ProScale 2.0

Methodological guidance

Version 1.0

ivl
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Summary

ProScale is a regulatory-aligned, screening-level chemical footprinting method for assessing the potential human toxicity and ecotoxicity impacts of substances, materials, and products throughout their respective life cycles. The ProScale Suite comprises four complementary modules: ProScale for Workers (ProScale-W), ProScale Service Life (ProScale-SL), ProScale Environment (ProScale-E), and ProScale for Indirect Human Exposure (ProScale-IE).

This guidance document presents the ProScale methodology, including the key elements that constitute a ProScale score and the four principles underpinning the method: i) utilize hazard and exposure information already generated within regulatory practice, ii) be compatible as a screening-level tool for Safe and Sustainable by Design (SSbD) applications, iii) adopt a conservative approach to deal with data gaps and uncertainties and iv) bridge risk assessment (RA) and life cycle assessment (LCA) paradigms.

ProScale scores are derived by combining hazard and exposure information and translating these into an LCA-compatible format through system-level parameters. Exposure information is based on methodologies recommended in the European Chemicals Agency (ECHA) Guidance on Information Requirements and Chemical Safety Assessment (CSA) under REACH (EU Regulation No. 1907/2006). ProScale-W and -SL use the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) Worker and Consumer Targeted Risk Assessment (TRA) tools, respectively, whereas ProScale-E and -IE estimate potential exposure using Environmental Release Categories (ERCs) and Specific Environmental Release Categories (SPERCs).

All modules share a common hazard basis derived from substance classifications under the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) and the EU Regulation No. 1272/2008 on Classification, Labelling and Packaging of substances and mixtures (CLP). Human-health hazard classifications are applied in ProScale-W, -SL, and -IE, while environmental hazard classifications are applied in ProScale-E. The hazard information from GHS/CLP is modified using hazard modifiers to account for substance potency.

This guidance also provides a comprehensive overview of the updates, revisions, and additions introduced in ProScale 2.0 compared to ProScale 1.5.

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List of Abbreviations

AC	Article category
AIE	Archetypal indoor environment
APF	Assigned protection factor
BAF	Bioaccumulation factor [L/kg biota]
BAT	Best available techniques
BCF	Bioconcentration factor [L/kg biota]
BREF	Best available techniques reference
CF	Characterization factor
CLP	EU Regulation No. 1272/2008 on classification and labelling of substances and mixtures
CMR	Carcinogenic, mutagenic and reprotoxic
CSA	Chemical safety assessment
DF	Degradation factor
DNEL	Derived no-effect level
E	Route relevance
ECETOC	European Centre for Ecotoxicology and Toxicology of Chemicals
ECF	Exposure concentration factor
ECHA	European Chemicals Agency
EoL	End of Life
ERC	Environmental release category
ERF	Environmental release factor
EU	European Union
FU	Functional unit
GHS	Globally harmonized system for classification and labelling
H'	Dimensionless Henry's law constant
HF	Hazard factor
H-phrase	Hazard statement
K_{OC}	Organic carbon-water partition ratio [L/kg organic carbon]
LCA	Life cycle assessment
LCI	Life cycle inventory
LEV	Local exhaust ventilation
log$D_{7.0}$	The decadic logarithm of the pH-dependent octanol–water distribution ratio at pH 7.0
logK_{oc}	The decadic logarithm of organic carbon-water partition ratio

logK_{ow}	The decadic logarithm of octanol-water partition ratio [L/kg organic compound]
MF	Mass flow
MW	Molecular weight
NRD	Non rapidly degrading
RA	Risk assessment
RD	Rapidly degrading
RMM	Risk management measure
RPE	Respiratory protective equipment
OEL	Occupational exposure limits
PC	Product category
PHF	Person-hour factor
PPE	Personal protective equipment
PPDD	Per-person daily dose
PROC	Process category
ProScale-E	ProScale Environment
ProScale-IE	ProScale for Indirect human Exposure
ProScale-SL	ProScale Service Life
ProScale-W	ProScale for Workers
REACH	EU Regulation No. 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals
SDS	Safety data sheet
SPERC	Specific environmental release categories
SSbD	Safe and Sustainable by Design
TRA	Target risk assessment
UVCB	Unknown or variable composition, complex reaction products or biological materials
VP	Vapor pressure

1. Introduction to ProScale

ProScale is a regulatory-aligned, screening-level chemical footprinting method for assessing human toxicity and ecotoxicity impact potential along the life cycle of substances, materials or products. The method is built upon four principles: i) utilize hazard and exposure information already generated within regulatory practice, ii) be compatible as a screening-level tool for Safe and Sustainable by Design (SSbD) applications, iii) adopt a conservative approach to deal with data gaps and uncertainties and iv) bridge risk assessment (RA) and life cycle assessment (LCA) paradigms.

Potential exposure to chemicals can occur along the entire life cycle of a product, material, or substance, thereby exposing different groups of people. Workers can be exposed during production, manufacturing and end-of-life, consumers can be exposed during service life (i.e., use phase), and the general population can be exposed indirectly via air inhalation and food and water intake. In addition to human exposure, chemical releases affect the environment. The ProScale Suite captures all these endpoints and exposure routes, via four modules: ProScale for Workers (ProScale-W), ProScale Service Life (ProScale-SL), ProScale Environment (ProScale-E) and ProScale for Indirect human Exposure (ProScale-IE). The coherence of the four modules is illustrated in Figure 1.

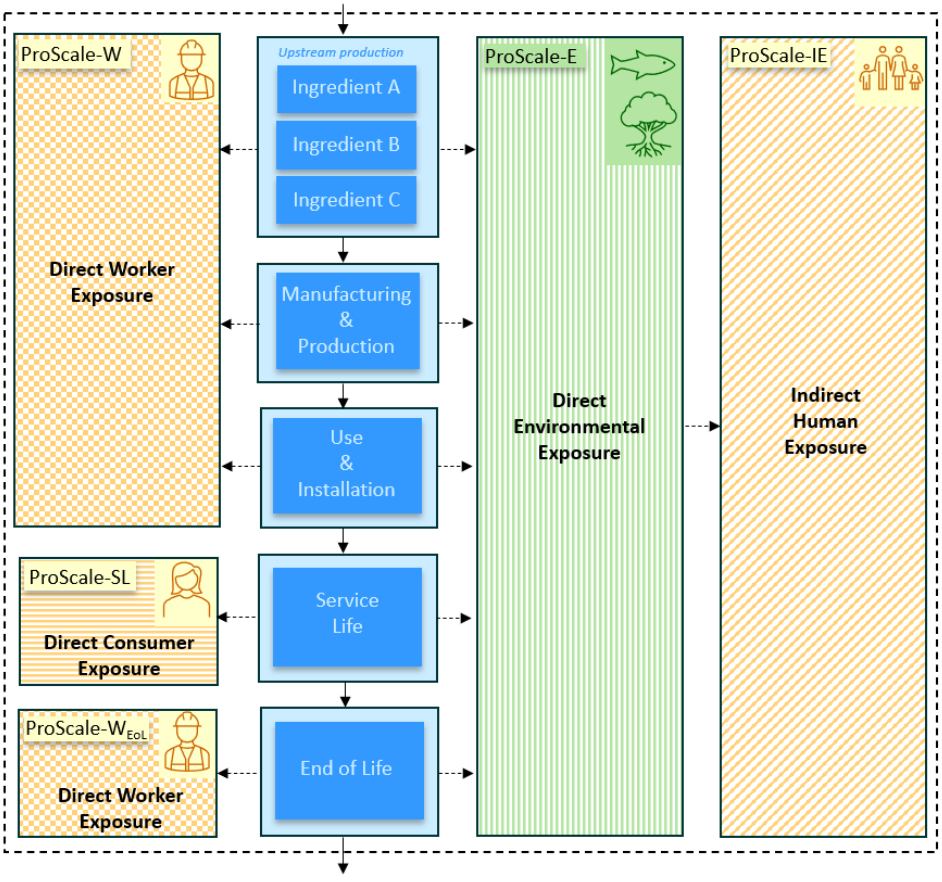

Figure 1. Conceptual illustration of the coherence of the ProScale Suite. Yellow patterns indicate human exposure, green pattern environmental exposure, and blue covers the life cycle. Abbreviations: W= Worker, SL = Service Life, W_{EoL} = End of Life exposure for Workers, E = Environment, IE= Indirect Exposure.

