Use-based approaches for the estimation of environmental exposure due to roof membranes (PT 9)

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Introduction

DE is finalising a Draft-CAR in PT 9 for an active substance, which is added to the plastics (flexible PVC) from which roof membranes are manufactured. In the CA-document "Guidance note on leaching rate estimations for substances used in biocidal products in Product Types 07, 09 and 10" (March 2010), it was agreed for PT 9 that in general the tonnage approach will be used to estimate the environmental exposure over service life. For specific uses use-based approaches may be justified. DE is of the opinion that roof membranes are a specific use because it is known that they are in direct contact with rainwater which is collected for each house and is either trickled away in the ground or discharged to the sewer systems. Especially direct emission to soil is not included in the tonnage approach, described in the ESD for plastic additives (OECD, 2009). Therefore, a suitable scenario was developed. In addition to this, a scenario was developed to reflect the situation that commercial buildings in cities are predominantly flat roof buildings frequently using roof membranes. The document was presented and discussed at TM II-2013. After the discussion, DE received useful comments from NL. All suggestions and improvements were incorporated in the document. The document was discussed again at WG III-2014 and finally endorsed by the WG members.

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Scenario I: Direct emission to soil

Release estimation

Basically, this approach is based on the house scenario of the Revised Emission Scenario Document for Wood Preservatives (Chapter 4.3.3.1, OECD ESD Nr. 2, 2013). According to the evaluation practice of wood preservatives, calculations are done for the initial assessment period (TIME1 = 30 days) and for the whole service life (TIME2). For PVC roofing materials the service life is 20 years (according to ESD for plastic additives, Table 6.2, OECD, 2009). There is an outstanding discussion on CA-level about the inclusion of an additional time point in case a risk for TIME1 is calculated (presumably 365 days, refer to minutes of WG-I-2014, item 6.2). Depending on the discussion results the scenario may have to be adapted.

The cumulative quantity of the a.s. leached out of 1 m^2 of roof membrane over the time period ($Q_{cum,\ leach,\ time}$) is estimated using the emission factor to water ($F_{service,\ water}$) , the concentration of a.s. in the roof membrane ($c_{roof\ membrane}$) and the weight of 1 m^2 of roof membrane ($W_{roof\ membrane}$):

$$Q_{cum,\ leach,\ time\ 1} = W_{roof\ membrane} \times c_{roof\ membrane} \times F_{service,\ water\_time1} \quad (1)$$

$$Q_{cum,\ leach,\ time\ 2} = W_{roof\ membrane} \times c_{roof\ membrane} \times F_{service,\ water,time2} \quad (2).$$

In general, no leaching data are currently available for the active substances, which are added to roof membranes. Therefore, $F_{service,\ water}$ should be 50% for TIME1 and 100% for TIME2 (according to the evaluation practice of wood preservatives, refer to minutes of WG-I-2014, item 6.2). In case leaching data is available, the information can be used as a refinement. It should be noted that more guidance is needed for the interpretation of leaching data in the future.

As the worst case for $c_{roof\ membrane}$ it is assumed that the roof membranes contain the same amount of a.s. as it is stated for the plastics from which roof membranes are manufactured. Because $W_{roof\ membrane}$ is not known for a.s. containing roof membranes, DE carried out Internet research in 2013 (see appendix). The data collected for several different roof membranes revealed that only in exceptional cases $W_{roof\ membrane}$ is more than 3 kg/m^2. Therefore, a value of 3 kg/m^2 for $W_{roof\ membrane}$ is used as worst case default value.

In order to calculate the cumulative quantity of the a.s. leached out of a single roof over the time period ($Q_{leach,\ time}$), one needs to know the roof area ($AREA_{roof}$):

$$Q_{leach,\ time\ 1} = AREA_{roof} \times Q_{cum,\ leach,\ time\ 1} \quad (3)$$

$$Q_{leach,\ time\ 2} = AREA_{roof} \times Q_{cum,\ leach,\ time\ 2} \quad (4).$$

Since roof membranes are predominantly installed in flat roof houses, $AREA_{roof}$ is calculated by multiplying length and width of the OECD house as defined in the Revised ESD for Wood Preservatives (Chapter 4.3.3.1, OECD ESD Nr. 2, 2013) considering a roof overhang of 0.5 m to each side. Using a length of 17.5 + 1 m and a width of 7.5 +1 m, a roof area of 157.25 m^2 is calculated. Therefore, a value of 158 m^2 for $AREA_{roof}$ is used in this scenario.

