

TMI04-item7-PT9.doc

**Supplement to the methodology for risk
evaluation of biocides
Environmental Emission
Scenarios for Biocides used as
Preservatives in rubber and
polymerised materials
(Product type 9)**

European Commission DG ENV / RIVM

January 2004

EUBEES



This report has been developed in the context of the EU project entitled "Gathering, review and development of environmental emission scenarios for biocides" (EUBEES 2).

The contents have been discussed and agreed by the EUBEES 2 working group, consisting of representatives of some Member States, CEFIC and Commission. The Commission's financial support of the project is gratefully acknowledged (Ref. B4-3040/2001/326154/MAR/C3).

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Document title Environmental Emission Scenarios

 Biocides: PT 9 – Fibre, leather, rubber and
 polymerised materials preservatives

Date January 2004

Project name Environmental Emission Scenarios for Biocides

Project number 4L1784.A0

Client European Commission DG ENV / RIVM

Reference 4L1784.A0/R019/FBA/TL/Nijm

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Date/initials approval 15 January 2004 FBA

FOREWORD

The European Parliament and the Council adopted in 1998 the Directive 98/8/EC on the placing of biocidal products on the market (Biocidal Products Directive, BPD). The background for the directive is a need for harmonisation of the legislation of the Member States regarding this type of chemicals, which are intended for exerting a controlling effect on higher or lower organisms. The Directive requires an authorisation process for biocidal products containing active substances listed in positive lists (Annex I and IA). Active substances may be added to the positive lists after evaluation of the risks to workers handling biocides, risks to the general public and risks to the environment. The risk assessments are carried out for the life cycle of the biocide: risks during and resulting from the application, risks associated with (the use of) the treated product and risks resulting from the disposal of the biocide and the treated product.

For the environmental risk assessment the environmental exposure needs to be evaluated. Within the risk assessment of industrial chemicals, emission scenario documents have been developed for a number of Industrial Categories (IC) that are included in section IV of the EU Technical Guidance Document (TGD, EC 2003). For Product type 9 covering preservatives for fibre, leather, rubber and polymerised materials, various applications and processes are expected to be similar to those for industrial chemicals. These emission scenario documents were checked on their suitability for use in the context of the BPD.

This report has been developed by Royal Haskoning, The Netherlands, in the context of the EU project entitled "Gathering, review and development of environmental emission scenarios for biocides" (EUBEES 2). The contents have been discussed and agreed by the EUBEES 2 working group, consisting of representatives of some Member States, CEFIC and Commission. The Commission's financial support of the project is gratefully acknowledged (Ref. B4-3040/2001/ 326154/MAR/C3).

For quick reference the conclusions are given in Section 5.

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1 INTRODUCTION

1.1 Background

In the Technical Guidance Document on risk assessment (EC 2003) emission scenarios are described that can be used to evaluate the environmental emission of chemical substances. In this document the suitability of the emission scenarios for industrial chemicals is checked for use in evaluation of biocidal products covered by Product type 9 (PT9), Preservatives in fibre, leather, rubber and polymerised materials as distinguished in the Biocidal Products Directive (BPD).

Biocidal products of Product type 9 are used for the preservation of fibrous or polymerised materials by the control of microbiological deterioration of the material itself. Relevant applications are for:

- Fibre (textile and fabrics (wood, cotton))
- Leather and hides
- Rubber, plastics and polymerised material
- Pulp, paper and cardboard.

In the EU Technical Guidance Document various documents are available on Industrial Categories (IC) that relate to fibrous or polymerised materials. In addition, in projects in various EU member states environmental emission scenarios were developed for relevant industry categories with particular emphasis on the use of biocides. These have already been discussed in the EUBEES Working Group. It should be realised that the scenarios for the Industrial Categories in the TGD are 'living documents': the developments go on and updated versions are circulating in the EU member states and in the OECD. For the purpose of this document, the versions as published in the TGD (EC 2003) have been used.

According to Annex VI of the Biocidal Products Directive the risk assessment shall cover the proposed normal use of the biocidal product together with a 'realistic worst case scenario'. The methods of estimating the emission rate of "Fibre, leather, rubber and polymerised materials preservatives" to the primary receiving environmental compartments are described. The calculation of a realistic worst case PEC using environmental interactions, for example subsequent movement of emissions to secondary environmental compartments (e.g. from soil to ground water), is the result of fate and behaviour calculations and models and is therefore considered outside the scope of this document.

The report was discussed in the working group for the EU project "Gathering, review and development of environmental emission scenarios for biocides (EUBEES 2)".

1.2 Available scenario descriptions

PT 9 relates to the use of preservatives in fibre, leather, rubber and polymerised materials. Table 1.1 presents the environmental emission scenarios available in the EU TGD (EC 2003) that may apply to PT9. In addition, some documents are included that are under discussion within the member states.

Table 1.1. Available emission scenario documents

Application in PT 9	Industrial Category # and Available scenario documents
Fibre (textile and fabrics (wood, cotton))	EU - TGD (EC 2003) IC-13 Textile processing industry. ¹⁾ BPT-9 Biocides used as preservatives. Assessment of environmental release of chemicals from the textile finishing industry
Leather and hides	EU - TGD (EC 2003) IC-7 Leather processing industry. ¹⁾ BPT-9 Biocides used as preservatives. Assessment of the environmental release of chemicals from the leather processing industry
Rubber, plastics and polymerised material	EU - TGD (EC 2003) IC-15 Others: Rubber industry. ²⁾ Assessment of environmental release of chemicals in the rubber industry.
	EA/UK: ESD – Additives used in the plastics industry (UK-BRE, 2001) ¹⁾
	EU - TGD (EC 2003) IC-11 (Polymers industry: no ESD available in TGD)
Pulp, paper and cardboard	EU - TGD (EC 2003) IC-12 Pulp, paper and board industry. Assessment of the environmental release of chemicals used in the pulp, paper and board industry. BPT-6,7&9 Biocides used as preservatives in paper coating and finishing. Assessment of the environmental release of biocides used in pulp, paper coating and finishing
	RIVM/NL and FEI/Finland: ESD for biocidal products applied in the paper and cardboard industry (Van der Poel and Braunschweiler 2002).
	EUBEES 2 Harmonisation of Environmental Emission Scenarios for Slimicides (PT-12) (Van der Aa and Balk 2003)

¹⁾ Documents have been submitted to the OECD for discussion and further development

²⁾ Document has been submitted for IC-11.

A very short description of the relevant contents of these and some other documents that have been agreed or are under discussion within the member states, is given in Appendix 1. These should be considered as helpful documents but the EUBEES group does not give any recommendation on their use.

Within the context of the EUBEES 2 project the aim was to check ESDs for industrial chemicals in the TGD for their suitability for biocidal products falling under PT9. Table 1.1 shows that for the application in Fibre (textile and fabrics), in Leather and hides and in Pulp, paper and cardboard this work has already been carried out. These documents were discussed and agreed in the EUBEES 1 Working Group and were incorporated in the TGD version of 2003. For the application in Rubbers, Plastics and Polymers no ESD was available in the former TGD (1996) but the current TGD (EC 2003) also includes an ESD on rubber. For plastics an ESD is available that was discussed within the OECD

Task Force on Environmental Exposure Assessment. The documents for Rubber and for Plastics and polymerised materials will be checked for their applicability for biocidal substances.