The purpose of this document is to provide guidance on the ProScale 2.0 method. This guide is a revision of the ProScale 1.5 guidance document (Lexén et al., 2017) and is structured as follows: first, a brief introduction to the modelling logic covering the similarities and differences between the four modules. Second, a description of each modelling parameter. Appendix I accounts for updates, adjustments and additions in ProScale 2.0 compared to ProScale 1.5. Guidance on how to apply the method is provided in the ProScale 2.0 Practical guidance, available as a downloadable document through the web tool and at the ProScale website (www.proscale.org).

2. The ProScale Method

All ProScale modules are based on the same modelling logic where a chemical mass flow is combined with a module-specific characterization factor (CF). The CF is built upon hazard information and exposure information combined with system-level transformation parameters. The exposure information is derived from exposure modelling as recommended by the European Chemicals Agency (ECHA) for chemical safety assessments (CSA) under the European Union (EU) Regulation No. 1907/2006 (REACH) (European Commission [EC], 2006). The hazard information is based on substance classifications under the Globally Harmonized System for Classification and Labelling (GHS) and the EU Regulation No. 1272/2008 (CLP) (EC, 2008; United Nations, 2025), and hazard modifiers. The purpose of the system-level transformation parameters is to express exposure in an LCA-compatible form. Table 1 provides a summary of the main parameters used in ProScale calculations and the following sub-sections provide a thorough explanation of each parameter.

Table 1. Summary of the main parameters used in ProScale calculations. Abbreviations: TRA = Targeted Risk Assessment; ECF = Exposure Concentration Factor; PPDD = Per-Person Daily Dose; ERC = Environmental Release Categories; ERF = Environmental Release Factor; H3XX = Health hazards according to GHS and CLP; H4XX = Environmental hazards according to GHS and CLP; HF_H = Hazard Factor for Human health; HF_E = Hazard Factor for Environment; OEL = Occupational Exposure Limit; DNEL = Derived No-Effect Level; RD = Rapidly Degrading; NRD = Non Rapidly Degrading; PHF = Person-Hour-Factor; DF = Degradation Factor; E = route relevance; MF = Mass Flow.

Module	Exposure or release basis	Hazard basis	Hazard modifier	System-level aggregation /translation	Functional unit scaling
ProScale-W	Worker TRA → *ECF*	GHS H3XX → HF_H	OEL/DNEL	PHF_W	*MF*
ProScale-SL	Consumer TRA → *PPDD*	GHS H3XX → HF_H	OEL/DNEL	PHF_{SL}	*MF*
ProScale-E	ERCs → *ERF*	GHS H4XX → HF_E	M-factor + RD/NRD	*DF*	*MF*
ProScale-IE	ERCs → *ERF*	GHS H3XX → HF_H	OEL/DNEL	*DF + E*	*MF*

2.1 Exposure Information

The exposure information is derived from sources in the ECHA *Guidance on Information Requirements (IR) and CSA* under REACH, Chapters R.12, R.14 – 16 (European Chemicals Agency [ECHA], 2015, 2016a, 2016b, 2026), hereafter referred to as Chapter R.X where X indicates the ECHA chapter number. For ProScale-W, this means that the exposure information is derived using the Worker Target Risk Assessment (TRA) module from the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) whereas ProScale-SL uses the corresponding Consumer TRA module. For ProScale-E and -IE, the exposure estimates are made using environmental release categories (ERCs) or specific environmental release categories (SPERCs). The following sub-sections introduce the information required to derive relevant exposure information for substance *i* for each module.

2.1.1 Exposure Concentration Factor (ECF) from ECETOC Worker TRA

ECETOC Worker TRA is the recommended tool for occupational exposure estimation under REACH according to Chapter R.14 (ECHA, 2016a). Exposure estimations, so-called exposure concentration factors (ECFs), are derived for inhalation and dermal exposure. Oral exposure is not considered in ProScale-W.

There are at least three input parameters that are required to retrieve an ECF per exposure route. The first is a process category (PROC) as defined by Chapter R.12 (ECHA, 2015). These PROCs define the type of activity or process and are dependent on the unit process being assessed.

The second parameter is the fugacity of substance *i*. Fugacity is a measure of the likelihood of a substance becoming airborne and is thus dependent on the physical state and vapor pressure or dustiness. It categorizes substance *i* in one of four or three blocks respectively according to Table 2 below and Table 3.

Table 2. Fugacity of fluids. Table extracted from ECETOC TRA (European Centre for Ecotoxicology and Toxicology of Chemicals [ECETOC], 2023).

Vapor pressure at 25°C [kPa]	**Fugacity**
<0.00001	Negligible
0.00001 – <0.5	Low
0.5 – 10	Medium
>10	High

Table 3. Dustiness of solids. Table extracted and modified from ECETOC (ECETOC, 2004, 2023).

General description	**Relative dustiness potential**	**Typical materials**	**Worker TRA selection value**
Not dusty	1	Plastic granulates, pelleted fertilizers*	Low
Slightly dusty	10 – 100 times dustier	Dry garden peat, sugar, salt	
Dusty	100 – 1 000 times dustier	Talc, graphite	Medium
Very/extremely dusty	More than 1 000 times dustier	Cement dust, milled powders, plaster, fluor, lyophilized powders, (process fumes**)	High

**Exposures to materials where a substance is contained and bound in a matrix (e.g., pigment within plastic, filler within paint) should also be included in this category. Although the real exposure is actually determined by a combination of physical form and the bioavailability of the substance within the matrix, because the bioavailability is very low under such circumstances, then this will result in a low exposure potential.*

***Process fumes (e.g., rubber, welding, soldering) behave like gases and would be considered within this category.*

For solids dissolved into liquids, the physical state is estimated as liquids with a vapor pressure of <0.00001 kPa. This corresponds to a negligible fugacity.

Solids dispersed into liquids follow these rules:

- If PROC7 (exposure scenario where aerosols are formed): The $ECF_{Inhalation}$ is determined using the substance dustiness (Low/Medium/High). *Aerosol formation*

related to PROC11 is not relevant since non-industrial settings are out of scope of ProScale 2.0.

- All other PROCs (exposure scenarios where no aerosols are formed): The $ECF_{Inhalation}$ is considered zero.

The third parameter is the molecular weight (MW) of substance *i*. Exposure estimation of liquids via inhalation is obtained in ppm in Worker TRA, thus the MW is used to transform the exposure into [mg/m^3].