According to the Revised ESD for Wood Preservatives (Chapter 3.4.1.2, OECD ESD Nr. 2, 2013) it is possible to refine the results of the house scenario by calculating a time dependent concentration in soil. In this case, the daily emission of a.s. to soil due to leaching over the time period ($E_{soil,\ leach,\ time}$) is needed. $E_{soil,\ leach,\ time}$ is calculated by dividing $Q_{leach,\ time}$ by the time period (TIME):

$$E_{soil,\ leach,\ time\ 1} = Q_{leach,\ time\ 1} / TIME1 \quad (5).$$

$$E_{soil,\ leach,\ time\ 2} = Q_{leach,\ time\ 2} / TIME2 \quad (6).$$

Table 1: Cumulative quantity of the a.s. leached out of a roof over the time period and daily emission rate due to leaching over the time period

Input parameters of the emission scenario	**Unit**	**Value**
Weight of 1 m^2 of roof membrane ($W_{roof\ membrane}$)[a]	kg m^{-2}	3
Fraction emitted to wastewater, outdoor use, initial time period ($F_{service,\ water,\ time1}$)[b]		0.5
Fraction emitted to wastewater over service life, outdoor use ($F_{service,\ water,\ time2}$)[b]		1
Concentration of a.s. in the roof membrane ($c_{roof\ membrane}$)[c]	g kg^{-1}	
Roof area ($AREA_{roof}$)[d]	m^2	158
Initial time period (TIME1)	day	30
Service life ($T_{service}$ = TIME2)[e]	day	7300
Calculation of the cumulative quantity and emission rate based on equations 1 to 6	**Unit**	**Value**
Cumulative quantity of the a.s. leached out of a single roof over the initial time period ($Q_{leach,\ time\ 1}$)	g	
Cumulative quantity of the a.s. leached out of a single roof over the service life ($Q_{leach,\ time\ 2}$)	g	
Local emission of a.s. to soil due to leaching over the initial time period ($E_{soil,\ leach,\ time\ 1}$)	g day^{-1}	

Local emission of a.s. to soil due to leaching over the service life ($E_{soil, leach, time 2}$)	g day^{-1}	

[a] Worst case result based on an Internet search carried out by DE (see appendix)
[b] Maybe refined, if leaching data are available.
[c] Applicant information, worst case assumption that the same value is valid for the plastics and for the roof membrane
[d] Calculated for an OECD house according to ESD for Wood Preservatives (OECD ESD Nr. 2, 2013) assuming a flat roof with a roof overhang of 0.5 m to each side (please refer to the text)
[e] From Table 6.2 (PVC roofing materials) of the ESD for plastic additives (OECD, 2009)

PEC estimation

The use based approach is based on the house scenario of the Revised ESD for Wood Preservatives (equation 5.17, Chapter 4.3.3.1, OECD ESD Nr. 2, 2013). The resulting concentration in local soil at the end of the time period ($Clocal_{soil, leach, time}$) is equivalent to $PEClocal_{soil}$:

$$Clocal_{soil, leach, time 1} = Q_{leach, time 1} / (V_{soil} \times RHO_{soil}) \quad (7).$$

$$Clocal_{soil, leach, time 2} = Q_{leach, time 2} / (V_{soil} \times RHO_{soil}) \quad (8).$$

The bulk density of wet soil (RHO_{soil}) is by default 1700 kg/m^3. But the default value for the soil volume (V_{soil}) in the house scenario of the Revised ESD for Wood Preservatives cannot be used in case of a.s. containing roof membranes. Rainwater from roofs does not run down the façades but is collected in rain gutters and trickled away in the ground in a controlled way. In Germany several infiltration techniques are applied like surface infiltration, hollow infiltration, and soakaway pits (rigole). As a worst case for surface soil DE proposes to reproduce hollow infiltration in the present scenario for the following reasons:

- Compared to the hollow, the rainwater is spread over much more soil surface in case of surface infiltration.
- In case of soakaway pits and similar techniques the rainwater is transported to the subsurface soil to infiltrate. The rainwater from the roof is not in contact with surface soil.

Hollow infiltration works with a temporary storage of the rainwater in open, grassy hollows (maximum depth 30 cm). In German practice, the dimension of the hollow is estimated in a first step according to the rule of thumb: 10 % of the connected, sealed area for good permeable soils and 20 % of the connected, sealed area for lesser permeable soils (DWA, 2005). If the cleaning capacity of the subsurface soil is poor, the depth of the surface soil should be at least 20 cm, otherwise a minimum of 10 cm surface soil depth is mandatory (DWA, 2005). DE proposes to use 10 % of the connected, sealed area (AREAroof = 158 m^2) to calculate a worst case hollow area ($AREA_{hollow}$ = 16 m^2) and a surface soil depth of 20 cm. Applying this depth, a soil volume ($V_{soil, hollow}$) of 3.2 m^3 is calculated for the receiving hollow.

