Final Background Document
on the sector

Tyre production

Prepared in the framework of EGTEI

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Summary

1. Data from the bibliography (p.3)

Data currently used in RAINS are displayed in this paragraph for three different countries. Data for other countries are downloadable on http://www.iiasa.ac.at/~rains/voc_review/single.html

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5. Emission abatement techniques and costs (p.6)

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Table 5.3.1 summarizes the emission factors with the corresponding abatement efficiencies for each combination of measures.
Table 5.3.2 summarizes investments and operating costs for each combination of measures.

If a measure is missing in the document, national experts have to contact the Secretariat to add it in the background documents.

6. Data to be provided by national experts for the completion of the database for their own country (p.8)

Tables to be filled in by national experts are displayed :

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Table 6.2.3 : Activity levels of Reference Installations. Production of tyres (t of tyres produced / y) in each type of reference installation (RI) is required.

Total activity (t of tyres produced / y) in 2000 to 2020.

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The default data mean can be modified in a range of ± 10%.

7. Explanatory notes on emission factors and costs (p.9)

Explanations are given in this paragraph. Investments and operating costs of primary measures have been provided by industrial experts. For secondary measures, costs are calculated from the equations given in the document "Methodology".

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Sector : Tyre production

SNAP: 06 03 05 02 or NFR 3C Chemical products, manufacture and processing.

This source category covers the production of all kinds of tyres, e.g. for passenger cars, trucks, mopeds, etc. As conventional production plants of tyres have production lines of 800 to 1 200 m length, spread over different buildings, fugitive emissions represent the major source of emissions [1].

Solvents in tyre manufacturing are predominantly used to increase rubber "tack" at certain stages of the manufacturing process and to offset natural drying. Solvents are also used for cleaning purposes [4].

ACTIVITY : tonnes of tyres produced / year.
POLLUTANT : VOC

1 Data from the bibliography

Data displayed in this chapter are just given for comparison reason

1.1 Data currently used in RAINS [6], [7]

In the current stage of development of the RAINS model, rubber processing is not considered as a separated sector. This sub-sector is studied under the category "Products Not Incorporating Solvents (Excluding Pharmaceuticals). This category covers a wide range of different processes but the largest portion (almost 2/3) of VOC emissions originates from rubber and polyvinylchloride (PVC) processing.

1.1.1 Control options

The following groups of control options are considered :

- NoC : Reference case.
- SMP : Solvent management plans (applicability : 25 to 80%; abatement efficiency : up to 10%);
- A_INC : Add-on techniques: adsorption or incineration can be used (applicability : up to 70%; abatement efficiency : 95%);
- SUB : Substitution : this is viable for rubber processing only. (applicability within the rubber industry : 25%; efficiency as high as 100%). Therefore, the contribution of this industry to total emissions of this sector has to be taken into account (it leads to typical applicability factors around 5 to 10%). This option is used in combination with solvent management plans (SMP+SUB) assuming an efficiency of 50% and an applicability to 30% of the sector.
- Other combinations are also considered.

1.1.2 Abatement costs

Examples for three countries are displayed below :

No comments are made on the figures displayed in the following tables because no further information is available.
Data on the other countries are downloadable on
http://www.iiasa.ac.at/~rains/voc_review/single.html

Table 1.1.2.1 : French situation

Activity level 1990 : 39,645 kt VOC emitted;
2010 : 46,741 kt VOC emitted,
VOC emission scenario business as usual : 1990 : 39,65 kt VOC;
2010 : 34,71 kt VOC,

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff, [%]	Applicability [%]	Unit cost [$€_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
SMP+SUB	0,9000	10	50	20	200
A_INC	0,5250	48	95	50	3 000
SMP+SUB+A_INC	0,4250	58	58	100	2 500

Table 1.1.2.2 : German situation (Old Laender)

Activity level 1990 : 27,026 kt VOC emitted;
2010 : 30,631 kt VOC emitted,
VOC emission scenario business as usual : 1990 : 27,03 kt VOC;
2010 : 21,59 kt VOC,

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff, [%]	Applicability [%]	Unit cost [$€_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
SMP+SUB	0,9500	5	50	10	200
A_INC	0,43000	57	95	60	3 000
SMP+SUB+A_INC	0,3800	62	62	100	2 500

Table 1.1.2.3 : German situation (New Laender)

Activity level 1990 : 5,000 kt VOC emitted;
2010 : 5,667 kt VOC emitted,
VOC emission scenario business as usual : 1990 : 5,00 kt VOC;
2010 : 4,96 kt VOC,

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff, [%]	Applicability [%]	Unit cost [$€_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
SMP+SUB	0,9500	5	50	10	200
A_INC	0,43000	57	95	60	3 000
SMP+SUB+A_INC	0,3800	62	62	100	2 500