A fourth, and optional, parameter is risk management measures (RMMs). The RMMs that can be considered in a ProScale-W assessment are Local exhaust ventilation (LEV), Personal protective equipment (PPE) and Respiratory protective equipment (RPE). Table 4 provides an overview of how each of these RMMs affects the exposure predictions in Worker TRA. More details on how RMM reduce the exposure predictions in ECETOC TRA are found in *ECETOC TRA version 3: Background and Rationale for the Improvements* (ECETOC, 2012).

Table 4. Overview on how RMM affects the ECETOC TRA exposure predictions. Table adapted from ECETOC (ECETOC, 2012, 2023). Abbreviations: LEV = local exhaust ventilation; RPE = respiratory protective equipment; PPE = personal protective equipment; RMM = risk management measure; APF = assigned protection factor; PROC = process category.

Risk Management Measure Type	**RMM options**	**Effect on ECETOC TRA exposure predictions**
Inhalation LEV	No	Default, no reduction.
	Indoors with LEV	Exposure is reduced by 90-95% depending on the selected PROC. Multiplicative with RPE if applied.
	Indoors with LEV and good general ventilation	Exposure is reduced by an additional 30% relative "Indoors with LEV". Multiplicative with RPE if applied.
	Indoor with LEV and enhanced general ventilation	Exposure is reduced by 70% relative "Indoors with LEV". Multiplicative with RPE if applied.
RPE	No	Default, no reduction.
	90%	Reduces the inhalation exposure by 90%. Multiplicative with inhalation LEV reduction if applied.
	95%	Reduces the inhalation exposure by 95%. Multiplicative with inhalation LEV reduction if applied.
Dermal LEV	No	LEV is not considered for dermal exposure.
	Yes	LEV is considered for dermal exposure. The initial exposure is reduced by 80-95% depending on selected PROC. Multiplicative with Dermal PPE reduction if applied.
Dermal PPE	No	Default, no reduction.
	Gloves APF 5	Exposure is reduced by 80%. Multiplicative with Dermal LEV reduction if applied.
	Gloves APF 10	Exposure is reduced by 90%. Multiplicative with Dermal LEV reduction if applied.
	Gloves APF 20	Exposure is reduced by 95%.

2.1.2 Per Person Daily Dose (PPDD) from ECETOC Consumer TRA

ECETOC Consumer TRA is used for exposure estimation in ProScale-SL since it is the recommended tool in Chapter R.15 (ECHA, 2016b). The exposure estimation, obtained in [mg/kg/day], is multiplied with 60kg to translate the exposure estimation into a per-person daily dose (PPDD) in [mg/person/day].

There are a few input parameters that are required to retrieve the exposure estimation in Consumer TRA. The first is an article category (AC) as defined in Chapter R.12 (ECHA, 2015). Such AC is used to describe the type of article substance *i* is bound to and is used to estimate how that substance may be released during the service life of the product. As an alternative to ACs, the user may use a product category (PC) instead, which applies to chemical products instead of articles.

Other parameters required to run Consumer TRA are the MW for substance *i* and its vapor pressure.

2.1.3 Environmental Release Factors (ERF)

For environmental exposure estimations, Chapter R.16 (ECHA, 2026) recommends the use of ERCs in the absence of more detailed information. These release categories represent a set of default worst-case emission factors for ten pre-defined processes (some of which are divided into sub-groups), see Appendix III of the ProScale 2.0 Practical guidance. The emission factors are assigned to air, water and soil. Some industrial sector groups have developed specific ERCs (SPERCs) that constitute a more refined set of emission factors (ECHA, 2026). The release factors (in %), either ERCs or SPERCs, correspond to the environmental release factor (ERF) in ProScale-E and IE. The use of these release factors fits well with the conservative ProScale approach. However, the ProScale-E methodology allows the user to substitute these release factors with more precise information if available. Note that this is not possible in ProScale-IE with the current methodology.

2.2 Hazard Information

All ProScale modules utilize a unified hazard basis, with substance classifications consistently based on the GHS and/or CLP. However, ProScale-E differs from the other modules since its hazard basis is focused on the environment instead of human health. The following sub-sections introduce the shared hazard basis, the hazard modifiers and the resulting hazard factors for human health (HF_H) and the environment (HF_E) respectively.

2.2.1 Hazard Basis

The hazard basis for all modules is hazard statements (H-phrases) from GHS and CLP. GHS is an internationally agreed-upon system created by the United Nations, while CLP is an EU regulation based on GHS. The classification system and H-phrases in GHS and CLP constitute a common and coherent approach to defining hazards, classifying substances and communicating information on labels and safety data sheets (SDSs).

ProScale makes use of H-phrases from both GHS and CLP since there are some differences in the types of hazards captured by the two systems. More specifically, when CLP was launched there were some hazard categories in GHS that were not adopted. Additionally, some EU-specific H-phrases (so called EUH-phrases) were added (EC, 2024). To ensure that the third ProScale principle (i.e., adopt a conservative approach) was followed, it was decided that both GHS and CLP should be used as the hazard basis in ProScale.

Human health H-phrases (i.e., those in the H3XX-series) are relevant for ProScale-W, -SL and -IE, while environmental H-phrases (i.e., those in the H4XX-series) are relevant for ProScale-E.

2.2.2 Hazard Modifier Human Health

To account for the potency of substance *i*, a hazard modifier is added. The human health hazard modifier is an occupational exposure limit (OEL) or derived no-effect level (DNEL) expressed in [mg/m^3]. The first is a legally derived limit that defines the maximum amount of a substance workers can safely be exposed to. Even though these OELs refer to occupational exposure, they are used in ProScale-SL and -IE as potency-related information and do not serve as consumer exposure thresholds. We will continuously revise this methodological decision by monitoring relevant legislation and potential replacement.

For those substances where no OEL has been established, DNEL values serve as substitutes. DNEL values are exposure levels above which adverse health effects are expected, established under REACH.

If no OEL or DNEL are available for a substance, the ProScale conservative approach is applied by assigning the substance the highest possible HF for that particular substance.

2.2.3 Hazard Factor Human Health (HF_H)

Human-health H- and EUH-statements are grouped into five ProScale hazard classes, A – E, where E represents the highest hazard class (Table 5). For each exposure route, the most severe applicable H- or EUH-statement for substance *i* determines the corresponding ProScale hazard class. Statements designated as applying to all routes are considered for dermal, inhalation and oral exposure. Consequently, a substance may be assigned to different hazard classes, and therefore different human-health hazard factors (HF_H) for different exposure routes. ProScale scores are correspondingly calculated separately for each route.

Table 5. Grouping of human-health H- and EUH-statements into ProScale hazard classes and corresponding HF_H ranges.

ProScale hazard class And HF_H ranges	**H- and EUH-phrases according to GHS/CLP, grouped per exposure route**
E 10 000 – 100 000 (highest hazard)	All routes: H340*, H350*, H360*, EUH380, EUH440, EUH441
D 1 000 – 10 000	Dermal: H310 Inhalation: H330, H334, EUH032 Oral: H300 All routes: H341, H351, H361, H362, H372, EUH381
C 100 – 1 000	Dermal: H311, H314, H317, H318, EUH070 Inhalation: H331, EUH029, EUH031, EUH071 Oral: H301, H304 All routes: H370, H373
B 10 – 100	Dermal: H312, H315, H319 Inhalation: H332, H335 Oral: H302 All routes: H371
A 1 – 10 (lowest hazard)	Dermal: H313, H316, H320, EUH066 Inhalation: H333, H336 Oral: H303, H305

**The HF_H for carcinogenic, mutagenic and/or reprotoxic (CMR) substances in hazard class E is divided by a factor of three if there is an officially recognized OEL.*

Once the ProScale hazard class has been determined, an OEL or, where an OEL is unavailable, a DNEL is used as a substance-specific potency-scaling modifier to derive the HF_H. Within each hazard class, HF_H is determined by linear interpolation in log-log space between the predefined OEL/DNEL limits, see Figure 2. Values outside this range are assigned the corresponding maximum or minimum HF_H. Thus, an OEL/DNEL ≤0.1 mg/m^3 results in the maximum HF_H for the corresponding hazard class, while an OEL/DNEL ≥250 mg/m^3 results in the minimum HF_H. If neither an OEL nor a suitable DNEL is available for substance *i*, the maximum HF_H of the assigned hazard class is used as a conservative default.

