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**Emission Scenario Document for Wood Preservatives
PART3**

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Emission Scenario Document for Wood Preservatives

[Part 3]

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7. REMOVAL PROCESSES IN THE RECEIVING COMPARTMENT

323. In a first tier estimation, removal processes from the receiving compartment due to degradation, volatilisation, leaching to groundwater (for soil) or sedimentation (in surface water) can be ignored. In the scenarios described in the preceding sections, the concentration in soil ignoring removal processes in the receiving compartments is calculated. For a second tier, the removal processes can be estimated e.g. according to [EU TGD (1997)]¹ and taken into account in the estimation of the concentrations in the receiving compartments as shown below. Other higher tier mathematical models can also be used.

324. The rate constant for removal can include degradation, volatilisation and leaching to groundwater. Estimation methods for removal constants and water-soil partition coefficients are for example available in [EU TGD (1997)].

325. In the following model, soil is described as consisting of three phases: air, solids and water. The bulk density of soil is thus defined by the fraction and bulk density of each phase. Both the fractions solids and water, and the total bulk density are used in subsequent calculations. All soil concentrations are related to “wet soil”. A conversion to “dry soil” can also be introduced. With “wet soil”, a predefined soil with a given water content is meant (e.g. with a field capacity water content, or as proposed in EC (1996) with a solids fraction of 0.6 (vol/vol), a water fraction of 0.2 (vol/vol), an air fraction of 0.2 (vol/vol) and a density of solids of 2500 kg.m⁻³). This predefined soil should be representative of the area or region where the assessment is being performed. Whichever type of soil is chosen, it should be used consistently throughout the calculations.

326. As the leaching rate from wood will be high just after application, to fall to a lower more constant rate after a few days or weeks, two time spans will be distinguished: a short time span just after application, to estimate soil concentrations after short-time high leaching rates (30 days), and a longer time span to estimate the long-term soil concentration (1 year or longer).

7.1 Soil

7.1.1 *Continuous releases into soil*

327. For continuous releases into soil, the following model can be used. The releases due to leaching from wood during storage can be assessed with this model in a first approach. Due to the periodic renewal of stored wood in the storage area, it can be considered that the release rate is continuous. An average daily release rate into soil due to leaching over the storage duration can be used.

¹ Technical Guidance Document in Support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances and Commission Regulation (EC) No. 1488/94 on Risk Assessment for Existing Substances. Office for Official Publication of the European Union, four parts. Luxembourg 1997. ISBN 92-827-8011-2.

Parameters

Parameter	Nomenclature	Value	Unit	Origin
Inputs				
Average daily flux i.e. the average quantity of an active ingredient that is daily leached out of 1 m ² of treated wood during a certain storage period	$FLUX_{storage}$		[kg.m ⁻² .d ⁻¹]	A
Effective surface area of treated wood, considered to be exposed to rain, per m ² storage area (i.e. soil)	$AREA_{wood-expo}$	11	[m ² .m ⁻²]	D
Average daily release onto soil of active ingredient due to leaching over the storage duration per m ² of storage area (see section 4.1.5 and 4.2)	$Elocal_{soil}$		[kg.m ⁻² .d ⁻¹]	O
Bulk density of wet soil	RHO_{soil}	1700	[kg.m ⁻³]	D
Depth of soil	$DEPTH_{soil}$	0,1	[m]	D
First order rate constant for removal from soil	k		[d ⁻¹]	A
Fraction of rainwater running off the storage site (i.e. not infiltrating in soil)	F_{runoff}	0,5	[-]	D
Outputs				
Steady-state concentration in local soil	$Clocal_{soil,ss}$		[kg.kg _{wwt} ⁻¹]	O
Steady-state concentration in soil pore water	$Clocal_{pore,ss}$		[kg.m ⁻³]	O

D=default, A=based on information of applicant, O=output

Calculations

$$Elocal_{soil} = FLUX_{storage} \cdot AREA_{wood-expo} \quad (7.1)$$

$$Clocal_{soil,ss} = \frac{Elocal_{soil}}{DEPTH_{soil} \cdot RHO_{soil}} \cdot \frac{1}{k} \cdot (1 - F_{runoff}) \quad (7.2)$$

$$Clocal_{pore,ss} = \frac{Clocal_{soil,ss} \cdot RHO_{soil}}{K_{soil_water}} \quad (7.3)$$

328. It should be noted however that the use of the average daily flux ($FLUX_{storage}$) in equation 7.1 is a simplification and it can underestimate the amount of wood preservative lost in some cases. Further explanations on this issue are provided in Appendix 2.

7.1.2 Time dependent concentrations in soil

329. If the emission into soil is based on a single emission during application, followed by an average leaching rate from treated wood in service, the following model could be used. The dimensions of the wooden structures and the receiving soil according to the different scenarios are described in Appendix 3.

Parameters

Parameter	Nomenclature	Value	Unit	Origin
Inputs				
Emission of active ingredient during application (assumed to occur over 1 day)	E_{applic}		[kg.d ⁻¹]	O
Duration of the initial assessment period	$TIME1$	30	[d]	D
Duration of the long-term assessment period	$TIME2$		[d]	D
Cumulative quantity of an active ingredient leached out of 1 m ² of treated wood over the initial assessment period is determined based on the results of a leaching test.	$Q^*_{leach,time1}$		[kg.m ⁻²]	A
Cumulative quantity of an active ingredient leached out of 1 m ² of treated wood over the a longer assessment period	$Q^*_{leach,time2}$		[kg.m ⁻²]	A
Leachable treated wood area, proposed in the relevant scenarios (cf. Appendix 3)	$AREA_{wood}$		[m ²]	D
Volume of receiving soil, proposed in the relevant scenarios (cf. Appendix 3)	V_{soil}		[m ³]	D
Bulk density of wet soil	RHO_{soil}	1700	[kg.m ⁻³]	D
Soil-water partitioning coefficient	$K_{soil-water}$		[m ³ .m ⁻³]	A
First order rate constant for removal from soil	k		[d ⁻¹]	A
Outputs				
Initial concentration in soil during application	$C_{local,soil,applic}$		[kg.kg _{wwt} ⁻¹]	O
Average daily emission of active ingredient due to leaching over the initial assessment period	$E_{soil,leach,time1}$		[kg.d ⁻¹]	O
Average daily emission of active ingredient due to leaching over a longer duration	$E_{soil,leach,time2}$		[kg.d ⁻¹]	O
Time weighted concentration in local soil over the initial assessment period	$C_{local,soil,time1}$		[kg.kg _{wwt} ⁻¹]	O
Time weighted concentration in local soil over a longer duration	$C_{local,soil,time2}$		[kg.kg _{wwt} ⁻¹]	O
Average concentration in soil pore water over the initial assessment period	$C_{local,pore,time1}$		[kg.m ⁻³]	O
Average concentration in soil pore water over a longer duration	$C_{local,pore,time2}$		[kg.m ⁻³]	O

D=default, A=based on information of applicant, O=output

Calculations

$$Clocal_{soil,applic} = \frac{E_{applic}}{V_{soil} \cdot RHO_{soil}} \quad (7.4)$$

$$E_{soil,leach,time1} = \frac{AREA_{wood} \cdot Q_{leach,time1}^*}{TIME1} \quad (7.5)$$

$$E_{soil,leach,time2} = \frac{AREA_{wood} \cdot Q_{leach,time2}^*}{TIME2} \quad (7.6)$$

$$Clocal_{soil,time1} = \frac{E_{soil,leach,time1}}{V_{soil} \cdot RHO_{soil} \cdot k} + \frac{1}{k \cdot time1} \left[Clocal_{soil,applic} - \frac{E_{soil,leach,time1}}{V_{soil} \cdot RHO_{soil} \cdot k} \right] \cdot (1 - e^{-time1 \cdot k}) \quad (7.7)$$

$$Clocal_{soil,time2} = \frac{E_{soil,leach,time2}}{V_{soil} \cdot RHO_{soil} \cdot k} + \frac{1}{k \cdot time2} \left[Clocal_{soil,applic} - \frac{E_{soil,leach,time2}}{V_{soil} \cdot RHO_{soil} \cdot k} \right] \cdot (1 - e^{-time2 \cdot k}) \quad (7.8)$$

$$Clocal_{pore,time1} = \frac{Clocal_{soil,time1} \cdot RHO_{soil}}{K_{soil_water}} \quad (7.9)$$

$$Clocal_{pore,time2} = \frac{Clocal_{soil,time2} \cdot RHO_{soil}}{K_{soil_water}} \quad (7.10)$$

330. If for a given product, no *in-situ* treatment is foreseen, i.e. if only pre-treated wood is used for the construction of a wooden structure, only the releases due to leaching from the wood are taken into consideration and $Clocal_{soil,applic} = 0$.

331. For the calculation of the average concentration in soil over a longer duration, alternatively, the concentration in soil after 30 days can be used as the initial concentration over the calculation period. The calculation above can then be adapted as follows, by calculating the concentration in soil after 30 days.

Parameters

Parameter	Nomenclature	Value	Unit	Origin
Outputs				
Concentration in local soil after the initial assessment period	$Clocal_{soil,time1}$		[kg.kg _{wwt} ⁻¹]	O
Time weighted concentration in local soil over a longer duration	$Clocal_{soil,time2}$		[kg.kg _{wwt} ⁻¹]	O

D=default, A=based on information of applicant, O=output

$$Clocal_{soil,time1} = \frac{E_{soil,leach,time1}}{V_{soil} \cdot RHO_{soil} \cdot k} - \left[\frac{E_{soil,leach,time1}}{V_{soil} \cdot RHO_{soil} \cdot k} - Clocal_{soil,applic} \right] \cdot e^{-time1 \cdot k} \quad (7.11)$$

$$C_{local,soil,time2} = \frac{E_{soil,leach,time2}}{V_{soil} \cdot RHO_{soil} \cdot k} + \frac{1}{k \cdot time2} \left[C_{local,soil,time1} - \frac{E_{soil,leach,time2}}{V_{soil} \cdot RHO_{soil} \cdot k} \right] \cdot (1 - e^{-time2 \cdot k}) \quad (7.12)$$

7.1.3 Conversion wet weight – dry weight

332. All concentration in soil estimated in this document are expressed in wet weight. The conversion to dry weight can be performed according to the calculation below.

Parameters

	Nomenclature	Value	Unit	Origin
Inputs				
Bulk density of wet soil	RHO_{soil}	1700	[kg _{wwt} ·m ⁻³]	D
Density of solid phase	RHO_{solid}	2500	[kg·m ⁻³]	D
Volume fraction of solids in soil	$F_{solid,soil}$	0,6	[m ³ ·m ⁻³]	D
Outputs				
Conversion factor for soil concentrations	$CONV_{soil}$		[kg _{wwt} ·kg _{dwt} ⁻¹]	O

D=default, A=based on information of applicant, O=output

Calculations

$$CONV_{soil} = \frac{RHO_{soil}}{F_{solid,soil} \cdot RHO_{solid}} \quad (7.13)$$

333. By using the default values as proposed in the table above, a conversion factor of 1.13 can be calculated.

7.2 Surface water

334. Two situations can be distinguished:

1. Release into a static water body e.g. a lake or pond. This situation corresponds to the scenario for a jetty in a lake (Chapter 5, Scenario 4b.1).
2. Release into a flowing water body. This situation corresponds to the scenario for a sheet piling (Chapter 5, Scenario 4b.2) as well as for a wharf on the sea (Chapter 5, Scenario 5).

7.2.1 Release into a static water body

335. The estimations are similar to the estimations for soil. The following model can be used to take into account removal processes. As shown for the description of the scenarios below, in-situ treatment of wooden structures in permanent contact with water is not very probable and therefore only the releases due to leaching are taken into account. The dimensions of the wooden structures and the water bodies according to the different scenarios are described in Appendix 3.

Parameters

	Nomenclature	Value	Unit	Origin
Inputs				
Duration of the initial assessment period	<i>TIME1</i>	30	[d]	D
Duration of the long-term assessment period	<i>TIME2</i>		[d]	D
Cumulative quantity of an active ingredient leached out of 1 m ² of treated wood over the initial assessment period is determined based on the results of a leaching test.	$Q^*_{leach,time1}$		[kg.m ⁻²]	A
Cumulative quantity of an active ingredient leached out of 1 m ² of treated wood over the a longer assessment period	$Q^*_{leach,time2}$		[kg.m ⁻²]	A
Leachable treated wood surface, proposed in the relevant scenarios (cf. Appendix 3)	$AREA_{wood}$		[m ²]	D
Volume of receiving water body, , proposed in the relevant scenarios (cf. Appendix 3)	V_{water}		[m ³]	D
First order rate constant for removal from water	<i>k</i>		[d ⁻¹]	A

Parameters, cont.