1.3 Harmonised presentation

In this report, the emission scenarios are presented in text and tables. In the tables, the input and output data and calculations are specified, and units according to USES are used. The input and output data are divided into four groups:

- S data Set parameter must be present in the input data set for the calculations (no method has been implemented in the system to estimate this parameter; no default value is set, data either to be supplied by the notifier or available in the literature);
- D Default parameter has a standard value (most defaults can be changed by the user);
- O Output parameter is the output from another calculation (most output parameters can be overwritten by the user with alternative data);
- P Pick list parameter values to be chosen from a pick list with values.

2 PRESERVATIVES IN RUBBER

2.1 Description of use area and processes

The ESD for IC-15 (Rubber industry) of the TGD (EC 2003) describes the processes in the rubber industry. The raw material for the production of synthetic rubber is provided by the chemical industry. The raw material for the production of natural rubber products is provided by countries outside of the EU. For the production of rubber, the rubber industry uses hundreds of different substances. Only by adding fillers, plasticisers, vulcanisation chemicals, anti-aging agents, adhesives and other chemicals like biocides the finished product gains its required attributes.

Depending on the production procedure, a difference is made between polymerisates, polycondensates and polyaddition products. According to DIN ISO 1629 rubbers in the form of hard rubbers and latex are divided into groups depending on the chemical makeup of the polymer chains. The rubber types are divided by their attributes and their function.

Formulation takes place at the site of the basic chemical industry for use in the manufacturing of the rubber product and also at the site of the rubber industry where the formulation of the rubber mixture is performed.

The emission during production depends on the type and makeup of the chemical and the process being used. The emission scenario document in IC-15 describes the emission of the specified substance during formulation and processing of rubber products. In the rubber industry these two life cycle steps can often not be separated. Depending on the process used they are often combined. The process steps to be taken into account are:

- the creation of the rubber mixture
- the mastication
- the shaping
- the vulcanisation
- the finishing

Mastication is a process in which the size of the rubber molecules is decreased to lower the viscosity. This is necessary to improve the workability of the rubber (extrusion, calander and others) and to spread the rubber chemicals throughout the matrix.

Rubber mixtures are usually not immediately reprocessed after the mixture has been created but are stored in a cool and dry environment. For the shaping, processes like extrusion, calandring, form moulding and transfer moulding are used.

The vulcanisation is a chemical process to link the polymer structure. The name vulcanisation is used for a linking procedure, during which the macromolecules of the rubber are linked to each other over linking bridges. This linking takes place with the help of vulcanising agents, usually sulphur, sulphur producers or peroxides as well as energy rich radiation.

While uncured, rubber is plastic. The molecules are not connected to each other. During vulcanisation the substance changes from the thermoplastic to the elastic condition.

After the initial composition the mixture is created with the aid of an internal mixer, a rolling mill, a batch-off-facility and an extruder. The shaping and semi-finished product

creation is done with an extruder, a plunger type injection moulder, through calendering, the spreading machine and assembly.

2.2 Description of types of substances used

A list of active substances currently notified for use as preservatives in the rubber industry can be found on the ECB Website: <http://ecb.jrc.it/biocides>. For PT9 a total of approximately 150 substances has been notified. It is not known how many of these are used in the rubber industry.

2.3 Information on the scale or size of the application and use area

In the EU only synthetic rubber is produced. In the year 1997 the total production of synthetic rubber in the EU was 2.280.222 tons. This amounts to about 25% of the total production world-wide. For comparison, the production of natural rubber has grown from 3 million tons (1980) to 6,2 million tons (1997). Unlike natural rubber, synthetic rubber is subject to strong fluctuations in the amount used and produced. This raw material was used to produce about 1 million tons of tires and about 530.000 tons of rubber products (“technical and other elastomere products”) in 1995 (Baumann et al. 2003).

2.4 Identification of the potential points of release in the application and use area

The natural imported and the synthetic rubber are being processed at production sites in the EU. Rubber preservatives may end up in the waste water of a site manufacturing rubber products. More information on emissions to other environmental compartments or during other parts of the life cycle is not given in the documents presently available.

The chemicals and raw rubbers used in the manufacturing of rubber products pass through all the steps of the life cycle, whereas additives such as the biocidal product may also be added at a later stage. The rubber product will then enter the life cycle step “service life” and, after some time, the life cycle step “waste/recovery”. During its service life, contamination of the environmental compartment water may take place through wear and subsequent leaching through rain water. The leaching of additives such as preservatives is a potential danger for the water compartment while volatile monomers and plasticisers will be the main contaminants for the compartment air. This is also the case during the life cycle step “waste/recovery”, see table 2.1.

Table 2.1 Emission points of release for preservatives used in rubber

Life cycle stage	Water	Air	Soil	Waste water
Production of rubber				
Manufacturing of rubber products				+
Service life	+	+	+	
Waste/ recovery	+	+		

3 PRESERVATIVES IN PLASTICS

3.1 Description of use area and processes

Within the plastics industry, polymers are converted into plastics materials using the following stages:

- *Compounding* involves the blending into the polymers of various types of additives to meet the requirements of specific applications for plastics materials. There are companies that specialise in this field, but many polymer makers and converters also undertake this work. Master batches are compounds made up to contain high concentrations of specific additives. These are then supplied to processors who disperse them into the main polymer matrix by simple mixing. There is a growing trend towards the use of master batches, especially where the additive requires careful handling for reasons of cleanliness or health. The compounding process can be considered as a formulation step of the lifecycle of the additive.
- *Conversion* of compounds into finished artefacts is carried out using a diversity of processes. In the case of thermoplastics, the materials are shaped by heat and pressure using moulding, extrusion and other processes. Thermosetting resins are similarly cured under heat and pressure, although some resins are capable of being cured at ambient temperatures. Thermosetting processes are irreversible. The conversion process can be considered as a processing step of the lifecycle of the additive.

Figure 3.1 summarises the life cycle of plastics, and includes the three categories of the conversion process: closed, partially open and open systems. These distinctions are important for estimating the loss factor to the environment.

The UK ESD on additives used in the plastics industry (UK-BRE, 2001) remarks that a wide range of different substances is added to polymers during their compounding and conversion to plastic materials. These additives include fillers, reinforcements, colours and other materials such as plasticisers which ensure the finished plastic has the required performance for its specific application. Other additives, such as blowing agents, heat stabilisers, lubricants, etc. are used to aid the manufacturing process. The preservatives in plastics consist of fungicides and bactericides.

