifications (e.g., pollution control equipment emission factors and removal efficiencies)

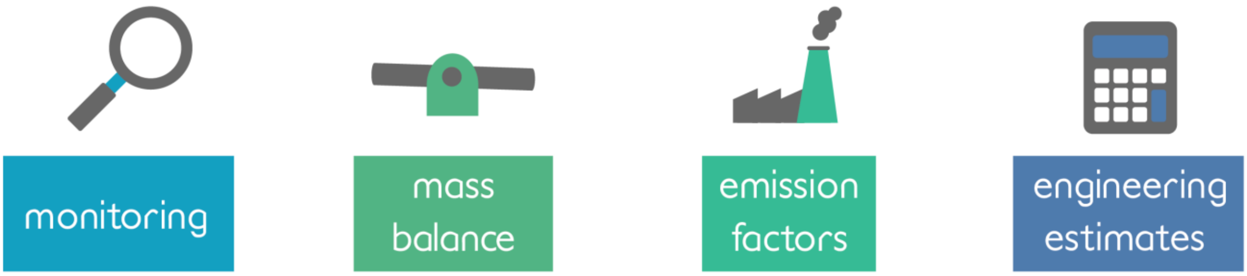
For more details on the process of identifying releases, see UNITAR's *Guidance for Facilities on PRTR Data Estimation and Reporting*. For industry-specific steps to identifying releases, see the industry-specific guidance documents developed for PRTRs in Australia, Canada, Japan, Spain, the United Kingdom, and the United States, available via OECD Resource Centre for PRTR Release Estimation Techniques (RETs).

IV. Release Estimation Techniques

For each release identified, the facility selects the most suitable release estimation technique. Most PRTR systems do not require that release be monitored or measured, instead facilities are required to make reasonable estimates using the best available information.

The same techniques that are used to estimate releases are also applicable to estimating other reportable quantities (e.g. off-site transfers and waste management). To simplify the discussion, this document uses the phrase "estimating releases" to mean "estimating releases or transfers or waste management quantities."

Several general approaches exist for estimating quantities of pollutants released to the environment and transferred. These range from simple professional judgements to analysis of continuous monitoring data. Among existing PRTR guidance, the most widely utilised categories of release estimation techniques (RETs) for point sources are:



The techniques listed above are presented in order of what is generally considered the most accurate (monitoring/direct measurement) to least accurate (engineering estimates), although there are exceptions due to availability of information and individual facility situations. Much of the information presented below was summarized from UNITAR's *Guidance for Facilities on PRTR Data Estimation and Reporting*.

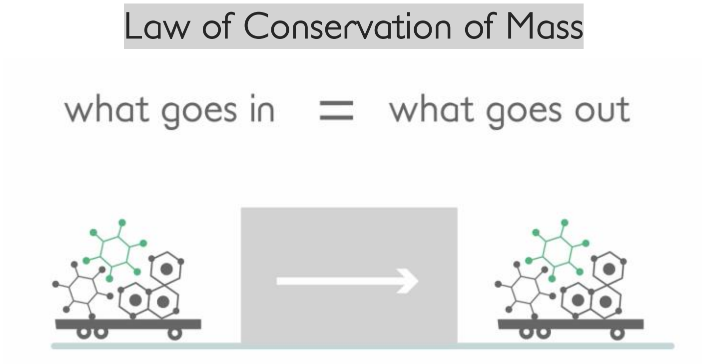
Direct **monitoring** is when releases of the chemical are directly measured, either continuously or periodically. Facilities often measure releases of specific pollutants or chemicals for reasons other than PRTR reporting, such as for a permit or compliance requirement under another law, for process control, or as part of a worker exposure assessment.

If quality control procedures are in place and the monitoring data are representative of the operating conditions, monitoring is expected to provide the most reliable and accurate release data possible.

The drawbacks of monitoring include:

- It can be expensive, requiring equipment, personnel training, and maintenance;
- Facilities may need to analyse large amounts of data to derive annual release estimates from, for example, continuous release monitoring; and
- Monitoring every release is not possible because practical technology is not always available or in place.

Using a **mass balance** approach (also called materials accounting) to estimate releases relies on the Law of Conservation of Mass, which states that the amount of chemical that enters a process equals the amount that leaves the process, such as in products, or is consumed in the process through chemical reactions.