	Nomenclature	Value	Unit	Origin
Outputs				
Average daily emission due to leaching over the initial assessment period	$E_{water,leach,time1}$		[kg.d ⁻¹]	O
Average daily emission due to leaching over a longer duration	$E_{water,leach,time2}$		[kg.d ⁻¹]	O
Time weighted concentration in local water over the initial assessment period	$Clocal_{water,time1}$		[kg.m ⁻³]	O
Time weighted concentration in local water over a longer duration	$Clocal_{water,time2}$		[kg.m ⁻³]	O

D=default, A=based on information of applicant, O=output

Calculations

$$E_{water,leach,time1} = \frac{AREA_{wood} \cdot Q^*_{leach,time1}}{TIME1} \quad (7.14)$$

$$E_{water,leach,time2} = \frac{AREA_{wood} \cdot Q^*_{leach,time2}}{TIME2} \quad (7.15)$$

$$Clocal_{water,time1} = \left(\frac{E_{water,leach,time1}}{V_{water}} \cdot \frac{1}{k} \right) \cdot \left[1 - \left(\frac{1 - e^{-time1 \cdot k}}{k \cdot time1} \right) \right] \quad (7.16)$$

$$Clocal_{water,time2} = \left(\frac{E_{water,leach,time2}}{V_{water}} \cdot \frac{1}{k} \right) \cdot \left[1 - \left(\frac{1 - e^{-time2 \cdot k}}{k \cdot time2} \right) \right] \quad (7.17)$$

336. For releases into a static water body, the removal from the water column due adsorption onto suspended matter and into sediment can be significant, especially for very lipophilic compounds. To take this phenomenon into account, the above model can be adapted as follows.

Parameters

	Nomenclature	Value	Unit	Origin
Inputs				
Volume of sediment compartment	V_{sed}		[m ³]	D
Total sediment – water partitioning coefficient	$K_{sed-water}$		[m ³ .m ⁻³]	A
concentration of suspended matter in the surface water	$SUSP_{water}$	15.10 ⁻³	[kg.m ⁻³]	D
Solids-water partitioning coefficient for suspended matter	Kp_{susp}		[m ³ .kg ⁻¹]	O
Outputs				
Time weighted dissolved concentration in local water over the initial assessment period	$Clocal_{diss,time1}$		[kg.m ⁻³]	O
Time weighted dissolved concentration in local water over a longer duration	$Clocal_{diss,time2}$		[kg.m ⁻³]	O

D=default, A=based on information of applicant, O=output

Calculations

$$Clocal_{diss,time1} = \left(\frac{E_{water,leach,time1}}{V_{water} + (K_{sed-water} \cdot V_{sed})} \cdot \frac{1}{k} \cdot \frac{1}{1 + (Kp_{susp} \cdot SUSP_{water})} \right) \cdot \left[1 - \left(\frac{1 - e^{-time1 \cdot k}}{k \cdot time1} \right) \right] \quad (7.18)$$

$$Clocal_{diss,time2} = \left(\frac{E_{water,leach,time2}}{V_{water} + (K_{sed-water} \cdot V_{sed})} \cdot \frac{1}{k} \cdot \frac{1}{1 + (Kp_{susp} \cdot SUSP_{water})} \right) \cdot \left[1 - \left(\frac{1 - e^{-time2 \cdot k}}{k \cdot time2} \right) \right] \quad (7.19)$$

337. The volume of the sediment compartment can be estimated by assuming a default depth of the sediment layer (e.g. 3 mm) and using the surface area of the water body (see Appendix 3).

7.2.2 Release into a flowing water body

338. For the release into a flowing water body, the overall removal will be function of the residence time of water in the waterway in contact with the wooden structure. The following model could be used to take into account the removal process in the calculation of the concentration in surface water. The dimensions of the wooden structures and the water bodies according to the different scenarios are described in Appendix 3.

Parameters

	Nomenclature	Value	Unit	Origin
Inputs				
Duration of the initial assessment period	<i>TIME1</i>	30	[d]	D
Duration of the long-term assessment period	<i>TIME2</i>		[d]	D
Cumulative quantity of an active ingredient leached out of 1 m ² of treated wood over the initial assessment period is determined based on the results of a leaching test.	$Q^*_{leach,time1}$		[kg.m ⁻²]	A
Cumulative quantity of an active ingredient leached out of 1 m ² of treated wood over the a longer assessment period	$Q^*_{leach,time2}$		[kg.m ⁻²]	A
Leachable treated wood surface, proposed in the relevant scenarios (cf. Appendix 3)	<i>AREA_{wood}</i>		[m ²]	D
Volume of receiving water body, , proposed in the relevant scenarios (cf. Appendix 3)	<i>V_{water}</i>		[m ³]	D
Residence time of water in waterway	<i>TAU_{wway}</i>		[d]	D
First order rate constant for removal from water	<i>k</i>		[d ⁻¹]	A
Outputs				
Average daily emission due to leaching over the initial assessment period	$E_{water,leach,time1}$		[kg.d ⁻¹]	O
Average daily emission due to leaching over a longer duration	$E_{water,leach,time2}$		[kg.d ⁻¹]	O
Time weighted concentration in local water over the initial assessment period	$Clocal_{water,time1}$		[kg.m ⁻³]	O
Time weighted concentration in local water over a longer duration	$Clocal_{water,time2}$		[kg.m ⁻³]	O

D=default, A=based on information of applicant, O=output

Calculations

$$E_{water,leach,time1} = \frac{AREA_{wood} \cdot Q^*_{leach,time1}}{TIME1} \quad (7.20)$$

$$E_{water,leach,time2} = \frac{AREA_{wood} \cdot Q^*_{leach,time2}}{TIME2} \quad (7.21)$$

$$Clocal_{water,time1} = \left(\frac{E_{water,leach,time1}}{V_{water}} \cdot \frac{1}{k} \right) \cdot \left[1 - \left(\frac{1 - e^{-TAU_{wway} \cdot k}}{k \cdot TAU_{wway}} \right) \right] \quad (7.22)$$

$$Clocal_{water,time2} = \left(\frac{E_{water,leach,time2}}{V_{water}} \cdot \frac{1}{k} \right) \cdot \left[1 - \left(\frac{1 - e^{-TAU_{wway} \cdot k}}{k \cdot TAU_{wway}} \right) \right] \quad (7.23)$$

339. For releases into a flowing water body, assuming thermodynamic equilibrium, the removal due to adsorption onto bottom sediment will have no influence upon the concentration in the water column due to the continuous renewal of the water. The removal due to adsorption onto suspended matter can nevertheless be taken into account. The above model can be adapted as follows.

Parameters

	Nomenclature	Value	Unit	Origin
Inputs				
Concentration of suspended matter in the surface water	$SUSP_{water}$	$15 \cdot 10^{-3}$	$[\text{kg} \cdot \text{m}^{-3}]$	D
Solids-water partitioning coefficient of suspended matter	Kp_{susp}		$[\text{m}^3 \cdot \text{kg}^{-1}]$	O
Outputs				
Time weighted dissolved concentration in local water over the initial assessment period	$Clocal_{diss,time1}$		$[\text{kg} \cdot \text{m}^{-3}]$	O
Time weighted dissolved concentration in local water over a longer duration	$Clocal_{diss,time2}$		$[\text{kg} \cdot \text{m}^{-3}]$	O

D=default, A=based on information of applicant, O=output

Calculations

$$Clocal_{diss,time1} = \left(\frac{E_{water,leach,time1}}{V_{water} \cdot k} \cdot \frac{1}{1 + (Kp_{susp} \cdot SUSP_{water})} \right) \cdot \left[1 - \left(\frac{1 - e^{-TAU_{wway} \cdot k}}{k \cdot TAU_{wway}} \right) \right] \quad (7.24)$$

$$Clocal_{diss,time2} = \left(\frac{E_{water,leach,time2}}{V_{water} \cdot k} \cdot \frac{1}{1 + (Kp_{susp} \cdot SUSP_{water})} \right) \cdot \left[1 - \left(\frac{1 - e^{-TAU_{wway} \cdot k}}{k \cdot TAU_{wway}} \right) \right] \quad (7.25)$$

340. The concentration in water can then also be used to estimate the concentration in sediment (e.g. according to [EU TGD 1997]).

APPENDIX 1

**GENERAL REQUIREMENTS FOR LEACHING TEST
METHODS AND PROTOCOLS FOR**

FLUX DETERMINATION

INTRODUCTION

1. The methodologies, developed in this document for estimation of the emissions of wood preservative components from treated wood over time, require that the calculation of:

- $Q^*_{leach,time}$, i.e. the cumulative quantity of a preservative component - active ingredient or any substance of concern - leached out of 1 m² of treated wood over a certain time period considered for assessment (Chapters 5 and 6) and;
- $FLUX_{storage}$, i.e. the average daily flux: the average quantity of a preservative component - active ingredient or any substance of concern- that is daily leached out of 1 m² of treated wood during a certain storage period (Chapter 4).

is based on experimental leaching data.

2. Therefore, a leaching test should provide the quantities of a preservative component(s) leached out of treated wood per wood surface area and time. The results can then be expressed as a $FLUX$, i.e. quantity of a preservative component that is leached out of 1 m² of treated wood per day [here expressed in kg.m⁻².d⁻¹], and the $Q^*_{leach,time}$ or $FLUX_{storage}$ can subsequently be calculated in principle for any time span of service life or of storage duration in the respective scenarios.

3. The principle of such a leaching test is that a piece of treated wood is exposed to a receiving medium (water or soil). The medium is sampled at different time points and concentrations of the preservative component(s) under consideration are measured.

4. In principle, the leaching test should be performed using the contact medium and/or the receiving environmental compartment of the scenario under consideration. However, for the reasons explained in Sections 4.1.5 and 5.3.2.1, it is acceptable for most scenarios that the calculations be based on the results of a single laboratory leaching test with wood in direct and continuous contact with water. Table A1_I provides an overview of the leaching tests required for estimation of the experimental $FLUX$ in the various scenarios.

5. Based on the experimentally determined $FLUX$, $Q^*_{leach,time}$ or $FLUX_{storage}$ can subsequently be calculated according to the methodology proposed in Appendix 2.

6. The aim of this Appendix is to provide guidance on important requirements for a laboratory leaching test and a leaching test protocol to fulfill in order the data, they deliver, are useful for exposure assessment to wood preservatives as defined in this document. The requirements outlined below concern a laboratory leaching test where treated wood is in direct and continuous contact with water (de-ionised or simulated sea water).

Table A1_I: Overview of the leaching tests required for estimation of *FLUX* in the wood-in-service and storage scenarios

Use Class	Service conditions	Scenarios for 'in service' life stage of treated wood	Contact medium/Receiving env. compartment	Leaching test required for determination of <i>FLUX</i>	Ratios of the scenarios	
					Wood area/wood volume [m ² .m ⁻³]	Wood area/contact medium volume [m ² .m ⁻³]
3	Exterior wood out of ground	House*	rain/soil	direct contact with water	40	83,3 ² [m ² wood.m ⁻³ water]
		Fence*	rain/soil	direct contact with water	40	idem
		Noise barrier*	rain/soil & STP	direct contact with water	40	idem
		Bridge [#]	rain/ fresh water	direct contact with water	54,2	idem
4a	In-ground	Transmission pole	rain/soil	direct contact with water	16,2	idem
		above soil part of pole	soil/soil	<ul style="list-style-type: none"> direct contact with water, if preservative is not a PWSS if preservative is a PWSS, a test with direct contact with soil may be required on a case by case basis 	16	6,7 [m ² wood.m ⁻³ soil volume]
		below soil part of pole	soil/soil	direct contact with water	40	83,3 ² [m ² wood.m ⁻³ water]
		Fence post	soil/soil	<ul style="list-style-type: none"> direct contact with water, if preservative is not a PWSS if preservative is a PWSS, a test with direct contact with soil may be required on a case by case basis 	40	4 [m ² wood.m ⁻³ soil volume]

² This ratio was calculated as follows: according to the rainfall pattern agreed in this document as a realistic worse case for many OECD countries (see Section 4.1.5), 3 rain events, lasting ca. 60 min each, with a flux of 4 mm h⁻¹ m⁻² are applied to the wood surface every third day. Therefore, the water volume that comes in contact with 1 m² of wood surface for one rain event of 60 min is 4.10⁻³ m³ or 12.10⁻³ m³ within a day (three rain events per day). This corresponds to a wood area / water volume ratio of 1m² wood area / 12.10⁻³ m³ = 83,3 m².m⁻³.

Table A1_I: Overview of the leaching tests required for estimation of *FLUX* in the wood-in-service and storage scenarios, cont.

Use Class	Service conditions	Scenarios for 'in service' life stage of treated wood	Contact medium/Receiving env. compartment	Leaching test required for determination of <i>FLUX</i>	Ratios of the scenarios
4b	Direct contact with fresh water	Jetty	rain/fresh water	direct contact with water	35,3
		poles of jetty	fresh water/fresh water	direct contact with water	20,1
5	Direct contact with sea water	Sheet piling	fresh water/fresh water	direct contact with water	39,2
		Wharf	rain/sea water	direct contact with water	4,82
		poles of wharf	sea water/sea water	direct contact with: - water (de-ionised) - simulated seawater	8
		Storage scenario	rain/soil	direct contact with water	varies among the scenarios for the 3 industrial treatments
All Use Classes	Storage of wood treated after industrial treatment				83,3 ² [m ² wood.m ⁻³ water] 6,4 .10 ⁻⁴ [m ² wood.m ⁻³ water volume] 0,63 [m ² wood.m ⁻³ water volume] 83,3 ² [m ² wood.m ⁻³ water] 0,91 [m ² wood.m ⁻³ water volume] 83,3 ² [m ² wood.m ⁻³ water]

* These scenarios apply for wood commodities industrially treated (see Chapter 5), before to put in service or for wood treated *in-situ* (Chapter 6).

The bridge scenario is proposed only for use for *in-situ* outdoor brushing.

