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WASTES GENERATED IN THE LEATHER PRODUCTS INDUSTRY

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* This document has been prepared without formal editing.

Table of contents

List of figures

List of tables

1. INTRODUCTION

According to the modified European Directive n° 75/442, a solid waste is

"any substance or object in the categories set out in the Annex I which the holder discards or intends or is required to discard.

Annex I:

- *"of" specification products;*
- *out of date products;*
- *materials accidentally spilled, lost or having undergone other mishap, including any materials, equipment etc., contaminated as a result of the mishap;*
- *materials contaminated or soiled as a result of planned actions (e.g. residues from cleaning operations, packing materials, containers etc.);*
- *substances which no longer perform satisfactorily (e.g. contaminated acids, contaminated solvents, exhausted tempering salts etc.);*
- *residues of industrial processes (e.g. slags, still bottoms, etc.);*
- *residues from pollution abatement processes (e.g. air scrubbing sludge, dust, used air filters, etc.);*
- *products for which the holder has no further use (e.g. agricultural, household, office, commercial and shop discards etc.);*
- *etc."*

We notice that

- the definition of waste is directly associated with regulations,
- solid wastes can be found in any place in a manufacturing plant. Some of them are produced on a regular basis and some may be the consequence of mishaps.

2. SCOPE OF THE PRESENT REPORT

2.1 Process wastes

The present report

- provides production ratios of solid wastes in leather, footwear and other leather products manufacture and analyse why such wastes are produced,
- analyses possible solutions in order to reduce the quantity of waste, or to recycle them.

2.2 Packaging

This report does not take into account the packaging waste in quantitative terms.

However, we explain in the figures "standard manufacturing process" dealing with each specific product where the packaging wastes are produced.

These wastes are more related to local practices than to the manufacturing process itself. Moreover, the recycling solutions rely on the local industrial facilities. It is then very difficult to establish ratios in this field and to recommend standard recycling solutions.

3. WASTES FROM LEATHER MANUFACTURING

The leather manufacturing process generates a variety of solid wastes which are well described in a UNIDO reference document[(i)]. In the present report, we only selected the wastes having a chemical composition comparable to finished leather:

- wet blue (WB) splits, trimmings and shavings,
- leather trimmings,
- leather dust.

For these wastes, the main waste production ratios [(ii)] are summarised in the Table 1 [(1)].

Table 1: waste ratios regarding the leather manufacturing process

	ratio for heavy bovine leather	ratio for light bovine leather	ratio for sheep and goat leather
	(t / t finished leather)	(t / million m² finished leather)	(t / million m² finished leather)
Unusable WB splits, WB shavings and WB trimmings	171.0	513.0	180.0
Dry leather wastes (trimmings, dust ..)	27.7	83.2	151.3

With the leather production data [(iii)] provided by the FAO [(2)], it is possible to estimate the quantity of waste which chemical composition is similar to finished leather (see Table 2).

The data from the FAO are the only ones which

- deal with production and not trade,
- provide figures in m² or tons,
- provide data per country or group of countries.

Hence, we could not compare them to another source of information.

Table 2 : estimation of the wastes generated by leather manufacturing - world wide basis

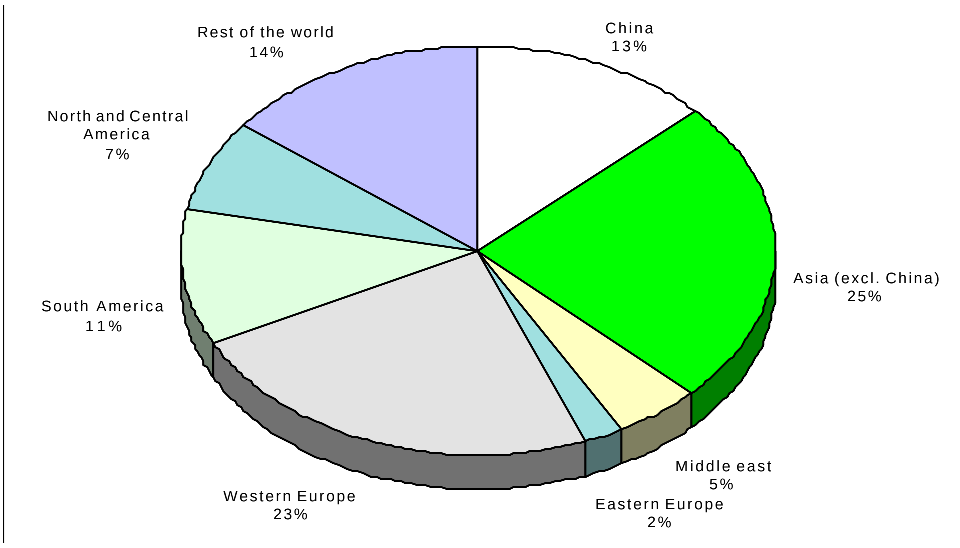
			Leather making								
	date		China	Asia (excl. China)	Middle east	Eastern Europe	Western Europe	South America	North and Central America	Rest of the world	Total
production (thousand of tons of finished leather)	1 996	heavy bovine leather	104	71.0	28.4	2.0	72.0	65.0	42.0	100.0	484
production (million of m² of finished leather)	1 996	light bovine leather	96	251	30	28	238	117	84	124	968
production (million of m² of finished leather)	1 996	light sheep and goat leather	82	96	42	3	92	14	5	64	399
Unusable WB splits, WB shavings and WB trimmings		(tons/year)	81 842	157 954	27 900	15 352	151 054	73 543	51 130	92 446	**651 221**
Dry leather wastes (trimmings, dust ..)		''	23 356	37 365	9 622	2 911	35 780	13 682	8 888	22 831	**154 436**
total		''	**105 198**	**195 319**	**37 521**	**18 264**	**186 834**	**87 225**	**60 018**	**115 277**	**805 656**

Figure 1 provides a graphical repartition of the total quantity of waste per geographical area.

1 In the calculations for this table, we consider that the heavy bovine finished leather weights about 3 kg/m² and a sheep/goat finished leather measures about 0.75m²

2 Food and Agricultural Organisation of the United Nations

Figure 1 : wastes generated by the leather manufacturing - % of world areas



Leather wastes are produced in various regions world-wide.

4. WASTES FROM THE MANUFACTURE OF LEATHER PRODUCTS

4.1 Introduction

According to the INTERNATIONAL TRADE CENTRE (ITC)[iv], the use of leather produced world-wide is detailed in the Table 3.

Table 3 : use of leather on a world-wide basis

Use	at the present time	in the future (2000 ...)
Footwear	~ 60 %	decreasing
Leather goods	~ 20 %	decreasing
Garments	~ 14 %	same
Upholstery, furniture	~ 5 %	increasing
Gloves	~ 1 %	???

Footwear is the sector which “consumes” the major part of leather (60 %). Logically, this industry is producing the largest quantity of leather wastes.

However, in spite of the specific application of their products, these industries a have some common points which are described hereafter:

- the process (and even the machines) involves similar production steps and technologies (except for footwear for which the assembling techniques can be sophisticated),
- the materials (leather, textiles etc.) are similar,

- the reasons why a solid waste is generated,

  In particular, the factors which influence the quantity of wastes are similar:
  - the quality of leather (with poor quality leather, the cutting rate can be 5 points higher than normal),
  - the type of leather (grain, split, side, belly etc.),

    With split, the cutting rate can be 10 points higher than normal
  - the size of the leather (lamb, bovine etc.),
  - the size of the item to produce and the combination (size, shape) of components to cut in the same piece of material,
  - the ability of the operator in charge of the cutting: a good clicker can cut 3-5% below the allotted surface,
  - the incentive given to the clicker,
- the solutions to reduce the quantity of waste

  In particular, with a good quality leather, the quantity of waste will be lower.
- the external solutions to recycle the solid wastes are the same.

  This aspect is developed in a specific paragraph "6. Waste management".

4.2 Global methodology

In the present report, each finished product is analysed in the following chapters.

- For each product, the wastes are presented according to the production stage and not to the type of material (textile, leather, plastics etc.). This way, it is easier to calculate the production of wastes with regional statistics. For example, India has a production capacity of 78 million pairs of footwear uppers; with the information of the "4.4 Footwear" chapter, the related quantity of wastes can be estimated.
- Regarding the production data, the only source of information available world wide[v] is managed by the customs. The database they manage is structured according to the customs directory which is applied world-wide according to an international convention (see the structure for the leather products in Annex 1).

  However, the major difficulties we had were
  - the data we selected were dealing only with **exports**, **not with real production**,
  - depending on the country, the data is either in tons or in number of pieces,
  - many countries did not declare their international exchanges; so **their activity is not taken into account in the present report**,
  - furniture and upholstery do not have any data.

The Annex 2 reproduces an extraction of this data base for leather garments.

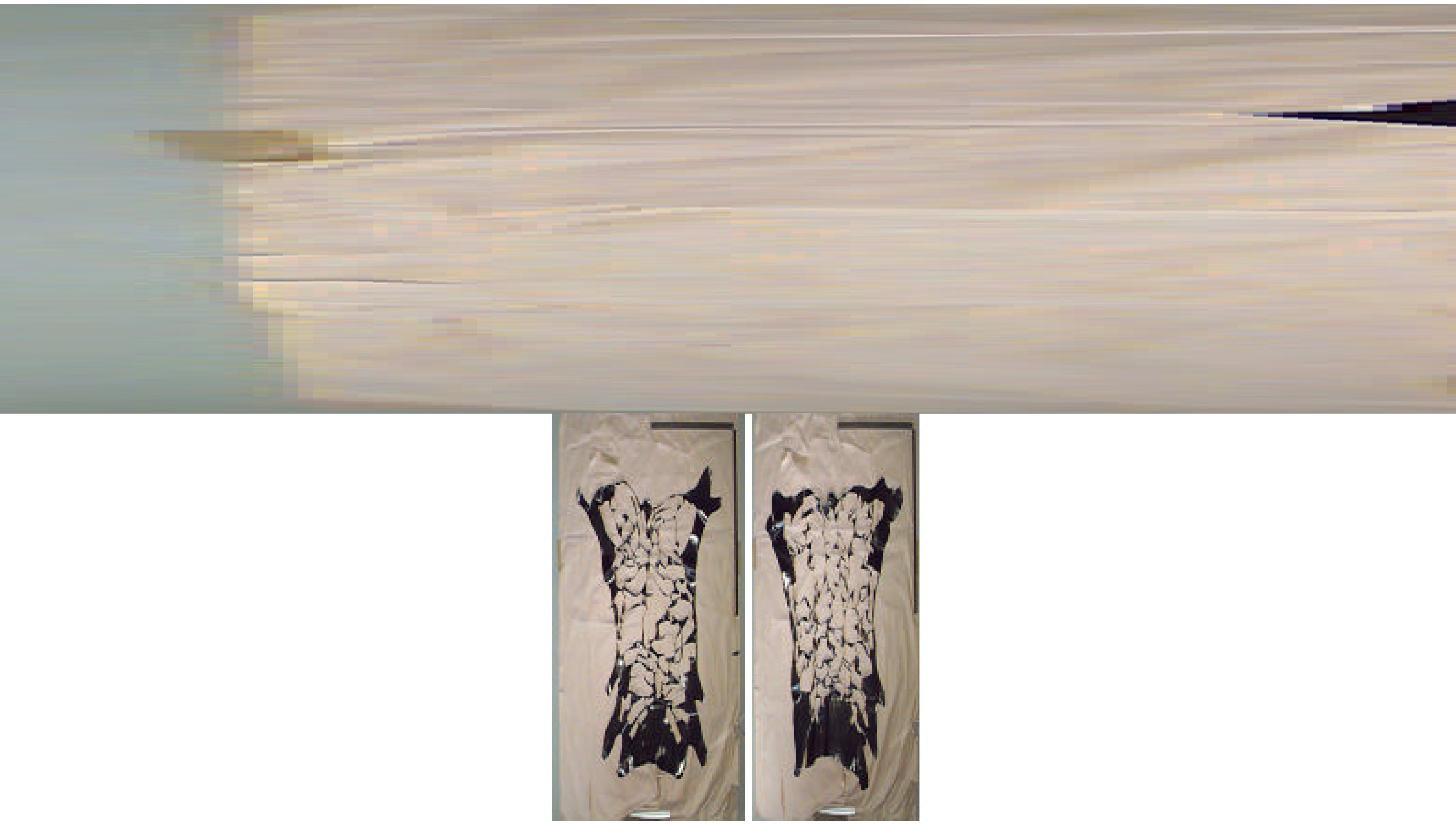
4.3 Special attention to the cutting rate

By far, the largest quantity of waste is generated at the cutting step. As mentioned in detail in the following chapters, the cutting rate for leather can range 25-60%.