The HF_H for carcinogenic, mutagenic and/or reprotoxic (CMR) substances in hazard class E is divided by a factor of three if there is an officially recognized OEL. Dividing by three lowers the HF_H by precisely half a class on the logarithmic scale, not removing the CMR severity but acknowledging the threshold information. The resulting E* curve shown in Figure 2 represents this adjusted E-class HF_H and is not a separate ProScale hazard class.

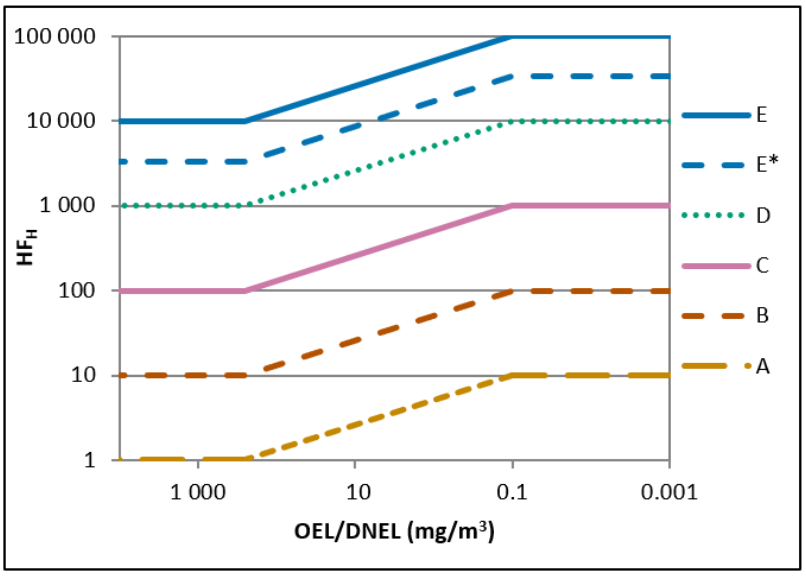

Figure 2. The relationship between OEL/DNEL and HF_H for ProScale hazard classes A-E. E represents the adjusted E-class HF_H applied to CMR substances with an officially recognized OEL. Abbreviations: HF = hazard factor, OEL = occupational exposure limit, DNEL = derived no-effect level.*

A substance that is not classified as hazardous to human health according to GHS/CLP but has a recognized OEL/DNEL is assigned to ProScale hazard class A for inhalation. Its inhalation HF_H is then determined according to the same potency-scaling procedure as for other substances in hazard class A. The HF_H for dermal and oral exposure is set to zero in such cases.

2.2.4 Hazard Modifier Environment

To account for the potency of substance *i*, a hazard modifier is added. There are two environmental hazard modifiers, the first being an M-factor. In GHS/CLP, M-factors are assigned to substances that are highly toxic to aquatic organisms (i.e., those classified as H400 and/or H410) to reflect that even small amounts of such substances may lead to

environmental hazards for the mixture in which they are present. In ProScale, these M-factors are used to separate substances that have different toxicity levels but the same H-phrase (e.g., H400).

The second hazard modifier is information on the biodegradability of substance *i*. In collaboration with ECETOC, it was determined that rapidly degrading (RD) substances are placed in a higher ProScale hazard class than non-rapidly degrading (NRD) substances (Tolls et al., 2025). The reason for separating RD and NRD substances at this stage is to compensate for the fact that those parameters are included in the H-phrase determination. By separating RD and NRD here, we eliminate the inherent biodegradability information from the H-phrases. Later, in the system-level aggregation/translation, the substance's biodegradability is accounted for by an addition of a degradation factor (DF). More information about the DF can be found in Section 2.3.3.

2.2.5 Hazard Factor Environment (HF_E)

The H-phrases for the environment are divided into seven ProScale hazard classes, AAA – E, where E represents the worst hazard. Using the collected H4XX-phrases, M-factors (if relevant) and biodegradability information, substance *i* is placed in any of the seven ProScale hazard classes according to Table 6. The most severe H-phrase of substance *i* determines which ProScale hazard class the substance is categorized to.

For those substances where there is no data on whether substance *i* degrades rapidly or not, it should always be placed in the ProScale hazard class corresponding to RD for the particular H4XX-phrase (if relevant), placing the substance in the higher hazard class in Table 6 and thus aligning with the conservative ProScale approach.

Table 6. Grouping of H4XX-phrases into hazard classes in ProScale.

ProScale-E hazard class and hazard factor	**H-phrases according to GHS/CLP**
E 100 000 (highest hazard)	EUH440, EUH441, EUH450, EUH451, EUH430 $H410_{RD}$ (M = 1000)
D 10 000	EUH431 $H400_{RD}$, $H410_{NRD}$ (M = 1000) $H410_{RD}$ (M = 100)
C 1 000	$H400_{NRD}$ (M = 1000) $H400_{RD}$, $H410_{NRD}$ (M = 100) $H410_{RD}$ (M = 10)
B 100	$H400_{NRD}$ (M = 100) $H400_{RD}$, $H410_{NRD}$ (M = 10) $H410_{RD}$ (M = 1)
A 10	$H400_{NRD}$ (M = 10) $H400_{RD}$, $H410_{NRD}$ (M = 1) $H411_{RD}$
AA 1	$H400_{NRD}$ (M = 1) $H411_{NRD}$, $H412_{RD}$
AAA 0.1	$H412_{NRD}$, $H413_{NRD}$*

(lowest hazard)	

**RD is not relevant for H413.*

2.3 System-Level Aggregation/Translation

All ProScale modules contain one or more parameters for translating RA information into LCA compatible information. This sub-section introduces each of those parameters.

2.3.1 Person-Hour Factor Workers (PHF_W)

The ECF in ProScale-W is not related to the throughput of the unit process as such. In order to allow a meaningful aggregation along the life cycle, a person-hour factor (PHF) is applied. The PHF transforms the potential exposure concentration to a dose so that the ProScale score can be related to the functional unit (FU).

Default PHF_W has been derived for a number of industrial sectors and processes. These default values are based on information on full-time equivalents and throughput per industry section in a single EU country or the entire EU, depending on which information that was available. All input data used for these calculations are summarized in Table 12 in Appendix II. This information has been obtained from best available techniques reference (BREF) documents, industry associations and environmental reports. Thus, the default PHF_W represents the manufacturing processes and countries/regions where the highest value obtained was chosen as the default. The default PHFs have been divided into three different categories: manufacturing processes, filling of different containers and waste management.

