

MANUFACTURE OF SHOES

SYNOPSIS SHEET

Prepared in the framework of EGTEI

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1. Activity description and EGTEI contribution - summary

Manual labour is predominant in shoe production due to the variety of models and materials used. Automation is only possible for some operations such as the molding injection. Cementing and molding are the two main shoe production techniques.

In the cementing technique, either solvent-based or water-based adhesives can be used for the stitching step. Solvent-based products are applied with a paint-brush. Water-based adhesives can be applied manually by spraying techniques or by paint-brushes. Then, the shoe upper part is fixed on the insole. Parts like rubber soles have to be pre-treated with a halogenizer (degreaser) to ensure a strong adhesion of the adhesive. The insole is attached to the sole with solvent-based adhesives. This operation is handled either manually or automatically. Finishing products (color, protection, water repellent products...) are applied with a paint-brush or by automatic guns in spray booths.

In the injection molding technique, the sole is directly molded adhesive-free onto the shoe upper part. The sole material is injected in a mould and forms a strong bond with the shoe upper while it cools off. Solvents are only used to withdraw the sole from the mould and during the finishing step.

Only shoes manufactured by the cementing technique are considered in the EGTEI document as NMVOC emissions from the injection molding technique are very low and below the regulation requirements.

This activity emits NMVOC originating from the solvent used. At a EU25 level for the year 2000 (according to RAINS: version CP_CLE_Aug04(Nov04)), NMVOC emissions were 31.31 kt representing 0.29% of total NMVOC emissions. Total activity being, 723.66 millions of pairs manufactured, average emission factor is about 43.3 g NMVOC/pair of shoes meaning that emissions from this sector are already partly treated in EU25 (unabated emission factor being 60g/pair). These estimations could be modified in a near future due to information delivered by national experts during bilateral consultations in 2005 with CIAM.

Footwear manufacture is addressed by the European Directive 1999/13/EC (SED) [1] related to the reduction of NMVOC emissions from the use of solvents in some industrial activities. In order to be able to better represent the impact of this Directive in terms of emission reduction and costs, **it has been considered as an individual activity by EGTEI [2]**. In the previous RAINS version [3], this sector was considered in the category "Other Use of Solvents in Industry" including activities from three major sectors: application of glues and adhesives, preservation of wood and other industrial use of solvents so it was very difficult to define it precisely. **EGTEI has been able to develop a specific approach for representing this sector and estimate costs of reduction techniques**. Costs were estimated in cooperation with an industrial process manufacturer [4]. Emission factors are derived from field observations. Presently, RAINS has been modified and integrates EGTEI proposals. **Data provided by EGTEI (emission factors and costs) have been implemented in the new RAINS version [5]** for the modelling work carried out in the scope of the CAFE programme and the revision of the Gothenburg Protocol and national emission ceiling Directive.

The representative unit used is the number of shoes manufactured annually (pairs/year). Two reference installations (RI) have been defined to take into account the differences in costs.

Three primary measures are considered based on different types of adhesives: solvent-based and water-based adhesives can be used. The material consumption can also be reduced with the use of automatic processes. For small installations, the increased use of water-based adhesives enables the respect of the Directive solvent consumption threshold (5 tonnes / year). For large installations, the use of automatic processes will be necessary to respect the emission limit value (defined in g of VOC/pair of shoes). When these primary measures are not technically viable (because of the type of shoes produced), end-of-pipe techniques can be installed.

Thermal oxidation and biofiltration are considered as secondary measures for this sector to be in compliance with the SED requirements. One or the other can be used but biofiltration is cheaper.

EGTEI provides default emission factors (EF) with abatement efficiencies, investments and variable and fixed operating costs (OC) as well as unit costs (€/t NMVOC abated and €/activity unit) for all the combinations of measures.

Automatic processes or biofiltration are the cheapest ways for complying with the SED requirements.

National experts have to collect 3 country specific parameters (wages, electricity and natural gas costs) and 3 country and sector specific parameters (costs of two different types of adhesives and halogenizer). The first ones can be very easily known. The second ones can be defined with the help of national leather associations. EGTEI provides default costs for country and specific parameters which can be used if no better national data exist. National experts have also to provide the trends in activity level from 2000 to 2020, the activity shares according to the different RI as well as the application and applicability rates of each abatement technique.

As the representation of this sector in RAINS is based on the EGTEI proposal, it is recommended to national experts to complete ECODAT with country specific parameters which are not known from CIAM.

EGTEI proposals for the representation of the manufacture of shoes and definitions of abatement techniques have been considered in the last update of RAINS [5]. In the future however, any new technology which could be developed should be considered by EGTEI in the background document to continuously improve the representation of the sector and the capacity of EGTEI to describe new technologies.

2. European regulation

As mentioned above, the European Directive 99/13/EC [1] applies to this sector (annex IIA, n°14).