Table 1.1.2.4 : Hungarian situation

Activity level 1990 : 0,013 kt VOC emitted;
2010 : 0,016 kt VOC emitted,
VOC emission scenario business as usual : 1990 : 0,01 kt VOC;
2010 : 0,02 kt VOC,

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff, [%]	Applicability [%]	Unit cost [$€_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
SMP+SUB	0,8500	15	50	30	200
A_INC	0,3350	67	95	70	3 000
SMP+SUB+A_INC	0,1850	82	82	100	2 500

1.2 UK situation [4]

According to [4], calculations from 1987 data give a total annual solvent use of 7000 tonnes for this sector, representing in average 185 tonnes of solvent per site.
The largest companies have achieved significant reductions of VOC emissions by replacing silicon based materials by pre-curing sprays.
Cost components are incurred by this technique as :

- Higher price materials,
- Need to slow down the process,
- Installation of additional heating systems to drive off water.

Small companies may not have enough R&D resources to develop and adopt this low solvent approach.

According to [4], the large companies have already made reductions in solvent uses by better housekeeping and material substitution. Additional costs exist but have not been assessed here.

2 Short technology description [5]

Tyres are produced using a large variety of materials. The main process steps are :

- Mixing,
- Extrusion,
- Calendering,
- Building,
- Curing (Vulcanisation).

3 EU regulation : Directive 1999/13/EC of 11 March 1999 [3]
Activity : Rubber conversion

Operators concerned can conform to the Directive in either of the following ways :

- by complying with the canalised and fugitive emission limit values (<u>option I</u>).
- by introducing a reduction scheme to comply with the total emission limit value (in particular by replacing conventional high solvent contents products by low-solvent or solvent-free products) (<u>option II</u>).

The Directive applies to installations with a solvent consumption above 15 t per year.

Emission limits for application of the Directive are presented in table 3.1.

Table 3.1 : Emission limits

	Option I		Option II
Solvent consumption threshold [t /y]	**VOC emission limit value in residual gases [mg C / Nm^3]**	**Fugitive emissions [% of solvent input]**	**Total emissions [% of solvent used]**
> 15	20	25	25

All obligations of the Directive are not described in this chapter.

4 Definition of Reference Installation

Reference installations are defined according to their production expressed in tonnes of tyres produced per year. This information is more appropriate than the number of tyres produced because, as mentioned above, all kinds of tyres are taken into account in this study.

This sector being rather homogeneous, only one reference installation has been defined in table 4.1.

Table 4.1 : Reference installation

Reference Installation Code RIC	Description
01	Reference Installation : production of tyres : 30 000 t / y

5 Emission abatement techniques and costs

5.1 Definitions of primary measures

Primary measures 00, 01, 02 have been defined to represent real average emission factors for the whole European tyre industry sector (from bicycle to truck tyres). These measures have been described with the help of BLIC [5].

Primary measure 00 reflects the European situation in 1990. Solvent emissions are estimated to 10 kg VOC / t products [5].
The percentage of solvent-based adhesives, coatings, inks, and cleaning agents can not be reduced to less than 25 % (estimation) due to safety reasons [PMC 02].

Table 5.1.1 : Primary measures

Primary Measure Code PMC	Description
00	• Production of 100 % vulcanised rubber • Use of 100 % solvent-based adhesives, coatings, inks and cleaning agents (90 wt.-% solvent content)
01	• Production of 100 % vulcanised rubber. ***Process optimisation*** (examples : avoiding wasting of solvent, limiting emission devices - Use of auto-spray systems instead of hand mopping components - Dip tank on extruder instead of hand brushing treads with dissolution). • Use of 70 % solvent-based adhesives, coatings, inks and cleaning agents (90 wt.-% solvent content)
02	• Production of 100 % vulcanised rubber. ***New processes*** (example : adhesive rubber band use – New type of building machine associated with extruder – New technology extrusion.). • Use of 25 % solvent-based adhesives, coatings, inks and cleaning agents (90 wt.-% solvent content)

5.2 Definitions of secondary measures

Table 5.2.1 : Secondary measures

Secondary Measure Code SMC	Description
00	No secondary measure
01	Thermal oxidation

If a measure is missing in the document, national experts have to contact the secretariat to add it in the background documents.

5.3 Emission factors and costs data for the different combinations

According to [5], in most cases, applying primary measures is an alternative solution to the use of abatement techniques. However, these two solutions will not be combined for cost effectiveness reasons.
Either a plant will reach the reduction targets with the implementation of a reduction scheme or, if this is not possible, the plant will invest directly in an end-of-pipe device.

That is why combinations of primary and secondary measures are not considered in the present document.