**LABORATORY TEST FOR ESTIMATION OF LEACHING OF WOOD PRESERVATIVES
FROM TREATED WOOD IN DIRECT CONTACT WITH WATER**

7. The wood test specimens should be treated with the wood preservative in accordance with the manufacturers recommendations, and in compliance with appropriate standards or specifications for the intended service (use). If possible, they should be representative of commercially used wood.

8. Preferably the test wood specimens should be treated by the test house performing the leaching study rather than by normal production plants. This makes it easier to guarantee the same treatment procedure for different tests (including selection and conditioning of wood specimens, and parameters of treatment). Homogeneity of the samples is preferred.

9. The wood preservative product used in the test should be the commercially available product. For products not yet commercialised (i.e. subject to a new registration), the formulation, that would likely be granted registration, should be used.

2.1 Prerequisite information on the wood preservative under test

10. For a proper evaluation of the test results, the following information on the wood preservative under study should be supplied:

- a. chemical form that the wood preservative components under study (i.e. active ingredient(s) or any other substance of concern) which are found in the wood preservative formulation supplied for test.
- b. if possible, the chemical form that the wood preservative components under study are found in the wood.
- c. interaction of the preservative components under study with the wood: are the substances chemically or by hydrophobic interactions bound to the wood
- d. the chemical form and species that the preservative components under study are likely to be found in the leachate solution (i.e. the water in directly contact with the wood)
- e. solubility of the preservative components under study in water [determined for example according to OECD Guideline 105];
- f. vapour pressure of the preservative components under study [e.g. OECD Guideline 104] or/and Henry's law constant;
- g. abiotic hydrolysis as a function of pH of the wood preservative components under study [e.g. OECD Guideline 111];
- h. pKa of ionisable preservative components ;
- i. direct photolysis in water of the wood preservative components under study (i.e. UV-Vis absorption spectrum in water, quantum yield)

11. A brief description of the above parameters should be included in the study report. If the information for the parameters e to i (see above) is given elsewhere in the applicant (registrant) dossier, the study report of the leaching test should include only references to the relevant sections of the dossier.

2.2 Wood test specimens

2.2.1 Wood characteristics

12. *Species of wood:* The wood species used for test samples should be:

- exclusively (100 %) softwood; heartwood should not be used as the distribution of the preservative in the wood is less homogeneous and it prevents even absorption of the preservative during impregnation
- if possible, representative of commercially used wood

13. A leaching test protocol should use an appropriate standardised wood species. If such a standard is not available, *Pinus sylvestris* sapwood is generally recommended. Experience with *Pinus sylvestris* sapwood shows [Ute Schoknecht, BAM, Germany, personal commun., 2001] that it offers good treatability and homogenous samples. Moreover, many available efficacy standard methods (e.g. CEN standards: EN 113, EN 117, EN 188, EN 152-1, EN 152-2, EN 252 – *the list is not exhaustive*) are also based on *Pinus sylvestris* and observations on the stability of the product from these tests can be related to leaching data.

14. *Quality of wood:* The wood block from which the test specimen are cut:

- should be free of damage, knots, visible resin as well as mould, stain or wood destroying fungi
- should not have been chemically treated
- comply with the following specific requirements of standard EN 113 of CEN:
 - have 2,5 to 8 annual growth rings per 10 mm
 - the proportion of late wood in the annual rings shall not exceed 30 % of the whole
 - the growth rings may run in any direction with the exception of a completely tangential orientation in the broad faces which is unacceptable
 - the longitudinal faces shall be parallel to the direction of the grain

15. The wood species, the origin of the wood used for the test specimens and the growth rate (number of annual rings per 10 mm) of the parent wood from where the wood specimen are cut should be given in the test report. If for justified reasons, the test could not be performed with 100% softwood specimens, the sapwood percentage of each wood specimen as well the method used to determine this percentage should also be given in the test report.

2.2.2 Size and geometry of wood test specimens

16. An analysis performed during development of this document [OECD 2001b] showed that the reliability in estimating the emissions for the different scenarios increases, if the design of the leaching tests follow the scenarios as close as possible with respect to the ratios: wood area/wood volume, and wood area/volume of the receiving compartment. In Table A1-I these ratios are indicated for each scenario.

17. However, it is recognised that as the above ratios may considerably vary for the scenarios of different Use Classes and even for the scenarios within the same Use Class, it would be difficult to standardise such a test. Furthermore, recent research results [Schoknecht U *et al.*, 2001] showed that especially the ratio wood area/volume of water considerably influences the flux rates.

18. Taking into account the above remarks, the ratios as well as the actual dimensions of wood specimens and water volume should be standardised in order for the results of a leaching test to be reproducible and comparable between different substances or products (comparative risk assessment).

Therefore, it is recommended that the test is performed with wood blocks with the following ratios:

- **wood area/wood volume:** $40 \text{ m}^2 \cdot \text{m}^{-3}$. This is the ratio applied in most scenarios in Table A1-I and represent a worst case (with the exception of bridge scenario where the ratio is 54,2).
- **wood area/wood volume:** $40 \text{ m}^2 \cdot \text{m}^{-3}$. According to recent research [Schoknecht U *et al.*, 2001], a ratio of 40 m^2 of sample area / m^3 of water proved to be workable for all experiments performed with timber, coatings, mortar and polymers containing a series of active ingredients like copper, chromium, boron, benzalkonium chloride, propiconazole, tolylfluanide, dichlofluanid, IPBC, zinc octoate, 2-n-octyl-4-isothiazolin-3-one (OIT), 4,5-dichloro-2-octyl-2H-isothiazol-3-one (DCOIT), oxybisphenoxyarsin (OBPA).

19. A leaching test protocol should standardise appropriate dimensions of wood blocks and water volume to fulfil the above ratios, so that the:

- test is technically possible regarding supply and handling of wood blocks, and apparatus set up required;
- water volume be 1) large enough to avoid saturation and 2) small enough to be analytically possible to determine the components of the wood preservatives under consideration in the leachate solution.

20. If such a standard is not available, it is recommended to use wood blocks with dimensions of $0,1 \text{ m} * 0,1 \text{ m} * 0,1 \text{ m}$ in 1 l water.

21. The wood test specimens should be cut to size before treatment. A leaching test protocol should standardise an appropriate technique to cut to size the specimens.

22. In the test report it should be reported:

- the shape (form) of the wood specimens;
- the dimensions (length, width, height) of each wood specimen;
- total surface area and wood volume of each wood specimen;
- wood face exposed to leaching test and structure of wood surface (i.e. planed or rough sawn wood)
- who has cut to size the test specimens (e.g. test house, treating plant, other??) and whether this has been before or after treatment;
- a description of how the wood specimens are cut from the parent wood block.

2.2.3 *Number of wood test specimens*

23. As a general recommendation especially for the industrially treated wood by vacuum-pressure, double-vacuum and dipping processes, the number of wood specimens that should be provisioned and be treated, should be at least the double than the wood test specimens needed for the actual leaching experiment. This is due to the fact that retention can differ from one wood specimen to the other, even if their wood species and dimensions, and the treatment conditions are the same. The retention of the specimens selected for the leaching test should be within $\pm 5 \%$ of the group's average retention.

24. In the above context, it is recommended that for the processes described above, a minimum number of 10 wood specimens be provisioned to carry out the leaching experiment as follows:

- the leaching experiment is performed with, **at least, three** replicate treated wood specimens.
- **at least one** additional treated wood specimen is kept which will not be subject to the leaching test. The retention of this specimen should be within the same range of retention as the specimens subject to the leaching test. These unleached specimens can be used to determine the total of each wood preservative component under consideration and perform a mass balance at the end of the leaching experiment, if technically possible.
- **at least one** untreated wood specimen should also be included in the leaching study. Apart from the treatment step, untreated specimen should be prepared and handled exactly as the treated test specimens.

25. For surface treatments such as brushing, spraying or for injection and wrapping treatments, the minimum number of wood specimens can be less than 10. However, care should be taken that the treated wood specimens subject to the leaching test have similar amounts of the biocidal substances under consideration ($\pm 5\%$ of the group's average amount).

2.3 Treatment of wood test specimens

2.3.1 *Moisture content of wood specimens prior to treatment*

26. The wood test specimens should have an appropriate moisture content before treatment according to the manufacturers specifications (or performance standards if available) for the kind of treatment under consideration.

27. If conditioning to a certain moisture content takes place before treatment, the conditioning technique and parameters should be described in the test report.

28. A leaching test protocol should standardise:

- an appropriate moisture content that the wood specimen should have before treatment
- the conditioning technique and parameters to obtain the moisture content recommended

29. If such a standard is not available, a moisture content of 11-12% is generally recommended. This moisture content can be achieved in a conditioning room that is maintained at 20 ± 2 °C and $65 \pm 5\%$ relevant humidity.

30. The moisture content and the weight of each conditioned wood test specimen (to the nearest 0.01g), just before the treatment, should be reported in the test report. It is recommended to choose wood specimens for treatment that have the narrowest spread in weight possible (less than 0.5 g).

2.3.2 Wood preservative

Wood preservative supplied for the test

31. The wood preservative product used for the treatment of test wood specimen as such or as a diluted solution should be the commercially available product. For products not yet commercialised (i.e. subject to a new registration), the formulation, that would likely be granted registration, should be used. The name of the supplier of the preservative under test should be given.

32. The identity of the wood preservative product should be included with the test report. It should be given:

- the name and other designation of the preservative
- *for active ingredients and co-formulants*: the trade and/or common name; the chemical name (IUPAC Nomenclature) and; CAS No.
Full description of co-formulants is not necessary if this information is given elsewhere in the applicant (registrant) dossier. In this case only a generic description of the co-formulants should be given as well as a reference to where the detailed information can be found
- the composition of the wood preservative product

Treating preservative solution

33. Depending on the treating process, the wood preservative product supplied for the test may have to be diluted to the final solution, used for treatment of the wood test specimens (i.e. the treating solution).

34. For penetrating industrial treatment processes (such as vacuum-pressure or double vacuum treatments), the percentage (expressed as % w/w) of the preservative product in the solution (the carrier can be water or solvent), used for the actual treatment of wood test specimens should be appropriate to achieve the retention needed for the intended use of the wood in permanent contact with water (e.g. fresh or sea water). Performance standards (e.g. EN 599) are available which specify the retentions that should be achieved when the wood preservative is applied using the relevant penetrating treatment process. In the test report it should be given: the percentage of the preservative product and of each active ingredient in the treating solution (in % w/w) and the method that these were determined.

35. For surface treatments such as spraying, brushing etc, the application rate of the preservative product i.e. kg of product applied per m² of wood as well as the concentration of each active ingredient in the 'in-use preservative' (kg.kg⁻¹) should be reported in the test report.

2.3.3 Treatment process

36. The wood test specimens should be treated, preferably by the test house conducting the study, according to manufacturers recommendations, and in compliance with appropriate standards or specifications for wood intended for use in applications with permanent contact with fresh or sea water. Such standards are for example the EN-599, 'Durability of wood and of wood-based products.

Performance of preventive wood preservatives as determined by biological tests - Part 1: Specification according to hazard classes of the European Committee for Standardisation (CEN).

37. The treatment process including post-treatment conditioning and the treatment apparatus should be standardised by a leaching test protocol and described in the test report. It should also be reported who has performed the treatment (e.g. the test laboratory in a self built set up or a treating plant).

38. As this document covers various treatment processes, a leaching test protocol should standardise the treatment process including post treatment conditioning and apparatus for the following processes:

- spraying
- dipping
- vacuum-pressure/double vacuum
- injection
- wrapping
- brushing

2.3.4 Retention of treated wood specimens

39. For penetrating industrial treatment processes, the retention of the wood preservative (synonymous terms used elsewhere: uptake of wood preservative or loading of wood preservative) in each treated wood specimen should be determined in $\text{kg}\cdot\text{m}^{-3}$.

40. To this end and only if no reliable and no destructive analytical methods exist, the retention of each wood specimen can be calculated as follows:

$$RETENTION = \frac{M_{wood-treated} - M_{wood-untreated}}{V_{wood}} \cdot \frac{C_{solution}}{100} \quad (A1-1)$$

where:

<i>RETENTION</i>	=	amount of the wood preservative product retained in the wood test specimen [kg of product per m^3 of wood]
<i>M_{wood-treated}</i>	=	mass of wood test specimen after the treatment [kg]
<i>M_{wood-untreated}</i>	=	mass of wood test specimen before treatment [kg]
<i>V_{wood}</i>	=	volume of wood test specimen [m^3]
<i>C_{solution}</i>	=	Concentration of the preservative product in the treating solution, i.e., the percentage (expressed as $\text{kg}\cdot\text{kg}^{-1}$) of the preservative product in the carrier (water or solvent) in the solution used for the actual treatment of wood

41. For each treated wood specimen, the retention of each individual product component under consideration and the total retention of the product, calculated or determined by an analytical method, should be reported in the test report, as well as the method for their calculation or determination. For comparison reasons, the retentions, specified in performance standards (e.g. EN 599) for wood in permanent (fresh or sea) water contact using the relevant penetrating treatment process, should be given in the test report. Also, the time period passed after the treatment in order to calculate or measure the retentions should be reported in the test report

42. The average retention of the group should be calculated and 4 specimens within $\pm 5\%$ of the group's average retention should be selected. Three of them will be subject to the leaching test while one is kept

unleached and used in case that it is technically possible to conduct a mass balance at the end of the leaching experiment.