Operators have to be in compliance with the total emission limit value defined in g of VOC per pair of shoes manufactures.

The SED applies to installations with a solvent consumption above 5 t per year. The total emission limit value is defined in the SED are presented in table 2.1. All obligations are not described in this chapter.

Table 2.1: Emission limit values

Solvent consumption threshold [t / year]	Total emissions [g VOC / pair]
> 5	25

The compliance date for existing installations is October 30th, 2007. Following the transcription of the Directive in Member States, this date can be different from country to country. For example, in France, the compliance date is October 30th, 2005.

3. Methodology developed within EGTEI to represent the sector

3.1 Definition of reference installations

Only installations using the cementing technique have been studied because installations using other manufacturing techniques are in compliance with the limit of 25 g VOC / pair of shoes.

Two reference installations are considered according to the annual production of shoes. This unit is easier to define than the amount of adhesives consumed in this sector. Annual solvent input in the small installation (RIC01) is 6 tonnes which is just above the SED solvent consumption threshold (5 tonnes / year). Some of the smallest installations will then be out of the scope of the Solvent Directive.

Table 3.1.1: Reference installations

Reference Installation Code RIC	Description	Technical characteristics
01	<u>Small installation:</u> 100,000 pairs of shoes / year	Solvent input: 6 t/y Full load hours: 1,840 h/y [VOC]: 1.0 g/m ³ Flow rate: 2,400 m ³ /h
02	<u>Large installation:</u> 200,000 pairs of shoes / year	Solvent input: 12 t/y Full load hours: 1840 h/y [VOC]: 1.0 g/m ³ Flow rate: 4,900 m ³ /h

3.2 Definition of emission abatement techniques

3.2.1 Primary measures

Emission levels in this sector are very sparse. Some installations emit 60 g/pair when others only emit 30 g/pair. These levels differ according to the technologies used. Three primary measures are considered below according to the type of adhesive used and to the level of automation of the production line.

Table 3.2.1.1: Definition of primary measures

Primary Measure Code PMC	Description
00	90% of solvent-based adhesives / 10 % of water-based
01	60% of solvent-based adhesives / 40 % of water-based Good housekeeping / Manual application
02	60% of solvent-based adhesives / 40 % of water-based Good housekeeping / Automatic application

3.2.2 Secondary measures

Two secondary measures are defined. Thermal oxidisers might be too expensive for small installations. Biological treatment can be an alternative (it has been already successfully implemented at Wellingborough-based R Griggs & Company Ltd in UK).

Table 3.2.2.1: Secondary measures

Secondary Measure Code SMC	Description
00	None
01	Thermal oxidiser
02	Biofiltration

4. Country specific data to be collected

Different types of country specific data have to be collected to give a clear picture of the situation in each Party. EGTEI proposes default values for the economical parameters which can be modified by the national expert if better data are available.

For this activity as for all NMVOC sectors, country specific economical parameters are used to calculate variable operating costs. They are presented in table 4.1 as the default costs proposed by EGTEI (these costs are entered only once in ECODAT).

Table 4.1: Country specific costs

Parameters	Default costs provided by EGTEI	Country specific costs
Electricity [€/kWh] (net of taxes)	0.0686	To be provided by national experts
Natural gas [€/GJ] (net of taxes)	5.926	To be provided by national experts
Wages [€/h]	25.9	To be provided by national experts

For the manufacture of shoes, some additional country and sector specific parameters are necessary to calculate variable operating costs. They correspond to costs of different types of adhesives and halogenizer. Default costs proposed by EGTEI are presented in table 4.2.

Table 4.2: Country and sector specific economic parameters

Parameters	Default costs provided by EGTEI [€/kg]	Country and sector specific costs [€/kg]
Solvent-based adhesives [€/kg] (net of taxes)	3.0	To be provided by national experts
Water-based adhesives [€/kg] (net of taxes)	3.9	To be provided by national experts
Halogenizers [€/kg] (net of taxes)	3.0	To be provided by national experts

The best source of information for the determination of country and sector specific economic parameters is the national federation of shoe manufacturers and it is recommended to national experts to take contact with it.

Default data have been used to calculate variable and annual unit costs presented in table 5.1.

Information concerning activity levels from 2000 to 2020 as well as the description of the control strategy is also necessary (these data can be directly entered in the database ECODAT). A full definition of the work to be done by national experts is provided in the general EGTEI methodology [6].

National experts can also modify the default unabated emission factor proposed by EGTEI to represent the reference situation for all Parties, in a range of $\pm 10\%$. If the modification is higher than 10%, then appropriate explanations are required.