Table 5.3.1 : Emission factors and abatement efficiencies for relevant combinations

RIC PMC SMC	VOC Emission Factor [kg / t tyres]	Abatement efficiency [%]	Q	CI [%]
01 00 00	10	0	5	10
01 00 01	2,5	75	5	10
01 01 00	7	30	5	10
01 02 00	2,5	75	5	10

Q : Quality of data
CI : Confidence Interval

Table 5.3.2 : Investments and operating costs for relevant combinations

RIC PMC SMC	Investment [€]	Q	CI [%]	Variable OC [€ / y]	Fixed OC [€ / y]	Savings on solvent purchase [€/y]	Q	CI [%]
01 00 00	0	-	-	-	-	0	-	-
01 00 01	1 000 000	4	20	63 000	50 000	-	4	20
01 01 00	40 000 *	5	30	NA	-	135 000	-	-
01 02 00	5 000 000	5	20	NA	-	NA	-	-

NA : Not applicable
* : probably underestimated because this measure has generally been already implemented and industry experts do not know exactly its associated costs.

6 Data to be provided by national experts for the completion of the database for their own country

The following tasks are required :

6.1 Validation work

For representing costs in this sector, the national expert is invited to comment the methodology defined by the Secretariat.

- Validate investment costs provided and,
- Validate the method of derivation of operating costs (see 7.3.2.1).

Or

- Provide other costs for the same combination of techniques and justify them.

Comments have to be sent to the Secretariat in the two weeks after electronic publication of the document.

6.2 Provision of specific data

Tables to be filled in by national experts

- Determination of country specific data to calculate variable costs (they are valid for all VOC sectors and only have to be entered in the tool once).

Table 6.2.1 : Country-specific data

Parameters	Default values	Country Specific costs
Electricity [€/kWh] (net of taxes)	0,0686	
Natural gas [€/kWh] (net of taxes)	0,0192	
Wages [€/h]	25,9	

Table 6.2.2 : Country and sector specific data

Parameters	Default values	Country Specific costs
Solvent costs [€/kg] (net of taxes)	1,5	

- Total activity level (production in t of tyres / y) in 2000, 2005, 2010, 2015, 2020. Some default values for the confidence interval are given. They can be used by the Party if no data are available.

The methodology used in Rains for estimating the future activity level will be described in the Methodology. This methodology can be used or information can be obtained fro the industry.

Table 6.2.3 : Activity levels on Reference Installations (production in t of tyres / y)

RIC	2000	CI%	2005	CI%	2010	CI%	2015	CI%	2020	CI%
01										
Default values proposed for CI		10		20		50		100		100
Total	Calculated automatically by the tool									

For explanations on the confidence interval (CI), please refer to the Methodology.

Total activity (production in t of tyres / y) should evolve from 2000 to 2020.

- Respective percentage of combinations of reduction measures in 2000 as well as if possible, the percentage of use in 2005, 2010, 2015, 2020 due to the VOC Directive or national regulations and applicability according to the definition used in the RAINS model.

Table 6.2.4 : Application rate and Applicability for each combination of reduction measures

RIC PMC SMC	Application rate in 2000 [%]	Application rate in 2005 [%]	Appl. [%]	Application rate in 2010 [%]	Appl. [%]	Application rate in 2015 [%]	Appl. [%]	Application rate in 2020 [%]	Appl. [%]
01 00 00									
01 00 01									
01 01 00									
01 02 00									
Total RIC 01	**100**	**100**		**100**		**100**		**100**	

Table 6.2.5 : Unabated emission factor [kg VOC / t of tyres produced]

Default data mean	CI %	User input mean	CI %
10	20		

The "default data mean" can be modified in a range of ± 10%.

7 Explanatory notes

7.1 Solvent consumption factors (SCF)

The solvent consumption factor is the amount of solvent consumed expressed in g per g of products used.

Table 7.1.1 : Solvent contents of products used

Type of System	Solvent Content [g solvent/g adhesives, etc.]
Conventional solvent-based (90 wt,-% solvent content)	0,9
Non-solvent-based process (0 wt,-% solvent content)	0,0

Table 7,1,2 : Solvent consumption factors for the different primary measures

PMC	Solvent Consumption Factor [g solvent/g adhesives, etc,]		Abatement Efficiency [%]
	Calculation	Result	
00	-	0,9	0
01	0,9 × 0,7	0,63	30
02	0,9 × 0,25	0,225	75

7.2 VOC emission factors (EF)

Based on the emission factor of 10 kg VOC / t tyres defined for PMC 00 [2], [5], the amount of products used can be estimated to 11,1 kg / t tyres (emissions are due to the use of solvent based products which contain 90 % of solvent).