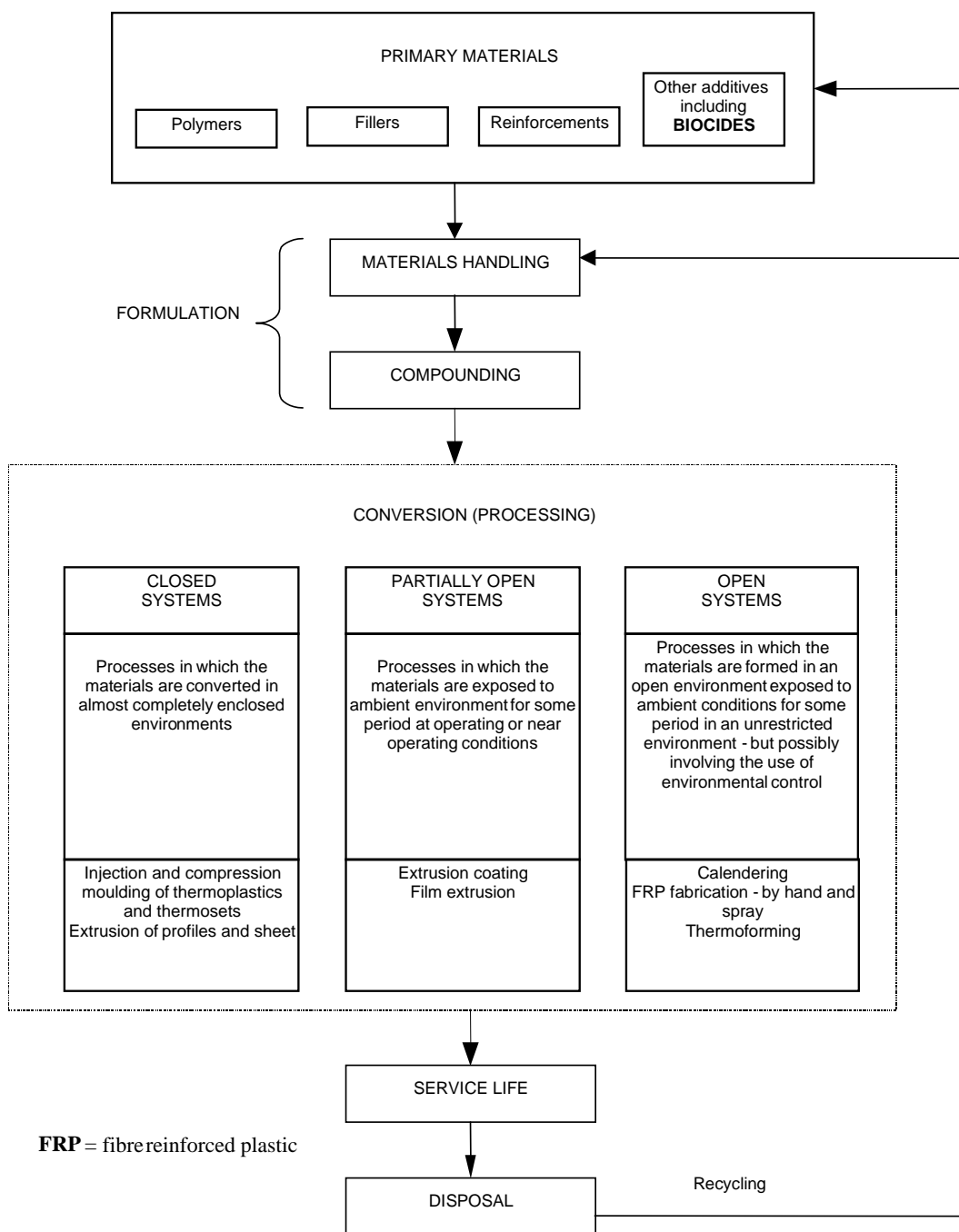


Figure 3.1 Life cycle scheme plastics industry (after UK-BRE, 2001).

3.2 Description of types of substances used

A list of active substances currently notified for use as preservatives in the plastics industry according to the BPD can be found on the ECB Website: <http://ecb.jrc.it/biocides>. For PT9 a total of 136 substances has been notified. The number used specifically in the plastics industry is not known.

For plastic formulations the following substances are mentioned as preservatives: mercury and other metal-containing compounds, sulphur, quaternary ammonium and halogenated compounds. Salicylaldehydes, dihydroxychlorodiphenyl-methane derivatives, thiurames and zinc dithiocarbamates are used as antimicrobial substances (Baumann et al. 2000).

Protection against fungicidal or bacteriological attack is achieved by the use of established biocides such as organotin or organomercury compounds, or by phenolics or their derivatives. Examples of the latter are the alkyl hydroxybenzoates ($\text{HO-C}_6\text{H}_4\text{CO}_2\text{R}$) or the chlorophenols such as 2,2'-thiobis(4,6-dichlorophenol). 8-Hydroxyquinoline or copper bis(8-hydroxyquinoline) are also used, as are other metal salts, notably of antimony, arsenic or borates. These may be expected to embrace a range of solubilities in the polymer and a tendency to surface migration cannot be ruled out, yet as preservatives for plastics, a primary requirement is that these additives at least remain within it (UK-BRE 1998).

3.3 Information on the scale or size of the application and use area

As an example, table 3.1 gives an overview of the polymer usage (by process type) in the plastics industry in the UK and estimated usage on site (UK-BRE 2001). These data are probably not representative for all of the EU.

Table 3.1: Polymer usage (by process type) in the UK and estimated usage on site (Q_{polymer}) (UK-BRE 2001).

Polymer	Tonnage (kT year ⁻¹)	Percentage by process type			Usage on site Q_{polymer} (tonnes year ⁻¹)		
		open	partially open	closed	open	partially open	closed
LDPE	710		88%	12%		23,100	528
HDPE	400		14%	86%		2,070	2,130
Polypropylene	500		48%	52%		8,880	1,610
Rigid PVC	400	19%		81%	988		2,010
Flexible PVC	220	26%	49%	25%	744	3,990	341
Polystyrene	150	31%	7%	62%	605	389	623
Expanded polystyrene	450			100%			2,790
ABS	75	8%		92%	78		428
PET	135	10%		90%	176		814
Polyamides	30	10%		90%	39		181
Acrylics	14	30%	40%	30%	55	207	28
Acetals	14		10%	90%		52	84
Polycarbonates	12		14%	86%		62	69
Polyurethanes	120			100%			804
Unsaturated polyesters	75	59%		41%	575		206
Phenolic resins	18			100%			121
Amino resins	70			100%			469
Epoxy resins	12			100%			80

If information on the content of the additive (preservative) in the plastic is available (% of weight), this value can be used to derive the quantity of preservative used on the site from the amount of polymer processed (table 3.1).

3.4 Identification of the potential points of release in the application and use area

The UK Use Category Document on Plastics additives (UK-BRE 1998) predicts the quantity of a particular additive which may be released during its use in the production of a plastics material, during its service life and, at the end of its life, as a result of its disposal. The majority of used and discarded plastics materials are currently disposed of to landfill. A small proportion is incinerated, either in municipal facilities or on sites operated by the plastics industry (see Appendix 2).

Raw materials' handling

Initially, some emissions will be to atmosphere, but ultimately all particulates will be removed or settle and losses will be to solid waste or to waste water as a result of wash down. Material remaining in packaging (bags) will be assumed to go to solid waste from the plastics processing site.

Compounding

Initially some releases will be to the atmosphere, but ultimately all particulates will be removed or settle and losses will be to solid waste or waste water. The losses are influenced by the susceptibility of the particulates to dust generation (particle size) and volatility of the organic preservative.

Conversion

Inorganic preservatives

Ultimately all particulates will settle and losses will be to solid waste or aqueous washings.

Organic preservatives

Initial losses will be to the atmosphere. Subsequent condensation could result in losses to waste water. Volatility influences the losses.

Service life

Inorganic preservatives

Ultimately all particulates will settle and losses will be to solid waste or waste water.