2.3.5 *Post-treatment conditioning*

43. In industrial penetrating processes a post-treatment conditioning is usually applied to allow the preservative to be firmly bound to the wood. The conditions and technology used for post-conditioning of the wood test specimens are important for the performance of the leaching test (e.g. for the reproducibility of leaching results between studies).

44. The post-treatment conditioning procedure should be standardised and well described in a leaching test protocol and test report. The post-treatment conditions and technology recommended by a standard leaching test protocol (or applied in the leaching study in the absence of such a protocol) should be close to common practices and manufacturers specifications. If needed, more than one 'standardised' post-conditioning regimes can be proposed in a leaching test protocol or leaching study in order to cover big differences that occur in reality for different products and processes. For any regime, the wood test specimens should receive the minimum post-treatment conditioning according to the relevant manufacturers' specifications.

45. The procedure, conditions and duration of the post-treatment conditioning and of drying of wood specimens (if drying takes place prior to the leaching test) should be given in the test report.

2.4 Leaching Procedure

2.4.1 *Selection of treated wood test specimens*

46. After the shortest post-treatment and drying, at least three wood test specimens should be selected with the most uniform retention (within $\pm 5\%$ of the group's average retention) for the leaching test. The moisture content and the weight of the wood test specimens when the leaching test starts should be given in the test report.

2.4.2 *Ratio wood area / water volume*

47. The ratio of the area of the wood test specimen in contact with water to the volume of water should be $40 \text{ m}^2 \cdot \text{m}^{-3}$ (see also Section 2.2.2).

48. In the test report the following should be given:

- the ratio wood area/water volume used in the leaching experiments
- the water volume at the beginning of the experiment.

2.4.3 *Test duration and number of measurements*

49. According to the methodology developed in this document the calculation of emissions from treated wood is based on fluxes i.e. the quantity of the preservative component under consideration leached per m^2 of wood per day. Curves of fluxes versus time are used to make long term predictions for the quantities of preservative components leached. Long term predictions are necessary in the case of wood preservatives products because the treated commodities are 'in service' for many years. Therefore a leaching experiment should be well designed to allow the reliable derivation of zero points, points of inflection, asymptotes and the 'like form' of $\text{FLUX}=\text{f}(\text{t})$ curves.

50. In this context, it is recommended that the test duration should be as long as needed to reach a constant leaching rate (i.e. an asymptote in FLUX-time curve). The time needed for the leaching rate to reach an asymptote depends on many parameters such as the preservative component under study, the wood species, the way the leaching test is performed etc. Generally 60 days would be sufficient.

51. The number of the measurements of the quantity of the wood preservative component in the leachate solution, performed within the total period of the leaching experiment, should be sufficient to reliably derive the 'like form' of the curve. It is recommended that measurements should be more often at the beginning of the leaching experiment. A recommended time pattern for measurement of the leachate solution (in days after the beginning of the leaching experiment) is: 1, 2, 4, 6, 8, 10, 20, 30, 40, 50, 60. However, the actual times could be considered with flexibility after the measurement of 10th day to fit with the laboratory work schedule e.g. a sampling/measurement due to 20th day can be done ± 2 days.

52. If an asymptote is clearly reached earlier than 60 days, the test does not have to be continued until 60 days. If no an asymptote is reached, then the test should be continued up to 100 days with one measurement every 10 days.

53. When experience is gained with the methodology proposed in this ESD for estimation of emissions from treated wood (either during storage or during service life), it should be re-considered whether a shorter in time test would equally serve the purposes of estimation of long term emissions.

2.4.4 Leachate solution

54. At each specified measurement time point, the whole leachate solution should be removed and its volume should be measured and replaced with a equal volume of fresh de-ionised water equal to the water volume at the beginning of the experiment.

2.4.5 Set-up of leaching apparatus

55. If possible, the system should be closed to avoid evaporation, photolytic effects and bio-contamination.

56. The wood test specimens should be completely submerged.

57. During the leaching test, the leachate solution should be agitated at low speed (few rpm). A leaching test should standardise the agitation speed and device. These should be reported in the study report.

58. The container(s) where the wood test specimens are submerged, should be made by inert material to minimise adsorption of the test substance on its surface. The dimensions of the test apparatus/container and the type of material is made of should be recorded in the test report.

59. A leaching test protocol should standardise an appropriate set up for the apparatus.

2.4.6 Test conditions

pH of water in contact with wood

60. De-ionised water of an appropriate pH for the wood preservative components analysed should be used. **A leaching test protocol should standardise an appropriate pH.** If such a standard is not available, a pH range between 5,5 – 5,8 is generally recommended.

61. If the leaching study is performed according to the pH value indicated in a standard leaching test protocol or recommended above (in the absence of such a standard protocol), a commentary should be included in the study report on:

- whether this pH was considered appropriate for the components under study or
- whether there was a need to deviate from the pH value indicated in the standard protocol or above due for example to the hydrolysis constant or pKa of the substance(s) in concern.

62. The pH of the leachate solution at each measurement time point should be recorded in the test report.

Simulated seawater

63. According to Section 5.3.2.1, if a product bears claims for use in contact with sea water (Use Class 5), then in addition to a test with de-ionised water, a test with simulated sea water should be performed.

64. A leaching test protocol should standardise the composition of a simulated sea water. If such a protocol is not available, the ASTM D1141-98 “Standard Practice for the Preparation of Substitute Ocean Water” can generally be used.

Temperature

65. The room temperature should be controlled so that the temperature of the leached solution be maintained at 20 ± 2 °C.

2.5 Analysis of samples

2.5.1 Analysis of leachate samples

66. It is recommended to performed at least three analyses of the same leachate solution,taken as a whole at each measurement time point.

67. In the test report, it should be provided the:

- concentration of the wood preservative component under consideration, found in each of the three measurements
- mean value of the three measurements
- standard deviation of each measurement
- volumes of the leachate solution taken for analysis

Analytical method

68. The analysis of each leachate sample for each preservative component under consideration should be done using an appropriate method of analysis. The reliability of the analytical method used must be checked at the concentration range which is likely to occur during the test. If standard methods are not appropriate due to low concentration involved, then generally accepted analytical methods should be used or the experimenter may develop an appropriate method with appropriate accuracy, precision, reproducibility, determination limits and recovery. The analytical methods used or developed should be described in the test report, including sample preparation, enrichment technique (if necessary), recovery data, precision and calibration.

2.5.2 Analysis of wood test specimens

69. If technically possible, it is recommended that at the end of the leaching test, the treated wood test specimens that were subject to leaching and the unleached treated specimen be analysed for each preservative component. The analytical method used for this analysis should fulfil the same requirements as the method for the analysis of the leachate samples with respect to its reliability for the concentration range of the preservative components which is likely to occur in wood. In case that the analysis of the preservative components is not technically possible, the reasons should be given in the test report.

2.6 Mass balance

70. In order to estimate the accuracy of the analytical results, it is recommended that a mass balance be determined for each preservative component under consideration. The balance shall be determined by comparing the total of each component in the unleached wood specimens with the total of the components in the leached specimens and the leachate.

71. The content of each preservative component in the unleached and leached specimen should be determined with an accurate analytical method, if available. For example for inorganic components, the determination can be done with 'mineralisation' of the treated wood specimen with acids and measurement of the metallic species with a suitable analytical (e.g. AAS, ICP-MS, Voltammetry etc.). The determined content of each component as well as the analytical method used should be given in the test report.

2.7 Test report

The test report of a leaching test should include the following information, if possible on a template form. Model templates are also proposed in this Appendix.

I. GUIDELINES AND QUALITY ASSURANCE	
Guideline study	Yes/No (If Yes, give guideline title and reference; if No, give justification, e.g. 'no guidelines available' or 'methods used compatible to guidelines xy'; give the title of the method used for the study and whether is an industry protocol, test house protocol etc.)
GLP	Yes/No (If No, give justification, e.g. state that GLP was not compulsory at the time the study performed)
Deviations	Yes/No (If yes, describe deviations from test guidelines or refer to respective fields where these are described)

Appendix 1

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II. MATERIALS	
II-1 WOOD PRESERVATIVE SUPPLIED FOR THE TEST	
Name of the supplier of the preservative product	
Specific and unique name or code of the preservative	
Physical state of preservative product supplied	<i>(Solution, emulsifiable concentrate, wettable powder etc). If solution specify the carrier (solvent).</i>
Composition of preservative product supplied for the test	<p><i>Give:</i></p> <p>a. <i>for active ingredients and co-formulants: the trade or common names of the active ingredient(s), chemical name (IUPAC nomenclature); empirical and mass molecular formula; CAS No. (tabular form; see Table A1_1).</i></p> <p><i>Note: Full description of co-formulants is not necessary if this information is given elsewhere in the applicant (registrant) dossier. In this case only a generic description of the co-formulants and their function should be given here as well as a reference where the detailed information can be found.</i></p> <p>b. <i>concentration of active ingredients as % w/w (tabular form; see Table A1_1)</i></p>
Further relevant information	<p><i>Give a brief description of:</i></p> <ul style="list-style-type: none"> • <i>the chemical form that the wood preservative components under study (i.e. active ingredient(s) or any other substance of concern) which are found in the wood preservative formulation supplied for test.</i> • <i>if possible, the chemical form that the wood preservative components under study are found in the wood.</i> • <i>interaction of the preservative components under study with the wood: are the substances chemically or by hydrophobic interactions bound to the wood.</i> • <i>the chemical form and species that the preservative components under study are likely to be found in the leachate solution (i.e. the water in directly contact with the wood)</i> <p><i>For the species of the preservative components measured in the leachate solution, give, if available:</i></p> <ul style="list-style-type: none"> • <i>solubility in water,</i> • <i>volatility (e.g. vapour pressure)</i> • <i>hydrolysis rate constant (k_h) as a function of pH</i> • <i>direct photolysis in water</i> • <i>pKa values</i> <p><i>[or make reference to the relevant sections, if the above information is found elsewhere in the applicant (registrant) dossier].</i></p>
II. MATERIALS	
II-2 Treating preservative solution	
Preparation of treating solution	<ul style="list-style-type: none"> • <i>Provide the carrier of the treating solution (whether water or solvent) and what kind of water or solvent is used</i> • <i>Describe preparation in detail (tabular form; see Table A1_2)</i>
Concentration of the treating preservative solution	<i>Provide the percentage (in % w/w) of the preservative product and of each active ingredient in the carrier; the method that these percentages were determined; the total volume of the treating solution used for the treatment (penetrating processes) or the application rate of 'in use preservative' (for surface treatments) (tabular form; see Table A1_2)</i>

II-3 Wood test specimens	
Species of wood	<i>Provide the wood species that wood test specimens are made of (scientific name and common name (e.g. Pinus sylvestris (Linnaeus), Scot pine, redwood)</i>
Origin of the wood	<i>Provide the origin of the parent wood block from which the test specimens were cut</i>
Number of annual rings per 10 mm	<i>Applicable only for the parent wood block</i>
Total number of specimens cut to size	
Cut-to size	<ul style="list-style-type: none"> Specify who has cut to size the test specimens (e.g. test house, treating plant, other??); Provide a description of how the wood specimens are cut from the parent wood block Note: this description is not necessary in case the procedure, recommended by a standard test protocol, has been followed and the standard is referenced in Section I 'Guideline and Quality Assurance'. Only a statement should be included that 'wood specimens were cut to size as described in the standard test protocol'
Dimensions of wood specimens	<i>Describe the shape (form) of the wood specimens; their dimensions (length, width, height); their surface area and volume; wood face exposed to leaching test and structure of wood surface (i.e. planed or rough sawn wood) (tabular form; see Table A1_3)</i>
Sapwood identification (%), if applicable	<i>Only 100% softwood specimen should be used in this test. If for justified reasons, this was not possible, give the sapwood percentage of each wood specimen (tabular form; see Table A1_3) and describe how it was calculated</i>
II. MATERIALS, cont.	
II-4 Simulated seawater leachate solution <i>(to be filled in only for products bearing claims for use in contact with seawater (Use Class 5)</i>	
Preparation of simulated seawater solution	<ul style="list-style-type: none"> <i>Test Guideline followed for the preparation of the solution: Yes/No (If Yes, give guideline title and reference; if No, give justification, e.g. 'no guidelines available' or 'methods used compatible to guidelines xy'; give the title of the method used for the study and whether is an industry protocol, test house protocol etc.)</i> <i>If no a standard Test Guideline was followed, describe preparation in detail</i>
Composition of simulated seawater solution	<i>Provide the percentage (in % w/w) of each component of the solution and the method that these percentages were determined.</i>
III. METHODS	
III-1 Treatment of wood test specimens	
Treating company	<i>Specify who has performed the treatment of wood test specimens (e.g. the test laboratory in a self built set up or a treating plant) and provide contact details of the treater</i>
Date of treatment	
Lot/Batch number	<i>In case that wood test specimens are derived from normal production plants list lot/batch number of the treated wood batch used to prepare the test wood specimens, if available</i>
Pre-treatment conditioning	<i>Specify whether a pre-treatment conditioning of the test specimens took place and describe it in detail</i>
Moisture content of wood test specimens prior to treatment	<i>Give the moisture content of each wood test specimen prior to treatment and explain how it was determined (tabular form; see Table A1_4)</i>
Weight of wood test specimens prior to treatment	<i>Give the weight of each wood test specimen prior to treatment (tabular form; see Table A1_4)</i>