In installations where the process is enclosed and with end-of-pipe devices, only fugitive emissions occur. They are estimated to be around 20 % of total emissions if the abatement efficiency is 95%. This means that about 25 % of solvent input are emitted.

Table 7.2.1 : Emission factors [kg VOC / t of tyres produced]

RIC PMC SMC	Emission Factor [kg VOC / t tyres produced]	
	Calculation	Result
01 00 00	11,1 × 0,9	10
01 00 01	10 × 0,25	2,5
01 01 00	11,1 × 0,63	7
01 02 00	11,1 × 0,225	2,5

7.3 Derivation of cost data

7.3.1 Primary Measures

Primary measure costs have been estimated by [5] on the base of a survey carried out in all European manufactures. Costs presented in table 7.3.1.1 correspond to real average costs.

Investments to achieve PMC 01 are relatively low : this is because this measure corresponds to process optimisations only. Operating costs can not be precisely defined. Only operating costs decrease due to savings in solvent consumptions can be estimated. A default cost of 1,5 €/kg of solvent is defined by BLIC [5]. Consumption savings are : 30 000 [t/y]× (10 - 7) [kg VOC/t]= 90 000 kg of VOC/y leading to “savings” on solvent purchases of 135 000 €/y.

To further reduce VOC emissions, processes have to be changed : that is why, investments incurred are very high (PMC 02).

Table 7.3.1.1 : Costs of primary measures [5]

RIC PMC SMC	VOC EF [kg / t tyres produced]	Investment [€]	Operating Costs [€ / y]	Savings on solvent purchase [€ / y]	Tech. Lifetime [y]
01 00 00	10	0	0	0	20
01 01 00	7	40 000 *	NA	135 000	20
01 02 00	2,5	5 000 000	NA	NA	20

NA : Not Applicable (less solvents will be used and production rates are increased with PMC 02 but these processes are not in use for the moment, it is currently impossible to estimate future operating costs)
* : probably underestimated because this measure has generally been already implemented and industry experts do not know exactly its associated costs.

7.3.2 Secondary Measures

Figures concerning the working time and VOC concentration are derived from real average data from [5]. The flow rate is calculated with the following equation :

Capacity [t tyres/y] × EF [kg VOC/t tyres] × 0,8 / (VOC conc. [kg/m^3] × production time [h/y])

Working time : 8 000 h/y,
VOC-concentration in the waste gas stream is assumed to be around 1,5 g/m^3. Gas flow rate is presented in table 7.3.2.1.

Table 7.3.2.1 : Flow rate calculations

RIC PMC SMC	Production time [h / y]	VOC conc. [g / m^3]	Flow rate [m^3 / h]
01 00 01	8 000	1,5	20 000

End-of-pipe device costs are derived from equations presented in the document "Methodology". Investment can be estimated to be around 750 000 €. According to [5], ducting costs are very high for this sector (up to 60 vents have to be collected and routed to the incinerator) and can represent up to 25% of the total investment, corresponding to 250 000 €.

Variable operating costs (wages + electricity + natural gas) account for 63 000 €/y. If we add 5% of the total investment cost (1 000 000) as fixed operating costs (50 000 €/y), total operating costs can be estimated around 113 000 €/y.

Table 7.3.2.2 : Emission factors, investments, operating costs and technical lifetime for secondary measures

RIC PMC SMC	VOC EF [kg / t tyres produced]	Investment [€]	Over-costs [€]	Variable OC [€ / y]	Fixed OC [€ / y]	Tech. Life time [years]
01 00 01	2,5	750 000	250 000	63 000	50 000	10

8 References

[1] Task force on the assessment of abatement options and techniques for VOC from stationary sources. Draft background document – Prepared by IFARE for UN/ECE-May 1999.

[2] N. ALLEMAND, R. BOUSCAREN, N. AVCI, T. ZUNDEL. Impact économique de la directive européenne sur la limitation des émissions de COV en provenance de l'utilisation des solvants en France. Tome III. Février 2000.

[3] Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations

[4] Regulatory and Environmental Impact Assessment for the Implementation of the EC Solvent Emissions Directive. Final Report. Entec UK Limited. 20 December 1999.

[5] Data presented to CITEPA by the BLIC (European Association of the Rubber Industry) VOC Working Group on the 14th March 2003. Brussels.

[6] Z. KLIMONT; M. AMANN; J. COFALA. Estimating costs for Controlling Emissions of Volatile Organic Compounds (VOC) from Stationary Sources in Europe. Interim Report IR-00-51. IIASA. August 1, 2000. http://www.iiasa.ac.at/~rains/voc_review/voc_ir-00-51.pdf

[7] Review of data used in RAINS-VOC model. http://www.iiasa.ac.at/~rains/voc_review/single.html

9 Modifications compared to the draft document

No modification has been done.