With some high quality items, only 40% of the surface of the leather is used.

The Figure 2 and Figure 3 show one example in high quality products and the related cutting rate.

Figure 2 : real cuttings in a ***high quality footwear*** *company*



In this trial during technical audits, CENTRE TECHNIQUE CUIR CHAUSSURE MAROQUINERIE (CTC) measured the cutting rate on 5 leather skins: **57%** (total weight of the leather = 8.9 kg and total weight of scraps = 5.04 kg). The pictures show 3 representative samples of this trial.

In another trial on 6 leather skins, the cutting rate was **60%** (total weight of leather = 12.52 kg and total weight of scraps = 7.37 kg).

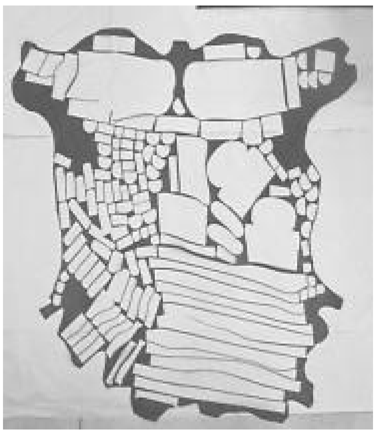


Figure 3 : real cuttings in a ***high quality leathergood*** *company (some samples)*

During other CTC technical audits, the cutting rat

- 1st trial on 1 leather skin **18 %** (total weight = 2.3 kg, scraps = 0.4 kg)
- 2nd trial on 1 leather skin **25 %** (total weight = 2.8 kg scraps = 0.7 kg)
- 3rd trial on 7 leather skins

25 % (total weight = 16.8 kg scraps = 4.1 kg)

These examples in footwear and leather good show

- the various values a cutting rate can reach,
- that its value can be very high (60%),
- that its value can hardly be lower that 25 %.

When the finished product is made out of pieces having a peculiar shape, the cutting rate can easily reach 35 %. Despite the high price of leather, the reasons of this relatively high cutting rate are

- a leather skin is never homogeneous and rectangular,
- the quality of the leather at the side of the skin is generally poor,
- the shape of the pieces to be cut are scarcely the same and the production delay does not allow the optimisation of their arrangement.

Regarding textile or fabrics, the cutting rate values are generally lower because the material is homogeneous. However, in high labour cost countries, it can be very different because there is no incentive for the cutter to optimise the arrangement of the knives.

4.4 Footwear

4.4.1 Scope

The Technical Committee (n° 309) within the CEN (COMITÉ EUROPÉEN DE NORMALISATION) has identified (vi) 9 different types of footwear:

- “General sports and leisure”,
- “Children’s school”,
- “Casual”,
- “Men’s town”,
- “Specialist cold weather”,

- “Women’s town”,
- “Fashion”,
- “Infants”,
- “Indoor”.

  The safety footwear is not included in this TC because is already covered by the CEN/TC161.

Some shoes are not made out of leather, this is why the present report

- covers “Men’s town”, “Women’s town”, “Children”, “Casual and general sports” and “Safety”,
- excludes “slippers (indoor)”, “light textile shoes”, “infants”, “baby”, “injected boots and shoes”.

4.4.2 Methodology

In the recent years, the CTC has conducted technical audits on waste in approximately 30 footwear manufacturing plants, covering a great variety of products.

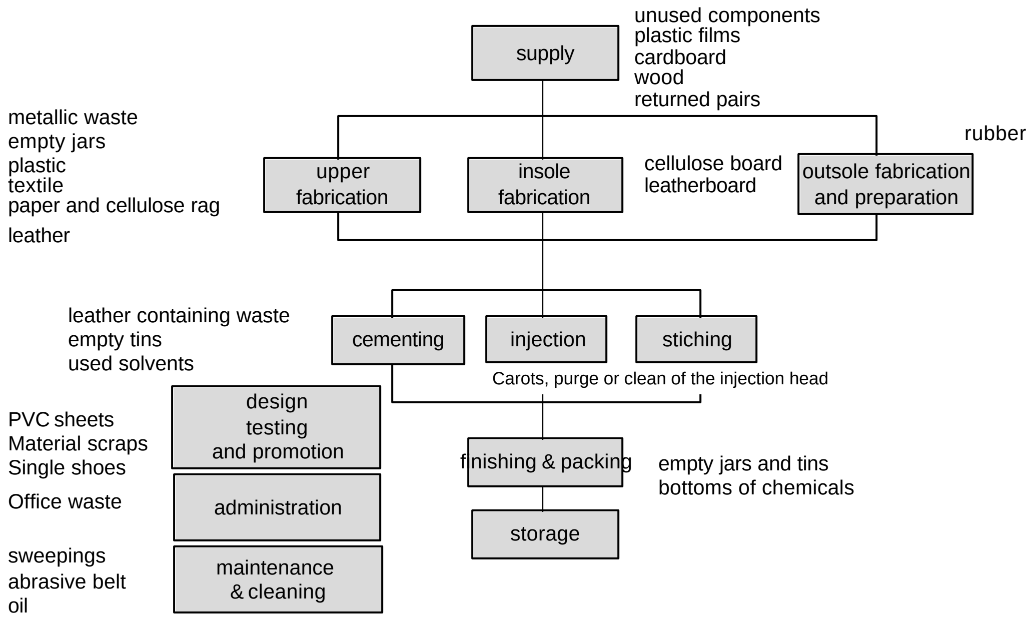
Each audit was completed by an auditor during 5 days. Each waste has been measured (on a weekly basis or yearly basis according to the methodology of CTC) and compared to the quantity of shoes being processed over the corresponding period.

Considering the number of footwear plants involved, we can consider that the ratios provided hereafter are satisfactory.

4.4.3 Standard manufacturing process

The complete standard process of footwear manufacture is presented in the Figure 4.

Figure 4 : complete standard footwear manufacturing process



Different assembling techniques are available

- cemented: assembling the upper and the sole with adhesive,
- injection: injecting the sole material directly to the upper,
- stitching: assembling upper and sole together with threads.

4.4.4 Wastes generated by the footwear industry

The nature and the quantity of such waste rely on two factors:

- the type of materials being processed (leather, textile, rubber, PU etc.),
  In this process, a wide range of materials can be used, as shown in the Table 4.
- the type of assembling technology (stuck-on, bonding, stitching, direct moulding etc.).

These materials have been taken into account in the ratios presented in Table 5, on the basis of an average shoe.

Table 4 : materials and chemicals processed during footwear manufacturing, reasons why they are produced and possible ways of reducing them

material or waste	use as or produced by	comments and reasons why they appear	reduction
Leather, Textile (cotton, polyester, nylon), Coated fabrics (PU and PVC)	upper and lining	the pieces to be used as component in the shoe are cut in leather and in other material. The average cutting rates are • leather: 25-35% • textile and fabrics: 20-25%	• the cutting ratio in leather is generally being optimised by the operators • with less expensive material, the ratio can vary from one country to the other: the only criterion of the footwear manufacturer is the optimisation between labour cost and material cost
Natural rubber/poly-isoprene, Reaction Injection Moulded (RIM) polyurethane (PU), Polyvinyl Chloride (PVC) and blends, Ethylene Vinyl Acetate (EVA) and blends, Styrene Butadiene Rubber (SBR), Thermoplastic Polyurethane (TPU), Thermoplastic Rubber (TR), Leather.	outsole	injected technique • due to the pressure, the thermoplastic material can flow out between the two parts of the mould. This generates wastes (flash) • the mould contains a tube through which the material is injected. The “carrots” are considered as waste • when the machine stops working (rest, team change etc.) or when the production changes the colour, some purges are produced which cannot be used afterwards	• the mould must be as tight as possible • the design of the mould reduces the quantity and the size of the carrots • worn moulds generally produce more wastes
		stitched technique very little waste is generated with this technique	
		cemented very little waste is generated with this technique	

material or waste	use as or produced by	comments and reasons why they appear	reduction
Leatherboard, Cellulose board, Non-woven (polyester), Leather.	insole	the cutting stage generates about 25%-35% of waste. This is particularly important when the labour cost is much higher than the one of the materials being cut. In practical terms, the operator is encouraged to do his best mainly with leather (bonus/malus on his wages, other incentive measure etc.) not with textile	This cutting rate can be reduced with the use of automatic cutting machines (water, laser etc.). With the latter, the cutting ratio can be reduced by 2 - 3 points
Leather, Coated fabrics (PU and PVC), Foams (EVA, PU, polyethylene (PE) natural rubber latex), Textile (nylon).	insock	‘’	‘’
Thermoplastic sheet type (polyamide, ABS, Surlyn, EVA), Impregnated fabrics, Fabric (polyester, cotton, nylon), Leather, Fibreboard.	reinforcement	‘’	‘’
Roughing dust or sludge	Cementing	• Before the sole is stuck on the upper, the latter must be prepared for adhesion. The roughing of the upper generated dust or sludge (when collected in a tank).	The only reduction is to avoid the collection in water. This is possible when the upper has no nail no metallic part
Bottom filler (cork/resin, foam), Shanks (metal, wood, plastic), Heels (polystyrene (PS), acrylonitrile butadiene styrene (ABS)), Eyelet, D rings, etc. (metal, plastic), Laces (leather, cotton, polyester, nylon) Threads (cotton, polyester, nylon), Top pieces (TPU, vulcanised rubber, PVC), Fasteners (metal, plastic, fabric).	miscellaneous	• these other components of a shoe are not solid waste as such • every 2 - 3 years, a footwear manufacturer can consider that these components are not going to be used anymore. In that case and if they cannot be sold, they become wastes	Two options are possible • the footwear manufacturer knows a footwear component retailer. The latter can often take most of the components and sell them to another country • the footwear manufacturer purchases most of its components on an order to order (just in time)

material or waste	use as or produced by	comments and reasons why they appear	reduction
During production steps	produced by		
Lacquers (nitro-cellulose, acrylic), waxes, dyes and oils.	finishing	• before being put into the box, the shoe must often be cleaned and prepared. Such liquids are used to give a good appearance to the product and usually bottoms of liquids become wastes. • In practice, such liquids are applied on town shoes	no particular way of reducing the quantity of liquid waste except the attention of the operator
Petroleum spirit, aqueous (mild detergent solutions).	cleaners	• the spray gun or brush used to apply the solvent based adhesives (cemented technique) need to be cleaned once a day. This operation is done with solvents which become “contaminated” and are discarded by the footwear manufacturer	• the manual application (in opposition with automatic spay application) of solvent based adhesives requires to clean the tools used by the operator. These tools generally dry quicker than the automatic ones. The use of machines reduce the drying of the tools and hence the need to clean them with solvents • the solvent based adhesive is progressively replaced by a water based adhesive. The tools can be easily washed with water and not with organic solvent. In this way, such waste can be avoided
Oil, Metallic spare parts Workshop sweepings	maintenance and cleaning activity	• maintenance activity means changing parts of machines which are out of order, etc. but also changing the oil of the cutting machines	• difficult to reduce
		• to sweep the workshops generates some wastes	• difficult to reduce

In quantitative terms, it is possible to provide some ratio per type of shoe, as shown in the Table 5.