Organic

Indoor service life: losses to the atmosphere and to waste water

Outdoor service life: losses to the atmosphere and leaching into the environment

Disposal

Landfill, leaching losses to water: these will depend on many factors, relating to the type of landfill as well as to the properties of the additive and the nature of the polymer in which it has been used. The maximum potential loss could be calculated from the amount of additive remaining in the plastic at disposal, but it is very unlikely that this amount would be released. For incineration, organic substances will be destroyed. There may be residues of inorganic materials left in the ash, which will be disposed of as solid waste.

Table 3.1 Emission points of release for preservatives used in plastics

Life cycle stage	Water	Air	Soil	Solid waste	Waste water
Formulation: Raw materials handling and compounding		+		+	+
Processing: Conversion		+		+	+
Service life		+			+
Disposal				+	+

4 EMISSION SCENARIOS FOR PRESERVATIVES IN FIBRE, LEATHER, RUBBER AND POLYMERISED MATERIALS

4.1 Description of available scenarios

For the Preservatives used in Fibre, leather, rubber and polymerised materials several emission scenarios are available. For a number of these applications emission scenarios were produced by the French INERIS during the EUBEES 1 project.

- For “Textile and fabrics”: This ESD estimates the emissions during application (industrial use) and service life.
- For “Leather and hides”: This ESD estimates the emissions during application.
- For “Pulp, paper and cardboard”: This ESD calculates the emissions during application and recycling in paper coating and finishing.

These documents are now included in the updated version of the TGD (EC 2003)

For the Paper and cardboard industry, an emission scenario document was also produced by the Finnish FEI and the RIVM (Van der Poel and Braunschweiler 2001). It contains an ESD for the preservation of pulp in the paper making process.

For Rubber and Plastics a description is given in the sections below. For other polymerised materials (recognised in the TDG as IC-11) no scenario descriptions are available.

4.2 Rubber

4.2.1 IC-15 Emission Scenario Document

The ESD included in the TGD (EC 2003) for IC-15 ‘Additives in the Rubber Industry’ can be used to estimate the environmental emission of rubber chemicals to the waste water of the manufacturing site. Direct emissions to other environmental compartments are not yet considered in this version of the scenario.

The emission rate $E_{local,water}$ is determined in $[kg \cdot d^{-1}]$ and can be used for the calculation of the predicted environmental concentration in the receiving STP and eventually in the receiving surface water. The sources of waste water pollution in the rubber industry are described. This ESD contains technological data and default values required for the determination of the emission rate. It is assumed that the wastewater from the rubber industry is discharged in a standard STP (SimpleTreat). Furthermore, the default dilution factor of 10 for the discharge of effluents on fresh surface water from the TGD is used.

The exposure assessment is made step by step and is given under realistic worst case conditions (according to the scenario description).

The chemicals used in the rubber industry may enter the environment via the product, unused material or wastes. Chemicals used in the rubber industry are only relevant for the compartment water if there is a direct contact with water. This happens in those processes, where water is used as cooling or heating medium or for the vulcanisation and therefore has direct contact with the rubber mixture. Also the contamination through

water used in cleaning steps throughout these processes has to be considered. To determine the release, a representative emission source is identified.

4.2.2 Definition of the point source

The total discharged quantity of waste water from the rubber industry can be divided into the areas sanitary, precipitation, metal working, rubber working and others. In the ESD the discharged amount below is given for the Association of the German Rubber Industry. Hitherto the point source is related to the Federal Republic of Germany. But the size for a typical manufacturer is applicable for the other member states of the EU because the general structure is similar. The waste water data was recorded for 18 direct dischargers and 70 indirect dischargers. It should be noted, that 3 companies discharge 75% of the total amount directly and 1 indirect discharger made up for 30% of the corresponding discharge.

This waste water amount not only covers the rubber working but also sanitary, metal working and other areas. The values for the determination of the relevant point sources are listed in table 4.1. Direct discharge and indirect discharge are combined.

Table 4.1 Statistical data for the determination of a reasonable worst case point source. These data are determined for sources below the default EU-STP-value of 2000 m³.d⁻¹.

number of samples	84
arithmetic average of the waste water volume	184 m ³ /d
minimum	10 m ³ /d
maximum	1154 m ³ /d
90 th percentile	438 m ³ /d

The ESD uses an EU standard sewage treatment plant with a flow of 2000 [m³.d⁻¹]. Table 4.1 includes only sources below the threshold value of 2000 m³.d⁻¹. A problem is posed by the uneven distribution of the flows: the 84 companies below the threshold value discharge together about 15000 [m³.d⁻¹], while the 4 very large companies (above the threshold) also discharge about 15000 [m³.d⁻¹].

To produce 1 ton of goods a water consumption of about 3 m³ is assumed for rubber processing. This water consumption relates only to the area of rubber production. With the assumption that the water consumption of the rubber production makes up 37% of the total waste water and a production ratio of 60:40 for tire:rubber products, a production of about 55 tonnes per day can be used for the defined point source.

4.2.3 Emission scenario

To estimate the release of a substance used in the production of rubber products, the life cycle steps formulation and processing are considered. The fate of the substance in the waste water depends on the function of the substance during the production process. If no specific information is given, it is assumed, that the substance will be used for the production of tires as well as for rubber products and default values will be assumed. The more detailed the information provided by the notifier, the more realistic the generic scenario will be. The release is calculated as shown in table 4.2. ¹

¹ Warning: It should be kept in mind that all emission scenarios will develop over time and therefore the reader should always refer to the latest version of the original documents (e.g. the EU Technical Guidance Document) to find out whether adaptations have been introduced.

Table 4.2 Emission scenario for calculating the release to waste water of substances used in rubber products (adapted from EC 2003 to a harmonised presentation)

Variable/parameter	Unit	Symbol	Default	S/D/O/P
Input				
Amount of the rubber product produced per day	[kg.d ⁻¹]	TONNAGE _{product}	(For default values see table 4.3)	D/P
Fraction of active substance ¹⁾ in the rubber product	[-]	F _{a.i.}		S
Fraction of substance remaining in the rubber product	[-]	F _{product}		S
Output				
Emission rate to waste water	[kg.d ⁻¹]	E _{local} _{water}		
Calculation				
E _{local} _{water} = TONNAGE _{product} * F _{a.i.} * (1 - F _{product})				

¹⁾ in the TGD this term refers to the fraction of additive in the product

Table 4.3 Produced Product amount (with regard to the point source). For simplification it is assumed that all products are produced in the defined point source (EC 2003)

Product	TONNAGE _{product} [kg .d ⁻¹]
tires	33000
tires total	26400
car tires	11600
truck tires	14800
retreated	6600
rubber products	22000
technical tubes, profiles	5320
form products, rubber-metal compounds	5190
glues, mixtures, repair materials	2840
foam, microcellular and cellular rubber products	2110
conveyor belts, flat- and vee belts	1940
sole material	550
sheet material, punching products	460
other technical products	1150
other rubber products	2440
total	55000

4.3 Plastics

The document UK-BRE (2001), which is based on the UK Use Category Document on Plastics additives (1998), sets out methods to predict the quantity of a particular additive which may be released during the production of a plastics material, during service life

and disposal. The document presents the distribution of plastics preservatives to several environmental compartments.