Releases are estimated based on the difference between material input and material output. The inputs and outputs needed for a mass balance calculation are usually quantities that facilities track for business reasons, such as the amounts of materials brought on site, amounts in inventory, and amount of product produced. Mass balance may be used to assess releases for single piece of equipment, for a process level, or across the entire facility.

Mass balance is a flexible method to estimating releases that, in theory, is possible to apply to nearly every release source.

The drawbacks to a mass balance approach include:

- The results are only as precise as the inputs and outputs used;
- Small errors or uncertainties in input and output quantities or concentrations can result in big differences in the release quantities estimated; and
- While it is a simple method for some processes, it can be difficult to obtain meaningful results using a mass balance approach for more complex processes.

emission factors

Emission factors are ratios that can be multiplied by an activity rate or by throughput data (such as the production output, water consumption, etc.), to estimate releases. Emission factors are usually expressed as the weight of a chemical released divided by a production metric, such as kilograms of lead released per tonne of coal combusted.

The basic release estimate equation using an emission factor is:

$E = A \times EF$, where:
- E = the emission estimate;
- A = the activity level or throughput; and
- EF = the emission factor.

Published emission factors are available through numerous sources around the world. In cases where the appropriate published emission factor is available for a given process, emission factors are quick and easy to use, and can be fairly accurate.

Emission factors depend on chemicals, processes, and equipment, so their primary limitation is that not all processes related to a given release source are designed or operated the same way. Facilities should consider how the emission factor was developed to determine if it is an appropriate factor to estimate releases for the process in question.

The drawbacks of using emission factors include:

- Emission factors are not available for many processes and chemicals; and
- How the emission factor was derived needs to be consistent with the facility's process

engineering estimates

Engineering estimate methods rely on the estimator's experience and knowledge of facility's operations. They offer a method to develop release estimates quickly and inexpensively when other methods are not practical or possible.

Common use of engineering estimates to estimate releases include:

- **Use of equipment specifications**, such as removal rate, efficiency, or yield to estimate releases. These types of calculations are often used to calculate point source air releases from pollution control equipment. For example, if a baghouse is designed to remove 99 percent of particulates by weight from an air stream, then 1 percent will be released to air. If the chemical composition of the particulates is known or can be calculated, then those values can be used to estimate releases of the individual chemicals.

- **Use of physical, chemical, and equilibrium properties of chemicals**. For example, the vapor pressure of a chemical can be combined with the ideal gas law and an appropriate diffusion coefficient to calculate the concentration of that chemical in an air waste stream. Chemical solubility in water is a frequent measure of concentration used to calculate surface water discharges.

Often, these kinds of engineering calculations are the only way to estimate certain small amounts of releases, for example in cases where measurement is difficult, and mass balance estimates would be too uncertain.

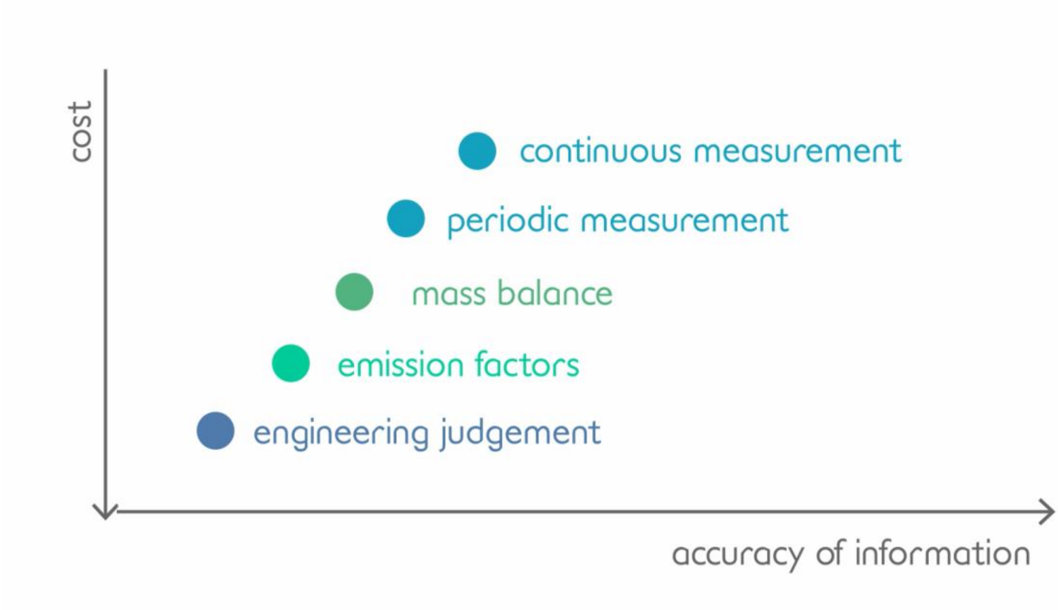
The drawbacks of using engineering estimates include:

- It has been recognised that the use of engineering estimates has the potential for errors and inconsistencies.

V. Selecting a Release Estimation Technique

Selecting which RET is most appropriate for a specific release needs to be determined case-by-case considering what data are available or can be reasonably obtained with the time and resources available. Often, a combination of the release estimation techniques is used. Facilities strive to strike a balance between maximizing the accuracy of the release estimate while minimizing the cost and effort to obtain the estimate.

Several factors influence what is determined to be the optimal approach. These factors include time and cost constraints, available data, required data quality and the ability of the estimation technique to best represent the release. The figure below, adapted from The OECD document, Framework for Selecting and Applying PRTR Release Estimation Techniques, illustrates the relationship between these factors for each of the RETs.



The OECD's Framework for Selecting and Applying PRTR Release Estimation Techniques document also includes the table below summarising information relevant to deciding the most appropriate RET, which should be considered along with cost and reliability factors when selecting a RET.

Examples of RET selection:

The simplest case is where there is no time or cost constraints and the relevant data are available. In this situation, the RET providing the most accurate release data should be selected and used;

Where all data inputs are not available, but resources allow these data to be collected, the RET providing the most accurate release data should be selected and used. An example could be where monitoring for the specific pollutant is cost-effective but where monitoring of the specific source has not previously been conducted;

Where adequate resources are not available for the necessary data collection required for the RET providing the most accurate release data, a next best RET would need to be selected. An example could be where monitoring is prohibitively expensive;

When a particular source is likely to be insignificant compared to other sources considered in the PRTR, the use of the most accurate RET may not be warranted due to the extra time or cost associated with this RET; and

Source-specific data may not be available and, therefore, it may not be possible to use the RET providing the most accurate release data.

OECD's Framework for Selecting and Applying PRTR Release Estimation Techniques document provides information about additional topics related to the RET selection process, such as, release data production chain principles, understanding uncertainty, and specific guidance on the selection and application of RETs to three industrial sectors: fossil fuel power generation, petroleum refining, and incineration.

The accuracy of release estimates often improves over time. Engineering estimates may be used in the first year or two that a facility reports to a PRTR. Over time, the facility may build on those initial calculations to develop methods and analyses that can improve the accuracy of the estimate.

VI. Example Calculations

The following relatively simple examples illustrate the RET selection process and release estimate calculations using each type of RET. For more detailed, sector-specific examples, see the OECD Resource Centre for PRTR Release Estimation Techniques (RETs). This website includes hundreds of documents related to RETs from industry-specific guidance documents developed over the past 20 years by established PRTR programmes in Australia, Canada, Japan, Spain, the United Kingdom, and the United States.

Example using Monitoring Data

- Methanol is produced as a byproduct in the paper making process.
- A paper mill needs to calculate the quantity of methanol discharged in their waste water.
- They monitored their waste water for methanol twice during the past year.