Table 5: quantity of waste during footwear manufacturing

	Type of footwear					
	t of waste / million pairs					
Category of waste	men's town	women's town	children	casual and general sport	safety shoe	average shoe
upper and lining materials - leather (chrome and veg.	96.2	70.6	46.9	32.9	176.0	84.5
upper and lining materials - other material	23.1	24.4	20.2	36.2	133.9	47.6
upper manufacturing waste	0.6	0.6	0.3	0.3	0.6	0.5
insole and reinforcement materials - all materials	72.6	45.7	50.4	58.1	32.3	51.8
outsole preparation & cementing (footwear)	20.2	68.7	21.8	32.1	15.1	31.6
injection wastes	0.0	12.8	1.0	14.1	144.8	34.6
adhesives, oil, solvents ...	7.3	6.1	1.1	2.6	6.1	4.6
household type waste	13.1	12.7	10.5	6.8	10.9	10.8
total	233	242	152	183	520	266

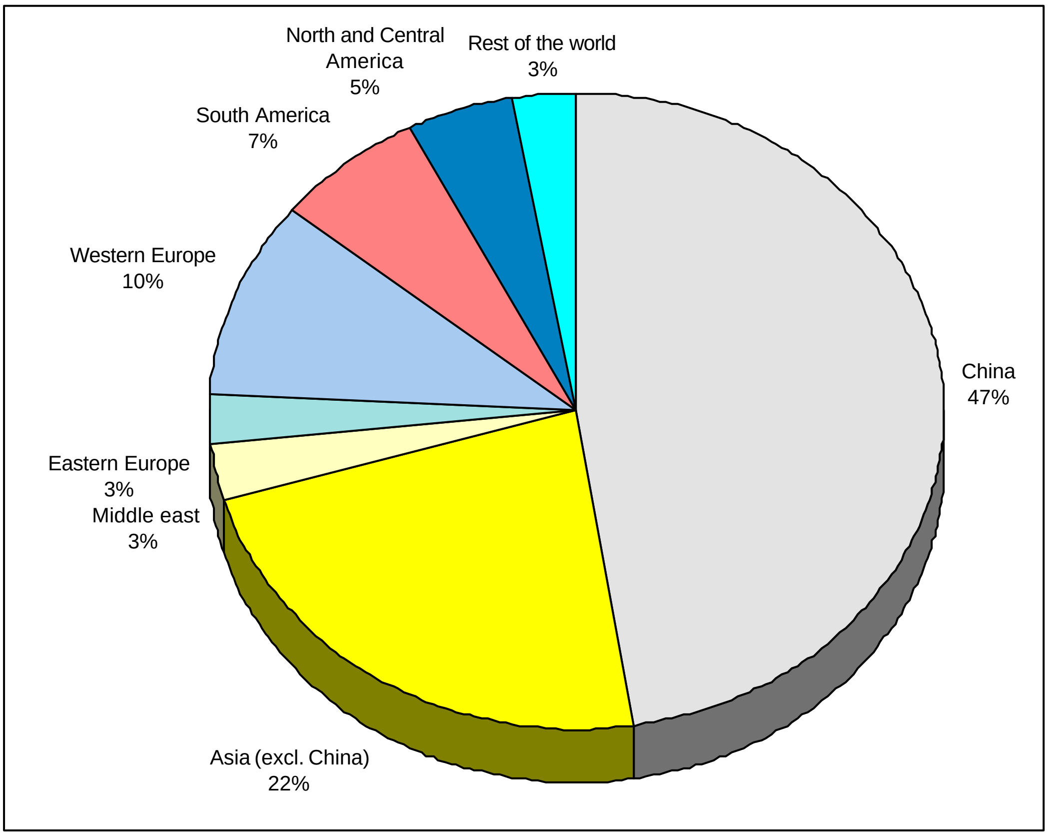
We notice that safety footwear which is heavier than the others generates a larger quantity of wastes.

Considering these ratios, and with the estimation of the world production of footwear(vii), it is possible to estimate the corresponding wastes (see Table 6 and Figure 5).

Table 6 : estimation of the wastes generated by the footwear manufacturing - world wide basis

			Footwear								
			China	Asia (excl. China)	Middle east	Eastern Europe	Western Europe	South America	North and Central America	Rest of the world	Total
production (million pairs)	1 997	Men's town, Wowen's town, children	2403.5	1168.9	131.6	131.6	500.9	349.1	227.7	146.7	5 060
	1 997	casual and general sports	926.3	450.5	50.7	50.7	193.1	134.6	87.8	56.6	1 950
	1 997	safety shoes	59.4	28.9	3.3	3.3	12.4	8.6	5.6	3.6	125
upper and lining materials - leather (chrome and veg.)		(tons/year)	212 131	103 163	11 611	11 611	44 213	30 815	20 097	12 951	**446 592**
upper and lining materials - other		"	95 699	46 540	5 238	5 238	19 946	13 901	9 066	5 843	**201 471**
upper manufacturing waste		"	1 501	730	82	82	313	218	142	92	**3 160**
insole and reinforcement materials -		"	190 881	92 828	10 448	10 448	39 784	27 728	18 083	11 654	**401 854**
outsole preparation & cementing (footwear)		"	119 253	57 995	6 528	6 528	24 855	17 323	11 298	7 281	**251 060**
injection wastes		"	32 788	15 945	1 795	1 795	6 834	4 763	3 106	2 002	**69 028**
adhesives, oil, solvents		"	14 334	6 971	785	785	2 988	2 082	1 358	875	**30 177**
household type waste		"	36 105	17 558	1 976	1 976	7 525	5 245	3 420	2 204	**76 010**
total		"	**702 692**	**341 730**	**38 463**	**38 463**	**146 456**	**102 075**	**66 571**	**42 901**	**1 479 351**

Figure 5 : wastes generated by the footwear manufacturing - % of world areas



4.5 Leather goods

As for the footwear industry, the leather good production is varied: the materials involved can be very different. The type and the size of the product of the products can be very different too.

It is then necessary to present the waste ratios per type of leather goods product.

4.5.1 Scope

The present report covers handbags, leather luggage, suitcases and technical items, small leathergoods items.

4.5.2 Methodology

The CTC conducted 2 years ago a complete waste audit in 2 leather goods manufacturing plants. In addition to that, the CTC has questioned by telephone approximately 12 different leather goods factories, in order to know the nature and quantity of waste being produced: it has been very difficult to determine the ratio for each nature of waste. On the contrary it was possible to know the global quantity of waste.

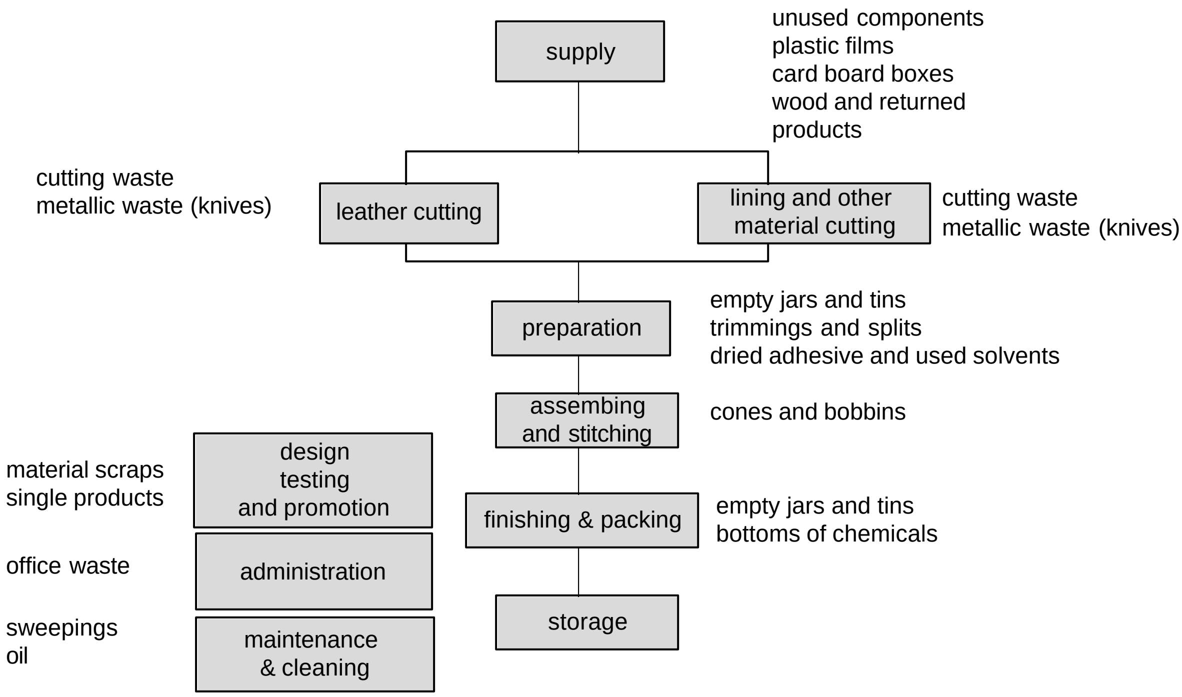
Leather goods process stages are comparable to footwear. The footwear process has been taken as a reference for the leather goods process stages except for lasting. The proportion by nature of waste known in the footwear process have been applied to the global quantities of waste declared by the leather goods manufacturer.

The ratios provided hereafter can be considered as acceptable.

4.5.3 Standard manufacturing process

The complete standard process of leather goods manufacture is presented in the Figure 6.

Figure 6 : complete standard leather goods manufacturing process



4.5.4 Wastes generated by the leather good industry

In this process, the wastes generated are listed in the Table 7 and quantified in the Table 8 and the Figure 7.

Table 7: materials and chemicals processed during leather goods manufacturing, reasons why they are produced and possible ways of reducing them

material or waste	**use as or produced by**	**comments and reasons why they appear**	**reduction**
Leather, textile (cotton, polyester, nylon), coated fabrics (PU and PVC)	outside material and lining	the pieces to be used as component in the product are cut in leather and other materials. The upper material can be PVC coated textile too. Generally, the average cutting rates are • leather - hand bags : 20 - 40 % - small items : 20 - 25 %. This ratio can raise up to 30 % with sheep skins - luggage (travel etc.) : 50 - 60 % - wrist watch : 30 - 40 % - suitcase : 40 % - belt : 20 -25 % • textile and fabrics : 20 - 25 %	• the cutting ratio in leather is generally being optimised by the operators • In less expensive material, the ratio can vary from one country to the other. The only criterion is the optimisation between labour cost and material cost
Impregnated fabrics, Fabric (polyester, cotton, nylon), Leather, Fibreboard.	reinforcement	Unlike the footwear industry, this industry is using more cellulose compounds than leatherboard. The latter is less efficient with thin sheets. The cutting rate is about 25%-35%. This is particularly important when the labour cost is much higher than the one of the materials being cut. In practical terms, the operator is encouraged to do his best mainly with leather (bonus/malus on his wages, other incentive measure etc.)	This cutting rate can be reduced with the use of automatic cutting machines (water, laser etc.). With the latter, the cutting ratio can be reduced by 2 - 3 %
Eyelet, D rings, etc. (metal, plastic), Laces (leather, cotton, polyester, nylon) Threads (cotton, polyester, nylon), Fasteners (metal, plastic, fabric).	miscellaneous	• same as footwear	• same as footwear

During production steps

Lacquers (nitro-cellulose, acrylic), waxes, dyes and oils	Finishing	• same as footwear	• same as footwear
Petroleum spirit, aqueous (mild detergent solutions).	Cleaners	• same as footwear. However, the type of adhesive is different: leathergoods manufacturers often use water based adhesives which reduces the global impact to the environment	• same as footwear
Oil, Metallic spare parts Workshop sweepings	maintenance and cleaning activity	• same as footwear	• same as footwear
		• same as footwear	• same as footwear