The operations of the industry and the fates of the materials concerned are discussed in terms of five generic stages, representative of a worst case scenario, during manufacturing (handling of raw materials, compounding, conversion), service life and disposal.

4.3.1 Release from manufacture of plastics materials

The estimation of the emission of additives during the manufacturing of plastics is given in a general form in table 4.4.²

Table 4.4 Emission scenario for calculating the total release of additives used during the manufacturing of plastics materials. Preservatives may be considered as additives. (adapted from UK-BRE 2001 to a harmonised presentation)

Variable/parameter	Unit	Symbol	Value	S/D/O/P
Input				
Amount of plastic produced	[kg.d ⁻¹]	TONNAGE _{local product}	1)	S/D/P
Fraction of active substance in the plastic	[-]	F _{a.i.}	2)	S
Fraction to air during materials handling	[-]	F _{handl, air}	5)	D
Fraction to water during materials handling	[-]	F _{handl, water}	5)	D
Fraction to air during compounding	[-]	F _{comp, air}	5)	D
Fraction to water during compounding	[-]	F _{comp, water}	5)	D
Fraction to air during conversion	[-]	F _{conv, air}	5)	D
Fraction to water during conversion	[-]	F _{conv, water}	5)	D
Fraction to air during plastic manufacturing	[-]	F _{manuf, air}		O
Fraction to water during plastic manufacturing	[-]	F _{manuf, water}		O
Intermediate calculations³⁾				
$F_{\text{manuf, air}} = F_{\text{handl, air}} + F_{\text{comp, air}} + F_{\text{conv, air}}$				
$F_{\text{manuf, water}} = F_{\text{handl, water}} + F_{\text{comp, water}} + F_{\text{conv, water}}$				
Output				
Emission from manufacturing site to air	[kg.d ⁻¹] ⁴⁾	E _{local, manuf_{air}}		

² **Warning:** It should be kept in mind that all emission scenarios will develop over time and therefore the reader should always refer to the latest version of the original documents (e.g. the EU Technical Guidance Document) to find out whether adaptations have been introduced.

Variable/parameter	Unit	Symbol	Value	S/D/O/P
Emission from manufacturing site to water	[kg.d ⁻¹]	E _{local, manuf_{water}}		
End calculation				
$E_{\text{manuf, air}} = \text{TONNAGE}_{\text{product}} * F_{\text{a.i.}} * F_{\text{manuf, air}}$				
$E_{\text{manuf, water}} = \text{TONNAGE}_{\text{product}} * F_{\text{a.i.}} * F_{\text{manuf, water}}$				

¹⁾ The document gives the tonnage for 18 types of polymer in the various process types for the UK, see table 3.1. (Q_{site} = the quantity of polymer consumed on a site using the appropriate conversion process (and possibly for the application of interest))

²⁾ The document table 2.2 (Annex) shows the levels of additives used in polymers. However, no data are available for preservatives (F_{a.i.} = maximum likely fractional content of a particular additive for this polymer, process and application - specific information or Appendix III of Use Category Document (UK-BRE 1998). No specific data is given on preservatives). The data are to be supplied by the notifier.

³⁾ As a worst case is assumed that handling, compounding and conversion takes place at the same manufacturing site. If compounding and conversion are separated F_{conv} = 0 for the compounding site and F_{handl} and F_{comp} = 0 for the conversion sites.

⁴⁾ If the number of days of emission (T_{emission}) for the processes are known, the local emissions can also be estimated on a daily basis. The TGD can be used to estimate T_{emission} for this purpose.

⁵⁾ Default values are described in section 4.3.4.

4.3.2 Release during service life

Some additives are destroyed or entirely released during the manufacturing process. For those which are not, estimates can be made of the quantities of the additive which will be released to the environment during service life of the articles. Unlike the emissions from manufacture, these are likely to be diffuse emissions, and so need to be calculated for an appropriate scale.

Table 4.5 Emission scenario for calculating the total release of chemicals in plastics materials from service life (adapted from UK-BRE 2001 to a harmonised presentation)

Variable/parameter	Unit	Symbol	Default	S/D/O/P
Input				
Amount of plastics used in a region	[kg.d ⁻¹]	TONNAGE _{reg_{product}}		S/D
Active substance in the plastic	[-]	F _{a.i.}	¹⁾	S
Fraction to air during service life	[-]	F _{serv, air}	²⁾	D
Fraction to water during service life	[-]	F _{serv, water}	²⁾	D
Output				
Emission during service life to air	[kg.d ⁻¹]	E _{serv_{air}}		O
Emission during service life to water	[kg.d ⁻¹]	E _{serv_{water}}		O
Calculation				
$E_{\text{serv, air}} = \text{TONNAGE}_{\text{product}} * F_{\text{a.i.}} * F_{\text{serv, air}}$				
$E_{\text{serv, water}} = \text{TONNAGE}_{\text{product}} * F_{\text{a.i.}} * F_{\text{serv, water}}$				

¹⁾ The document table 2.2 (Annex) shows the levels of additives used in polymers. However, no data are available for preservatives

²⁾ Default values are described in section 4.3.4.

For some additives the Use Category document (UK-BRE 1998) gives default values for the fractions to air and water on an annual basis, for others fractions during service are estimated. In order to estimate annual releases for the region being considered, some account of the accumulation of articles in use over the lifetime of the materials is needed. For example, for a product with a 3 year lifetime, over any one year period there will be emissions from articles in the first, second and third year of use. Information on the expected service life of plastics products in different applications is given in Table 4.3 of the Use Category Document (UK-BRE 1998). For factors which give annual releases, the suggestion is to multiply the release factor by the expected lifetime of the relevant article (note that some factors already do this, for example in Section 14.2.4 of the document). For release estimates over the product lifetime, the factor should be applied directly to the annual tonnage used. These estimates assume a consistent use of the additive and plastic over the expected lifetime. The above calculation assumes that the quantities of additive lost during manufacture are negligible. If this is not so, then the losses in use need to be corrected for the earlier losses during manufacturing.

Table 4.4 of the Use Category Document shows that the majority of used and discarded plastics materials are currently disposed of to landfill. A small proportion is incinerated, either in municipal facilities or on sites operated by the plastics industry.

The EUBEES Working Group remarks that it is not clear how the ‘amount of plastic used in a region’ (kg.d^{-1}) is to be interpreted. The amount is to reflect the total tonnage of plastic articles in service life in the region (per year) assuming a steady state. The life time depends on the type of article made out of the plastic.

4.3.3 Release from disposal of plastics materials

Some additives are destroyed or entirely released during the manufacturing process or service life. For those which are not, estimates can be made of the quantities of the additive which will be released to the environment. Unlike the emissions from manufacture, these are likely to be diffuse emissions, and they need to be calculated for an appropriate scale.