Table 4.3: Unabated emission factor [g of NMVOC / pair of shoes]

Default emission factor	Country specific emission factor
60	To be provided by national expert

5. Default emission factors and cost data defined with the EGTEI methodology

Table 5.1 gives an overview of all data provided by EGTEI: default emission factors (EF) with abatement efficiencies, investments, and variable and fixed operating costs (OC) as well as unit costs per t NMVOC abated and per unit of activity.

Variable costs account for the consumption of products (adhesives and halogenizer) for primary measures and electricity, natural gas and labour if a secondary measure is used. Fixed operating costs are only considered for secondary measures and correspond to 5% of the secondary measure investment (for maintenance and insurance). As no economic data is available, it is assumed that fixed operating costs are the same for all primary measures so no additional costs are taken into account (that is why fixed operating costs appear as 0 costs in table 5.1).

Investments of primary measures are derived from data provided by the industry [4]. Investments correspond to the adaptation of the dryer for water-based adhesives and to the automation of the application devices. Secondary measures are also taken into account when it is relevant.

Investments and variable costs of secondary measures presented in table 5.1 are calculated from the equations defined in the documents "derivation of secondary measure costs: thermal oxidation" and "derivation of secondary measure costs: biofiltration" downloadable on EGTEI website [7] and [8]. Technical characteristics of the installation are given in table 3.1.1.

Table 5.1: Default emission factors (EF), abatement efficiencies and costs for each combination

RIC PMC SMC	NMVOC EF [g NMVOC / pair]	Abatement efficiency [%]	Investment [k€]	Variable Operating Costs [k€/ year]	Fixed Operating Costs [k€/y]	Unit cost [k€/t NMVOC abated]	Unit cost [€/ 1000 pair]
01 00 00	60	0	0	18.2	0	-	-
01 00 01	17.2	71	236	23.0	11.8	10.7	457.0
01 00 02	17.2	71	42.8	22.1	2.2	2.7	113.8
01 01 00	31	48	22.9	15.8	0	-0.2	-7.1
01 01 01	8.9	85	187.5	19.7	8.2	6.1	310.9
01 01 02	8.9	85	48.3	19.3	1.3	1.4	72.3
01 02 00	23	62	100	13.5	0	0.7	26.6
02 00 00	60	0	0	36.4	0	-	-
02 00 01	17.2	71	350	43.0	17.5	7.9	336.3
02 00 02	17.2	71	75.8	41.2	3.8	2.1	89.7
02 01 00	31	48	45.7	31.6	0	-0.2	-7.2
02 01 01	8.9	85	286.7	36.5	12	4.4	224.1
02 01 02	8.9	85	89.9	35.5	2.2	1.0	51.5
02 02 00	23	62	200	27.0	0	0.7	26.6

Unit costs [k€/ t of NMVOC abated] are obtained by dividing the annual total additional cost of a measure by the amount of NMVOC abated (costs and emissions are compared to the uncontrolled measure PMC 00/SMC 00).

6. Relevance of EGTEI information for Integrated Assessment Modelling (IAM)

In the previous RAINS version [3], this sector was considered in the category “Other Use of Solvents in Industry” including activities from three major sectors: application of glues and adhesives, preservation of wood and other industrial use of solvents (mostly fat edible and non-edible oil extraction and in some countries, other sectors like leather tanning and textile finishing might be of importance). Control options defined for the application of glues and adhesives were: the modification of the application technique to improve the transfer efficiency, the substitution with water-based or hot melts adhesives, and the use of add-on techniques such as thermal oxidation.

EGTEI provides now an approach to consider this sector and to test the impact of the current legislation.

Data provided in the EGTEI approach (emission factors and costs) have been implemented in the new RAINS version [5] for the modelling work carried out in the scope of the CAFÉ programme and the revision of the Gothenburg protocol.

7. Perspective for the future

In the future, any new technology which could be developed should be considered by EGTEI in the background document to continuously improve the representation of the sector.

8. Bibliography

- [1] 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.
- [2] EGEEI background document. http://citepa.org/forums/egtei/manufacture_of_shoes.pdf
- [3] KLIMONT; M. AMANN; J. COFALA. Estimating costs for Controlling Emissions of Volatile Organic Compounds (NMVOC) 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
- [4] Communication: BERAUD industry - September 2002.
- [5] Review of the RAINS model:
<http://www.iiasa.ac.at/web-apps/tap/RainsWeb/>
- [6] Methodology: http://citepa.org/forums/egtei/egtei_index.htm
- [7] http://citepa.org/forums/egtei/thermal_oxidation_costs_170603.pdf
- [8] http://citepa.org/forums/egtei/biofiltration_costs_170603.pdf
- [9] CITEPA: National reference centre for emission inventories

ANNEXE: Example of data collection and use of EGTEI data – Case of France

A. Country specific data collection and scenario CLE developed

The French national expert has been able to complete ECODAT with the help of CITEPA [9].

All collected data have been provided to CIAM for the bilateral consultation France – CIAM in March 2004.