Table 8: quantity of waste during leather goods manufacturing

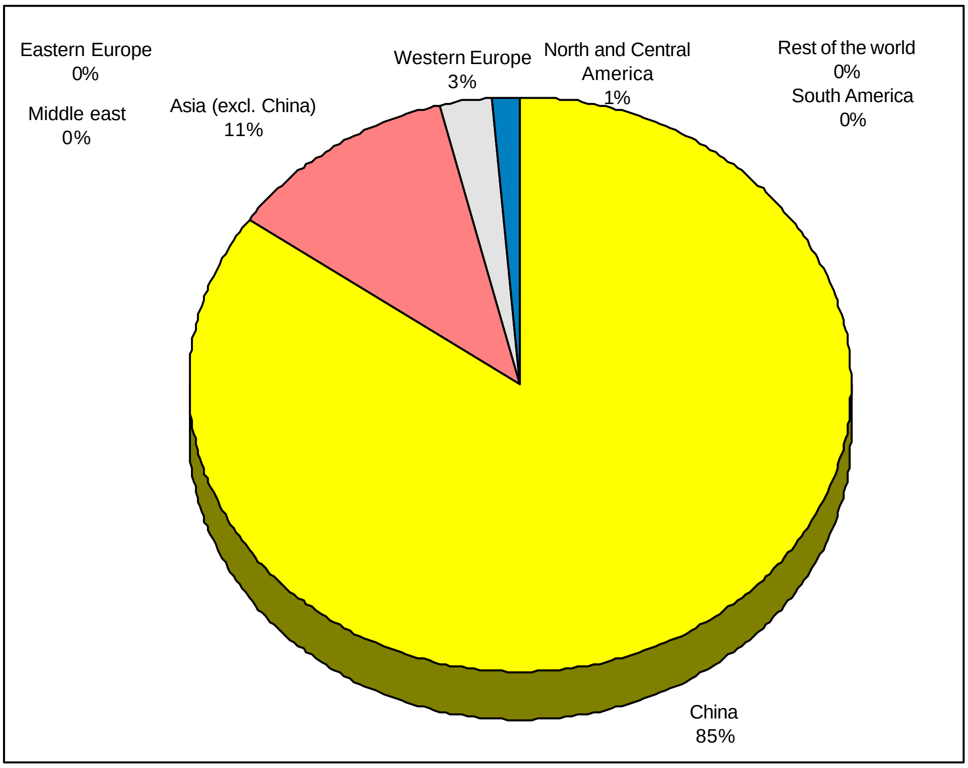
	Leathergood					
	t of waste / million pieces					
	Hand bag	Leather luggage	Suitecases, technical bags	Small leathergood items	Belt	Average leathergood
upper and lining materials - leather (chrome and veg.)	362.6	207.1	13.1	96.3	19.7	139.8
upper and lining materials - other material	66.4	95.7	42.7	33.4	0.2	47.7
reinforcement materials - all materials	37.7	66.3	10.3	10.7	0.4	25.1
adhesives, oil, solvents ... (approx. 2% of upper mat.)	4.8	4.8	4.8	1.8	0.4	3.3
household type waste (approx. 7% of upper mat.)	14.8	14.5	5.3	9.2	0.0	8.8
total	486	388	76	152	21	224.6

Table 9 : estimation of the wastes generated by leather goods manufacturing - world wide basis

			Leathergoods								
			China	Asia (excl. China)	Middle east	Eastern Europe	Western Europe	South America	North and Central America	Rest of the world	Total
exports (million pieces)	1 997	hand bags	24.3	17.2		0.1	3.6		0.9		46
	1 997	luggage, suitecases, technical bags	84.5	2.2			0.3		2.8		90
	1 997	small items	278.2	26.2					0.4		305
	1 997	belts	1 157.1	0.9			62.9		15.7		1 237
upper and lining materials - leather (chrome and veg.)		(tons/year)	67 711	9 039		48	2 559		966		**80 323**
upper and lining materials - other		"	16 985	2 174		9	267		267		**19 702**
reinforcement materials - all materials		"	7 611	1 016		5	170		150		**8 953**
adhesives, oil, solvents ... (approx. 2% of upper mat.)		"	1 495	142		1	43		25		**1 706**
household type waste (approx. 7% of upper mat.)		"	3 767	519		2	55		44		**4 387**
total		"	**97 569**	**12 891**		**65**	**3 095**		**1 452**		**115 071**

The information provided by the customs data base is unfortunately incomplete. For most of the countries, it was impossible to find data, in tons or in number of pieces. Moreover, the data deals with exports and not production.

Figure 7 : wastes generated by leather goods manufacturing - % of world areas



4.6 Garments

The leather garment industry is very difficult to know. The companies are small and the manager is generally not in favour of giving information. So we contacted the CETIH [3] which is similar to CTC in the garment industry. This centre has very little information concerning leather garments.

This is why we followed an analytical approach which is detailed in the paragraph “4.6.2 Methodology ”.

4.6.1 Scope

The present study covers jackets, skirts and trousers. The gloves are detailed in a specific chapter. The belts could considered as leather goods (see the relevant chapters)

4.6.2 Methodology

It has been difficult to get information on real cases. The methodology was to find:

- the average cutting rate for leather garments
- the average weight of a leather garment
- the proportion for each material in a leather garment

and to combine them.

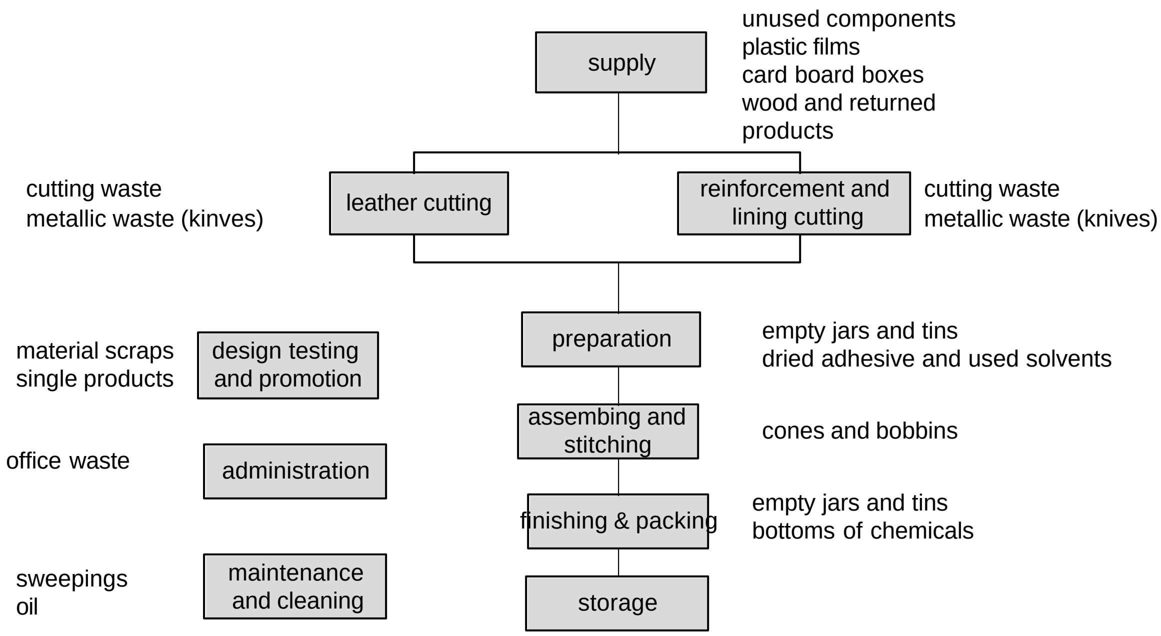
3 Centre d'Etudes Techniques des Industries de l'Habillement

The quantitative estimations are presented in the Table 11. These ratios have not been compared to the reality; they have to be considered as estimations.

4.6.3 Standard manufacturing process

The complete standard process of garment manufacture is presented in the Figure 6.

Figure 8 : complete standard garment manufacturing process



4.6.4 Wastes generated by the garment industry

In this process, the wastes generated are listed in the Table 10 and quantified in the Table 11.

The two major differences with leathergood are

- the number of materials in garments are much lower,
- the pieces to be assembled are less prepared (splitting, skiving, cementing, thermo-adhesive reinforcement etc.),
- the leather is generally supplied at the right thickness. The manufacturer does not need to split the pieces.

Table 10: materials and chemicals processed during garment manufacturing, reasons why they are produced and possible ways of reducing them

material or waste	**use as or produced by**	**comments and reasons why they appear**	**reduction**
Leather, textile (cotton, polyester, nylon), coated fabrics (PU and PVC)	outside material and lining	the pieces to be used as components in the product are cut in leather and other materials. Leather garments are mainly made out of leather 80-90 % (in weight). It can be even 95 %. Lining (polyamide, polyester, cotton) represents about 7-12 % in weight. The lining is generally made out of polyester and polyamide. The weight of this material is 70 g/m² (trousers) to 100-150 g/m² (jacket-coat). This weight has to be compared with leather in garment (~680 g/m²). The average cutting rates are • leather in high quality (lamb) : 50-60 % - • textile and fabrics : 20 - 25 %	• the cutting ratio in leather is always being optimised by the operators • In less expensive material, the ratio can vary from one country to the other. The only criterion is the optimisation labour cost versus material cost
other wastes	same as for leathergoods	same as for leathergoods To maintain its productivity during this assembling stage, this industry is using more thermo-adhesive reinforcements than other industries.	• same as for leathergoods

Table 11: quantity of waste during garments manufacturing

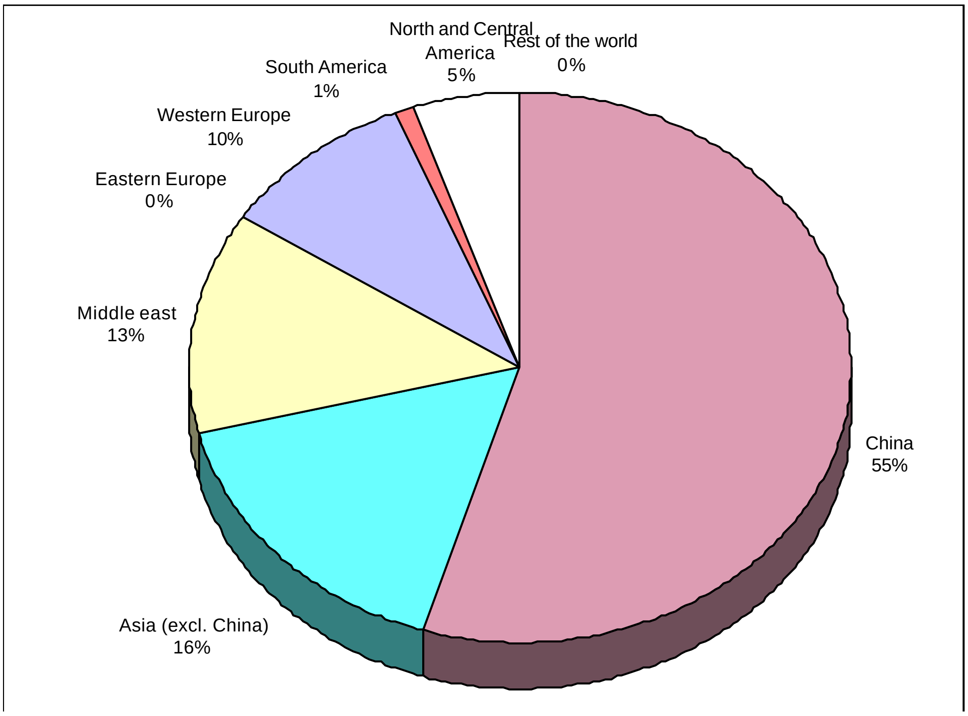
	Garment			
	t of waste / million pieces			
	Jacket	Skirt	Trousers	average garment
upper and lining materials - leather (chrome and veg.)	955.5	202.1	279.9	479.2
upper and lining materials - other material	103.4	21.9	30.3	51.9
reinforcement materials - all materials	33.1	7.0	9.7	16.6
adhesives, oil, solvents ... (approx. 2% of upper mat.)	21.2	4.5	6.2	10.6
household type waste (approx. 7% of upper mat.)	66.9	14.1	19.6	33.5
total	1 180	250	346	591.8

Table 12 : estimation of the wastes generated by garment manufacturing - world wide basis

			Garment								
			China	Asia (excl. China)	Middle east	Eastern Europe	Western Europe	South America	North and Central America	Rest of the world	Total
exports (million pieces)	1 997	leather	45.2	14.0	10.0		6.7		3.6		80
		double face	2.2	0.1	1.1		1.7	0.9	0.9		7
upper and lining materials - leather (chrome and veg.)		(tons/year)	22 728	6 763	5 348		4 011	428	2 156		**41 434**
upper and lining materials - other		"	2 460	732	579		434	46	233		**4 484**
reinforcement materials - all materials		"	787	234	185		139	15	75		**1 435**
adhesives, oil, solvents ... (approx. 2% of upper mat.)		"	504	150	119		89	9	48		**918**
household type waste (approx. 7% of upper mat.)		"	1 591	473	374		281	30	151		**2 900**
total		"	**28 069**	**8 353**	**6 605**		**4 954**	**528**	**2 663**		**51 172**

The information provided by the customs data base is unfortunately incomplete. For most of the countries, it was impossible to find a data, in ton or in number of pieces. Moreover, the data deal with exports and not with production.