Table 4.6 Emission scenario for calculating the total release of chemicals in plastics materials from use and disposal

Variable/parameter	Unit	Symbol	Default	S/D/O/P
Input				
Amount of the product used in a region	$[\text{kg.d}^{-1}]$	TONNAGE _{regproduct}		S/D
Active substance in the product	[-]	F _{a.i.}	1)	S
Fraction to air during disposal	[-]	F _{disp, air}	2)	D
Fraction to water during disposal	[-]	F _{disp, water}	2)	D
Emission from manufacturing site to air	$[\text{kg.d}^{-1}]$	E _{manuf,air}	(table 4.4)	O
Emission from manufacturing site to water	$[\text{kg.d}^{-1}]$	E _{manuf,water}	(table 4.4)	O
Emission during service life to air	$[\text{kg.d}^{-1}]$	E _{serv,air}	(table 4.5)	O
Emission during service life to water	$[\text{kg.d}^{-1}]$	E _{serv,water}	(table 4.5)	O

Variable/parameter	Unit	Symbol	Default	S/D/O/P
Output				
Total amount of the a.i. remaining in the product used in a region	[kg.d ⁻¹]	TONNAGE _{reg a.i.}		
Emission during disposal to air	[kg.d ⁻¹]	Edisp _{air}		
Emission during disposal to water	[kg.d ⁻¹]	Edisp _{water}		O

Intermediate calculations

$$\text{TONNAGE}_{\text{reg a.i.}} = \text{TONNAGE}_{\text{reg product}} * F_{\text{a.i.}} - (\text{Emanuf}_{\text{air}} + \text{Emanuf}_{\text{water}}) - (\text{Eserv}_{\text{air}} + \text{Eserv}_{\text{water}})$$

End calculations

$$\text{Edisp}_{\text{air}} = \text{TONNAGE}_{\text{reg a.i.}} * F_{\text{disp, air}}$$

$$\text{Edisp}_{\text{water}} = \text{TONNAGE}_{\text{reg a.i.}} * F_{\text{disp, water}}$$

¹⁾ The document table 2.2 (Annex) shows the levels of additives used in polymers. However, no data are available for preservatives

²⁾ Default values are described in section 4.3.4.

The EUBEES Working Group remarks that the fraction actually going to disposal is missing in the above scenario. If assuming F=1, it assumes that no incineration is taking place.

4.3.4 Fractions to the environment for preservatives

The loss to the environment for preservatives can be estimated as a fraction of the quantities used on the processing site or of the tonnage used in a region. The fractions for preservatives are taken from the document UK-BRE (1998).

Raw materials' handling

The fractions are applied to the quantities used on the plastics processing site. Initially, some emissions will be to atmosphere, but ultimately all particulates will be removed or settle and losses will be to solid waste or to waste water as a result of wash down.

Material remaining in packaging (bags) will be assumed to go to solid waste from the plastics processing site. The fractions, for a worst case scenario, are as follows:

For powders of particle size <40 µm:

- 0.006 to solid waste/water

- 0.01 to solid waste as residue in bags

For powders of particle size >40 µm:

- 0.002 to solid waste/water

- 0.0001 to solid waste as residue in bags

Compounding

Fractions are applied to the quantities used on the plastics processing site.

Initially some releases will be to atmosphere, but ultimately all particulates will be removed or settle and losses will be to solid waste or waste water. On the basis of susceptibility to dust generation the loss factors are as follows.

For powders of particle size <40 µm: 0.0005 to solid waste/water

For powders of particle size >40 µm: 0.0001 to solid waste/water

On the basis of volatility, there is an additional loss to air of 0.0005, 0.0001 or 0.00002 for high, medium and low volatility organic preservatives. These should be combined with the losses from above. It is suggested that 50% of the loss to air is directed to water due to deposition (for example 0.0005 to water and 0.00002 to air becomes 0.00051 to water and 0.00001 to air).

Conversion

Fractions apply to the quantities used on the plastics processing site.

Inorganic

Ultimately all particulates will settle and losses will be to solid waste or aqueous washings. On the basis of attrition of compound the loss factors are as follows.

For grinding/machining: 0.025 to solid waste/water

For all other processes: 0.0001 to solid waste/water

Organic

Initial losses will be to atmosphere. Subsequent condensation could result in losses to liquid waste. On the basis of volatile losses the worst case fractions are as follows.

Open processes:

For solid articles: 0.0025, 0.0005 or 0.0001 for high, medium or low volatility

For foamed articles: 0.005, 0.001 or 0.0002 for high, medium or low volatility

Partially-open processes:

0.0015, 0.0003 or 0.00006 for high, medium or low volatility

Closed processes:

0.0005, 0.0001 or 0.00002 for high, medium or low volatility

It is suggested 50% of the loss to air is directed to water due to deposition (for example 0.005 to air becomes 0.0025 to water and 0.0025 to air).

Service life

Factors apply to the annual tonnage used in the region being considered.

Ultimately all particulates will settle and losses will be to solid waste or waste water. On the basis of degradation and abrasion the fractions are as follows.

Inorganic

0.0001 to solid waste/water

Organic

Indoor service life, volatility to air over life time: 0.0005

Indoor service life, leaching to water over life time: 0.0005

Outdoor service life, volatility to air over life time: 0.0005

Outdoor service life, leaching to water: 0.007 leaching loss to environment over 4 years + 0.15%*Tservice life over life time (where Tservice life = service life of product in year (see table 4.7 (table 3.6 of BRE, 1998))

Table 4.7 Service life of plastics for various applications

Applications	Tservice in years
Agriculture	2
Building and construction	>10
Domestic appliances – white goods	5 to 10
Domestic appliances – brown goods	5 to 10
Electrical	10 to 20
Electronic	0 to 5
Furniture	5 to 10
Housewares	0 to 5
Marine	>10
Miscellaneous	0 to 10
Packaging	2
Sports	0 to 5
Transport and automotive	10 to 20

Disposal

Factors apply to the annual tonnage used in the region being considered.

Leaching losses to water from a landfill depend on many factors, relating to the type of landfill as well as to the properties of the additive and the nature of the polymer in which it has been used. The maximum potential loss could be calculated from the amount of additive remaining in the plastic at disposal, but it is very unlikely that this amount would be released.

For incineration, organic substances will be destroyed so the loss fraction = 0.

5 CONCLUSION

5.1 Textile and fabrics

For “Textile and fabrics” an emission scenario document for biocides was developed under EUBEES 1 that is now included in the TGD (EC 2003). This ESD calculates the emissions during application and service life and can be used for the calculation of the emission from textile and fabrics preservatives.

5.2 Leather and hides

For preservatives used in “Leather and hides” an emission scenario document is included in the TGD (EC 2003). This ESD calculates the emissions during application and can be used for the calculation of the emission of preservatives used in leather and hides. The emission of preservatives during service life is not included.

5.3 Rubber, plastics and other polymerised materials preservatives

5.3.1 Rubber

For the subgroup “Rubber preservatives” an emission scenario document is available in the TGD (EC 2003), IC-15. The emission of substances, including additives used in the manufacturing of rubber products to wastewater is calculated during the phase of application. The scenario can be used for the calculation of the emission of preservatives used in the manufacturing of rubber products.

Contamination of the environmental compartment water may take place through wear and subsequent leaching through rain water. However, the life cycle step “service life” is not covered in the emission scenario document. This life cycle step may be covered by the section in the environmental part of the TGD (EC 2003) on ‘Emissions during service-life of long-life articles’. The life cycle step “disposal/waste/recovery” may be dealt with according to the section on ‘Waste disposal including waste treatment and recovery’ which is now included in the TGD (EC 2003).