Country and sector specific economic parameters

Country specific parameter costs have been defined from costs encountered in the medium size industry which are monthly published by official French statistic organisations.

Table A.1: French specific costs

Parameters	French specific costs
Electricity [€/kWh] (net of taxes)	0.05
Natural gas [€/GJ] (net of taxes)	5.33
Wages [€/h]	23.4

As no better product costs are available, default costs for country and sector specific parameters are taken into account for describing the French situation.

Table A.2: French and sector specific costs

Parameters	Default costs [€/kg]	French and sector specific costs [€/kg]
Solvent-based adhesives [€/kg] (net of taxes)	3.0	3.0
Water-based adhesives [€/kg] (net of taxes)	3.9	3.9
Halogenizers [€/kg] (net of taxes)	3.0	3.0

Activity level

Activity level in 2000 comes from the French statistics: all types of shoes are described and among them, only shoes manufactured with the cementing technique are taken into account. The activity forecast from 2000 to 2020 comes from data provided by the French national expert. These data are based on the trend of the branch "leather" from 1995 to 2001. The production is assumed to decrease but the manufacture of shoes in the luxury industry should remain stable.

The distribution of activity between RIC 01 and 02 is deduced from the number of employees per installation (given in the annual statistics per branch). From these data, it is possible to calculate an average production per employee, and thus, per installation. This survey leads to a share of 9.4% of the activity in RIC 01 and 90.6% in RIC 02.

Table A.3: Activity levels on Reference Installations (M pairs / year)

RIC	2000	2005	2010	2015	2020
01	3.8	3.6	3.3	3.1	2.9
02	36.9	34.4	32.1	30.0	28.0
Total (Mpairs)	40.7	38.0	35.4	33.1	30.9

Current legislation control scenario (CLE)

In the current legislation control scenario (CLE), the application rates of the different abatement techniques depend on the regulation implemented and on the compliance dates.

In 2000, 50% of the production is assumed to be produced for the luxury industry. Usually, more adhesives are used for these products (this corresponds to the combination PMC 00/SMC 00). As no reduction technique is used in this sector yet, the remaining 50% correspond to the combination PMC 01/SMC 00.

From 2005 onwards, all installations in France consuming more than 5 tonnes of solvents have to respect the emission limit values defined in the Solvent Directive. Half of RIC 01 emitting 60g of

VOC/pairs (PMC 00) are assumed to invest in a secondary measure (the other half is assumed to consume less than 5 tonnes). RIC 01 emitting 31 g of VOC/pair (PMC 01) are under the consumption threshold (they consume 3.1 tonnes of solvents/year).

RIC 02 emitting 60 g/pair are assumed to invest in biofiltration and the other installations emitting 31 g of VOC/pair should invest in primary measure 02 to be in compliance with the emission limit of 25 g/pair. These hypotheses are presented in the table below.

Table A.4 Definition of the CLE scenario

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	50	25	25	25	25	25	25	25	25
01 00 01	0	0	50	0	50	0	50	0	50
01 00 02	0	25	50	25	50	25	50	25	50
01 01 00	50	50	50	50	50	50	50	50	50
01 01 01	0	0	50	0	50	0	50	0	50
01 01 02	0	0	50	0	50	0	50	0	50
01 02 00	0	0	50	0	50	0	50	0	50
Total RIC 01	100	100		100		100		100	
02 00 00	50	0	0	0	0	0	0	0	0
02 00 01	0	0	50	0	50	0	50	0	50
02 00 02	0	50	50	50	50	50	50	50	50
02 01 00	50	0	0	0	0	0	0	0	0
02 01 01	0	0	50	0	50	0	50	0	50
02 01 02	0	0	50	0	50	0	50	0	50
02 02 00	0	50	50	50	50	50	50	50	50
Total RIC 02	100	100		100		100		100	

The default emission factor provided by EGTEI is suitable for France according to CITEPA.

B. Trends in emissions and total costs of the CLE scenario

Data shown in the tables below are directly provided by ECODAT and based on input parameters defined in chapter A.

Table B.1 presents NMVOC emissions from 2000 to 2020 and total annual costs of emissions reduction for the CLE scenario.

Table B.1: Trends in emissions and total annual costs of emission reductions in the CLE scenario

	2000	2005	2010	2015	2020
NMVOC emissions	t NMVOC	t NMVOC	t NMVOC	t NMVOC	t NMVOC
CLE scenario	1,851	816	761	711	663
Annual total costs	k€/year	k€/year	k€/year	k€/year	k€/year
CLE scenario	-145.7	2,089.7	1,950.5	1,820.8	1,699.5

Emissions shown in table B.1 for the year 2000 according to the CLE scenario have been calculated with EGTEI emission factors. These emissions are not directly calculated in the French inventory because this sector is considered as part of the industrial use of adhesives.