According to the Revised ESD for Wood Preservatives (Chapter 3.4.1, OECD ESD Nr. 2, 2013) it is possible to refine the results of the house scenario by calculating the time weighted concentration in local soil over the time period ($Clocal_{soil, leach, time , refined}$). In the respective chapter of the ESD it is recommend to use equation 11 or 12 in case no in-situ application takes place. However, the discussion about the correct or applicable equation for the refinement of the soil concentration has not come to an end yet. Depending on the discussion results the scenario may have to be adapted.

$Clocal_{soil, leach, time , refined}$ is equivalent to $PEClocal_{soil, refined}$.

Table 2: Concentration in local soil at the end of/over the time period

Input parameters of the emission scenario	**Unit**	**Value**
Cumulative quantity of the a.s. leached out of a single roof over the initial time period ($Q_{leach, time 1}$)[a]	g	
Cumulative quantity of the a.s. leached out of a single roof over the service life ($Q_{leach, time 2}$)[a]	g	
Local emission of a.s. to soil due to leaching over the initial time period ($E_{soil, leach, time 1}$)[a]	g day^{-1}	
Local emission of a.s. to soil due to leaching over the service life ($E_{soil, leach, time 2}$)[a]	g day^{-1}	
Bulk density of wet soil (RHO_{soil})[b]	kg m^{-3}	1700
Soil volume ($V_{soil, hollow}$)[c]	m^3	3.2
Initial time period (TIME1)	day	30
Service life ($T_{service}$ = TIME2)[e]	day	7300
Degradation rate constant of a.s. in soil at 12°C (k_{soil})[d]	day^{-1}	
Calculation of the concentration in local soil based on equations 7 and 8 and on the Revised ESD for Wood Preservatives (2013, Chapter 3.4.1)		**Value**
Concentration in local soil at the end of the initial time period ($Clocal_{soil, leach, time 1}$)	g kg^{-1}	
Concentration in local soil at the end of the service life ($Clocal_{soil, leach, time 2}$)	g kg^{-1}	
Time weighted concentration in local soil (initial time period) ($Clocal_{soil, leach, time 1, refined}$)	g kg^{-1}	
Time weighted concentration in local soil (service life) ($Clocal_{soil, leach, time 2, refined}$)	g kg^{-1}	

[a] Please refer to Table 1
[b] Default value from EU TGD, part 2 (2003)
[c] Calculated for a worst case hollow infiltration (please refer to the text)
[d] Specific for each a.s.

Scenario II: City scenario

This scenario was developed to reflect the situation that commercial buildings in cities are predominantly flat roof houses using frequently roof membranes. No further small standard houses in addition to the commercial houses are considered in this city scenario because their contribution to emission is assumed to be limited with regard to the use of roof membranes. The approach is principally based on information from the Emission Scenario Document for Insecticides, Acaricides and Products to Control Other Arthropodes for Household and Professional Uses (OECD ESD Nr. 18, 2008).

As in scenario I, the cumulative quantity of the a.s. leached out of 1 m^2 of roof membrane over the service life ($Q_{cum, leach, time 2}$) and the cumulative quantity of the a.s. leached out of a single roof over the service life ($Q_{leach, time 2}$) are estimated (refer to scenario I, equation [2] and [4]). The same assumptions regarding $c_{roof membrane}$, $F_{service, water,time2}$ and $W_{roof membrane}$ are used. In the ESD for Insecticides, Acaricides and Products to Control Other Arthropodes for Household and Professional Uses (chapter 2.6, OECD ESD Nr. 18, 2008) the surface of a typical commercial building is defined as 3,280 m^2. This value is used as the roof area ($AREA_{roof}$).

The local emission of a.s. to water due to leaching over the service life ($Elocal_{leach}$) is calculated taking into account the number of houses connected to a sewer system (N_{house}), the market share factor ($F_{market\ share}$), and the service life ($T_{service}$):

$$Elocal_{leach} = Q_{leach,\ time\ 2} \times N_{house} \times F_{market\ share} / T_{service} \quad (11).$$

In the environmental risk assessment of PT 18 it was agreed that 300 commercial houses are connected to a sewer system (refer to MOTA Version 5, chapter 5.2.9, Q.4). This value is used in this scenario for N_{house}. In order to take into account the market share of the installation of a.s.-containing roof membranes in a city, a market share of 100% may be assumed in a first step. A reduction of $F_{market\ share}$ may be possible, if the value is sufficiently substantiated by tonnage data.