5.3.2 Plastics

For the application as preservatives in plastics an emission scenario description was found in UK-BRE (2001). This document was developed taking into account discussions under the EU Existing Substances Regulation and in the OECD Task Force on Environmental Exposure Assessment. It describes the emission of preservatives during the manufacturing, use (service life) and after discharge of plastics into air and water. However, no further specifications are given of the receiving environment. The manufacturing scenario could be used, but it is still a draft. The EUBEES Working Group considers the current scenario for service life and disposal not suitable as the required input is not available. It is recommended to refer to the TGD section on ‘Waste disposal including waste treatment and recovery’ which is now included in the TGD (EC 2003).

Table 5.1 Summary of recommended environmental emission scenarios for preservatives used in rubber and plastics

Life cycle stage	Water	Air	Soil	Solid waste	Waste water
<i>RUBBER</i>					
Manufacturing of rubber products				?	IC-15
Service life	TGD II §2.3.3.5	TGD II §2.3.3.5	TGD II §2.3.3.5	TGD II §2.3.3.5	TGD II §2.3.3.5
Waste/recovery	TGD II §2.3.7.2	TGD II §2.3.7.2	TGD II §2.3.7.2	TGD II §2.3.7.2	TGD II §2.3.7.2
<i>PLASTIC</i>					
Manufacturing of plastic products		UK-BRE		UK-BRE	UK-BRE
Service life ¹⁾	TGD II §2.3.3.5	TGD II §2.3.3.5	TGD II §2.3.3.5	TGD II §2.3.3.5	TGD II §2.3.3.5
Disposal ¹⁾	TGD II §2.3.7.2	TGD II §2.3.7.2	TGD II §2.3.7.2	TGD II §2.3.7.2	TGD II §2.3.7.2

? : not considered

¹⁾ : The EUBEES Working Group considers the current description in the UK-BRE document for emission to all compartments during Service life and for Disposal not suitable as the required input is not available.

6 REFERENCES

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IC-7. Leather processing industry &

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Assessment of environmental release of chemicals from the leather processing industry

IC-12. Pulp, paper and board industry. Assessment of the environmental release of chemicals used in the pulp, paper and board industry.

BPT 6,7 & 9. Biocides used as preservatives in various applications. Emission scenario document for biocides used in paper coating and finishing

IC-13 Textile processing industry &

BPT-9 Biocides used as preservatives in the textile wet processing

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IC-14. Paints, laquers and varnishes industry. Assessment of the environmental release of chemicals from the paints, lacquers and varnishes industry.

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Appendix 1: Available sources of information for PT 9

AVAILABLE SOURCES OF INFORMATION FOR PT 9

1) *Tissier & Migné, 2001, INERIS (ESD in TGD, EC 2003)*

This document contains an emission scenario for products from PTs 6, 7 and 9 in papermaking processes. In this scenario releases from different stages of the papermaking process are taken into account.

Next to the scenario description information is provided on:

- the paper industry and papermaking processes;
- biocides used in papermaking processes;
- expected release routes;
- data and estimates concerning production, process parameters, water consumption and waste water treatment in France, Germany and the EU in general.

2) *Tissier & Chesnais, 2001, INERIS (ESD in TGD, EC 2003)*

This document contains an emission scenario for products from PT 9 used in the leather industry. In this scenario releases from the most important steps (according to the scenario description) of processing hides and skins are taken into account.

Next to the scenario description information is provided about:

- the leather industry and the processing of hides and skins;
- biocides used in the leather industry;
- expected release routes;
- data and estimates concerning production, process parameters, water consumption and waste water treatment in several EU countries.

3) *Tissier & et al., 2001, INERIS (ESD in TGD, EC 2003)*

This document contains an emission scenario for products from PTs 9 and 18 used in the textile processing industry. In this scenario releases from different stages of the textile processing are taken into account.

This scenario is meant for biocides that are applied on textile. The production phase of textile is not taken into account here.

Synthetic fibres are made of polymers and have a specific preparation. During the production phase of synthetic textile, biocides are added (formulation phase of these polymers). The release of these biocides is treated in the scenario for plastic additives (BRE, 1998).

Next to the scenario description information is provided about:

- the textile industry and the processing of textile;
- biocides used in the textile industry;
- expected release routes;
- data and estimates concerning production, process parameters, water consumption and waste water treatment in several EU countries.

4) *UK Emission Scenario Document – additives used in the plastics industry, July 2001.*

This document is based on a Use category Document on Plastics Additives, produced in 1998 by BRE for Chemicals Assessment Unit of the Environment Agency (UK). The technical content has been modified from the original document to take account of developments in the assessment of a number of plastics additives under the EU Existing Substances Regulation, and as a result of comments received from the OECD Task Force on Environmental Exposure Assessment.

The document provides an overview of the polymer lifecycle and conversion processes and contains models for the estimation of quantities of additives lost to the environment during manufacture, use and disposal.

5) *Baumann et al. (or Gräfen et al.) 2003 Emisison Scenario Document - Additives in the rubber industry*

Assessment of the environmental release of chemicals in the rubber industry IC-15 ('others'). Institute for Environmental Research University of Dortmund. (INFU).

The document describes the European Rubber industry and includes a description of the biocides used. It also gives release estimations per process.

This is a newer version of the ESD included in the TGD 2003 as IC-15: 'Others: Rubber industry. Assessment of environmental release of chemicals in the rubber industry.'

6) *Luttik et al. 1993, RIVM report 679 102 021 ESPE*

In Luttik et al. 1993 simple scenarios are described for:

- textile industry,
- and paper and cardboard industry.

The scenario for the textile industry discusses preservatives of textile (PT9). The scenario for the paper and cardboard industry discusses biocides for waste water treatment (PT12, slimicides).

7) *Fielden et al. 1997*

This draft-document contains general information concerning papermaking processes based on the situation in the UK. In some areas wider information on Europe has been included. The data were gathered mostly in de period 1994-1997. The report provides, among others, information on the amount of biocides for water treatment (slimicide, PT12) used and the releases of these substances. Biocides from PT9 (preservatives for fibre, leather, rubber and polymerised materials) are not discussed.

8) *Baumann et al. 2000, Institute for Environmental Research (INFU), University of Dortmund, UBA Berlin: Gathering and review of Environmental Emission Scenarios for biocides (2000)*

This document contains information on the use of preservatives in different subgroups of PT9 and expected emission routes.

Furthermore it describes:

- a simple model for the textile industry,
- a PEC calculation for leather production location including on-site sewage treatment (Bohm et. 1999)
- the scenario for paper and cardboard industry from Luttik, 1993: this scenario only discusses slimicides (PT12)

9) *Van der Poel and Bakker 2001, RIVM report 601 450 009*

This document is divided in sections for the different kinds of products in PT6 (for example textile and fabrics). Life cycle schemes are given.

It includes:

- textile and fabrics: the ESD of Tissier et al. (2001) is described (names and symbols are somewhat modified);
- leather and hides: the ESD of Tissier and Chesnais (2001) is described;
- rubber, plastics and other polymerised materials: No emission scenario is presented. A draft ESD on additives in the rubber industry has been produced by

the German UBA (INFU,2001). This document only states “biocides” in the table on emission factors. However for the amounts used in rubber products it is stated that there are no data. In Ulmann (2001) no data on biocides were found. According to Baumann and Ismeier (1998) biocides are added to rubber during the production of rubber shoes, gloves and hygienic rubber articles. This, however, is not a preservative for the leather and so does not belong to one of the Product types of the Directive;

- paper and cardboard: the ESD of Tissier and Migné (2001) is described;

10) *OECD ESD on textile finishing industry. Draft. Revision by Thomas Schäfer (incl. comments of TEGEWA, 5 November 2002) Version 24 January 2003. UBA Germany.* The document describes the European textile industry and the main processes in the textile industry. Also the textile auxiliaries, basic chemicals and biocides are described. Furthermore it presents a release estimation per process, branch specific parameters and emission calculations.