Figure 9 : wastes generated by garment manufacturing - % of world areas



4.7 Gloves

4.7.1 Methodology

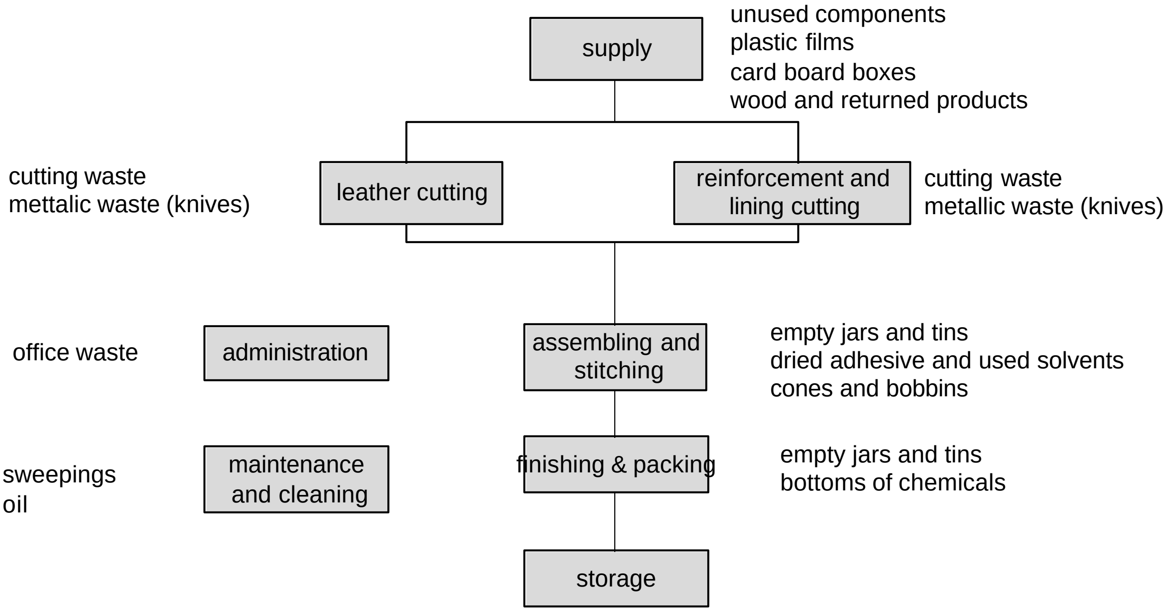
Data was obtained by questioning some professionals in this sector in order to know accurately their cutting rate, the nature of the material cut and the average weight of a pair of gloves.

The ratios provided in this chapter refer to an "average" pair of gloves. The weight of a glove can vary from 1 to 10. The average pair of gloves taken here as a reference is 0.200 kg/pair of safety gloves and 0.070 kg/pair of town gloves. This information will enable UNIDO to estimate the quantity of waste referring to the number of pieces or to the total weight of the goods.

4.7.2 Standard manufacturing process

The complete standard process of glove manufacture is presented in the Figure 6.

Figure 10 : complete standard glove manufacturing process



4.7.3 Wastes generated by the glove industry

In this process, the wastes generated are listed in Table 13 and quantified in the Table 14.

Table 13: materials and chemicals processed during glove manufacturing, reasons why they are produced and possible ways of reducing them

material or waste	use as or produced by	comments and reasons why they appear	reduction
Leather, textile (cotton, polyester, nylon), coated fabrics (PU and PVC)	outside material and lining	the pieces to be used as component in the product are cut in leather and other material lane. Besides leather which represents 90% of the material being cut, the lining material can be: cotton, kevlar, wool or nylon (in particular when applied in the car manufacturing plants) The average cutting rates regarding leather are • town glove : 40 - 50 % The reason of such a high value is that the cutting process is completed in two separate steps (preparation of a "block" after trimmings and then cutting in the block) which both generate solid wastes • safety glove : 30 - 40 %	• the cutting ratio in leather is always being optimised by the operators • In less expensive material, the ratio can vary from one country to the other. The only criterion is the optimisation labour cost versus material cost
other wastes	same as for leathergood	same as for leathergoods To maintain productivity during this assembling stage, this industry is using more thermo-adhesive reinforcements than other industries.	• same as for leathergoods

Table 14: quantity of waste during glove manufacturing

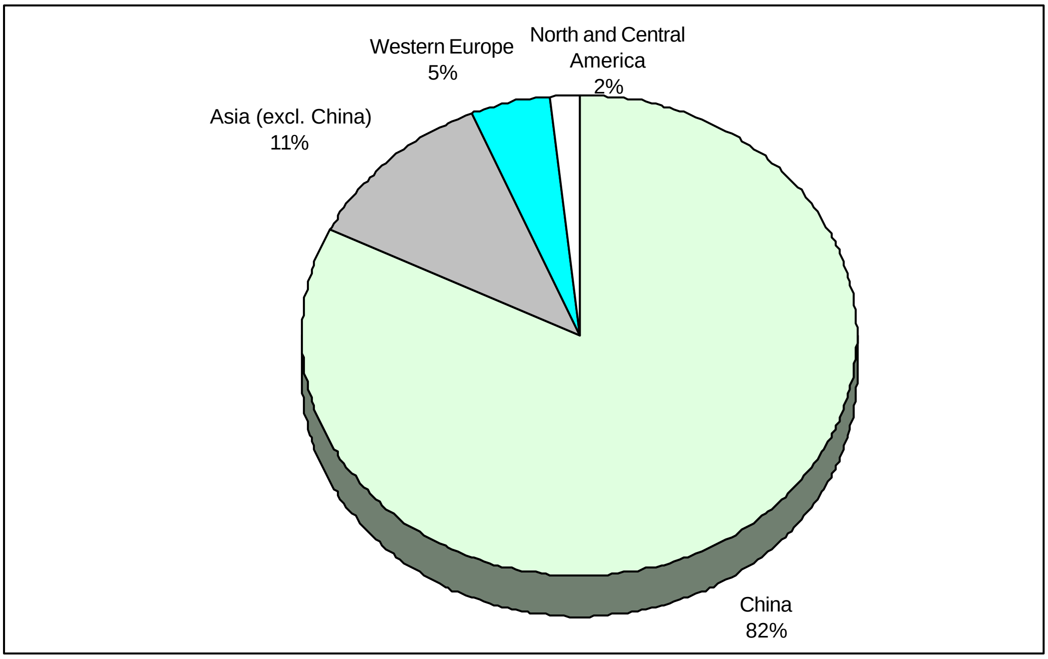
	Gloves		
	t of waste / million pairs		
	Safety	Town	average glove
upper and lining materials - leather (chrome and veg.)	63.0	32.6	47.8
upper and lining materials - other material	3.5	1.8	2.6
reinforcement materials - all materials	3.5	0.7	2.1
adhesives, oil, solvents ... (approx. 2% of upper mat.)	1.3	0.7	1.0
household type waste (approx. 7% of upper mat.)	4.4	2.3	3.3
total	76	38	56.9

Table 15 : estimation of the wastes generated by footwear manufacturing - world wide basis

			Gloves								
			China	Asia (excl. China)	Middle east	Eastern Europe	Western Europe	South America	North and Central America	Rest of the world	Total
exports (million pieces)	1 997	sport gloves		53.5			0.8		0.4		55
		other gloves	488.6	14			27		10		540
upper and lining materials - leather (chrome and veg.)		(tons/year)	23 343	3 234			1 349		497		**28 423**
upper and lining materials - other		"	1 283	178			74		27		**1 562**
reinforcement materials - all materials		"	1 032	143			60		22		**1 256**
adhesives, oil, solvents ... (approx. 2% of upper mat.)		"	493	68			28		10		**600**
household type waste (approx. 7% of upper mat.)		"	1 634	226			94		35		**1 990**
total		"	**27 784**	**3 849**			**1 606**		**592**		**33 831**

The information provided by the customs data base is unfortunately incomplete. For most of the countries, it was impossible to find data, in tons or in number of pieces. Moreover, the data deal with exports and not with production.

Figure 11 : wastes generated by glove manufacturing - % of world areas



4.8 Furniture and Upholstery

4.8.1 Methodology

As for gloves, it has been difficult to know from the manufacturing plants the total quantity of waste produced by furniture or upholstery manufacturers.

The method consisted of determining:

- how much leather used in such products
- the kind of leather is used (in particular its weight kg/m²)
- the average cutting rate for furniture and upholstery
- the other materials used in such products

and to combine this information.

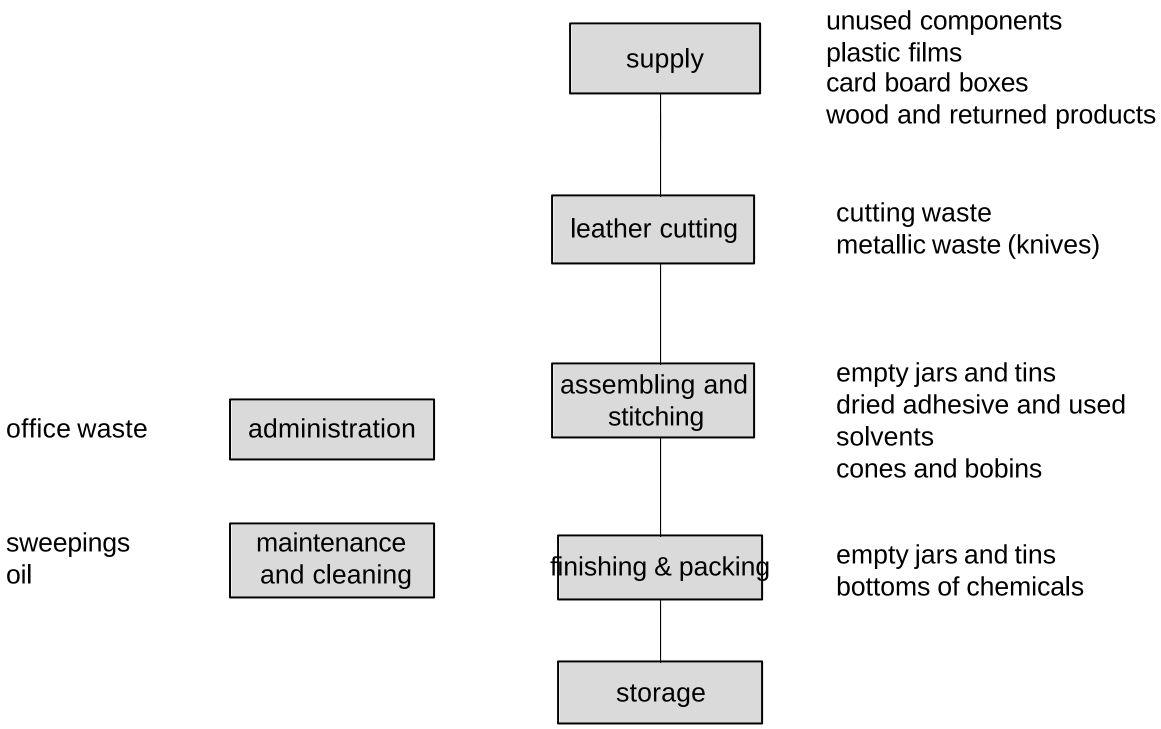
The quantitative estimations are presented in the table 17 (furniture) and in the table 18 (upholstery).

Unfortunately, we could not compare these ratios to the reality so they have to be considered as estimations.

4.8.2 Standard manufacturing process

The complete standard process of furniture or upholstery manufacture is presented in the Figure 12.

Figure 12 : complete standard furniture or upholstery manufacturing process



4.8.3 Wastes generated by the furniture or upholstery industry

In this process, the wastes generated are listed in Table 16 and quantified in the Table 17.