If none of the default parameters matches the unit process under study, a new PHF_W can be calculated via the following equation:

$$PHF_W \left[\frac{hr}{kg}\right] = \frac{Annual\ hours\ worked \left[\frac{hr}{year}\right]}{Annual\ production\ volume \left[\frac{kg}{year}\right]} \quad (1)$$

The annual hours worked are a function of the number of full-time equivalents for an industrial sector or specific process, multiplied by the number of hours that each full-time employee works during a year. This is then related to the annual production volume of that industrial sector or specific process. When calculating new PHFs, it is recommended to use figures for entire industry sectors rather than using information relating to a single company, so that the PHF represents an industry average. Recommended data sources for information about labor force and output of a process are: i) BREF documents/best available techniques (BAT) documents, ii) industry associations, and iii) company environmental reports.

2.3.2 Person-Hour Factor Service Life (PHF_{SL})

The PHF for the selected ProScale-SL environment (PHF_{SL}) represents the cumulative population-time associated with an Archetypal Indoor Environment (AIE) over the FU horizon. It is calculated as:

$$PHF_{SL} = \rho_{AIE} \times A_{AIE} \times U_{AIE} \times T \quad (2)$$

Where ρ_{AIE} is people density [persons/m^2], A_{AIE} is reference area [m^2], U_{AIE} is annual use time [days/person/year], and T is the product residence time [year] which represents the assessment period during which the active product stock (or exposure scenario) is represented in the AIE. The default AIEs used in ProScale-SL are defined in Table 7.

Table 7. Default Archetypal Indoor Environments (AIEs) for ProScale-SL with corresponding people density, environment surface area and time per person year. Sources for each AIE are listed in Appendix III.

AIE	People density [persons/m^2]	Reference Area [m^2]	Annual use time [days/year]
Household	0.04	50	330
Office / administrative	0.10	100	220
Classroom	0.50	60	200
Passenger car cabin	0.20	6	24
Retail / shopping floor	0.14	300	13
Hospital ward / patient room	0.125	200	3.8
Preschool / daycare	0.50	80	240
Public bus / regional train	0.30	50	25
Aircraft cabin	1.20	150	0.30

2.3.3 Degradation Factor (DF)

A DF is included in ProScale-E and -IE to account for a substance's biodegradability by reducing the toxicity by a factor of 10 or 100 for biodegradable substances. DF stretches from 0.01 to 1, where readily biodegradable substances are assigned DF = 0.01, inherently/rapidly biodegradable substances are assigned DF = 0.1, and all other degradability options (including Missing) are assigned DF = 1.

2.3.4 Route Relevance (E)

For potential human exposure of chemicals via the environment (i.e., indirect human exposure), one must consider the relevance of the possible exposure routes. Chemical fate and exposure are functions of both release patterns, release compartment, and the physicochemical properties of the substance. The exposure-route relevance factor, E, is introduced in ProScale-IE to represent whether the physicochemical profile of a substance makes a certain exposure route plausible for indirect human exposure. It complements the release, degradation, and human-health hazard components by differentiating inhalation, drinking-water, and food-consumption pathways after environmental release.

For some activities, selecting a primary emission compartment is possible. However, when the process under study is not sufficiently specified or when an ERC/SPERC spans multiple plausible release patterns, selecting a single "relevant compartment" is not possible. In such cases, ProScale-IE scores are recommended to consider bounding scenarios corresponding to the ERCs/SPERCs compartment-specific releases. In ProScale-IE, factor E also supports this bounding.

Mathematically, the bounding scenarios are expressed by nine equations (three release scenarios and three exposure routes). Taking the maximum PS_{IE} score per exposure route gives a single score per exposure route, which can be combined into aggregated scores. These equations are introduced in Table 8.

Table 8. Exposure route relevance equations for ProScale-IE.

Bounding scenarios:	
1	$PS_{IE_{inhalation,air}} = HF_{inhalation} \times MF \times ERF_{air} \times DF \times E_{inhalation}$

2	$PS_{IE_{inhalation,water}} = HF_{inhalation} \times MF \times ERF_{water} \times DF \times E_{inhalation}$
3	$PS_{IE_{inhalation,soil}} = HF_{inhalation} \times MF \times ERF_{soil} \times DF \times E_{inhalation}$
4	$PS_{IE_{drinking,air}} = HF_{oral} \times MF \times ERF_{air} \times DF \times E_{drinking}$
5	$PS_{IE_{drinking,water}} = HF_{oral} \times MF \times ERF_{water} \times DF \times E_{drinking}$
6	$PS_{IE_{drinking,soil}} = HF_{oral} \times MF \times ERF_{soil} \times DF \times E_{drinking}$
7	$PS_{IE_{food,air}} = HF_{oral} \times MF \times ERF_{air} \times DF \times E_{food}$
8	$PS_{IE_{food,water}} = HF_{oral} \times MF \times ERF_{water} \times DF \times E_{food}$
9	$PS_{IE_{food,soil}} = HF_{oral} \times MF \times ERF_{soil} \times DF \times E_{food}$
Route relevance determination:	
$PS_{IE_{inhalation}} = \max(PS_{IE_{inhalation,air}}, PS_{IE_{inhalation,water}}, PS_{IE_{inhalation,soil}})$	
$PS_{IE_{drinking}} = \max(PS_{IE_{drinking,air}}, PS_{IE_{drinking,water}}, PS_{IE_{drinking,soil}})$	
$PS_{IE_{food}} = \max(PS_{IE_{food,air}}, PS_{IE_{food,water}}, PS_{IE_{food,soil}})$	
Aggregating:	
$PS_{IE_{oral}} = PS_{IE_{drinking}} + PS_{IE_{food}}$	
$PS_{IE_{total}} = PS_{IE_{inhalation}} + PS_{IE_{oral}}$	

Factor E accounts for the most relevant exposure route (air inhalation, drinking-water or food consumption) for a particular environmental medium/compartment/matrix and is based on a number of substance-specific properties. Its assignment logic is thoroughly explained in Table 9 and summarized in the hierarchy below:

1. If any applicable high-relevance criterion is met, *E* = 1 (high) is assigned.
2. If no high criterion is met, *E* = 0.01 (low) is assigned only where the route-specific minimum evidence set is available and all other available descriptors are consistent with low relevance.
3. Where usable information is available but low relevance cannot be established, *E*=0.1 (medium) is assigned.
4. Where no usable route-relevant information is available, *E* = 1 (high) is assigned as a conservative default.

References for the route relevance criteria are found in Appendix IV.

Table 9. Criteria for assigning exposure-route relevance factors, E, in ProScale-IE. Any applicable high-relevance criterion overrides evidence supporting a lower band. Low relevance requires the route-specific core evidence and consistency among all available alternative or supporting descriptors. Medium relevance applies where usable information is available but neither high nor low relevance is established; absence of usable route-relevant information results in the conservative default, E = 1. Abbreviations: VP = Vapor Pressure; H' = dimensionless Henry's law constant; log K_{OW} = the decadic logarithm of octanol-water partition ratio (L/kg organic compound); log D_7 = the decadic logarithm of the pH-dependent octanol–water distribution ratio at pH 7.0; log K_{OC} = the decadic logarithm of organic carbon-water partition ratio; BCF = Bioconcentration Factor [L/kg biota]; BAF = Bioaccumulation Factor [L/kg biota]; K_{OC} = organic carbon-water partition ratio [L/kg organic carbon].