Table 3 Daily emission rate due to leaching over the service life

Input parameters of the emission scenario	**Unit**	**Value**
Weight of 1 m^2 of roof membrane ($W_{roof\ membrane}$)[a]	kg m^{-2}	3
Fraction emitted to wastewater over service life, outdoor use ($F_{service,\ water,\ time2}$)[b]		1
Concentration of a.s. in the roof membrane ($c_{roof\ membrane}$)[c]	g kg^{-1}	
Roof area of commercial flat roof building ($AREA_{roof}$)[d]	m^2	3280
Number of commercial houses connected to a sewer system (N_{house})[d]		300
Market share factor ($F_{market\ share}$)[e]		1
Service life ($T_{service}$)[f]	day	7300
Local emission to water based on equations 2, 4, and 11		**Value**
Local emission of a.s. to water due to leaching over the service life ($Elocal_{leach}$)	g day^{-1}	

[a] Worst case result based on an Internet search carried out by DE (see appendix)
[b] Maybe refined if leaching data are available.
[c] Applicant information, worst case assumption that the same value is valid for the plastics and for the roof membrane
[d] According to ESD for Insecticides, Acaricides and Products to Control Other Arthropodes for Household and Professional Uses (OECD ESD Nr. 18, 2008).
[e] May be refined, if the refined value is sufficiently substantiated by tonnage data
[f] From Table 6.2 (PVC roofing materials) of the ESD for plastic additives (OECD, 2009)

Remark: The present scenario was specially developed for the environmental risk assessment of roof membranes in PT 9. For the environmental risk assessment of substances in paints, plasters, and filters applied in cities, Elocal is calculated according to the city scenario endorsed at TM IV-2013 (refer to MOTA chapter 5.2.6, Q1).

References

CA, 2010: Guidance note on leaching rate estimations for substances used in biocidal products in Product Types 07, 09 and 10, adopted March 2010.

DWA, 2005: Planung, Bau und Betrieb von Anlagen zur Versickerung von Niederschlägen, Arbeitsblatt DWA-A 138, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V., p. 59.

EU TGD, 2003: Technical Guidance Document on Risk Assessment, part II, Environmental Risk Assessment, European Commission, p. 328.

OECD, 2008: Emission Scenario Document for Insecticides, Acaricides and Products to Control Other Arthropodes for Household and Professional Uses, OECD Series on Emission Scenario Documents, Number 18, p. 188.

OECD, 2009: Emission Scenario Document on Plastic Additives, OECD Series on Emission Scenario Documents, Number 3, p. 141.

OECD, 2013: Revised Emission Scenario Document for Wood Preservatives, OECD Series on Emission Scenario Documents, Number 2, p. 268.

Appendix

Internet search to determine the weight of 1 m^2 of roof membrane ($W_{roof\ membrane}$) from 2013

Following websites are used:

http://deu.sika.com/de/solutions_products/02/dachabdichtung.html

http://www.wolfin.de/

http://www.bauder.de/de/flachdach/flachdach-produkte/kunststoff-dachbahnen.html

Results:

Name Roof Membrane and properties	$W_{roof\ membrane}$ [kg/m2]
Sikaplan® 24 G, PVC + polyester fabric, 2.4 mm thick	2.90
Sikaplan® SGmA24, PVC + glass fibre mat, 2.4 mm thick	3.0
Sikaplan® SGK 15, PVC + glass fibre mat + polyester fabric, 1.5 mm thick	2.10
Sikaplan® RV-s, PVC + glass fibre mat + self-adhesive, 1.5 mm thick	2.63
Sarnafil® TS 77-25, FPO + glass fibre mat + polyester fabric, 2.5 mm thick	2.75
Sarnafil® TG 66-20, FPO + glass fibre mat, 2.0 mm thick	2.00
Sarnafil® TG 76-20 Felt, FPO + glass fibre mat + polyester fabric, 2.0 mm thick	2.35
Wolfin® IB, PVC, 2.0 mm thick	2.5
Wolfin® M, PVC + glass fibre, 2.0 mm thick	2.5
Wolfin® PV, PVC + acrylic synthetic rubber, 3.0 mm thick	2.72
INOFIN® FR, FPO, 1.5 mm thick	1.5
BauderTHERMOPLAN T 20, FPO-PP, 2.0 mm thick	2.3
BauderTHERMOFOL M 20, PVC-P, 2.0 mm thick	2.4
BauderTHERMOFOL U 24, PVC-P, 2.4 mm thick	2.9

FPO: Flexible Polyolefines