Date	Methanol Concentration (mg/liter)	Flow (million liter/day)	Methanol Discharge (mg/day)	Methanol Discharge (kg/day)
March 1	1.0	3.5	3.5E6	3.5
Sept 8	0.8	3.9	3.12E6	3.12
			Average =	3.31

- Using these monitoring data, calculate the methanol released to water for the year:
    - Assuming 365 days of discharge and no other sources of methanol releases
    - 3.31 kg/day × 365 day = 1,208 kg
    - Discharges to water of methanol from this process = 1,208 kg

Example using Mass Balance

- A facility uses xylene (a volatile organic solvent) to make an adhesive product.
- They need to calculate their xylene releases to air.
- No monitoring data are available.
- No emission factor is available.
- They use a mass balance approach:
    - Review purchasing and inventory records for the year to determine the quantity of xylene added to the production process:
        - Input = 5,000 kg of xylene were added during the year to the adhesive manufacturing process
    - Review production records to determine the quantity of adhesive produced and the concentration of xylene in the final product:
        - Output = 4,950 kg of xylene are contained in the adhesive product manufactured during the year
    - Input (5,000 kg) - Output (4,950 kg) = Air Loss (50 kg).
    - Fugitive air emissions of xylene from this process = 50 kg

Example using an Emission Factor

- A facility combusts coal on-site for energy.
- They need to calculate their mercury releases to air that result as a by-product of coal combustion.
- No monitoring data are available.
- The facility finds an **emission factor** in U.S. EPA's AP-42 (Compilation of Air Emission Factors) specific to their type of coal and combustion unit: 0.11 lb mercury emitted / 1,000,000 lb coal combusted in a fluidized bed combustor.
- Convert units to those accepted by the PRTR: 110 kg mercury emitted /million tonne coal
- Review production data for the year to determine how much coal was combusted:
  - 500,000 tonnes of coal were combusted in a fluidized bed combustor
- Apply the emission factor:
  - 500,000 tonnes x (110 kg mercury / 1,000,000 tonne coal) = 55 kg mercury
  - Stack air emissions of mercury from this process = 55 kg

Example using Engineering Estimates

- A textile facility uses 30,000 kg of an organic coating with a 15% concentration of toluene, present as a solvent, during finishing operations. The coated product goes through a dryer that vents to a scrubber.
- The facility needs to calculate their toluene releases to air and to water.
- They have no monitoring data but have vendor data on the scrubber efficiency and will use this information to estimate releases.
- They assume that the toluene volatilizes completely in the dryer.
- The dryer vent stack leads to the scrubber, which has a vendor-specified removal efficiency of 95 percent for volatile organic compounds (toluene is a volatile organic compound).
- The scrubber water is then sent directly to an off-site wastewater treatment plant.
- The amount of toluene emitted to the dryer vent stack is:
  - (30,000 kg organic coating) × (0.15, the toluene concentration in the coating) = 4,500 kg toluene emitted to the dryer vent stack
  - The amount of toluene passing through the scrubber and released to air = (4,500 kg toluene) × (1 - 0.95) = 225 kg reported as a stack air emission
- The remaining toluene is in the scrubber water:
  - (4,500 kg toluene) × (0.95) = 4,275 kg reported as transferred to an off-site wastewater treatment plant
- Toluene releases from this process:
  - Stack air emissions = 225 kg
  - Off-site transfer to the wastewater treatment plant = 4,275 kg

VII. Conclusion

This factsheet summarizes fundamental information on the release estimation techniques currently used by facilities reporting to most PRTRs around the world. Providing clear and consistent guidance on how to estimate releases helps to maximize the quality and transparency of the data collected by the PRTR. High quality data are essential for the PRTR to meet its goals of providing reliable information to the public, governments, and other stakeholders. Since the 1990s, PRTR systems around the world have been developing guidance on release estimation techniques – both general and industry-specific – that are available as a resource for developing PRTRs. PRTR programmes and other technical organizations will continue to generate and update RET guidance into the future.

VIII. Resource Centre for PRTR Release Estimation Techniques

The Resource Centre is a website that has been developed by the OECD's Working Group on PRTRs. The purpose of the Resource Centre is to provide a clearinghouse of guidance manuals/documents of release estimation techniques for the principal pollutant release and transfer registries developed by OECD member countries. The manuals and documents include descriptive information on the sources of pollutant releases, as well as information on emission factors, mass balance methods, engineering calculations, and monitoring information.

The Resource Centre for PRTR RETs includes links to hundreds of documents on release estimations, both general guidance as well as industry- and chemical-specific guidance, from Australia, Belgium, Canada, Israel, Japan, Spain, the United Kingdom, and the United States. Links to guidance documents from the OECD, UNEP, UNECE, and UNITAR are also included.

See http://www.prtr-rc.fi/documents_e.php?switch=all