Route	**Properties considered**	**High (E=1) assigned if any listed criterion is met**	**Medium (E=0.1) usable non-high information, but low relevance not established**	**Low (E=0.01) assigned only where the listed core and consistency conditions are met, and no high criterion is met**
Inhalation	VP (core) *H*' (alternative)	VP ≥ 10 Pa, or $H' \geq 10^{-3}$	Otherwise, where usable route-relevant information is available	VP < 0.1 Pa, or $H' < 10^{-5}$; where both descriptors are available, both must satisfy their respective low-relevance criteria
Drinking water	log K_{OW} for neutral substances, log $D_{7.0}$ for ionizable substances, and water solubility (core) log K_{OC} (supporting)	log K_{OW} or log $D_{7.0}$ ≤ 2, or water solubility ≥ 100 mg/L, or log K_{OC} < 2	Otherwise, where usable route-relevant information is available	log K_{OW} or log $D_{7.0}$ ≥ 4, and water solubility < 1 mg/L; where log K_{OC} is available, it must be ≥ 3
Food	log K_{OW} for natural substances, log $D_{7.0}$ for ionizable substances (core) BCF, BAF and K_{OC} (supporting)	log K_{OW} or log $D_{7.0}$ > 4.5, or BCF or BAF > 2000, or K_{OC} > 5000	Otherwise, where usable route-relevant information is available	log K_{OW} or log $D_{7.0}$ ≤ 3, and at least one supporting descriptor satisfies BCF or BAF < 500, or K_{OC} < 500; where more than one supporting descriptors (BCF, BAF, K_{OC}) are available, they must also be consistent with low relevance

2.4 Mass Flow (MF)

The Mass Flow (MF) of substance *i* is included in all ProScale modules and represents one of the factors that translates the RA elements into an LCA compatible ProScale score. It is expressed in kg and represents the amount of substance *i* involved in the unit process that is being assessed.

2.4.1 MF in W-Module

For the W-module the MF [kg] corresponds to the inputs and outputs of each unit process, i.e., common Life Cycle Inventory (LCI) data.

2.4.2 MF_{active} and m_{ref} in SL-Module

To facilitate comparison of products that provide the same function but have different service lives, and to avoid treating replacement flows as simultaneously active exposure sources, ProScale-SL distinguishes between two mass terms:

i) m_{ref} [kg], the exposure-reference mass corresponding to the product unit for which the PPDD is estimated,
ii) MF_{active} [kg], the total mass of product units that are simultaneously active in the selected exposure context (AIE),

Where n_{active} exposure-reference units are simultaneously required to provide the relevant function,

$$MF_{active} = n_{active} \times m_{ref} \quad (3)$$

2.4.3 MF and ERF in E- and IE-Modules

ProScale-E and -IE modules share the same LCI data as the ProScale-W module [*kg*], i.e., LCI data for the main inputs and outputs to the unit process. However, to only consider the fraction released to the environment, emission flows are estimated by multiplying the LCI MFs with ERFs, as described in Section 2.1.3.

2.5 Module Specific Equations

The toxicity impact potential for each module and endpoint is summarized in Table 10, where all modules follow the general structure of $PS = CF_{module} \times MF$, where PS is the ProScale score. PSs are calculated for each substance *i*, per exposure route *r*, for each unit process and release compartment *c* (where relevant).

Table 10: ProScale equations per module.

Module	Exposure details	ProScale equation
ProScale-W	Direct occupational exposure via inhalation and dermal exposure	$PS_{i,r} = HF_{H_{i,r}} \times ECF_{i,r} \times PHF \times MF_i$
ProScale-SL	Direct consumer exposure via oral, dermal and inhalation	$PS_{i,r} = \frac{HF_{H_{i,r}} \times PPDD_{i,r} \times PHF_{SL}}{m_{ref}} \times MF_{active}$
ProScale-E	Release to air, water and soil	$PS_{i,r,c} = HF_{E_{i,r}} \times DF_i \times ERF_{i,c} \times MF$

ProScale-IE	Indirect human exposure via inhalation and food and water intake	$PS_{i,r,c} = HF_{H\,i,r} \times DF_i \times E_{i,r} \times ERF_{i,c} \times MF$

3. Method Limitations

There are some limitations that the user must be aware of when interpreting the result from ProScale assessments. The main limitations are listed below.

- The PROCs and ERCs are not always perfect for the system being assessed. For example, there is no suitable ERC for crude oil extraction, a unit process that occurs in most life cycles of chemicals. In practice this means that the ProScale scores from the -E and -IE modules are zero. This issue could be solved in ProScale-E by populating the data gap with measured or estimated emissions in life cycle inventory (LCI) data. ProScale-IE does not allow the user to apply any other data than emission estimations derived from LCI data and ERCs. Furthermore, release to the environment does not necessarily imply exposure, and the ERCs are screening-level descriptors rather than mass-balance-based distributions between environmental compartments. The ProScale assessment results will therefore be screening-level estimations and should not in any way be considered as measurements of exposure.
- Polymers, nanomaterials and substances of unknown or variable composition, complex reaction products or biological materials (UVCBs) are groups of chemical entities that are difficult to capture by current legislation due to unknown, complex and highly variable compositions. For example, many substances in raw material extraction operations are not classified conclusively under GHS/CLP, often due to being complex UVCB substances. This may generate an underestimation of the HF, and subsequently the ProScale scores, associated with these unit processes.
- As ProScale is a regulatory-aligned approach, generally this means that any limitation, data gap and/or uncertainty in relevant legislation is inherited. Results are recommended to always be evaluated in the context of known regulatory and data limitations affecting hazard classification, exposure estimation, and release characterization.
- ProScale-W is only designed to be applied to industrial uses. Professional use is recommended to be assessed with other modules.
- DIY and professional end-use scenarios may create overlaps between life cycle stages, increasing the risk of double counting unless functional units, system boundaries, and phase definitions are carefully established.
- ProScale-SL is not designed to be applied to maintenance activities during use of products.
- Limited information on emissions and exposure during waste treatment affects the robustness of assessments. Furthermore, waste cannot be classified under GHS, constraining direct application of hazard-based approaches.
- ProScale-SL is not recommended to be used across multiple AIEs. Aggregation or addition of ProScale-SL scores for several AIEs would potentially result in an overestimation of exposure due to underlying assumptions regarding time spent in the environment and the number of exposed people. However, if a product is used across several AIEs, the relevant environments may be modelled separately. The residence time assigned to each AIE should reflect the share of the assessment period associated with that environment, and the resulting ProScale-SL scores may

be summed where the exposure context is distinct and consistently defined. The same product mass or use event should not be counted in full in more than one AIE. Where the distribution of use is uncertain, separate AIEs may instead be assessed as scenarios.

- The ProScale methodology does not have a data quality indicator, and manual measures are required to ensure no misleadingly high or low results are used for decision-making. Examples of such measures are further explained in Section 4 of the Practical guidance.

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Appendix I – Change Log

Table *11* provides an overview of changes and updates since the previous ProScale version.

Table 11. Updates in the ProScale 2.0 Practical guidance and Methodological guidance compared to the ProScale 1.5 guidance.