Table 16: materials and chemicals processed during Furniture and Upholstery manufacturing, reasons why they are produced and possible ways of reducing them

material or waste	use as or produced by	comments and reasons why they appear	reduction
Leather, textile (cotton, polyester, nylon), coated fabrics (PU and PVC)	outside material and lining	The average cutting rates are the following • furniture - high quality (aniline type finishing, natural leather): 35-40% - middle quality (coated leather, pigmented leather): 25-35 % • upholstery - seat high quality: 35-40% - seat middle quality: 25-30 - doors, dash-board and other parts: 35-40% ; the cutting rate is higher because these parts have a peculiar shape and are often large pieces	• the cutting ratio in leather is always being optimised by the operators. However, in one big French furniture company, with the implementation of an automatic cutting machine and a better combination of different parts to be cut, the cutting rate imp roved by 3-4 points and in some case 8 points. • In less expensive material, the ratio can vary from one country to the other. The only criterion is the optimisation labour cost versus material cost
other wastes	same as for leathergoods	same as for leathergood To maintain its productivity during this assembling stage, this industry is using more thermo -adhesive reinforcements than other industries.	• same as for leathergoods

Table 17: quantity of waste during furniture manufacturing

	Furniture		
	t of waste / million pieces		
	1 seat	2 seats	3 seats
upper and lining materials - leather (chrome and veg.)	2 180.8	2 907.7	3 949.6
upper and lining materials - other material	256.6	342.1	464.7
reinforcement materials - all materials	15.1	20.1	27.3
adhesives, oil, solvents ... (approx. 2% of upper mat.)	48.7	65.0	88.3
household type waste (approx. 7% of upper mat.)	152.7	203.5	276.5
total	2 654	3 538	4 806

Table 18: quantity of waste during upholstery manufacturing

	Upholstery
	t of waste / million pieces
	1 seat
upper and lining materials - leather (chrome and veg.)	423.9
upper and lining materials - other material	49.9
reinforcement materials - all materials	2.9
adhesives, oil, solvents ... (approx. 2% of upper mat.)	9.5
household type waste (approx. 7% of upper mat.)	29.7
total	516

It has been impossible to get information on either the production or the trade regarding furniture or upholstery. Hence, the quantities of wastes generated by this industry has not been estimated.

5. COMPILATION ON A WORLD-WIDE BASIS

5.1 All wastes

As already mentioned, the information provided as a basis for wastes estimation by the customs data base is unfortunately incomplete.

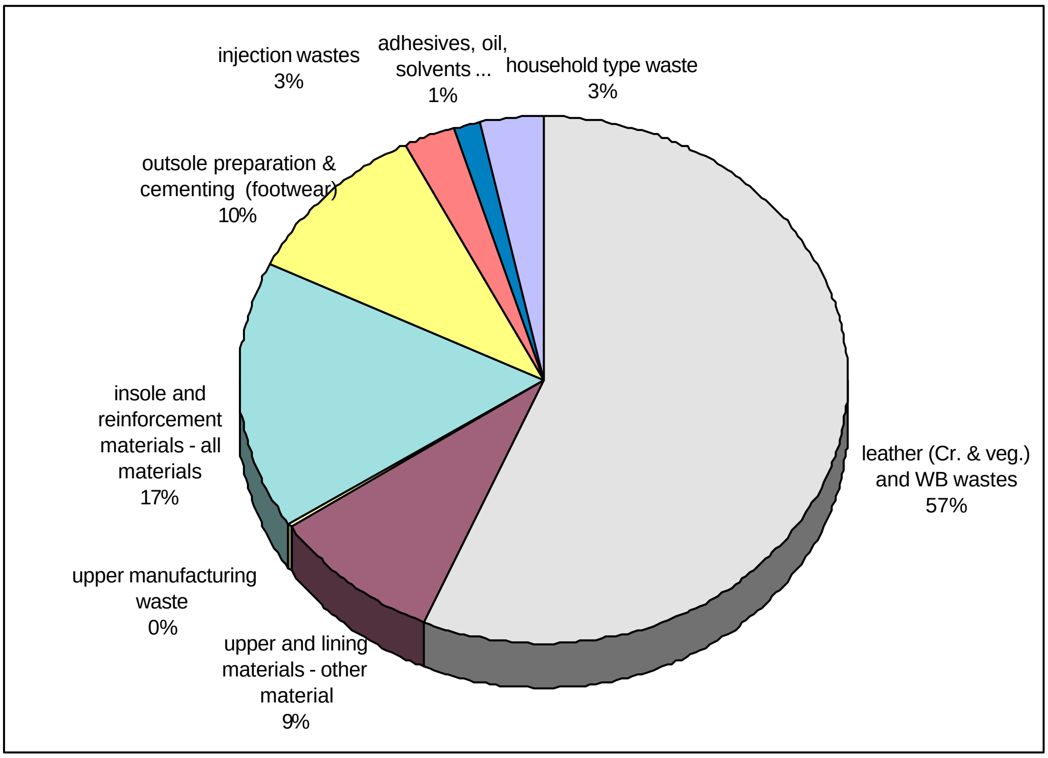
For most of the countries, it was impossible to find a data on finished products in tons or in number of pieces. Moreover, the available data deal with exports and not with production.

The Table 19 and the Figure 13 summarise the total quantity of waste produced by the leather and leather products sector. It is very difficult to distinguish the different materials used in the finished products (second line of the Table 19); in fact they all depend on the production technology and the materials used which often depend on the fashion.

Table 19: compilation of all wastes generated by the leather and leather products sector

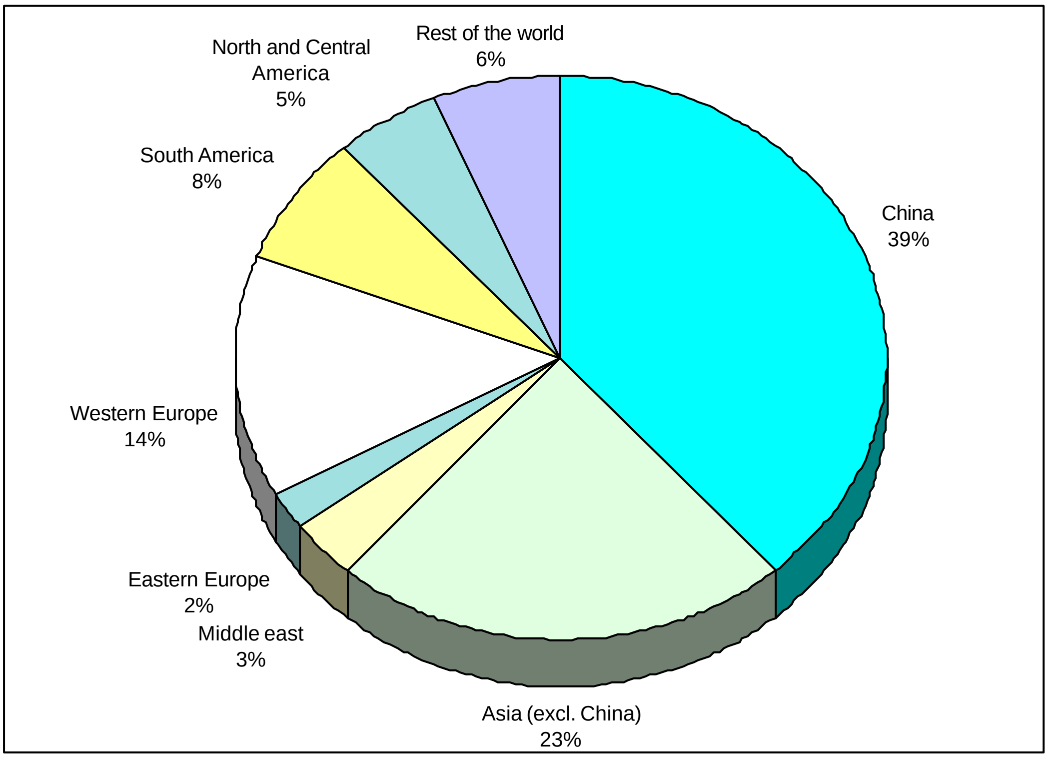
			Leather & all leather finished products								
			China	Asia (excl. China)	Middle east	Eastern Europe	Western Europe	South America	North and Central America	Rest of the world	Total
leather (Cr. & veg.) and WB wastes		(tons/year)	431 111	317 519	54 481	29 923	238 966	118 468	83 734	128 228	**1 402 429**
upper and lining materials - other		"	116 426	49 623	5 817	5 247	20 721	13 948	9 594	5 843	**227 219**
upper manufacturing waste		"	1 501	730	82	82	313	218	142	92	**3 160**
insole and reinforcement materials -		"	200 311	94 222	10 633	10 453	40 152	27 743	18 330	11 654	**413 498**
outsole preparation & cementing (footwear)		"	119 253	57 995	6 528	6 528	24 855	17 323	11 298	7 281	**251 060**
injection wastes		"	32 788	15 945	1 795	1 795	6 834	4 763	3 106	2 002	**69 028**
adhesives, oil, solvents		"	16 826	7 331	903	785	3 148	2 092	1 441	875	**33 401**
household type waste		"	43 096	18 777	2 351	1 978	7 955	5 275	3 650	2 204	**85 287**
total		"	**961 312**	**562 142**	**82 589**	**56 791**	**342 944**	**189 829**	**131 296**	**158 178**	**2 485 082**

Figure 13 : compilation of all wastes generated by the leather and leather products sector (graphic view)



The following picture only deals with the wet blue and leather scraps production on a world wide basis.

Figure 14 : wastes generated by the leather and leather products sector - % of world areas



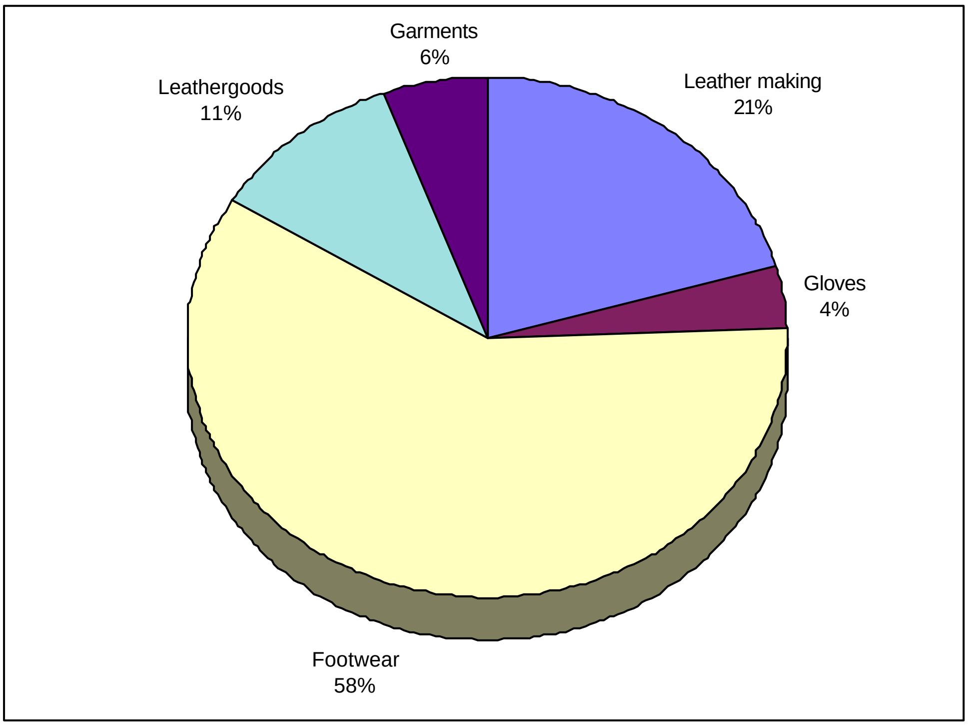
5.2 Dry and finished leather scraps

The Table 20 and the Figure 15 present the proportion for each industry regarding the production of dry leather scraps.

Table 20 : Dry and finished leather scraps produced by all industries - world-wide basis

dry and finished leather scraps generated by each industry			
Leather making			154 436
Gloves			28 423
Footwear			446 592
Leathergoods			80 323
Garments			41 434
			751 209

Figure 15 : Dry and finished leather scraps produced by all industries - world-wide basis



The footwear industry seems to be generating the largest quantity of dry leather and finished wastes. This means that footwear is the sector on which actions (if any) should apply first.