11) *Van der Poel & Braunschweiler 2003, Emission Scenario Document for biocidal products applied in the paper and cardboard industry (draft, 2002) RIVM/FEI report* National Institute of Public Health and the Environment (RIVM), Finnish environment Institute (FEI):

Emission scenario with focus on slimicides intended for use in paper and cardboard manufacturing but it contains also a scenario for PT9 products used for preservation of fibre in paper industry. In the paper and cardboard industry preservatives are used for the preservation of pulp in the paper machine. These biocidal products belong to product-type 9. The subject is discussed in Chapter 5 of the report and it is proposed to use the main slimicide emission scenario also for this application with certain specific assumptions.

Appendix 2: Emission scenario for plastics

PLASTICS

The UK Use Category Document on Plastics additives (1998) sets out methods to predict the quantity of a particular additive which may be released during its use in the production of a plastics material, during its service life and, at the end of its life, as a result of its disposal.

The operations of the industry and the fates of the materials concerned are discussed in terms of five generic stages each of which has a generic loss factor, ie:

Source Loss factor

- raw materials' handling L1
- compounding L2
- conversion L3
- service L4
- disposal L5

All the loss factors relate to worst case scenarios. This is a consequence of the wide ranges in type of plastics material, the processing conditions used, the form of the product and the service conditions. Because of these variations, the concept of 'average' in this industry is meaningless.

Release from manufacture of plastics Materials

The emission on an annual basis resulting from manufacture (Esite) can be obtained from these Loss Factors by the expression:

$$E_{site} = Q_{site} \times F \times (L1 + L2 + L3)/100$$

Where:

Qsite = the quantity of polymer consumed on a site using the appropriate conversion process (and possibly for the application of interest)

F = maximum likely fractional content of a particular additive for this polymer, process and application - specific information or Appendix III of Use Category Document

Ln = percentage release of an additive from processes used in manufacture of plastics materials -

Release from Use and Disposal of Plastics Materials

Some additives are destroyed or entirely released during the manufacturing process. For those which are not, estimates can be made of the quantities of the additive which will be released to the environment. Unlike the emissions from manufacture, these are likely to be diffuse emissions, and so need to be calculated for an appropriate scale.

$$E_{use} = L4 \times QR \times F/100$$

Here QR is the amount of polymer used in the relevant region.

For some additives the Use Category document gives values for L4 which are given on an annual basis; for others a total loss during service is estimated. In order to estimate annual releases for the region being considered, some account of the accumulation of articles in use over the lifetime of the materials is needed. For example, for a product with a 3 year lifetime, over any one year period there will be emissions from articles in the first, second and third year of use.

Information on the expected service life of plastics products in different applications is given in Table 4.3 of the Use Category Document. For factors which give annual releases, the suggestion is to multiply the release factor by the expected lifetime of the relevant article (note that some factors already do this, for example in Section 14.2.4 of the document). For release estimates over the product lifetime, the factor should be applied directly to the annual tonnage used. These estimates assume a consistent use of the additive and plastic over the expected lifetime. The above calculation assumes that the quantities of additive lost during manufacture are negligible. If this is not so, then the losses in use need to be corrected for the earlier losses. This was estimated in the previous section as ER. Thus the corrected emission is:

$$E_{use} = L_4 \times ((QR \times F)/100) - ER$$

Table 4.4 of the Use Category Document shows that the majority of used and discarded plastics materials are currently disposed of to landfill. A small proportion is incinerated, either in municipal facilities or on sites operated by the plastics industry.

$$E_{disp} = L_5 \times ((QR \times F)/100) - (E_{use} + ER)$$

Preservatives

The loss factors (L1 to L5) for preservatives can be estimated as follows:

Raw materials' handling

Factors apply to the quantities used on the plastics processing site.

Initially, some emissions will be to atmosphere, but ultimately all particulates will be removed or settle and losses will be to solid waste or to waste water as a result of wash down.

Material remaining in packaging (bags) will be assumed to go to solid waste from the plastics processing site. The loss factors, for a worst case scenario, are as follows:

For powders of particle size <40 µm:

$$L_1 = (0.1 + 0.5) = 0.6\% \text{ to solid waste/water} \\ = 1.0\% \text{ to solid waste as residue in bags}$$

For powders of particle size >40 µm:

$$L_1 = (0.1 + 0.1) = 0.2\% \text{ to solid waste/water} \\ = 0.01\% \text{ to solid waste as residue in bags}$$

Compounding

Factors apply to the quantities used on the plastics processing site.

Initially some releases will be to atmosphere, but ultimately all particulates will be removed or settle and losses will be to solid waste or waste water. On the basis of susceptibility to dust generation the loss factors are as follows.

For powders of particle size <40 µm, L2 = 0.05%

For powders of particle size >40 µm, L2 = 0.01%

On the basis of volatility, there is an additional loss of 0.05%, 0.01% or 0.002% for high, medium and low volatility organic preservatives. These should be combined with the losses from above.

Conversion

Factors apply to the quantities used on the plastics processing site.

Inorganic

Ultimately all particulates will settle and losses will be to solid waste or aqueous washings. On the basis of attrition of compound the loss factors are as follows.

For grinding/machining L3 = 2.5%
For all other processes L3 = 0.01%

Organic

Initial losses will be to atmosphere. Subsequent condensation could result in losses to liquid waste. On the basis of volatile losses the worst case loss factors are as follows.

Open processes:

For solid articles, L3 = 0.25, 0.05 or 0.01% for high, medium or low volatility
For foamed articles, L3 = 0.5, 0.1 or 0.02% for high, medium or low volatility

Partially-open processes:

L3 = 0.15, 0.03 or 0.006% for high, medium or low volatility

Closed processes:

L3 = 0.05, 0.01 or 0.002% for high, medium or low volatility

Service

Factors apply to the annual tonnage used in the region being considered.

Inorganic

Ultimately all particulates will settle and losses will be to solid waste or waste water. On the basis of degradation and abrasion the loss factors are as follows.

L4 = 0.01%

Organic

Indoor service, volatility to atmosphere L4 = 0.05%
Indoor service, leaching to liquid waste L4 = 0.05%
Outdoor service, volatility to atmosphere L4 = 0.05%
Outdoor service, leaching to environment L4 = 0.7%

Disposal

Factors apply to the annual tonnage used in the region being considered.

Landfill, leaching losses to water: these will depend on many factors, relating to the type of landfill as well as to the properties of the additive and the nature of the polymer in which it has been used. The maximum potential loss could be calculated from the amount of additive remaining in the plastic at disposal, but it is very unlikely that this amount would be released. For incineration, organic substances will be destroyed so L5 = 0 for incineration. There may be residues of inorganic materials left in the ash, which will be disposed of as solid waste - similar considerations to those above will apply.