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Treatment procedure	Describe in detail the treatment process including post-treatment conditioning and drying, if relevant; describe the method of application; the apparatus used, their dimensions; the operation conditions; the time schedule of the treatment, of the post-treatment conditioning and drying, if relevant.	
Retention of wood preservative	<ul style="list-style-type: none"> • For penetrating industrial treatment processes, give the individual and total component retentions (i.e. uptake of wood preservative or loading of wood preservative) in each treated wood specimen in kg.m^{-3} (tabular form; see Table A1_4) • Specify and describe the method that these (individual and total component) retentions were calculated or measured • Specify the time period passed after treatment to calculate or measure the retentions [min] • Specify whether the retentions of the unleached wood specimens were measured by an analytical method. If yes, describe the method in detail 	
Relevant retention or loading specified in performance standards for wood used in (fresh or sea) water contact	If relevant performance standards available, give the relevant retention [kg.m^{-3}], specified in the performance standards (e.g. EN 599) for wood used in water contact. Give the reference of the performance standard and use (hazard) classes according to the performance standard.	
	Performance standard:	
	(Hazard or Use) Class	Retention [kg m^{-3}]
III. METHODS		
III-2 Leaching procedure		
Moisture content of wood test specimens prior to treatment	Give the moisture content of each wood test specimen prior to leaching test and explain how it was determined (tabular form; see Table A1_5)	
Weight of wood test specimens prior to leaching	Give the weight of each wood test specimen prior to leaching (tabular form; see Table A1_5)	
Ratios of wood area/water volume	Give the volume of the leachate solution and ratio of wood area/leachate solution in each container at the beginning of the experiment (tabular form; see Table A1_5)	
Set-up of leaching apparatus	Describe in detail the set up of the leaching apparatus including kind of containers used; dimensions of the container; other equipment used (e.g. thermometer, thermostat, pH-meter, agitation device); explain whether the system is closed or not; whether the wood specimens are totally submerged in the leachate solution; measures eventually applied for avoiding photolytic effects. If possible provide a drawing of the leaching set up	
Sampling schedule	<ul style="list-style-type: none"> • Specify whether at each sampling point the whole leachate solution was sampled and replaced by a volume of fresh de-ionised water equal to the water volume at the beginning of the experiment • Give details of the sampling intervals (tabular form; see Table A1_6) • Give the volume of the leachate solution sampled at each sampling/measurement time point (tabular form; see Table A1_6) 	

Duration of the leaching test	<i>Give the time range of the leaching test</i>
pH	<i>Give the pH of the leachate solution at each sampling time point (tabular form; see Table A1_6). If a standard test protocol followed, commend whether the pH value indicated in the standard was considered appropriate for the components under the current study or whether there was a need to deviate from the pH value indicated</i>
Number of replicates	<i>At least 3 replicates are recommended</i>
Number of untreated wood specimen subject to leaching test	<i>At last 1 untreated wood specimen is recommended to be used as a control</i>
III. METHODS	
III-3 Analysis	
<i>III-3.1 Analysis of leachate samples</i>	
Analytical methods	<i>Describe the analytical method used for determination of the concentration of each wood preservative component of concern, including sample preparation, enrichment technique (if necessary), recovery data, precision and calibration)</i>
<i>III-3.2 Analysis of wood specimens, if applicable</i>	
Analytical methods	<i>Describe the analytical method used for determination of the concentration of each wood preservative component under consideration, in the unleached and leached wood preservatives, including sample preparation, enrichment technique (if necessary), recovery data, precision and calibration)</i>
IV. RESULTS	
Concentration in the leachate solution [mg.l ⁻¹]	<i>In tabular form (see Table A1_6), present the analysis results i.e. concentration of wood preservative component in the leachate solution (C) for all measurement time points and all wood preservative components analysed. For replicate samples present the raw numbers, mean numbers and standard deviations. Describe any anomalies or problems encountered.</i>
$Q_d(\Delta t)$ [mg.m ⁻² *]	<i>If the leaching test was performed by removal and replacement of the leachate solution at each measurement time point, give all $Q_d(\Delta t) - \Delta t$ points in tabular form (see Table A1_7). $Q_d(\Delta t)$ represents the <u>total quantity leached within a time interval</u> ($t_{n+1} - t_n$) per 1 m² of wood area and it is calculated as following: $Q_d(\Delta t) = \frac{C \cdot V_{leachate}}{A_{wood}^{exp}} \quad A1_2$ where C : concentration of the wood preservative component in the leachate solution at time point t_n [mg.l⁻¹] $V_{leachate}$: Volume of leachate solution [l] A_{wood}^{exp}: the area of the wood specimen from which the wood preservative component is leached [m²].</i>

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$Q_c(t)$ [mg.m ⁻² *]	<p>Give all $Q_c(t) - t$ points in tabular form (see Table A1_7). $Q_c(t)$ represents the <u>cumulative quantity</u> leached per 1 m² of wood area at a time point t after the beginning of the experiment. As the leaching test is done by removal and replacement of the leachate solution at each measurement time point, the Q_c can be calculated from the $Q_d(\Delta t)$ according to the equation:</p> $Q_c(t) = \sum_{j=\Delta t_1}^{\Delta t_n} Q_d(\Delta t)(j) \quad A1_3$ <p>For example, the Q_c at the measurement time $t_3 = Q_d(\Delta t_1) + Q_d(\Delta t_2) + Q_d(\Delta t_3)$</p>
$FLUX(\Delta t)$ [kg.m ⁻² .d ⁻¹]	<p>Give all the $FLUX(\Delta t) - \Delta t$ points in tabular form (see Table A1_7). As $FLUX$ is described the quantity of a substance leached per 1 m² of wood area and per day [kg m⁻² d⁻¹]. $FLUX(\Delta t)$ represents the <u>average daily flux for each time interval</u> (Δt) and it is calculated according to the equation:</p> $FLUX(\Delta t) = \frac{Q_d(\Delta t)}{\Delta t} \quad A1_4$
Plots	<p>Give the plots of $Q_d(\Delta t) = f(t)$*; $Q_c(t) = f(t)$; $FLUX(\Delta t) = f(t)$. Guidance on how these plots should be done is given under Table A1_8. Examples of plots are also provided. *$Q_d(\Delta t) = f(t)$ plots are not obligatory</p>
Mass balance, if applicable	<p>Give the quantity [kg] of each wood preservative component of concern in the unleached wood specimens, the leached wood specimens and leachate solution in tabular form (example table is not provided)</p>

* The quantities leached [$Q_d(\Delta t)$ and $Q_c(t)$] can be provided in mg rather than in kg for an easier readability of the data. However, these data should be converted in kg for calculation of the $FLUX$ according to equation (A1-4) of this Appendix.

Table A1_1: Description of the wood preservative product supplied for the test

Physical state of the product:.....

Solution carrier, if appropriate:.....

	Active ingredient 1	Active ingredient 2	Active ingredient n	Co-formulant 1*	Co-formulant n*
Common name					
Trade name					
Chemical name (IUPAC nomenclature)					
Mass Molecular Formula					
Empirical Formula					
CAS No.					
Concentration in the product supplied for test as % w/w					

* Full description of co-formulants is not necessary if this information is given elsewhere in the applicant (registrant) dossier. In this case only a generic description of the co-formulants and their function should be given as well as a reference where the detailed information can be found.

Table A1_2: Description of preservative treatment solution

Criteria	Details		
Industrial penetrating processes:			
Carrier			
Purity of the carrier	e.g reagent-grade , de-ionised water etc.		
Preparation of the solution	<i>Describe preparation in detail</i>		
Concentrations		% w/w	Method of percentage determination (If the percentage measured by an analytical method)
	Product		
	Active ingredient 1 (Each time, specify the chemical form of the substance that the % refer to)		
	Active ingredient 2		
	Active ingredient n		
Total volume (l) of the solution used for the treatment			
Surface processes (e.g. spraying, brushing etc)			
'In-use preservative'	Specify whether the 'in-use preservative' applied to wood is different than the wood preservative product, supplied for the test. Describe how the 'in-use preservative' was prepared from the preservative product supplied.		
Concentration of each active ingredient in the 'in-use preservative'		% w/w	Method of percentage determination (If the percentage measured by an analytical method)
	Product		
	Active ingredient 1 (Each time, specify the chemical form of the substance that the % refer to)		
	Active ingredient 2		
	Active ingredient n		
Application rate of the 'in-use preservative'	<i>Provide the quantity of the 'in-use preservative' (i.e. treating solution) in kg applied per m² of wood.</i>		

Table A1_3: Characteristics, shape and size of wood test specimens

Total number of wood specimens cut to size:.....

Note: If parameters are the same for all wood specimens, the data should be given once, specifying that they apply for all specimens.

Parameter	Unit	Wood specimens*					Specimenn .m
		1.1	1.2	...	2.1	...	
Form							
Structure of wood surface (i.e. planed or rough sawn wood)							
Wood face exposed to leaching test							
Length	m						
Width	m						
Height	m						
Surface area	m ²						
Volume	m ³						
Ratio Area/Volume	m ² .m ⁻³						
**Sapwood percentage	%						

* If specimens are arranged to sets for parallel tests the specimens should be listed corresponding to these sets. This could be expressed by their numbers

** It should be provided for each wood specimen only when, for justified reasons, use of 100% softwood specimen was not possible.

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Table A1_4: Retention [kg.m⁻³] of preservative and its components in wood test specimens

Total number of wood specimens treated:.....

% moisture content of wood test specimen just before treatment:.....

Time passed after treatment to calculate the retentions [d].....

Parameter	Weight of test specimen (to the nearest 0,01 g)		Retention of wood preservative in test specimens	Retention of individual preservative components*	
	before treatment	after treatment		Component 1	Component n
Unit	g**	g**	kg.m ⁻³	kg.m ⁻³	kg.m ⁻³
Specimen***					
TS 1.1					
TS 1.2					
TS 1.3					
TS 1.4					
TS 1.5					
TS 2.1					
...					
TS n.m					
average retention of the wood specimens treated					
relevant retention specified in the performance standards					

* Only components that are analysed in the test; the molecular formula of the components that these retentions refer to should be indicated.

** In this table the weight can be provided in g rather than in kg for an easier readability of the data. However, these data should be converted in kg for calculation of the retention according to equation (A1-1) of this Appendix.

*** **TS:** treated specimen. If specimens are arranged to sets for parallel tests the specimens should be listed corresponding to these sets. This could be expressed by their numbers

Table A1_5: Description of the leaching test system

Total number of wood specimens subject to the leaching test:.....

Notes:

- the wood specimens, subject to the leaching test, are selected among the wood specimens treated (see Table A1_4), based on the criterion that their retention should be within $\pm 5\%$ of the group's average retention.
- if the parameters in the table below are standardised, their values should in principle be the same for all wood specimens; in this case the data should be given once, specifying that they apply for all specimens.

Parameter	Unit	Wood specimen			
		TS 1.1	TS 1.2	TS n.m	US1
Moisture content of wood test specimen before the leaching experiment starts	%				
Weight of test specimen before the leaching experiment starts	kg				
Retention of the preservative in wood test specimens selected for the leaching test	kg.m ⁻³				
Wood area in contact with the leachate solution	m ²				
Volume of the leachate solution at the beginning of the experiment	m ³				
Wood area/Volume of the leachate solution	m ² .m ⁻³				

TS: treated wood specimen; US: Untreated wood specimen

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Table A1-6: Concentration of preservative component in the leachate solution [mg.l⁻¹].

One table for each of the wood specimens subject to leaching test (adjust table size as required)

- Wood specimen: *e.g specimen m.n where m and numbers or letters*.....
- pH of the leachate solution, indicated in the standard test protocol:.....
(entry applicable only if a standard test protocol was followed)

Sampling dates	Sampling times	Volume of leachate solution sampled	Concentration of the component in the leachate solution					pH
			1 st measur.	2 nd measur.	3 rd measur.	mean value	SD	
11-9- 2001	d	l	mg.l ⁻¹	mg.l ⁻¹	mg.l ⁻¹	mg.l ⁻¹	mg.l ⁻¹	
Component 1: (Specify, name and chemical form of the component analysed)								
12-9-2001	t 1							
	t 2							
	t 3							
	...							
	t n							
Component n: (Specify, name and chemical form of the component analysed)								
	t 1							
	t 2							
	t 3							
	...							
	t n							

Table A1-7: Differential [$Q_d(\Delta t)$, ($\text{mg}\cdot\text{m}^{-2}$)] and Cumulative [$Q_c(t)$, ($\text{mg}\cdot\text{m}^{-2}$)] quantities leached and average daily Fluxes [$F(\Delta t)$ ($\text{kg m}^{-2} \text{d}^{-1}$)] over time.