6. WASTE MANAGEMENT

6.1 Priorities in waste management

To improve the waste management, first of all, the following steps should be followed (see Figure 16):

Figure 16: steps to improve the waste management

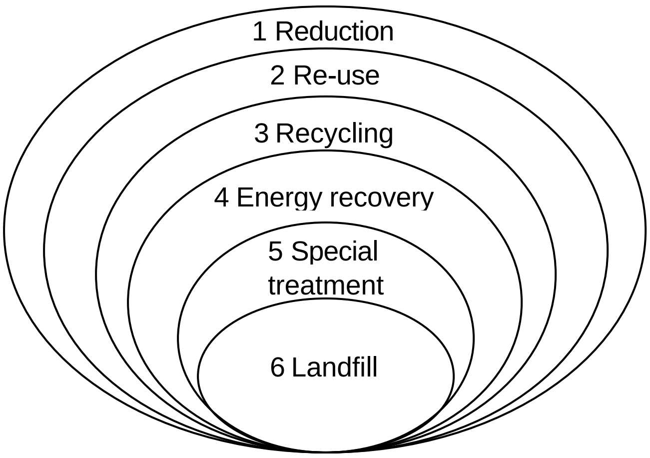


Table 21 : explanations for the Figure 16 and current practices ; ideally, all manufacturers should follow the 6 steps detailed in this table

	Explanations	**Current practices in the leather product industry**
Step 1	Quantity of waste generated can be reduced : • material scraps, • packaging which are too small and too numerous, A special attention is paid on the production of scraps at an early stage (see the paragraph "6.5 Ways of reducing the toxicity of leather scraps (early geometrisation)").	Material scraps • The finished product manufacturers are not aware of their cutting rates in leather. They only pay attention to the allocation ratio (for accounting, planification and purchase purposes) which is quite different. The cutting rate refers to the real surface they throw away. • The allocation rate is generally lower than the cutting rate as it is calculated on the basis of the relative surface occupied by a piece to be cut. Packaging • when they have the possibility to recycle the drums, some companies purchase their solvents and adhesives in greater metallic packaging. Automatically, this practice reduces the quantity of packaging.
Step 2	The wastes/packaging can be re-used, like: • cardboard boxes, • empty thread cones, • some tins	Most of the footwear companies having the components made in other companies do re-use part c their cardboard packaging. They either send the unuse packaging for recycling or dump them into landfills. In order to re-use the cones and some tins, the supplier must be in the same geographical area. This is now scarcely the case so very few manufacturers do this. In general, these wastes are sent to a landfill.

	Explanations	Current practices in the leather product industry
Step 3	Waste can be recycled inside or outside the company : • leather, • thermoplastics and RIM PU, • cotton textile, • metallic pieces, • solvents, • oil, • paper and cardboard	• Cr leather: sent to landfill or to a household waste incinerator, • Veg. leather: landfill or leatherboard making • pure cotton: recycled in cotton compounds (automobile, thermal insulators etc.) or sent to landfill • other materials: landfill • solvent: evaporation, burning in the courtyard, destruction in specialised units, scarcely recycled • oil: burnt in the courtyard, recycled in specialised units, burnt in some specific applications
Step 4	Waste can be incinerated with energy recovery such as : • leather, • “off” specification materials • compounds which cannot be recycled, • coated fabrics (multi-layer material with/without PU foam), • “off” specification components or shoes.	• in some cases, these wastes are either sent to a municipal incinerator (mixed with domestic wastes) or to landfill • a household waste incinerator is scarcely designed to produce energy. In fact it is designed to destroy the wastes; the company operating the incinerator is generally not interested in the thermal content of the synthetic materials.
Step 5	For, hazardous waste for which no other solution exists, a special treatment is needed for : • dried adhesives residues, • bottoms of chemicals (finishing, used solvents etc.), • jars, tins and drums containing product residues (adhesive etc.).	• the dried adhesives are generally sent to landfill • the bottoms of chemicals are left in the tins and drums and sent to landfill as such • the empty metallic packaging are usually sent to landfill; sometimes, they are recycled when they are accepted by recycling company

	Explanations	Current practices in the leather product industry
Step 6	When no solution can be applied for solid wastes, the manufacturer has to consider landfilling. In most developed countries, landfilling is now considered as the last solution, which should be applied to a small amount of wastes. Now regulations generally require controlled landfilling which means that the emissions of the landfill must controlled and treated before being discharged to the environment.	Unfortunately, the current practice world-wide for most of the wastes is landfilling. With this practice, one big issue is to know whether the landfill emissions to the environment (leachates, gazes) are correctly controlled.

6.2 Current costs in wastes management

It is very difficult to provide a global image of the costs related to each practice; each country has its own costs and regulations. The major common point is: the costs regarding landfilling is the lowest everywhere.

In France, the global landfilling cost (container renting, transportation, landfilling) is approximately 100 Euro/ton and is raising under the pressure of lobbies and regulations.

On the other side in Europe, the treatment of hazardous solid wastes costs about 300-400 Euro/ton.

The recycling of material like cotton, cardboard, metallic parts can be profitable or not. This business depends very much on the world market. If the prices are low, the finished product manufacturer in Europe can pay up to 30-50 Euro/ton.

6.3 Classification

Usually, most of the wastes generated by the footwear industry are classified as non hazardous (except for oil, solvent, solvent adhesive and finishing products).

The Organisation for Economic Co-operation and Development (OECD)[4] has established internal rules[viii] in order to improve the control of solid waste trans-national transfers. In particular, it regularly updates three lists of waste:

- "green" list — the companies involved in that business only need to conform to commercial requirements with respect to their transnational transfers
- "amber" list — the holder and the recipient of the goods are required to inform their local or national environment administration concerning the commercial transaction
- "red" list — the trans-national exchanges have to be formally approved by the administrations of both countries.

4 is based in Paris-France. Mexico joined OECD in 1994

Regarding the leather sector, the OECD considers that leather, plastic, textile etc. are to be included on the green list. On the other hand, leather dust and sludge are included on the "amber" list.

6.4 Methodological tool

Within the CEN[5] system, a Technical Committee dealing with footwear (n° TC 309) has prepared a standard[6] entitled :

"Footwear manufacturing waste. Waste classification and management".

As a "tool", this experimental standard is intended to help the footwear manufacturer to have a clearer view of his waste management. This standard can be used to compare his situation year by year or with other manufacturers using the same standard. This standard should be published during the 3rd trimester of the current year.

When applying this standard, the footwear manufacturer should be able to produce results as in the Table 22.

Table 22: Expression of results according to the ENV 12940 CEN standard

		Ratio (kg / 1 000 pairs) per type of waste management practices (Average weight of the representative pair: 1,5 kg)							
List of solid or liquid waste		**A**	**B**	**C**	**D**	**E**	**F**	**G**	
Waste code	Waste name	Reuse as it is	Recycle within or outside the company (specify)	Incinerate with energy recovery	Special destruction treatment (specify)	Controlled landfill	Incinerate without energy recovery	Others (specify)	Total
xxx	Waste 1				3				3
yyyy	Waste 2		30	1	12	4	1		48
	Waste 3		10	1	5	5	1		22
	Waste 4	15	20	5	10	1	25		76
	…								
	Total	15	60	7	30	10	27		149

NOTE: The figures in the table are provided as ***examples****.*

The advantage of this standardised presentation is to provide internal ratios which can be compared to previous years, to other companies, to component suppliers etc. It can also be a basis to start waste management costs accounting.

In this table, recycling is one approach to manage the waste. The following chapters will develop on a technical point of view the recycling solutions[ix][x] which could be applied to the specific wastes of the finished products manufacturing.

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5 Comité Européen de Normalisation. At the European level, the equivalent of ISO at the international level

6 n° ENV 12940, which is an experimental standard

6.5 Ways of reducing the toxicity of leather scraps (early geometrisation)

With European partners (research institutes, industries of the leather sector, machinery makers), the CTC has just completed a 24 month CRAFT[(7)] project aiming to develop a cutting system able to "geometrise" the raw hides. The objective of this approach is to generate the solid wastes at the earliest possible stage. This means that the best place is in the tanneries, before the beamhouse stage.

Practically the geometrisation consists in a automatic (CD camera + water jet cutting) trimming device. Thanks to a specific software, the width to be cut at the side of the hide/skin is optimised; the size of the trimmings are automatically calculated according to the area of the hide/skin itself (belly etc.).

In this way, the trimmings contain less chemicals (raw hide) and can be easily recycled. In the whole leather processing chain, the minimum quantity of chrome containing wastes can then be generated. The conclusion of the project has been presented at the latest IULTCS congress in Chennai[(8)]:

"The work completed has made possible to:

- *Define early geometrisation principles that can be generalised for the entire line of leather products.*
- *Reveal geometrisation principles that guarantee a right material return. This point is crucial for the project since it guarantees its economic importance.*
- *Carry out the complete study of the prototype according to constraints that are particularly significant in terms of speed and environment.*
- *Manufacture a cutting prototype.*
- *Develop the contour optimisation software, on the basis of modelling.*
- *Integrate the prototype into the software and start the trial and development period.*

In conclusion, an early geometrisation of hides is possible by hand cutting or with a machine. This can induce profit and this is the best way to reduce waste at every production stage."

In this way, both tanners and product manufacturers can gain because they only process the right part of the hide/skin. At the end also, the environment is getting profit because the industry is generating wastes that can be more easily recycled.

6.6 The recycling of leather

Technically, we have to remember that leather used in finished products has been dyed, fat liquored and finished (coated). In other words, some recycling techniques (e.g. leatherboard) which could operate with tanning wastes (blue shavings) are not applicable to finished leather.

Due to its chromium content and environmental regulation[(xi)], few solutions can be applied to chrome tanned leather.

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7 Ref CR-2125, from January 1997 to December 1998, Coordinated by CTC

8 former Madras, India

The solutions hereafter presented have been applied to finished leather scraps with a technical but not always with commercial success.

6.6.1 Incineration in a special furnace: Bubbling fluidized bed (xii) (xiii) (xiv)

Before being introduced into the furnace, the leather wastes are ground down to 10-12 mm. Then a special pneumatic feeding system introduces the scraps at the right place into the furnace.

A fluidized bed is created by blowing air under pressure through sand set in the base of the combustion chamber. The upward flow of air via distributor plates set at the bottom of the bed creates a movement maintaining the grains in suspension. As the grains are continuously moving in the chamber, a constant temperature (400-500 °C) is easily maintained across the whole bed. A post combustion chamber at 850°C and an average dwell time of 2 seconds forces the organic gases to burn completely.

Advantages	Disadvantages	Com. success?
• Leather can be mixed with other materials • Energy can be recovered • Ashes approximately contain - 45 % of SiO_2 - 32 % of Cr_2O_3 (trivalent chromium) - 0.01 % of Cr VI (hexavalent chromium) Chromium III is not converted into Chromium VI • Both chromium and energy can be recovered. • Environmentally acceptable (on the long term) as chromium is concentrated, isolated and can be treated separately	• Sophisticated technology, now starting in household waste treatment • Needs to carefully prepare the leather scraps • High NO_x content in the combustion gases • No information on the possible production of dioxin due to the presence of chloride in the leather scraps	-

6.6.2 Fertilisers (xv)

For this recycling technique, two recycling processes are available

- Acid digestion,
- Thermal denaturation.

<u>Acid digestion</u>

A very strong acid (sulphuric) transforms the leather scraps into a liquor. Then, the solution is mixed with an alkaline reactive (lime). At a neutral pH, the mixture becomes solid, like a powder. As it contains nitrogen and calcium, it can be applied on land for fertilisation purposes.

Advantages	Disadvantages	Commercial success?
• Simple and cheap process	• The nitrogen content is low (~3%). It is not worth mixing it with other components in fertilisers • Due to its chromium content, the produced fertiliser is scarcely applied on land pure at 100 %. Moreover, in order to avoid chromium accumulation in the soil, the application of such fertiliser has to be controlled	++

<u>Thermal denaturation</u>

The product obtained in this process is a brown leather powder.

The process involves a thermal denaturation, a dryer (if using a autoclave) or a rotating roaster and a grinder. This powder has been used in Europe for years as a additive to fertilisers formula (addition of Nitrogen).