Change	Version
The guidance is divided into a Practical guidance and a Methodological guidance.	ProScale 2.0, Guide version 1.0
Most of the LCA instructions are removed, the reader is recommended to obtain necessary information about LCA procedure elsewhere. This document instead focuses specifically on the ProScale method.	ProScale 2.0, Guide version 1.0
Motivations related to method choices are removed, this will be included in publications instead. This document focuses on what is relevant to know for a ProScale practitioner that will perform a ProScale assessment.	ProScale 2.0, Guide version 1.0
The possibility to apply professional setting is removed in ProScale-W. The method is only recommended for industrial setting.	ProScale 2.0, Guide version 1.0
New modules for ProScale-SL, ProScale-E and ProScale-IE are added.	ProScale 2.0, Guide version 1.0
Specific end-of-life guidance on PHF and PROC is added.	ProScale 2.0, Guide version 1.0
Hazard banding for environmental hazards is added.	ProScale 2.0, Guide version 1.0
The EU hazard phrases for ED, PBT, vPvB, PMT, vPvM are added to the human health hazard banding. H362 is moved from class A to class B.	ProScale 2.0, Guide version 1.0
The ECF transformation in ProScale-W is removed.	ProScale 2.0, Guide version 1.0
Unit modification of ProScale-W by i) dividing the PHF with 8/24, ii) multiply the ECF_{dermal} with 70kg and, iii) introduce an inhalation rate of 1.6 m^3/hr for $ECF_{inhalation}$.	ProScale 2.0, Guide version 1.0
The methodological recommendation to divide the PHF by the number of unit processes, if the process of the default PHF covers more than one unit process and the unit processes are physically separated, is removed.	ProScale 2.0, Guide version 1.0
$PHF_{default}$ values for waste management processes has been updated.	ProScale 2.0, Guide version 1.0

Appendix II – Input Data for PHF_W Default Values

Table 12 provide a list of all input data used for the calculations of the PHF_W default values. This information has been obtained from best available techniques reference (BREF) documents, industry associations and environmental reports.

Table 12. Input Data for PHF_W Default Values.

Type of production process	**Region/Country**	**Full time equivalents (FTE) at plant [persons]**	**Working time [h/FTE*yr]**	**Annual hours worked [h/year]**	**Production volume (or capacity) [kg/year]**	**Person-hour factor [h/kg]**	**Person-hour factor [days/kg]**
Organic commodity chemicals manufacturing, large to medium size chemical plant							**3E-03**
Maximum of below PHFs = $PHF_{default}$ =							
Refinery, very large chemical plant	Preem, Sweden	900	2 000	2E+06	1E+10	1E-04	4E-04
Refinery, large chemical plant	ST1, Sweden	200	2 000	4E+05	3E+09	1E-04	4E-04
Refinery, very large chemical plant	EU	55000	2 000	1E+08	7E-11	2E-04	5E-04
Lubricant refinery	Nynas, Sweden	160	2 000	3E+05	8E+08	4E-04	1E-03
Naphta cracker	Borealis, Sweden	500	2 000	1E+06	1E+09	1E-03	3E-03
Cracker products	Borealis, Sweden	100	2 000	2E+05	2E+09	1E-04	3E-04
Organic commodity chemicals manufacturing, small to medium size chemical plant							**8E-03**
Maximum of below PHFs = $PHF_{default}$ =							

Ethanol manufacturing from wheat	Agroetanol, Sweden	100	2 000	2E+05	2E+08	1E-03	3E-03
Lubricant production	Axel Christiernsson, Sweden	30	2 000	6E+04	3E+07	2E-03	6E-03
Lubricant production	Petrolia, Loudden, Sweden	40	2 000	8E+0	3E+07	3E-03	8E-03
					Oil and fuel handling, depot **Maximum of below PHFs = $PHF_{default}$ =**		**3E-03**
Oil depot	Loudden, Sweden	1250	2 000	3E+06	2E+10	1E-04	4E-04
Oil depot	Univar, Loudden, Sweden	4	2 000	8E+03	8E+06	1E-03	3E-03
Fuel handling	Skoogs, Sweden	2	2 000	4E+03	1E+08	4E-05	1E-04
Fuel handling	Skoogs, Sweden	2	2 000	4E+03	1E+08	4E-05	1E-04
Fuel handling	Pampus, Sweden	10	2 000	2E+04	1E+08	2E-04	6E-04
					Inorganic chemicals manufacturing, large to medium size chemical plant **Maximum of below PHFs = $PHF_{default}$ =**		**2E-02**
Ammonia manufacturing		100	2 000	2E+05	8E+08	3E-04	8E-04
Hydroflouric acid manufacturing	EU	400	2 000	8E+05	3E+08	3E-03	8E-03
Chlorine manufacturing	EU	39 000	2 000	8E+07	1E+10	6E-03	2E-02

Chlorine manufacturing	INOVYN, Sweden	303	2 000	6E+05	1E+08	5E-03	2E-02
Fine/specialty chemicals manufacturing, small to medium size chemical plant **Maximum of below PHFs = $PHF_{default}$ =**							**3E-01**
Manufacturing of fine organic chemicals such as pigments and dyes, flame retardants, plasticisers such as phtalate esters, pharmaceuticals etc	EU	600 000	2 000	1E+09	1E+10	1E-01	3E-01
Silicone production	EU	10 000	2 000	2E+07	6E+08	3E-02	1E-01
Plasticiser production	EU	1 500	2 000	3E+06	1E+09	3E-03	9E-03
Plastics manufacturing **Maximum of below PHFs = $PHF_{default}$ =**							**9E-03**
PE/PP manufacturing	Boeralis, Sweden	500	2 000	1E+06	8E+08	1E-03	4E-03
Polymer manufacturing	France	9 300	2 000	2E+07	7E+09	3E-03	9E-03
Polymer manufacturing	EU	71 200	2 000	1E+08	6E+10	2E-03	7E-03
Plastics processing **Maximum of below PHFs = $PHF_{default}$ =**							**4E-02**

Plastics extrusion etc	Nordiska Plast, Sweden	45	2 000	9E+04	1E+07	7E-03	2E-02
Plastics extrusion etc	Arla Plast, Sweden	220	2 000	4E+05	3E+07	1E-02	4E-02
					Mixing and blending batch processes, such as paint manufacturing **Maximum of below PHFs = $PHF_{default}$ =**		**1E-01**
Liq. Coatings production	AkzoNobel, Malmö, Sweden	600	2 000	1E+06	7E+07	2E-02	5E-02
Paint and varnish production	EU	120 000	2 000	2E+08	7E+09	3E-02	1E-01
					Oil extraction **Maximum of below PHFs = $PHF_{default}$ =**		**1E-03**
Oil and gas extraction at sea	Norway	30 100	2 000	6E+07	2E+11	3E-04	9E-04
Crude oil extraction	USA	90 000	2 000	2E+08	5E+11	4E-04	1E-03
					Portland cement and limestone manufacturing **Maximum of below PHFs = $PHF_{default}$ =**		**2E-03**
Portland cement manufacturing	EU	54 000	2 000	1E+08	3E+11	4E-04	1E-03
Portland cement manufacturing	Cementa, Degerfors, Sweden	80	2 000	2E+05	3E+08	5E-04	2E-03
Portland cement manufacturing	Cementa, Slite, Sweden	220	2 000	4E+05	2E+09	2E-04	6E-04