This table should be done for each wood specimen subject to the leaching test and for each preservative component under consideration

Notes:

Symbol	Unit	Description
$V_{leachate}$	[l]	Volume of leachate solution sampled t each sampling/measurement time point
$AREA_{wood}^{exp}$	[m^2]	Area of wood specimen in contact with the leachate solution
C	[$\text{mg}\cdot\text{l}^{-1}$]	Concentration of wood preservative component in the leachate solution <i>Use the mean concentration (\bar{x}) of the component in the leachate solution [$\text{mg}\cdot\text{l}^{-1}$], given in Table A1-6.</i>
$Q_d(\Delta t)$	[$\text{mg}\cdot\text{m}^{-2}$]*	represents the <u>total quantity</u> of a substance (i.e. wood preservative component) leached out of 1 m^2 of wood area <u>within a time interval</u> ($t_{n+1} - t_n$). If the leaching test was performed by removal and replacement of the leachate solution at each measurement time point, $Q_d(\Delta t)$ is calculated as following: $Q_d(\Delta t) = \frac{C \cdot V_{leachate}}{AREA_{wood}^{exp}}$
$Q_c(t)$	[$\text{mg}\cdot\text{m}^{-2}$]*	represents the <u>total quantity</u> of a substance leached out of 1 m^2 of wood area at a time point t after the beginning of the experiment. If the leaching test was done by remove and replacement of the leachate solution at each measurement time point, the Q_c can be calculated from the $Q_d(\Delta t)$ according to the equation: $Q_c(t_i) = \sum_{j=\Delta t_1}^{\Delta t_m} Q_d(\Delta t)(j)$
$FLUX(\Delta t)$	[$\text{kg m}^{-2} \text{d}^{-1}$]	As FLUX is described the quantity of a substance leached per 1 m^2 of wood area and per day [$\text{kg m}^{-2} \text{d}^{-1}$]. The $FLUX(\Delta t)$ represents the <u>average daily flux</u> for <u>each time interval</u> (Δt) and it is calculated according to the equation: $FLUX(\Delta t) = \frac{Q_d(\Delta t)}{\Delta t}$

* In the following table the quantities leached [$Q_d(\Delta t)$ and $Q_c(t)$] can be provided in $\text{mg}\cdot\text{m}^{-2}$ rather than in $\text{kg}\cdot\text{m}^{-2}$ for an easier readability of the data. However, these data should be converted in kg for calculation of the FLUX according to equation (A1-4) of this Appendix.

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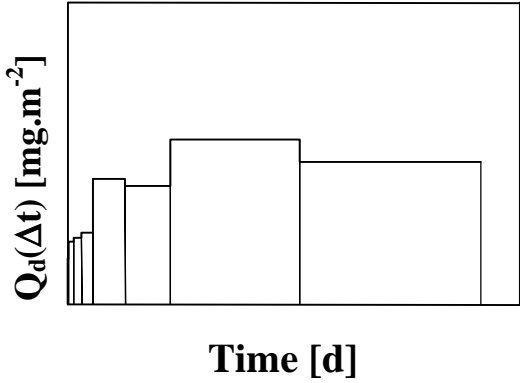
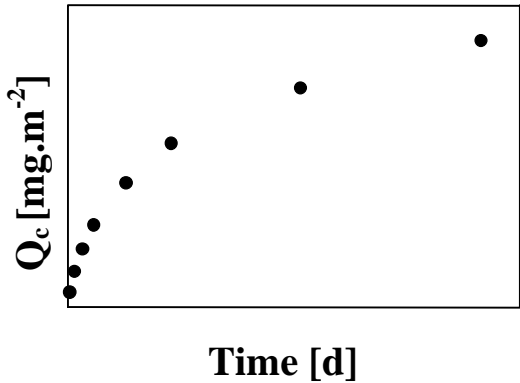
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Table A1-7: Differential [Q_d (Δt), (mg)] and Cumulative [Q_c (t), (mg)] quantities leached and average daily Fluxes [$F(\Delta t)$ ($\text{kg m}^{-2} \text{d}^{-1}$)] over time.

Raw data		Calculations							
Wood Specimen	AREA ^{exp} _{wood} [m ²]	V _{leachate} [l]	C [mg l ⁻¹]	Standard deviation	Time interval [d]	Mean $\Delta t/2$ [d]	Q _d (Δt) [mg]	Q _c (t) [mg]	F(Δt) [$\text{kg m}^{-2} \text{d}^{-1}$]
Component 1: (Specify, chemical name and chemical or empirical form of the component analysed)									
Sampling time point [d]									
t ₁					$\Delta t_1 = t_1 - 0$	$\Delta t_1/2$		Q _d (Δt_1)	
t ₂					$\Delta t_2 = t_2 - t_1$	$\Delta t_2/2$		Q _d (Δt_1)+Q _d (Δt_2)	
t ₃					$\Delta t_3 = t_3 - t_2$	$\Delta t_3/2$		etc	
t ₄					$\Delta t_4 = t_4 - t_3$	$\Delta t_4/2$			
t ₅					$\Delta t_5 = t_5 - t_4$	$\Delta t_5/2$			
...									
t _n					$\Delta t_n = t_n - t_{n-1}$	$\Delta t_n/2$			
Component n: (Specify, chemical name and chemical or empirical form of the component analysed)									
t ₁					$\Delta t_1 = t_1 - 0$	$\Delta t_1/2$		Q _d (Δt_1)	
t ₂					$\Delta t_2 = t_2 - t_1$	$\Delta t_2/2$		Q _d (Δt_1)+Q _d (Δt_2)	
t ₃					$\Delta t_3 = t_3 - t_2$	$\Delta t_3/2$			
t ₄					$\Delta t_4 = t_4 - t_3$	$\Delta t_4/2$			
t ₅					$\Delta t_5 = t_5 - t_4$	$\Delta t_5/2$			
...									
t _n					$\Delta t_n = t_n - t_{n-1}$	$\Delta t_n/2$			

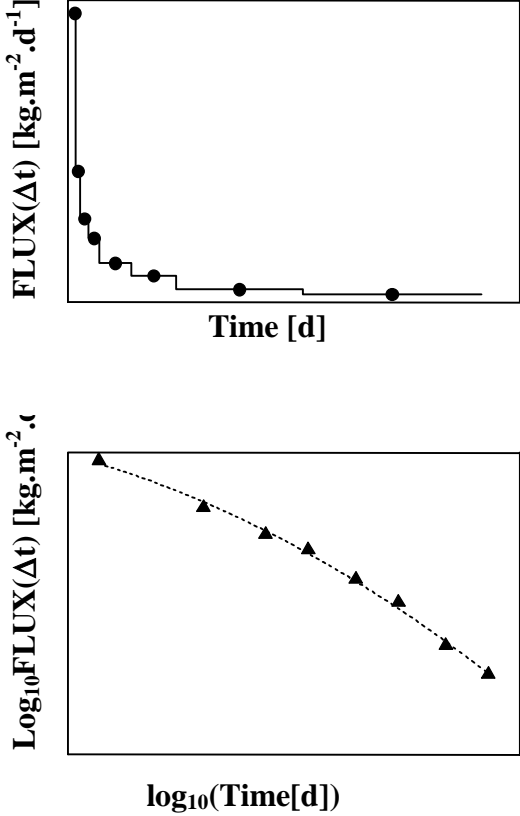
Table A1_8: Plots of $Q_d(\Delta t)$, $Q_c(t)$ and $FLUX(\Delta t)$ versus time

The $Q_d(\Delta t)$, $Q_c(t)$ and $FLUX(\Delta t)$ should be plotted versus time as following:

<p>$Q_d(\Delta t)$ versus time (This plot is not obligatory)</p>	<p>The $Q_d(\Delta t)$ [$\text{mg}\cdot\text{m}^{-2}$] of a substance (i.e. a preservative component, represents the <u>total quantity</u> leached out of 1 m^2 wood area within the time interval $(t_{n+1} - t_n)$. The $Q_d(\Delta t)$, derived by a leaching test, should be plotted versus time as a step function between $(t_n$ and $t_{n+1})$, and <u>not</u> plotted at time t_{n+1}. Figure A1_1 provides an example of such a plot (each $Q_d(\Delta t)$ value used is the mean value of three measurements).</p>  <p>Figure A1_1: Variation of the differential quantity $Q_d(\Delta t)$ [$\text{mg}\cdot\text{m}^{-2}$] of the substance leached within a time interval as a function of time</p>
<p>$Q_c(t)$ versus time</p>	<p>Plots of the cumulative quantity of the substance leached $Q_c(t)$ [$\text{mg}\cdot\text{m}^{-2}$] at each measurement time point t should also be done. An example of such a plot is given in Figure A1_2.</p>  <p>Figure A1_2: Cumulative quantity $Q_c(t)$ [$\text{mg}\cdot\text{m}^{-2}$] of the substance leached as a function of time.</p> <p>Note that, since any fundamental or analytical function has not been defined for this curve, points must not be linked.</p>

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<p>FLUX(Δt) versus time</p>	<p>The average daily flux, $FLUX(\Delta t)$, [$\text{kg m}^{-2} \text{d}^{-1}$] for each time interval (Δt) should be plotted versus the mean time of the time interval (Δt) considered, i.e. at the time point $t_i + (\Delta t)/2 = t_i + (t_{i+1}-t_i)/2$.</p> <p><i>Note: in reality FLUX is changing within a time interval. However, as the experiment is being done by time steps, the function of FLUX variation within a time interval is not known. Therefore the experimental results should be plotted for an average daily FLUX for each time interval.</i></p> <p>For example, if we assume that the differential quantity leached $Q_d(\Delta t)$ between $t_1 = 4$ and $t_2 = 9$ days is 10 mg and the wood surface is 1 m^2, then the <u>average daily flux</u> for the time interval $\Delta t = t_2 - t_1 = 9 - 4 = 5$ days is $FLUX(\Delta t) = 10 / (5 * 1) = 2 \text{ mg m}^{-2} \text{d}^{-1}$. This $FLUX$ value should be plotted for the time point $t_1 + (t_2 - t_1) / 2 = 4 + (9 - 4) / 2 = 6.5$ days and not at $t_2 = 9$ days. The value of $2 \text{ mg m}^{-2} \text{d}^{-1}$ is valid for any time point (as a function of an integer number of days) within the time interval considered.</p> <p>An example of such a $FLUX(\Delta t)$ versus time plot, both in linear and logarithmic scales, is given in Figure A1_3.</p> <div style="text-align: center;">  </div> <p>Figure A1_3: Variation of the average daily $FLUX(\Delta t)$ for a time interval Δt versus time</p>
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APPENDIX 2

GUIDANCE FOR CALCULATION OF *FLUX*, AND SUBSEQUENTLY OF $Q^*_{LEACH, TIME}$ AND OF $FLUX_{STORAGE}$ BASED ON RESULTS FROM LEACHING STUDIES

INTRODUCTION

1. The curves of differential quantities leached [$Q_d(\Delta t)$] or cumulative quantities leached [$Q_c(t)$] versus time that result from leaching tests (see Appendix 1) reflect complex physical phenomena. For short times after the beginning of the experiment (except those times nearing 0, where the so-called edge effects occur), the functions are governed by kinetics law. With increasing time, thermodynamics take place (e.g. edge, small pieces of wood, degradation, colloids, passivation etc), introducing deviations from pure kinetics.

2. Therefore any fundamental equation which can include and describe all these phenomena cannot be written. Only analytical functions with no physical or chemical meaning can be proposed to characterise the overall phenomena, and make predictions for long-term emissions from treated wood.

3. The aim of this Appendix is to provide guidance to exposure assessors on how the results of the leaching tests, reported as outlined in Appendix 1, can be used for estimation of fluxes for long-term prediction of emissions.

CALCULATION OF $Q^*_{LEACH, TIME}$ AND $FLUX_{STORAGE}$ FROM A LEACHING EXPERIMENT WITH WOOD IN DIRECT AND CONTINUOUS CONTACT WITH WATER

4. *The methodologies proposed in this Section are relevant for the:*

- *calculation of $Q_{leach, time1}$ and $Q_{leach, time2}$ for all scenarios of treated wood-in-service (Chapter 5) for which a leaching test with wood in direct and continuous contact with water is required for exposure assessment (see Table A1_I in Appendix 1 or Table 5.3, Chapter 5).*
- calculation of $FLUX_{storage}$ for all storage scenarios of Chapter 4.

5. Since the long term emissions cannot be calculated based on fundamental equations (see Section 1 above), an analytical function must be used that fits well the experimental $FLUX(\Delta t)=f(t)$ or $Q_c(t)=f(t)$ curves (see Appendix 1, Section IV 'Results'). The fitted $FLUX(\Delta t)$ or $Q_c(t)=f(t)$ curves can then be

used for calculation of the quantities leached ($Q^*_{leach,time1}$ and $Q^*_{leach,time2}$) for periods longer than the duration of the leaching experiment, considered for exposure assessment.

6. The Expert Group analysed and compared the performance of three analytical functions for fitting the experimental $FLUX(\Delta t)$ or $Q_c(t)=f(t)$ curves [Paneli M, 2001a; Paneli M, 2001b] and concluded that the model proposed below appeared to fit the experimental data well. The data calculated according to this model were compared with 12 sets of experimental leaching data, 3 different substances each set. This comparison showed very good correspondence between calculated and measured values [Paneli M, 2001a].

7. In the following sections the theoretical basis of the model is described. Numeric examples that illustrate how the model should be applied in practice are given in Appendix 5.

2.1 Fitting of the experimental $FLUX(\Delta t)=f(t)$ curves

8. The model described below is for fitting the experimental $FLUX(\Delta t)=f(t)$ curve. $FLUX(\Delta t)$ represents the average daily flux for each time interval (Δt). It should be pointed out that in reality $FLUX$ is also changing within a time interval, however, as the leaching experiment is done by ‘steps’ (at each sampling/measurement time point, the whole leachate solution is removed and replaced by a fresh one), the function of the variation of the experimental $FLUX$ within a time interval is unknown. Therefore only an average daily flux for each time interval (step) (Δt) can experimentally be determined. In other words, the experimental $FLUX(\Delta t)=f(t)$ curve is a step function and should not be fitted with a continuous one.