Advantages	Disadvantages	Commercial success?
• High nitrogen content (11%) in the powder • No transformation Cr III -> Cr VI	• Complex process • Needs a minimum quantity of leather (2000 t/an) to be profitable • Due to its chromium content, the produced fertiliser is scarcely applied on land pure at 100 %. Moreover, in order to avoid chromium accumulation in the soil, the application of such fertiliser has to be controlled	++

6.6.3 Fibre and filler [xvi]

The principle is to mix ground leather with a binder that can be thermoplastic (PVC, PE) or rubber.

Leather plays both roles of a filler and a strengthener. Depending on the proportion of leather, binder and plasticizer, the compound can provide the feeling of real leather or plastic (like for example in heels for which a patent has been filed).

Walled compound can be manufactured with up to 95% of ground leather.

Advantages	Disadvantages	Commercial success?
• simple process	• Needs a very good preparation of the scraps • High constraints on industrial applications: markets difficult to identify (for example: construction, where many technical standards apply)	-

6.6.4 Gelatine / chrome extraction

Leather contains 30-35 % collagen. This is why it is possible to produce gelatine after a physical / chemical reaction. After grinding, the leather scraps become digested in an acid or alkali solution with enzymes. From the resulting solution, a last step separates chromium from collagen and produces industrial gelatine.

Advantages	Disadvantages	Commercial success?
• Environmentally acceptable (on the long term) as chromium is concentrated, isolated and can be treated separately • Produces a high value by-product (gelatine)	• Complex process • Does not accept all types of coated leather	+

6.6.5 Non woven

After a very complete grinding phase, it is possible to separate the collagen fibres themselves. From leather fibres it is then possible to produce non woven materials.

Advantages	Disadvantages	Commercial success?
• Interesting product with high perspiration capacity and high absorbency • Mainly mechanical process • Accepts all types of leather	• Expensive process (grinding phase) • Markets difficult to identify	-

6.6.6 Paper compound

Leather fibres from uncoated leather can be used as a co-raw material in the manufacture of paper. Up to 10 % of leather fibres can be added.

Advantages	Disadvantages	Commercial success?
• the cellulose fibres gain in cohesion thanks to leather fibres, • the compound paper has an attractive appearance and a high absorbency	• Expensive process (grinding phase)	- -

6.6.7 Absorbing material

Due to the hygroscopic nature of leather, it is possible to use ground leather as an absorbing material. Successful experiments have been carried out with crude oil pollution on the French beaches.

Advantages	Disadvantages	Commercial success?
• high absorbency	• Spot market	+

Some of these applications require specialised production equipment. The most sophisticated techniques need annually a high quantity of leather (approx. > 2000 t/year). This is why they can only be applied to concentrated areas of finished products manufacturers.

Among these techniques and up to now, only the solution dealing with fertilisers seems to have a commercial success.

6.7 The recycling of other materials

Some recycling techniques can be applied to the main materials found in the plants. They are briefly presented hereafter.

6.7.1 Textiles

Due to fashion, textiles in finished products can be of any type: natural (cotton, wool, linen) or polyamids, polyester, compound, PVC coated etc..

The main recycling technique applicable word-wide to textiles is the production of fibres. The principle is to use a high speed rotating drum with nails. When touching this drum, textile pieces become transformed into fibres.

Then it is possible to produce textile compounds, felts etc. The common cases apply to cotton or wool for: textile car upholstery, bed mattress and water pipe insulation.

Advantages	Disadvantages	Commercial success?
• Simple process • Market exists	• Low added value • Needs large quantities of natural fibres to be profitable	++

6.7.2 Thermoplastics (footwear industry)

TR, TPU, PVC wastes that are not denatured (not burned) can easily be recycled within the company.

Advantages	Disadvantages	Commercial success?
• Easy to implement in the factory	• Only concerns a small quantity of waste • Can be difficult to handle with light colours	++

When they are denatured because of the injection head temperature, the only way is to destroy them according to the steps 4 to 6.

6.7.3 RIM PU (xvii) (footwear industry)

Many experiments have been carried out by large PU suppliers in order to find a solution for RIM PU carrots, purges etc.

Before trying to recycle those wastes, the first point again is to try to reduce their quantities (step 1).

In step 3, two solutions can be industrially applied to footwear PU RIM:

- chemical recycling,
- recycling as a filler during the injection itself.

Chemical recycling

The PU scraps are ground and mixed with an alcohol. After the chemical reaction (glycolysis), the recovered polyol is incorporated at a certain percentage (<25% of polyol) to the fresh polyol during the production process.

Advantages	Disadvantages	Commercial success?
• Operates at the industrial scale • Over 100 t/year, reduces the cost of RIM-PU waste treatment	• As it changes the formula provided by the PU supplier, we think this solution applies to casual shoe PU more than to safety shoe PU • Needs a large quantity of waste (100 t/year)	+

Recycling as a filler during the injection itself

The PU scraps need to be ground in small particles (< 3 mm). The PU powder can be incorporated at the injection head during production. This of course requires a new injection equipment.

Advantages	Disadvantages	Commercial success?
• Can be implemented in the footwear manufacturing plant itself • Offers a new outlook to such new products	• Requires sophisticated equipment (grinder, injection head) • The operational cost of grinding is expensive • Needs new markets for the new products. Such markets can be influenced by fashion • Few industrial applications for the moment	+/-

6.7.4 Oil

Oil coming from the cutting presses is a very harmful waste to the environment. Recycling oil produces new oil with high commercial value.

Advantages	Disadvantages	Commercial success?
• Can be easily recycled by specialised companies	• Storage arrangements must be clean in the plant before the collection of such oil	++

6.7.5 Solvents

Regarding used solvents (mainly MEK[9]), some small recycling units are now available on the market.

Advantages	Disadvantages	Commercial success?
• Such units are profitable when the company purchases more than 2 m^3 solvent / year.	• Needs to be operated by a specialised operator	+

7. WORN FINISHED LEATHER PRODUCTS

7.1 Introduction

When they are sorted up after they are discarded by the first consumer, part of good worn leather products are sold as a second hand product in the country itself or in the developing countries. An increasing business is made out of this but does not solve the question of the end of life of the product.

A shoe, a leathergood product, a garment is made of different materials. Few information is available on the detailed average composition of leathergood and garment.

9 Methyl Ethyl Keton

On the contrary, the worn shoes are being more and more analysed by research institutes. Approximately 40 different materials can be part of a shoe. In Germany(xviii), the average composition of a "statistic" footwear has been measured after grinding (see Table 23).

Table 23 : proportion of material (statistics in mass for all types of shoes)

Leather	25 %
Textiles and fabrics	6 %
Thermoplastic rubber (TR)	16 %
PU	17 %
EVA copolymer	14 %
Rubber	7 %
PVC	8 %
other (adhesives, metallic parts, sand etc.	7 %

When we want to consider the end of life of a footwear, we have to take in account all these materials.

7.2 Worn shoes - material recycling

All these materials are very difficult to separate. If we can separate them (grinding and sorting), some materials can potentially be recycled, in particular the thermoplastic compounds.

Still now, no unit which would recycle a whole ground shoe is operational now. In fact, the main issues are

- the compounds being produced after material recycling must meet the technical requirements of their target application (in or outside the footwear sector),
- the cost of the recycled compounds are generally not competitive.

For such an activity, the footwear recycling company must charge the shoes being taken. We can make a simple comparison with the tire recycling activity in France. The tire recycling companies (grinding and selling as a filler) must charge more than 60 Euro/ton of car tires. Considering the difficulty to recycle the shoes, such a business would be more expensive in the footwear sector.

7.3 Worn leather products - incineration with energy recovery

Except for PVC and metallic parts

- all the materials have an interesting low heat value (minimum 17 MJ/kg).
- the ash content of these materials is very low (a few %).

This means that burning worn leather products can be very profitable in terms of energy recovery. However, the incineration plant must be equipped with an exhaust emissions treatment unit because:

- the combustion of PVC and PU (soles, coating agent etc.) generates acid gases which have to be neutralised,

- the materials (and in particular leather) may contain heavy metals. The latter go away with the fumes and gazes. In particular, Cr III transforms into Cr VI during the combustion. We have to remember that unlike Cr III, Cr VI is highly toxic and carcinogenic. To prevent this, a complete filtration of the fumes is absolutely necessary.

With this global environmental approach in mind, the CTC is co-ordinating a European research project. The aim of the latter is to develop a method to measure the heavy metal concentration in a footwear and, as an extension, to other leather products.

The results of this work will be introduced in a European standard dealing with eco-criteria regarding footwear. This standard is currently being prepared within the technical committee CEN/TC309/WG2[10] and should be ready by June 2002. This standard will also provide requirements regarding the heavy metal concentrations (10 mg/kg for Arsenic, Lead, Cadmium and Cr VI each).

7.4 Worn leather products - landfilling

The main issue regarding landfilling is the production of harmful leachates: when the rain falls on a landfill, the water penetrates into the piles of wastes and becomes polluted with a lot of chemicals.

At the bottom of the pile, the leachates have to be treated to avoid a burden to the environment (water, ground etc

Hence, due to the content of their materials, worn leather products have to be stored in controlled landfills.

In Germany, a recent federal law[xix] "Kreislaufwirtshafts/Abfallgesetz" is stating that the wastes containing organic matter will not be allowed in the landfills after 2005. Among other wastes, this applies to both materials wastes from manufacturing plants and to worn products. Due to this specific regulation, the worn finished products will have to be recycled as raw material or incinerated with energy recovery.

8. CONCLUSION

The quantification of the wastes produced is a difficult task; the production data (number of pairs of shoes, number of gloves etcare not available on a world wide basis except for leather and for leather footwear. The calculations for the other products have been made from exportation data which do not represent production.

However, with the figures obtained, it seems that Asia is the 1st region regarding the production of wastes in the leather sector. It is producing more than 60 % of the wastes in the world.

Leather scraps represent a large part of these wastes; at the same time, scraps from wet blue (tanning process) are very important too.

In most cases, internal reduction solutions can not reduce the quantities of waste very much and internal recycling solutions can only be applied in large scale to thermoplastics.

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10 CEN = Comité Européen de Normalisation, TC = Technical Committee, WG2 = Working Group n°2

This is why recycling solutions must be found outside the factories. As the recycling technologies need large quantities of wastes (>2000 t/year), the leather sector must organise the collection, the transport and the recycling operations in order to find a solution.

Regarding finished leather specifically, it seems that two recycling options are available now:

- as a component for fertilisers (after keeping or removing chromium),
- as a source of chromium after incineration under controlled conditions.

For the other wastes, it will be difficult to find a recycling solution which could be operational rapidly. This is why the valorisation solution seems to be the incineration with energy recovery and under controlled conditions (exhaust gazes treatment). In that way, scraps containing PVC will probably become a problem due to the production of chlorhydric acid during the combustion. As a consequence, and unlike the other wastes, waste containing PVC will probably continue to need landfills in the next future.

These considerations also apply to worn finished products as the contain the same materials.

In any case, and in order to start/improve the recycling treatment of wastes, the leather sector will need to develop a new internal organisation and new internal responsibilities in the factories as well as a structured organisation between the factories which could deal with these new environmental issues [(xx)].

ANNEX 1

Extraction from the customs directory regarding finished leather products

ANNEX 2

Extraction from the CFCE data base (world-wide customs data base) as an example for leather garments (code 42.03.10). When available in the data base, the values can be in number of pieces and/or in tons.

The complete extraction purchased during this study is available at UNIDO-Vienna

ANNEX 3

List of abbreviations used in the present document

CFCE	Centre Français du Commerce Extérieur
Cr	Chromium
Cr III	Trivalent Cr
Cr VI	Hexavalent Cr
CTC	Centre Technique Cuir Chaussure Maroquinerie, Lyon, France
EVA	Ethylene Vinyl Acetate
IULTCS	International Union of Leather Technologists and Chemists Societies
MJ	Mega Joule
PU	PolyUrethane
PVC	Poly Vynil Chloride
RIM PU	Reaction Injection Moulding PU
TP	Thermoplastic Rubber
TPU	Thermoplastic PU
UNIDO	United Nations Industrial Development Organisation
WB	Wet Blue

ANNEX 4

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