Portland cement manufacturing	Cementa, Skövde, Sweden	25	2 000	5E+04	6E+08	8E-05	3E-04
Limestone industry	Nordkalk, Gotland, Sweden	57	2 000	1E+05	3E+09	4E-05	1E-04
Limestone industry	EU	10 550	2 000	2E+07	3E+10	8E-04	2E-03
						Steel manufacturing **Maximum of below PHFs = $PHF_{default}$ =**	**6E-03**
Steel production	Sweden	3 300	2 000	7E+06	4E+09	2E-03	6E-03
Steel production, smelter	Boliden, Sweden	800	2 000	2E+06	1E+09	1E-03	4E-03
Steel production, smelter	SSAB raw iron, Sweden	1 660	2 000	3E+06	2E+09	2E-03	5E-03
						Transportation **Maximum of below PHFs = $PHF_{default}$ =**	**1E-03**
Transportation at sea with tanker	Transatlantic	25	360*	9 000**	3E+08	3E-05	9E-05
Transportation by tank truck (30 000 L)	Amsterdam-Gothenburg	1	12*	12**	3E+04	4E-04	1E-03
Transportation by train in tank car (100 000 L)	Amsterdam-Gothenburg	2	20*	40**	1E+05	4E-04	1E-03
						Filling	
Filling of an oil tanker	Oil tanker example	5	22	110	3E+08	4E-07	**$PHF_{default}$ =1E-06**

Filling, low viscous materials	Drum, can, IBC, tank etc	Assumption: Filling time 0.15 s/kg, only 10 % of the filling time is relevant for exposure				4E-06	**$PHF_{default}$ =1E-05**
Filling, middle viscous materials	Drum, can, IBC, tank etc	Assumption: Filling time 0.3 s/kg, only 10 % of the filling time is relevant for exposure				8E-06	**$PHF_{default}$ =3E-05**
Filling, high viscous materials	Drum, can, IBC, tank etc	Assumption: Filling time 4 s/kg, only 10 % of the filling time is relevant for exposure				1E-04	**$PHF_{default}$ =3E-04**
					Waste management		
Recycling	EU	75	2 000	1E+12***		1E-07	**$PHF_{default}$=3E-07**
Incineration	EU	26	2 000	1E+11***		4E-07	**$PHF_{default}$=1E-06**
Landfill	EU	14	2 000	9E+11***		3E-08	**$PHF_{default}$=9E-08**

*Working time per trip and person
**Working time per trip
***Amount waste handled in 2022

Appendix III – References for Archetypal Indoor Environments

Appendix III provides an overview of the factors used to calculate the PHF for each AIE and, where available, the references used to derive the default values for annual use time, people density, and reference area, see Tables 13-15.

Table 13. Selected annual use time (8-h-eq d yr^{-1}) and reference(s) per AIE.

Archetypal Indoor Environment	Selected default	Reference URL
Residential dwelling	330	https://ec.europa.eu/eurostat/web/time-use-surveys https://ec.europa.eu/eurostat/statistics-explained/index.php?title=How_do_women_and_men_use_their_time_-_statistics
Office/administrative	220	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32003L0088
Classroom	200	https://eurydice.eacea.ec.europa.eu/data-and-visuals/european-school-calendars
Passenger-car cabin	24	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Main_place_of_work_and_commuting_time_-_statistics
Retail/shopping floor	13	https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20181123-1
Hospital ward/patient room	3.8	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Hospital_discharges_and_length_of_stay_statistics
Preschool/daycare	240	
Public bus/regional train	25	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Main_place_of_work_and_commuting_time_-_statistics
Aircraft cabin	0.3	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Air_passenger_transport_statistics

Table 14. Selected people density (persons m^{-2}) and reference per AIE.

Archetypal Indoor Environment	Selected default	Reference URL
Residential dwelling	0.04	https://www.bpie.eu/publication/europes-buildings-under-the-microscope/
Office/administrative	0.1	https://doi.org/10.1016/j.enbuild.2020.109819
Classroom	0.5	https://neu.org.uk/advice/classroom/class-sizes
Passenger-car cabin	0.2	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Passenger_mobility_statistics
Retail/shopping floor	0.14	https://doi.org/10.1016/j.enbuild.2020.109819
Hospital ward/patient room	0.125	https://www.hewi.com/en/mag/153-patient-room-hospital
Preschool/daycare	0.5	https://neu.org.uk/advice/classroom/class-sizes
Public bus/regional train	0.3	https://publications.iadb.org/publications/english/document/Evaluation-of-Passenger-Comfort-in-Bus-Rapid-Transit-Systems.pdf
Aircraft cabin	1.2	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Air_passenger_transport_statistics

Table 15. Selected default reference area (m^2) and reference per AIE.

Archetypal Indoor Environment	Selected default	Reference URL
Residential dwelling	50	https://www.bpie.eu/publication/europes-buildings-under-the-microscope/
Office/administrative	100	
Classroom	60	
Passenger-car cabin	6	

Retail/shopping floor	300	
Hospital ward/patient room	200	
Preschool/daycare	80	
Public bus/regional train	50	
Aircraft cabin	150	

Appendix IV – References for E-factor criteria

Appendix IV provides an overview of the references used for derivation of the route relevance, E-factor, criteria for ProScale-IE, see Table 16.

Table 16. References for the criteria for assigning exposure-route relevance factors.

E-factor role	Reference
Food: log KOW >4.5 bioaccumulation-screening anchor.	European Chemicals Agency (2023). *Guidance on Information Requirements and Chemical Safety Assessment, Chapter R.11: PBT/vPvB assessment*, Version 4.0. https://doi.org/10.2823/312974
Drinking water: log KOC mobility categories.	European Commission (2023). Commission Delegated Regulation (EU) 2023/707. https://eur-lex.europa.eu/eli/reg_del/2023/707/oj/eng
Food: log POW >3 dietary/fat-solubility trigger.	European Commission DG SANTE (2021). *Commission Working Document 1: Nature of pesticide residues in fish.* (SANTE/10254/2021) https://food.ec.europa.eu/system/files/2021-10/pesticides_mrl_guidelines_app-j-10254-2021_en.pdf
Food: log POW >3 / fat-solubility criterion.	European Food Safety Authority (2015). *Estimation of animal intakes and HR, STMR and MRL calculations for products of animal origin.* https://food.ec.europa.eu/system/files/2016-10/pesticides_mrl_guidelines_animal_intake_mrl_2015_en.pdf
Food: BCF >2000; also contextual basis for descriptor availability under REACH.	European Parliament & Council (2006). Regulation (EC) No 1907/2006 (REACH), particularly Annex XIII. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R1907
Inhalation: 10 Pa VOC anchor.	European Parliament & Council (2010). Directive 2010/75/EU on industrial emissions. https://doi.org/10.3000/17252555.L_2010.334.eng
Food: KOC <500 and >5000 retention/mobility anchors.	McCall et al. (1980). *Estimation of chemical mobility in soil from liquid chromatographic retention times.* https://doi.org/10.1007/BF01608096

Drinking water: <1 mg/L solubility and log KOW ≥4 anchors.	OECD (2001). *Guidance Document on the Use of the Harmonised System for the Classification of Chemicals Which Are Hazardous for the Aquatic Environment.* https://www.oecd.org/content/dam/oecd/en/publications/reports/2002/05/guidance-document-on-the-use-of-the-harmonised-system-for-the-classification-of-chemicals-which-are-hazardous-for-the-aquatic-environment_g1gh2b68/9789264078444-en.pdf
Drinking water: 100 mg/L solubility anchor.	OECD (2019). *Guidance Document on Aquatic Toxicity Testing of Difficult Substances and Mixtures.* https://doi.org/10.1787/0ed2f88e-en
Inhalation: Henry's-law/volatilization classification underlying H′ bands.	Thomas (1982). *Volatilization from water.* https://hero.epa.gov/reference/1333858/
Inhalation: VP <0.1 / ≥10 Pa screening structure.	Zaleski et al. (2023). *An assessment of the ECETOC TRA Consumer tool performance as a screening level tool.* https://doi.org/10.1038/s41370-022-00510-0

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