9. In logarithmic plots of experimental $FLUX(\Delta t) = f(t)$ curves, i.e., $\log_{10} FLUX(\Delta t) = f[\log_{10}(t)]$ (see Figure A1_3 of Appendix 1), all measurement points are usually distributed regularly. Simple polynomial regression of **second order** can fit the data well.

$$\log_{10} FLUX(t) = a + b \cdot \log_{10}(t) + c \cdot \log_{10}(t)^2 \quad A2_1$$

10. Once the parameter a, b and c are determined the experimental $FLUX(t) = f(t)$ curve, can be re-calculated by using the function:

$$FLUX(t) = 10^a \cdot t^b \cdot t^{c \log t} \quad A2_2$$

An example of a fitted $FLUX(t) = f(t)$ is given in Figure A2_1 plotted for a long time exposure (10 years).

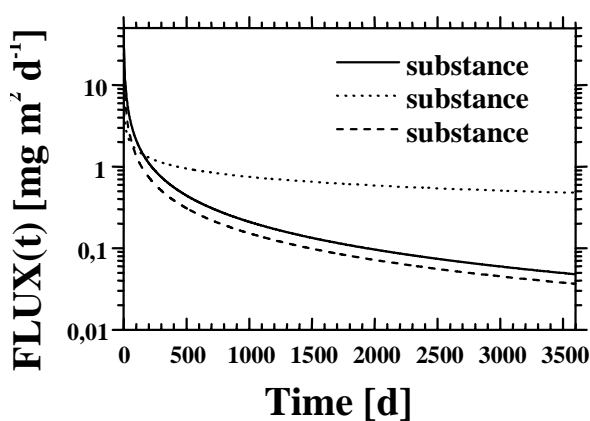


FIGURE A2_1: FITTED DAILY FLUX(T) VERSUS TIME

11. The fitted daily $FLUX(t)$ corresponds to the quantity of the preservative component leached per m^2 wood within the one day interval of the specific day t , while the experimental $FLUX(\Delta t)$ represents the average quantity of the preservative component leached per m^2 wood per day for a specific time interval Δt , and this time interval is more than one day. It should be pointed out that due to limitations in presentation the function of fitted $FLUX(t) = f(t)$ appears continuous. However, it is still a 'step function' with a time step of **one day**.

2.2 Calculation of $Q^*_{leach,time}$ [$kg \cdot m^{-2}$]

12. In the scenarios of treated wood-in-service (Chapter 5), $Q^*_{leach,time}$ [$kg \cdot m^{-2}$] is defined as the cumulative quantity of an active ingredient (or any other substance of concern in a wood preservative formulation) leached out of $1 m^2$ of treated wood over a certain time period of service, considered for assessment.

13. The calculation of $Q^*_{leach,time}$ can be done by summation of daily $FLUX(t)$ for the time period considered for assessment according to the following equation:

$$Q^*_{leach,time} = \sum_{t=1day}^{nday} FLUX(t) = (FLUX)_{1day} + (FLUX)_{2day} + (FLUX)_{3day} + \dots + (FLUX)_{nday} \quad A2_3$$

$n = \text{integer number of days, i.e., } 1, 2, 3, 4, \dots$

14. It should be noted that:

1. *the extrapolation of the data for prediction of long term emissions can only be done by summation and not by integration of the FLUX(t)=f(t) function (equation A2_2). The reason for this is that, although the fitted FLUX(t) values correspond to one day time intervals, the function is still a ‘step function’ and not continuous, and therefore it should not be integrated.*
2. *fitting with a polynomial regression of second order will not take in account the ‘saturation term’, FLUX_{time→0}, that occurs when time approaches 0. To avoid the artefact of “zero region”, the summation of FLUX(t) can start, for example, from day 1 of the experiment. However, it is possible to calculate the total quantity leached starting from time zero of the leaching experiment by adding to the Q_{leach,time}^{*}, calculated according to equation A2_3, the quantity experimentally determined during the first day of the experiment Q_{leach,0-1}^{exp}. In this case equation A2_3 will read:*

$$Q_{leach,time}^* = \left(\sum_{t=1day}^{nday} FLUX(t) \right) + \left(\frac{Q_{leach,0-1}^{exp}}{AREA_{wood}^{exp}} \right) \quad A2_4$$

where AREA_{wood}^{exp}, area of wood specimen in contact with the leachate solution during the leaching experiment.

15. *Once the Q_{leach,time}^{*} is calculated, the cumulative quantity leached (Q_{leach,time}) from the treated wood area considered in the relevant scenarios within the time period of 0-n days (with n, an integer number of days) can then be calculated from the following equation:*

$$Q_{leach,time} = AREA_{wood} \cdot Q_{leach,time}^* \quad A2_5$$

where AREA_{wood} is the leachable wood area [m²] in the relevant scenarios.

16. An example of comparison between cumulative quantities Q_{leach,time}, calculated as described above, and the cumulative quantities determined experimentally is given for three substances in Table A2_1 below:

Table A2_1: Comparison of $Q_{leach,time}$ calculated according to the proposed model and the experimentally determined $Q_{leach,time}$

(Note that summation starts from the day 1 after the beginning of the leaching experiment)

Time interval [d]	$Q_{leach,time}$ experimental [mg]	$Q_{leach,time}$ calculated with the proposed model [mg]
Substance 1		
1 - 9	15,18	14,6
1 - 36	28,4	27,9
1 - 64	34,95	34,7
1 - 365 (1 year)	/	58,0
1 - 3653 (10 years)	/	87,0
Substance 2		
1 - 9	7,33	7,2
1 - 36	14,87	14,8
1 - 64	19,08	18,95
1 - 365 (1 year)	/	34,2
1 - 3653 (10 years)	/	55,3
Substance 3		
1 - 9	2,46	2,55
1 - 36	6,23	7,04
1 - 64	8,19	10,6
1 - 365 (1 year)	/	35,1
1 - 3653 (10 years)	/	162,5

2.3 Calculation of $FLUX_{storage}$ [$kg \cdot m^{-2} \cdot d^{-1}$]

17. The emissions from a storage place, where treated wood are shipped out off site in variable time intervals, are cumulative with the time. According to the equation 4.3 in Section 4.1.5 of the main report, the emissions from storage ($Q_{leach,storage}$) can be calculated as follows without taking into account removal processes:

$$Q_{leach,storage,time} = FLUX_{storage} \cdot AREA_{wood-expo} \cdot AREA_{storage} \cdot TIME \quad (4.3)$$

where:

- $Q_{leach,storage,time}$ = cumulative quantity of an active ingredient (or any substance of concern in a wood preservative product), leached due to rainfall from stored treated wood, within a certain assessment period [kg]
- $FLUX_{storage}$ = average daily flux i.e. the average quantity of an active ingredient (or any substance of concern in a wood preservative product) that is daily leached out of 1 m² of treated wood during a certain storage period [$kg \cdot m^{-2} \cdot d^{-1}$]
- $AREA_{wood-expo}$ = effective surface area of treated wood, considered to be exposed to rain, per m² storage area (i.e. soil) [$m^2 \cdot m^{-2}$]
- $AREA_{storage}$ = surface area of the storage place [m²]
- $TIME$ = time period considered for assessment [d]

18. $FLUX_{storage}$, can be calculated from the results of a leaching test as follows:

$$FLUX_{storage} = \frac{Q_{leach,time}^*}{TIME_{storage}} = \frac{\left(\sum_{t=1day}^{nday} FLUX(t) \right) + \left(\frac{Q_{leach,0-1}^{exp}}{AREA_{wood}^{exp}} \right)}{TIME_{storage}} \quad A2_6$$

$n = \text{integer number of storage days}$

where:

$TIME_{storage}$	=	duration of storage of treated wood prior to shipment (default values for storage duration are proposed by the Expert Group for each storage scenario) [d]
$Q_{leach,0-1}^{exp}$	=	quantity leached during the first day of the leaching experiment [kg]
$AREA_{wood}^{exp}$		area of wood specimen in contact with the leachate solution during the leaching experiment

19. It should be noted however that the use of the average daily flux in equations 4.3 is a simplification, and it can underestimate in some cases the long-term cumulative emissions of a substance at a storage place. These cases are described in the following Section.

2.4 Applicability of $FLUX_{storage}$ [$kg \cdot m^{-2} \cdot d^{-1}$] for calculation of long-term cumulative emissions at storage place

20. As mentioned earlier, the emissions from a storage place, where treated wood are shipped off site in variable time intervals, are **cumulative with the time**. The applicability of $FLUX_{storage}$ in equation 4.3 for estimation of these cumulative emissions depends on **two factors**:

- the like form of the experimental leaching curve [$Q_c(t)=f(t)$ or $FLUX(t)=f(t)$]: whether the curves reach an asymptote (saturation) or not during the leaching experiment;
- if saturation is reached, the relation between the saturation time and the default storage duration proposed in the storage scenarios for the three industrial treatments.

21. The applicability of $FLUX_{storage}$ for calculation of long-term cumulative emissions at storage place is investigated in the following two examples:

- **Example 1:** when the leaching rate of a substance does not reach an asymptote within the time span of a leaching experiment
- **Example 2:** when the leaching rate of a substance reaches an asymptote within the time span of a leaching experiment.

2.4.1 Example 1: an asymptote is not reached during the leaching experiment

22. The curves in Figure A2_2 are based on experimental leaching data where the saturation (asymptote) of the $Q_c(t)=f(t)$ or $FLUX(t)=f(t)$ curves was not reached after 64 days of a leaching experiment.

23. The cumulative emissions at storage place as a function of time are calculated for the 3 default storage durations proposed in this document:

- 3 days for the automated spraying scenario: the total quantity of wood is removed and replaced every 3 days;
- 14 days for the dipping scenario: the total quantity of wood is removed and replaced every 14 days;
- 35 days for the vacuum-pressure/double vacuum scenario: the total quantity of wood is removed and replaced every 35 days.

24. For each storage duration, the cumulative emissions at storage place for a given assessment period (here 100 days are used as an example) are calculated by two different ways:

- adding the calculated $Q^*_{leach,time} = f(t)$ curves for time intervals equal to the given storage duration up to 100 days used, as an example, for assessment. In these curves, $Q^*_{leach,time}$ is calculated according to equation A2_4.
- using $FLUX_{storage}$ which represents an average quantity of a substance daily leached out of 1 m^2 wood during the given storage duration.

25. It can be seen that when stored wood is removed/replaced every 3 days, the function $Q^*_{leach,time} = f(t)$ is linear. In this case, the above two calculation options are identical and give the same results.

26. However, as the storage duration increases, the function is not linear and depends very much of the 'like form' of the experimental leaching curve. For storage duration of 14 and 35 days, use of $FLUX_{storage}$ tends to slightly underestimate the emissions. This is demonstrated in Figure A2_2 with the dotted red (14 days storage) and blue lines (35 days storage). The linear extrapolation (i.e. use of $FLUX_{storage}$) can be used without the constraints of underestimating the emissions when the assessment time is a multiple of storage duration: e.g. if the storage duration chosen is 14 days, then the assessment is done for 28 days, 42 days etc.

27. Another conclusion that can be derived from the curves in Figure A2_2, is that for a given assessment period and regardless of which calculation option will be followed, the cumulative emissions will be decreasing as the storage duration used in the scenarios is increasing. In other words the cumulative emissions, calculated for a given assessment period, depends very much on what storage duration will be chosen. The influence of the relation between the assessment period and the storage duration chosen on the calculated cumulative emissions is even greater in the case of substances for which the leaching rate reaches quickly an asymptote. This is showed in Example 2 below.

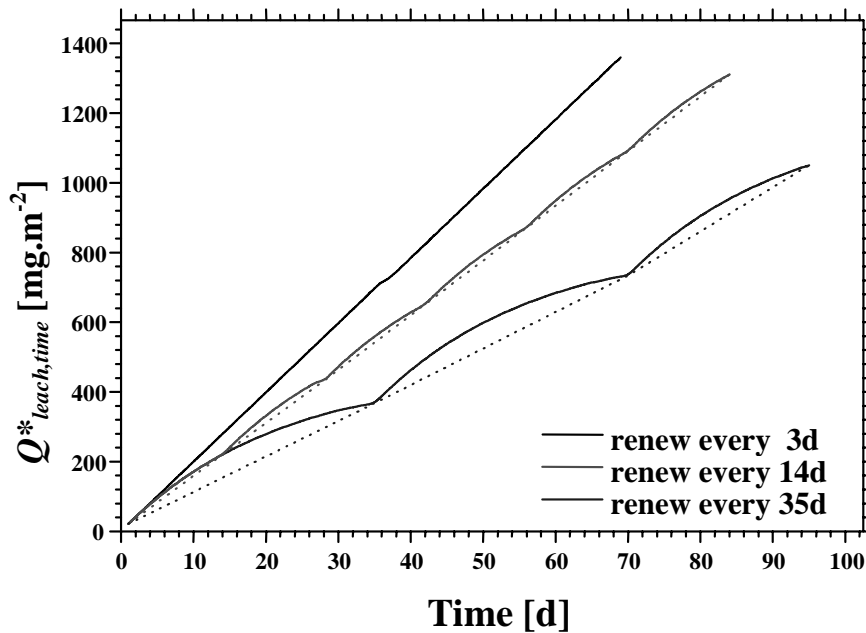


Figure A2_2 : Comparison of the cumulative quantities leached ($Q^*_{leach,time}$, mg.m^{-2}) from stored, treated wood, when renewing the total quantity of wood every 3, 14 and 35 days.
Example 1: an asymptote is not reached during the leaching experiment of 64 days.

2.4.2 Example 2: an asymptote is reached during the leaching experiment

28. The curves in Figure A2_3 are based on experimental leaching data for a substance that is quickly leached leading to a saturation (asymptote) of the $Q_c(t)=f(t)$ or $FLUX(t)=f(t)$ curves much earlier than 64 days (approx. after 10 days) that the leaching experiment last.

29. For each storage duration, the cumulative emissions at storage place for a given assessment period (here 100 days are used as an example) are calculated by the two ways, described earlier in Section 2.4.1.

30. It can be seen that also in this case when stored wood is removed/replaced at time intervals inferior than the time that saturation is reached (e.g. 3 day storage duration), the function $Q^*_{leach,time}=f(t)$ is linear. In this case too, the above two calculation options are identical and give the same results.

31. However, as the storage duration increases, the function is not linear and use of $FLUX_{storage}$ can considerably underestimate the emissions especially for long storage durations (see difference between the blue curve and blue dotted line for 35 days of storage in Figure A2_3). Again, the linear extrapolation (i.e. use of $FLUX_{storage}$) can be used without the constraints of underestimating the emissions when the assessment time is a multiple of storage duration: e.g. if the storage duration chosen is 14 days, then the assessment is done for 28 days, 42 days etc.

32. Moreover, as mentioned earlier in Example 1, for a given assessment period, the difference between the calculated cumulative emissions when short or long storage durations are chosen is very important. Therefore, it is advised that for substances that leach quickly leading to an asymptote, the cumulative emissions be calculated with all 3 default values for storage duration proposed in this document (i.e. 3, 14 and 35 days). The exposure assessors should consider the realistic worst case based on expert judgement.

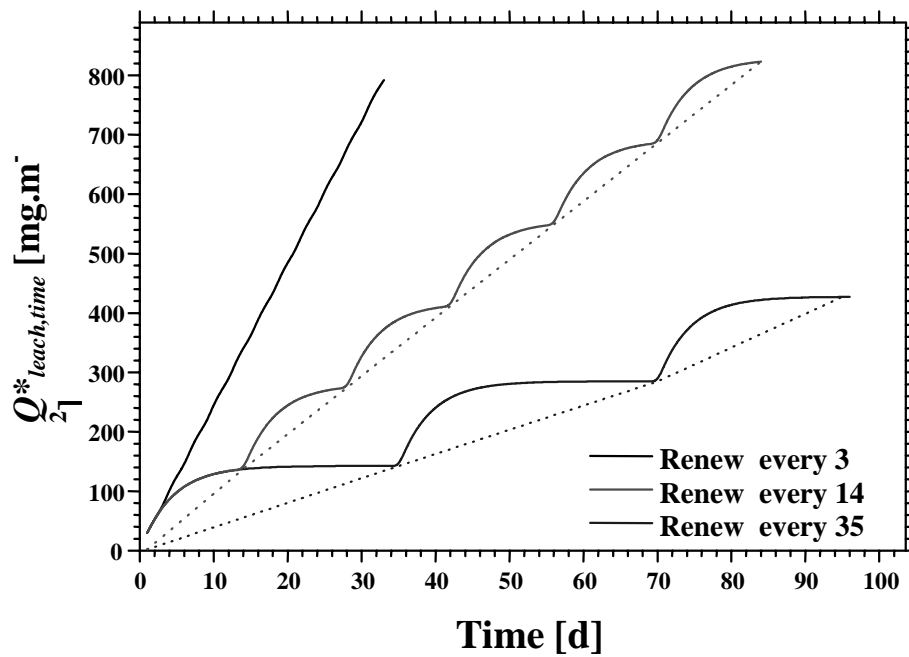


Figure A2_3: Comparison of the cumulative quantities leached ($Q^*_{leach,time}$, mg.m⁻²) from stored, treated wood, when renewing the total quantity of wood every 3, 14 and 35 days.

Example 2: an asymptote is quickly reached during the leaching experiment of 64 days.

APPENDIX 3

FULL DESCRIPTION OF DIMENSIONS FOR WOOD-IN-SERVICE SCENARIOS

Fence

	Value	Unit
wood		
form: poles and planks		
width	0,025	[m]
length	1	[m]
height	2	[m]
total wood volume per m length	0,05	[m ³]
total wood area per m length	2	[m ²]
soil		
form: rectangular box next to fence		
width	0,1	[m]
depth	0,1	[m]
length	1	[m]
soil volume per m fence length	0,01	[m ³]
ratio's		
wood area: wood volume	40	[m ² ,m ⁻³]
wood area: soil volume	200	[m ² ,m ⁻³]
wood volume: soil volume	5	[m ³ ,m ⁻³]

Noise barrier

	Value	Unit
wood		
form: poles and planks		
width	0,025	[m]
length	1000	[m]
height	3	[m]
total wood volume	75	[m ³]
total wood area	3000	[m ²]
soil		
form: rectangular box next to fence		
width	0,1	[m]
depth	0,1	[m]
length	1000	[m]
soil volume	10	[m ³]
ratio's		
wood area: wood volume	40	[m ² .m ⁻³]
wood area: soil volume	300	[m ² .m ⁻³]
wood volume: soil volume	7,5	[m ³ .m ⁻³]

House

	Value	Unit
wood		
form: timber house, leaching from outside		
circumference of house	50	[m]
height of house	2,5	[m]
thickness of claddings/boards	0,025	[m]
total wood volume	3,125	[m ³]
total wood area	125	[m ²]
soil		
form: rectangular box around house		
width	0,1	[m]
depth	0,1	[m]
length	125	[m]
soil volume	0,50	[m ³]
ratio's		
wood area: wood volume	40	[m ² .m ⁻³]
wood area: soil volume	250	[m ² .m ⁻³]
wood volume: soil volume	6,25	[m ³ .m ⁻³]

Bridge over pond

	Value	Unit
Wood		
form: bridge or walkway on poles with railing		
width of bridge	1,2	[m]
length of bridge (0,2 m free space)	4	[m]
number of transversal planks	40	
length of transversal planks	1,2	[m]
thickness of transversal planks	0,025	[m]
width of transversal planks	0,095	[m]
number of supporting planks (pressure impregnated)	2	
length of supporting planks	4	[m]
thickness of supporting planks	0,2	[m]
width of supporting planks	0,1	[m]
number of handrails	2	
length of handrail	4	[m]
thickness of handrail	0,05	[m]
width of handrail	0,08	[m]
number of railing supports	20	
length of railing supports	0,9	[m]
thickness of railing supports	0,05	[m]
width of railing supports	0,05	[m]
number of poles (pressure impregnated)	4	
diameter of poles	0,2	[m]
height of poles	2,5	[m]
total transversal plank volume	0,114	[m ³]
total transversal plank area	9,12	[m ²]
total supporting plank volume	0,16	[m ³]
total supporting plank area	4,88	[m ²]
total handrail volume	0,032	[m ³]
total handrail area	2,1	[m ²]
total railing support volume	0,045	[m ³]
total railing support area	3,7	[m ²]
total pole volume	0,31	[m ³]
total pole area	6,28	[m ²]
treated plank area	4,56	[m ²]
treated handrail area	2,1	[m ²]
treated railing support area	3,7	
<i>total treated area</i>	<i>10,36</i>	<i>[m²]</i>
<i>total treated volume</i>	<i>0,191</i>	<i>[m³]</i>
water		
water volume	20 m ³	[m ³]
ratio's		
wood area : wood volume	54,2	[m ² .m ⁻³]
wood area :water volume	1:2	[m ² .m ⁻³]

Transmission pole

	Value	Unit
wood		
form: cylindrical		
diameter	0,25	[m]
total length	9	[m]
above ground length	7	[m]
below ground length	2	[m]
total volume	0,4	[m ³]
total area	7,07	[m ²]
volume above ground	0,34	[m ³]
volume below ground	0,10	[m ³]
area above ground	5,5	[m ²]
area below ground	1,6	[m ²]
soil		
distance from pole	0,1	[m]
depth under pole	0,1	[m]
soil volume	0,24	[m ³]
ratio's		
above soil wood area: wood volume	16,2	[m ² .m ⁻³]
above soil wood area: soil volume	23	[m ² .m ⁻³]
above soil wood volume: soil volume	1,5	[m ³ .m ⁻³]
below soil wood area: wood volume	16	[m ² .m ⁻³]
below soil wood area: soil volume	6,7	[m ² .m ⁻³]
below soil wood volume: soil volume	0,4	[m ³ .m ⁻³]

Fence post

	Value	Unit
wood		
form: rectangular		
width	0,1	[m]
total length	2	[m]
above ground length	1,5	[m]
below ground length	0,5	[m]
total volume	0,02	[m ³]
total area	0,80	[m ²]
volume above ground	0,015	[m ³]
volume below ground	0,005	[m ³]
area above ground	0,6	[m ²]
area below ground	0,2	[m ²]
soil		
distance from post	0,1	[m]
depth under post	0,1	[m]
soil volume	0,049	[m ³]
ratio's		
above soil wood area: wood volume	40	[m ² .m ⁻³]
above soil wood area: soil volume	12	[m ² .m ⁻³]
above soil wood volume: soil volume	0,3	[m ³ .m ⁻³]
below soil wood area: wood volume	40	[m ² .m ⁻³]
below soil wood area: soil volume	4	[m ² .m ⁻³]
below soil wood volume: soil volume	0,1	[m ³ .m ⁻³]

Jetty

	Value	Unit
wood		
form: rectangular walkway on poles		
width of jetty	1,5	[m]
length of jetty	8	[m]
thickness of jetty	0,025	[m]
number of supporting planks	2	[m]
length of supporting planks	8	[m]
depth of supporting planks	0,2	[m]
thickness of supporting planks	0,05	[m]
number of poles	8	
diameter of poles	0,2	[m]
height of poles	2	[m]
total plank volume	0,46	[m ³]
total plank area	32,5	[m ²]
total pole volume	0,50	[m ³]
total pole area	10,05	[m ²]
leachable plank area	16,24	[m ²]
water		
form: circular pond		
diameter	100	[m]
depth	2	[m]
water volume	1,6e4	[m ³]
ratio's		
leachable plank area: plank volume	35,3	[m ² .m ⁻³]
plank area: water volume	0,001	[m ² .m ⁻³]
plank volume: water volume	2,9E-05	[m ³ .m ⁻³]
Pole area: pole volume	20,1	[m ² .m ⁻³]
pole area: water volume	6,4E-04	[m ² .m ⁻³]
pole volume: water volume	3,2E-05	[m ³ .m ⁻³]

Sheet piling

	Value	Unit
wood		
form: sheet piling of poles		
number of poles	10	[m] per m waterway
width of poles [m]	0,1	[m]
height of poles [m]	1,5	[m]
submerged depth of poles	1,5	[m]
submerged pole volume	0,12	[m ³] per m waterway
submerged pole area	4,7	[m ²] per m waterway
water		
form: rectangular waterway		
width	5	[m]
depth	1,5	[m]
volume	7,5	[m ³] per m waterway
ratio's		
pole area: pole volume	39,2	[m ² .m ⁻³]
pole area: water volume	0,63	[m ² .m ⁻³]
pole volume: water volume	0,016	[m ³ .m ⁻³]

Wharf

	Value	Unit
wood		
length of wharf	100	[m]
width of wharf	3	[m]
number of poles	40	
diameter of poles	0,5	[m]
height of poles	14,5	[m]
above water length of poles	4,00	[m]
below water part of poles	4,00	[m]
intertidal part of poles	3,00	[m]
sides with waling	2	
length of waling	100	[m]
width of waling	0,2	[m]
height of waling	0,45	[m]
number of rubbing strips	40	
length of rubbing strips	0,6	[m]
width of rubbing strips	0,45	[m]
height of rubbing strips	0,2	[m]
length of kerbing	100	[m]
height of kerbing	0,3	[m]
width of kerbing	0,45	[m]
pole volume	114	[m ³]
above water pole volume	31	[m ³]
below water pole volume	31	[m ³]
intertidal pole volume	24	[m ³]
pole area	911	[m ²]
above water pole area	251	[m ²]
below water pole area	251	[m ²]
intertidal pole area	188	[m ²]
decking area	300	[m ²]
leachable decking area	150	[m ²]
waling area	260	[m ²]
kerbing area	150	[m ²]
leachable kerbing area	120	[m ²]
rubbing strip area	31,2	[m ²]
leachable rubbing strip area	26,4	[m ²]
total plank volume	61,38	[m ²]
total leachable area planks	296	[m ²]
total pole area	911	[m ²]
water		
distance from wharf	5	[m]
depth	2	[m]
replacements per day	2	[d ⁻¹]
volume	1000	[m ³]
volume considered per day	2000	[m ³]
volume considered per week	14000	[m ³]
ratio's		
plank area: plank volume	296/61,38 =4,8	[m ² .m ⁻³]
plank area: water volume	0,15	[m ² .m ⁻³]
plank volume: water volume	0,061	[m ³ .m ⁻³]
pole area: pole volume	8	[m ² .m ⁻³]
pole area: water volume	0.91	[m ² .m ⁻³]
pole volume: water volume	0.11	[m ³ .m ⁻³]

